School Start Time
RESEARCH & INFORMATION

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March 8, 2017

Re: SB 328: School Start Time

Dear Public School Supporter,

I recently introduced SB 328, which will require California school districts to start the middle and high school day no earlier than 8:30 a.m.

The vast majority of middle and high schools in California begin at times that are contrary to the sleep-health-needs and developmental norms of adolescents. Currently, California has over 3 million middle school and high school students. The average school start time for these students is 8:07 a.m.

The purpose of this booklet is to share research and information on the importance of setting the proper school start time to benefit all our children. Included are reports, statistics and research on school start time. It is my hope that, upon review, you will join me in seeing the benefit for our middle and high school students to moving the start time back. This small change will improve student health, safety, and educational development.

I would like to acknowledge and thank the Start School Later organization, the researchers, the media, and the bill's supporters for sharing the enclosed information.

Sincerely,

Anthony J Portantino

ANTHONY J. PORTANTINO
State Senator, 25th District

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SB 328 (Portantino)
School Start Time

PROBLEM

The vast majority of middle and high schools in California begin at times that are contrary to the sleep-health needs and developmental norms of adolescents. Currently, California has over 3 million middle school and high school students. The average school start time for these students is 8:07am, according to the Centers for Disease Control and Prevention.

BACKGROUND

California sets the standard for many aspects of the school system. For example, the number of days and hours schools must be in session, what tests need to be administered, and graduation requirements. However, local school districts are provided no guidance about what school hours are most appropriate for students' safety, health and learning. Today, over twenty school districts throughout California have begun discussing or planning for later school day start times, while some school districts have already implemented the 8:30am or later start time.

The American Academy of Pediatrics issued a policy statement advising school districts to change the school day start time to no earlier than 8:30am, specifically for middle schools and high schools. Studies have confirmed that insufficient sleep in teenage adolescents poses a public health risk and has an adverse effect on academic success.

According to the American Psychological Association, reports on school districts that have adopted the policy to start the school day no earlier than 8:30am have found increased attendance rates, grade point averages, state assessments scores, college admission test scores, student attention, and student and family interaction. Additionally, studies found decreases in student-involved car accidents, disciplinary actions, and students sleeping during lectures.

The American Medical Association encourages physicians to actively educate parents, schools, teachers and community members about the importance of sleep for adolescent mental and physical health based on their proven biological needs.

Furthermore, the National Highway Traffic Safety Administration reported that traffic accidents are the leading cause of death for teenagers in the United States and roughly 100,000 traffic accidents each year are due to drowsiness and fatigue. Over 20 studies since 1994 using driving simulators demonstrate drowsy driving impairment being equivalent to driving legally drunk.

BILL SUMMARY

SB 328 addresses the need for California middle and high schools to start the school day no earlier than 8:30am.

EXISTING LAW

California requires the governing board of each school district to fix the length of the school day for the several grades and classes with the schools being maintained by the school district in accordance with specified provisions of law.

SUPPORT

Start School Later.net (Sponsor)
Children's Hospital Los Angeles

Version: 3/6/2017

Office of Senator Anthony J. Portantino
SB 328 – Fact Sheet
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Reports/Research

REPORTS, RESEARCH and ARTICLES about the need for SAFE AND HEALTHY SCHOOL HOURS

Content included up to February 2017

Start School Later is a 501(c)(3) nonprofit organization of health professionals, sleep scientists, educators, parents, students, and other concerned citizens who are working to ensure that all public schools can set hours compatible with health, safety, equity, and learning.

INTRODUCTION

The majority of our nation's public schools require students to be in class at times that are incompatible with adolescent sleep needs and patterns. Nearly 10 percent of U.S. high schools currently start before 7:30 a.m., 40 percent before 8 a.m., and only about 15 percent after 8:30 a.m. Bus pick-ups begin at around 5:30 a.m. in some districts, so teens must wake at 5 or 6 a.m. to get to school on time.

These early hours, set in the mid-20th century largely to save money on buses, interfere with the quality, quantity, consistency, and timing of adolescent sleep and create a huge sleep debt every week of the school year. That is why both the American Academy of Pediatrics and the U.S. Centers for Disease Control and Prevention now recommend that middle and high schools start class no earlier than 8:30 a.m.

The health, safety, and equity benefits of starting middle and high school at times more in-sync with the sleep needs of students are irrefutable. The benefits include:

- Improved alertness, memory, attention, and cognitive processing skills
- Improved academic performance that may be twice as great in disadvantaged students
- Reduced tardiness, truancy, and drop-out rates
- More sleep per night and reduced fatigue
- Reduced depression, anxiety, and suicidal thoughts and behaviors
- Improved athletic performance and fewer athletic injuries
- Reduced risk of obesity, eating disorders, and diabetes
- Improved mood and impulse control
- Stronger immune system
- Reduced risk of stimulant use, substance abuse, and high-risk health behaviors, especially during unsupervised afternoon hours
- Reduced delinquency
- Increased visibility during commutes to school, fewer car crashes, and better psychomotor performance
- Long-term economic and equity benefits. For example, a report published by the Brookings Institution estimates that early school start times reduce performance among disadvantaged students by an amount equivalent to having a highly ineffective teacher and that moving bell times an hour later would result in higher future lifetime earnings at a benefit:cost ratio of at least 9:1.

The need for safe and healthy K-12 school hours is a national public health concern that is still being treated like a negotiable school budget item. Returning to later, healthier, safer, evidence-based school hours is a reform with the potential to improve the health, safety, and academic achievement of all students, immediately and often at low or even no cost. To do so, however, school communities need help recognizing that sleep and sleep-friendly school hours are critical matters of child health and safety.

Terra Ziporyn Snider, Ph.D. Executive Director and Co-Founder, Start School Later
terra@startschoollater.net (June 2016)

THE CONTENTS OF THIS PACKET

- The materials in this packet are examples of the reports, research and articles that have been published about school start times and the need for safe and healthy school hours.
- The PDFs and screenshots gathered here are provided for convenience. Start School Later encourages readers to visit the original source documents when able.
- The contents are generally organized by the most prominent or recent studies and articles first followed by materials in alphabetical order by source.
- Among the multi-media materials that exist on this topic is the following Huffington Post video featuring the Start School Later movement and its co-founder, Terra Ziporyn Snider. Watch the video at http://rise.huffingtonpost.com/watch/case-starting-school-later or by visiting the home page of www.startschoollater.net

Why do we need healthy school hours? Terra Ziporyn Snider explains on **HuffPost RISE**.

Why We Must - and Can - Restore Safe & Healthy School Hours

From www.startschoollater.net/why-change

Search

Returning to later, healthier, safer, evidence-based school hours is a reform with the potential to improve the health, safety, and academic achievement of all students. What are we waiting for?

Why is this a problem?

Sleep experts have determined a shift in sleep cycles (circadian rhythms) beginning in adolescence that makes it more difficult for most adolescents to fall asleep as early as younger children or older adults. Typical sleep cycles begin around 11 p.m. for teenagers and continue through 8 a.m.. This means that an early wake-up call (5 or 6 a.m. to allow many teens to catch buses or commute to early-start schools) not only allows 6 or 7 hours of sleep per school night at most but also requires students to wake up in the middle of deep sleep. According to most sleep experts, most adolescents need about 9 hours of sleep per night. Today nearly 2/3 get under 8, and 2/5 get under 6 hours of sleep per night.

Nearly 10% of U.S. high schools currently start before 7:30 a.m., 40% start before 8 a.m., and only about 15% start after 8:30 a.m. Over 20% of U.S. middle schools start class at 7:45 a.m. or earlier. Bus pick-ups start shortly after 5:30 a.m. in some districts, and teens must wake at 5 or 6 a.m. to get to school on time. Meanwhile, the school day ends in the early afternoon, sometimes even before 2 p.m. These schedules are out-of-sync with the sleep needs and patterns of middle and high school students, whose brains and bodies are still growing, and create a huge sleep debt every week of the school year.

Early school hours PREVENT many students and young teachers from getting the 9 or so hours of sleep per night that most teenagers and young adults need. The health, safety, and equity benefits to starting middle and high school at times more in sync with the sleep needs and patterns of students are irrefutable.

History and Status Quo

A hundred years ago most schools (and places of business) started the day around 9 a.m. In the 1970s and 1980s, however, many schools shifted to earlier hours. Back then the importance of sleep and the nature of the adolescent sleep shift weren't understood, and the cost savings of running the fewest possible buses in three cycles was appealing. Even schools that didn't run buses often found it helpful to move start times earlier so that after-school schedules coordinated with those of nearby schools. As a result, many students today are asked to go to school on a "morning shift" schedule, one that requires that they be in class much earlier than many of their parents and grandparents might have been. When public school times change, the whole community's rhythms change: "after" school stretches to four hours (and fills up with activities) or kids are unsupervised during the peak period for adolescent crime and risky behavior until the typical adult workday ends. Elementary schools start as late as 9:15 or 9:30, forcing working parents to send their young children to before-school care as well as after-care. Families whose children are in multiple school levels often have start and end times that span two hours in the morning and another two hours in the afternoon. The cost is being borne by students and their families.

Health Impact

Since the 1990s, sleep researchers and other health professionals have been telling us that these early school hours are harming children. It's not just the numbers of hours of sleep, but also the timing of sleep that is required for optimal health. Sleep deprivation's impacts include: weight gain and eating disorders and increased risk of obesity, cardiovascular problems, and diabetes; reduced immunity; depression; anxiety; substance abuse; mood swings; behavior problems; suicidal ideation; and potential impacts on brain development.

Safety

Kids are out walking to the bus or driving to school in the dark for most of the school year in many communities. With few adults around, they are at risk. Drowsy driving increases - for our newest drivers. Teens released in the early afternoon (sometimes well before 2 p.m.!) have hours of unsupervised time until the typical adult work day ends. Sleep deprivation increases risk-taking behavior, substance abuse, and impedes judgment and decision-making ability.

Equity and Achievement Gap

Private schools rarely start earlier than 8 a.m. - and even those that start this early do so primarily to accommodate community life that centers on early-starting public schools. Parents with means can pull their children out of early-starting schools or they can choose to drive them to school or provide them with cars to give their children extra sleep in the mornings. They can drive provide late rides to school and absence notes on occasion to overcome the health, safety, and learning impact of chronic sleep deprivation. Families with fixed work schedules or lacking transportation aren't able to help their kids if they miss the bus and thus put their children at risk of tardiness or absence. As a result, children from disadvantaged backgrounds not only risk higher rates of tardiness and truancy, but also higher rates of dropping out of school - potentially increasing the achievement gap. When school start times are moved later, not only do rates of tardiness, truancy, absenteeism, and dropping-out decline, but improvements in academic achievement are nearly twice as high in students from economically disadvantaged homes.

School Success

Kids who are tired can't learn at their best, and sleep deprivation impairs learning, memory, and attention as much as it impairs health and overall well-being. Academic improvements have been shown, and overall school climate has been measurably improved when high schools have restored later start times. Teachers have commented extensively about the improvement in the classroom environment when students are more alert, less moody, and less likely to sleep in class.

Successful Change

Hundreds of schools around the United States have restored later start times, and many more never moved to extremely early hours in the first place. The schools that have found affordable, feasible ways to do so have been both large and small. Some have seen cost-savings by redesigning transportation systems more efficiently and applied those cost-savings to any expense incurred by re-scheduling. These districts can say they looked at the science of what's best for the students and made the change accordingly. They are seeing large and small benefits to physical and mental heath, learning, attendance, graduation rates, car crashes, and overall student well-being.

Let Them Sleep: AAP Recommends Delaying Start Times of Middle and High Schools to Combat Teen Sleep Deprivation

8/25/2014

For Release: August 25, 2014

Studies show that adolescents who don't get enough sleep often suffer physical and mental health problems, an increased risk of automobile accidents and a decline in academic performance. But getting enough sleep each night can be hard for teens whose natural sleep cycles make it difficult for them to fall asleep before 11 p.m. – and who face a first-period class at 7:30 a.m. or earlier the next day.

In a new policy statement published online Aug. 25, the American Academy of Pediatrics (AAP) recommends middle and high schools delay the start of class to 8:30 a.m. or later. Doing so will align school schedules to the biological sleep rhythms of adolescents, whose sleep-wake cycles begin to shift up to two hours later at the start of puberty.

"Chronic sleep loss in children and adolescents is one of the most common – and easily fixable – public health issues in the U.S. today," said pediatrician Judith Owens, MD, FAAP, lead author of the policy statement, "School Start Times for Adolescents," published in the September 2014 issue of Pediatrics.

"The research is clear that adolescents who get enough sleep have a reduced risk of being overweight or suffering depression, are less likely to be involved in automobile accidents, and have better grades, higher standardized test scores and an overall better quality of life," Dr. Owens said. "Studies have shown that delaying early school start times is one key factor that can help adolescents get the sleep they need to grow and learn."

Many studies have documented that the average adolescent in the U.S. is chronically sleep-deprived and pathologically sleepy. A National Sleep Foundation poll found 59 percent of 6th through 8th graders and 87 percent of high school students in the U.S. were getting less than the recommended 8.5 to 9.5 hours of sleep on school nights.

The policy statement is accompanied by a technical report, "Insufficient Sleep in Adolescents and Young Adults: An Update on Causes and Consequences," also published online Aug. 25. The technical report updates a prior report on excessive sleepiness among adolescents that was published in 2005.

The reasons for teens' lack of sleep are complex, and include homework, extracurricular activities, after-school jobs and use of technology that can keep them up late on week nights. The AAP recommends pediatricians counsel teens and parents about healthy sleep habits, including enforcing a media curfew. The AAP also advises health care professionals to educate parents, educators, athletic coaches and other stakeholders about the biological and environmental factors that contribute to insufficient sleep.

But the evidence strongly suggests that a too-early start to the school day is a critical contributor to chronic sleep deprivation among American adolescents. An estimated 40 percent of high schools in the U.S. currently have a start time before 8 a.m.; only 15 percent start at 8:30 a.m. or later. The median middle school start time is 8 a.m., and more than 20 percent of middle schools start at 7:45 a.m. or earlier.

Napping, extending sleep on weekends, and caffeine consumption can temporarily counteract sleepiness, but they do not restore optimal alertness and are not a substitute for regular, sufficient sleep, according to the AAP.

The AAP urges middle and high schools to aim for start times that allow students to receive 8.5 to 9.5 hours of sleep a night. In most cases, this will mean a school start time of 8:30 a.m. or later, though schools should also consider average commuting times and other local factors.

"The AAP is making a definitive and powerful statement about the importance of sleep to the health, safety, performance and well-being of our nation's youth," Dr. Owens said. "By advocating for later school start times for middle and high school students, the AAP is both promoting the compelling scientific evidence that supports school start time delay as an important public health measure, and providing support and encouragement to those school districts around the country contemplating that change."

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The American Academy of Pediatrics is an organization of 62,000 primary care pediatricians, pediatric medical subspecialists and pediatric surgical specialists dedicated to the health, safety and well-being of infants, children, adolescents and young adults. For more information, visit www.aap.org.

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POLICY STATEMENT

School Start Times for Adolescents

abstract

FREE

The American Academy of Pediatrics recognizes insufficient sleep in adolescents as an important public health issue that significantly affects the health and safety, as well as the academic success, of our nation's middle and high school students. Although a number of factors, including biological changes in sleep associated with puberty, lifestyle choices, and academic demands, negatively affect middle and high school students' ability to obtain sufficient sleep, the evidence strongly implicates earlier school start times (ie, before 8:30 AM) as a key modifiable contributor to insufficient sleep, as well as circadian rhythm disruption, in this population. Furthermore, 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. The American Academy of Pediatrics strongly supports the efforts of school districts to optimize sleep in students and urges high schools and middle schools to aim for start times that allow students the opportunity to achieve optimal levels of sleep (8.5–9.5 hours) and to improve physical (eg, reduced obesity risk) and mental (eg, lower rates of depression) health, safety (eg, drowsy driving crashes), academic performance, and quality of life. *Pediatrics* 2014;134:642–649

ADOLESCENT SLEEP WORKING GROUP, COMMITTEE ON ADOLESCENCE, AND COUNCIL ON SCHOOL HEALTH

KEY WORDS

adolescents, insufficient sleep, school start times

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FACTORS INFLUENCING INSUFFICIENT SLEEP IN ADOLESCENTS

Insufficient sleep represents one of the most common, important, and potentially remediable health risks in children,[1,2] particularly in the adolescent population, for whom chronic sleep loss has increasingly become the norm.[3] The reasons behind the current epidemic of insufficient sleep are complex and interrelated. From a biological perspective, at about the time of pubertal onset, most adolescents begin to experience a sleep–wake "phase delay" (later sleep onset and wake times), manifested as a shift of up to 2 hours relative to sleep–wake cycles in middle childhood.[4] Two principal biological changes in sleep regulation are thought to be responsible for this phenomenon.[5,6] One factor is delayed timing of nocturnal melatonin secretion across adolescence[5,7,8] that parallels a shift in circadian phase preference from more "morning" type to more "evening" type, which consequently results in difficulty falling asleep at an earlier bedtime.[4] The second biological factor is an altered "sleep drive" across adolescence, in which the pressure to fall asleep accumulates more slowly, as demonstrated by the adolescent brain's response to sleep loss[9]

and by a longer time to fall asleep after being awake for 14.5 to 18.5 hours in postpubertal versus prepubertal teenagers.[10] Thus, these 2 factors typically make it easier for adolescents to stay awake later. At the same time, several studies from different perspectives indicate that adolescent sleep needs do not decline from preadolescent levels, and optimal sleep for most teenagers is in the range of 8.5 to 9.5 hours per night.[5,11,12] On a practical level, this research indicates that the average teenager in today's society has difficulty falling asleep before 11:00 PM and is best suited to wake at 8:00 AM or later.[4,12,13]

The sleep–wake changes that flow from this biological maturation may enable teenagers' interactions with such environmental factors and lifestyle/social demands as homework, extracurricular activities, after-school jobs, and use of technology.[14–16] As a result, most teenagers stay up late on school nights, getting too little sleep, and then sleep in on weekends to "catch up" on sleep. Although this weekend oversleeping can help offset the weekly sleep deficit, it can worsen circadian disruption and morning sleepiness at school.[9,17,18]

The Extent and Effects of Adolescent Sleep Loss

Given both biological demands and today's sociocultural influences, it is not surprising that many studies have documented that the average adolescent in the United States is chronically sleep deprived and pathologically sleepy (ie, regularly experiencing levels of sleepiness commensurate with those of patients with sleep disorders such as narcolepsy).[19] For example, a recent National Sleep Foundation poll[20] found that 59% of sixth- through eighth-graders and 87% of high school students in the United States were getting less than the recommended 8.5 to 9.5 hours of sleep on school nights; indeed, the average amount of school night sleep obtained by high school seniors was less than 7 hours. In this same survey, however, 71% of parents believed that their adolescent was obtaining sufficient sleep. This mismatch indicates a significant lack of awareness among adults regarding the extent of adolescent sleep loss. As a result, many middle and high school students are at risk for adverse consequences of insufficient sleep, including impairments in mood, affect regulation, attention, memory, behavior control, executive function, and quality of life (Table 1).[21–26]

Insufficient sleep also takes a toll on academic performance. In the National Sleep Foundation poll cited previously,[20] 28% of students reported falling asleep in school at least once a week, and more than 1 in 5 fell asleep doing homework with similar frequency. Many studies show an association between decreased sleep duration and lower academic achievement at the middle school, high school, and college levels, as well as higher rates of absenteeism and tardiness and decreased readiness to learn (Table 1).[17,27–30]

An increased prevalence of anxiety and mood disorders has also been linked to poor quality and insufficient sleep in adolescents.[31–33] Other specific health-related effects of sleep loss include increased use of stimulants (eg, caffeine, prescription medications) to counter the effects of chronic sleepiness on academic performance.[34,35] Adolescents are also at greater risk of drowsy driving–related crashes as a result of insufficient sleep.[36,37] Chronic sleep restriction increases subsequent risk of both cardiovascular disease and metabolic dysfunction, such as type 2 diabetes mellitus.[38,39] An association between short sleep duration and obesity in children and adolescents has been demonstrated in several cross-sectional and prospective studies, underscoring how chronic sleep restriction can undermine health (Table 1).[40,41]

IDENTIFYING SOLUTIONS: THE ROLE OF DELAYING SCHOOL START TIMES

This "epidemic" of delayed, insufficient, and erratic sleep patterns among adolescents and the accompanying negative effects on adolescent health and well-being highlight the importance of identifying potentially modifiable factors. The quest to reduce the high cost of sleep loss in adolescents is not only an important public health issue but one of paramount importance to educators, pediatric health care providers, and

TABLE 1 Impact of Chronic Sleep Loss in Adolescents

Physical health and safety
Increased obesity risk
Metabolic dysfunction (hypercholesterolemia, type 2 diabetes mellitus)
Increased cardiovascular morbidity (hypertension, increased risk of stroke)
Increased rates of motor vehicle crashes ("drowsy driving")
Higher rates of caffeine consumption; increased risk of toxicity/overdose
Nonmedical use of stimulant medications; diversion
Lower levels of physical activity
Mental health and behavior
Increased risk for anxiety, depression, suicidal ideation
Poor impulse control and self-regulation; increased risk-taking behaviors
Emotional dysregulation; decreased positive affect
Impaired interpretation of social/emotional cues in self and others
Decreased motivation
Increased vulnerability to stress
Academics and school performance
Cognitive deficits, especially with more complex tasks
Impairments in executive function (working memory, organization, time management, sustained effort)
Impairments in attention and memory
Deficits in abstract thinking, verbal creativity
Decreased performance efficiency and output
Lower academic achievement
Poor school attendance
Increased dropout rates

advocates for adolescent health. Although many changes over the course of adolescence can affect the quality and quantity of sleep, one of the most salient and, arguably, most malleable is that of school start times. Numerous studies have demonstrated that early start times impede middle and high school students' ability to get sufficient sleep. Studies comparing high schools with start times as little as 30 minutes earlier versus those with later start times demonstrate such adverse consequences as shorter sleep duration, increased sleepiness, difficulty concentrating, behavior problems, and absenteeism.[29,30,42–46] For example, in one key school transition study, Carskadon et al[19] evaluated the effects of a 65-minute advance (ie, move earlier) in school start time from grade 9 to grade 10 in 40 students. They found a delay in the biological markers of circadian timing but also objectively measured daytime sleepiness levels typical of patients with sleep disorders.

Because circadian-based phase delays emerge at around the time of pubertal onset, they also affect younger adolescents, who increasingly are subject to many of the same environmental and lifestyle competing priorities for sleep as older teenagers. Recent research shows that delaying school start times for middle school students is accompanied by positive outcomes similar to those found in high schools, including later rise times, more school night total sleep, less daytime sleepiness, decreased tardiness rates, improved academic performance, and better performance on computerized attention tasks.[30,47,48]

According to the US Department of Education statistics for 2011–2012,[49] approximately 43% of the over 18 000 public high schools in the United States currently have a start time before 8:00 AM. Over the last 15 years, however, a small but growing number of school districts have responded to research reports regarding insufficient sleep among middle and high school students with what may be viewed as a "systematic countermeasure" to reduce the prevalence of sleepiness and its consequences: delaying school start times. Early studies addressed a core question: "Does delaying start time result in students obtaining more sleep, or do students just stay up later and thus negate the effects of the delayed start time?" Wahlstrom et al[50,51] assessed more than 18 000 high school students in Minneapolis before and after the district's school start time changed from 7:15 AM to 8:40 AM beginning with the 1997–1998 school year. Bedtimes after the change were similar (ie, did not shift to a later time) to those of students in schools that did not change start times, and, as a result, students obtained nearly 1 additional hour of sleep on school nights during the 1999–2000 school year. Other studies have also failed to show a delay in bedtime in response to delayed start times. In a study involving grades 6 through 12 in a school district that delayed high school start times by 1 hour (7:30 to 8:30 AM), students averaged 12 to 30 minutes more nightly sleep, and the percentage of students who reported ≥8 hours of sleep increased from 37% to 50%.[52] Owens et al,[53] in a study of adolescents attending an independent school that instituted a start time delay of 30 minutes (from 8:00 to 8:30 AM), reported that average bedtimes actually shifted *earlier* by an average of 18 minutes, and mean self-reported school night sleep duration increased by 45 minutes. In addition, the percentage of students getting less than 7 hours of sleep decreased by 79%, and those reporting at least 8 hours of sleep increased from 16% to 55%. Finally, in a 3-year study of >9000 students from 8 public high schools in 3 states (Colorado, Wyoming, and Minnesota), the percentage of students sleeping ≥8 hours per night was dramatically higher in those schools that had a later start time (eg, 33% at 7:30 AM vs 66% at 8:55 AM).[54]

Moreover, a number of studies have now clearly demonstrated that delaying school start times not only results in a substantive increase in average sleep duration but also has a significant positive effect on a variety of key outcomes; these effects range from decreased levels of self-reported sleepiness and fatigue to improvements in academic measures. In the Minneapolis study,[50,51] attendance rates for students in grades 9 through 11 improved, and the percentage of high school students continuously enrolled increased. Likewise, Dexter et al[42] found that public high school sophomores and juniors at a later- versus earlier-starting high school reported more sleep and less daytime sleepiness. Htwe et al[55] reported that high school students slept an additional 35 minutes, on average, and experienced less daytime sleepiness after their school start time was delayed from 7:35 to 8:15 AM.

Improvements in academic achievement associated with delayed start times have been somewhat less consistently demonstrated; in the Minneapolis study, grades showed a slight but not statistically significant improvement,[50] and standardized test scores were not increased overall compared with those before the start time change.[46,56] However, several recent studies have documented improvements in academic performance associated with later start times. A study of students in Chicago public high schools demonstrated that absences were much more common and student grades and test score performance were notably lower for first-period classes compared with afternoon classes and that performance on end-of-year

subject-specific standardized tests (ie, math, English) correlated with whether the student was scheduled for that subject during first period.[56] Similarly, first-year Air Force Academy students assigned to start classes after 8:00 AM (compared with before 8:00 AM) performed better in their first-period course and, in addition, had a 0.15 SD increase in performance across all of their courses.[44] In a study focusing on middle school students,[45] a 1-hour later shift in school start times was associated with an increase in reading test scores by 0.03 to 0.10 SD and in math test scores by 0.06 to 0.09 SD. The author concluded that an increase in start times by 1 hour would result in a 3 percentile point gain in both math and reading test scores for the average student. Furthermore, students performing in the lower end of the test score distribution seemed to benefit most, with gains roughly twice those in above-average students, and the effects persisted into high school. In a more recent middle school study by the same research group, the results suggested that moving school start later by 1 hour can have an impact on standardized test scores comparable to decreasing the class size by one-third. Finally, in a recent 3-state study, 5 of the 6 high schools in which grade point average was assessed showed a significant pre–post increase in grade point average in core subjects of math, English, science, and social studies.[54]

Finally, there may be additional health-related and other benefits associated with delays in start time. For example, students in the independent school study cited previously[53] reported significantly more satisfaction with their sleep. In addition, class attendance improved, as did health-related variables, including fewer visits to the campus health center for fatigue-related complaints.[53] Although not specifically assessed as an outcome in previous research, later start times might increase the likelihood that students will eat breakfast before school and thus further enhance their readiness to learn.[57] Finally, improvements in teacher satisfaction linked to increased sleep offers yet another potential mechanism for classroom enrichment.

Several other outcome measures examined in these studies also deserve emphasis. In the study by Owens et al,[53] there were significantly fewer students self-reporting symptoms of depressed mood as well as improved motivation after the start time delay. In a more recent study, also conducted in an independent school setting, a 25-minute delay in start time was associated not only with increased sleep duration and decreased daytime sleepiness but also with less self-reported depressed mood.[58] Although more research is needed, given the mounting evidence supporting a bidirectional link between sleep patterns and problems and mood disorders in this population[59] (including an increased risk of suicidal ideation[57]), countermeasures that could potentially mitigate these effects have important public health implications.

Furthermore, adolescents are at particularly high risk of driving while impaired by sleepiness, and young drivers aged 25 years or younger are involved in more than one-half of the estimated 100 000 police-reported, fatigue-related traffic crashes each year.[60] Danner and Phillips[52] examined the relationship between automobile crash records for students 17 to 18 years of age and high school start times. Car crash rates for the county that delayed school start times decreased by 16.5% over the 2 years before and after the school-start change, whereas those for the state as a whole increased by 7.8% across the same time period. In another recent study conducted in 2 adjacent, demographically similar cities, there were significantly increased teen (16- to 18-year-olds) crash rates over a 2-year period in the city with earlier high school start times (2007: 71.2 per 1000 vs 55.6 per 1000; 2008: 65.8 per 1000 vs 46.6 per 1000 [$P < .001$]), and teen drivers' morning crash peaks occurred 1 hour earlier.[61] Finally, the recent study by Wahlstrom et al[54] found a crash rate reduction in 16- to 18-year-olds of 65% and 70%, respectively, in 2 of the 4 high schools studied; notably, the high school with the latest start time (Jackson Hole, WY) had the largest decline in car crashes.

Although considerable empiric support exists for the concepts that early school start times are detrimental to adolescents' health and well-being and that delaying school start times results in substantive and sustained benefits to students, the ongoing debate among school districts in the United States regarding the widespread institution of later start times for middle and high schools continues to spark controversy. Moreover, the logistical considerations in implementing delayed school start times in middle and high schools are far from trivial. Wolfson and Carskadon[62] surveyed 345 public high school personnel regarding their perspective on high school start times, factors influencing school start times, and decision-making around school schedules. Most respondents at that time had not changed or contemplated changing their school start times. Perceived barriers to changing school schedules commonly endorsed included curtailed time for athletic practices and interference with scheduling of games, reduced after-school employment hours for students, challenges in providing child care for younger siblings, adjustments in parent and family schedules, potential safety issues, effects on sleep duration in younger children if

elementary school schedules are "flipped" with those of middle/high school students, and the need to make alternative transportation arrangements. However, to date, to our knowledge, there have been no published studies that have systematically examined the impact of school start time delay on these parameters, although anecdotal evidence suggests that many of these concerns are unfounded (www.sleepfoundation.org). Moreover, communities across the country have adopted a variety of creative solutions to address these problems, including shifting to public transportation for older students, enlisting community volunteers to provide supervision at bus stops, adjusting class schedules to minimize late dismissal times, scheduling free periods/study halls at the end of the school day to allow participation in after-school extracurricular activities, exempting student athletes from physical education requirements, and installing lights for athletic fields.

In addition, as outlined in a recent Brookings Institute Report ("Organizing Schools to Improve Student Achievement: Start Times, Grade Configurations, and Teacher Assignments"),[63] economists have suggested that delaying school start times would have a substantial benefit-to-cost ratio (9:1). This finding is based on a conservative estimate of both costs per student ($0–$1950, largely related to transportation) and the increase in projected future earnings per student in present value because of test score gains related to moving start times 1 hour later (approximately $17 500). Finally, because the appropriation of federal dollars for schools is partially dependent on student attendance data, reducing tardiness and absenteeism levels could result in increased funding and further offset costs related to moving start times later.

CONCLUSIONS

Taken together, these studies support the presence of significant improvements in benchmarks of health and academic success in a variety of settings in association with later school start times, including in urban school districts with a large percentage of low-income and minority students, suburban public schools, and college-preparatory independent schools. It is clear that additional research is needed to further document the effects of changes in school start times over time, to examine specific factors that increase or decrease the likelihood of positive outcomes, and to assess the effect on families, the community, other stakeholders, and the educational system in general. However, it may be strongly argued that both the urgency and the magnitude of the problem of sleep loss in adolescents and the availability of an intervention that has the potential to have broad and immediate effects are highly compelling.

It should also be emphasized that delaying school start times alone is less likely to have a significant effect without concomitant attention to other contributing and potentially remediable factors, such as excessive demands on students' time because of homework, extracurricular activities, after-school employment, social networking, and electronic media use. One of the biggest challenges school districts face is the need to inform community stakeholders (eg, parents, teachers and administrators, coaches, students, bus drivers, businesses that employ students, law enforcement officials) about the scientific rationale underpinning the merits of delaying school start times; the threats to health, safety, and academic success posed by insufficient sleep; and the potential benefits for adolescents of school start time delay. Thus, education and community engagement are equally key components in increasing the likelihood of success.

The American Academy of Pediatrics recognizes insufficient sleep in adolescents as a public health issue, endorses the scientific rationale for later school start times, and acknowledges the potential benefits to students with regard to physical and mental health, safety, and academic achievement. The American Academy of Pediatrics lends its strong support to school districts contemplating delaying school start times as a means of optimizing sleep and alertness in the learning environment and encourages all school administrators and other stakeholders in communities around the country to review the scientific evidence regarding school start times, to initiate discussions on this issue, and to systematically evaluate the community-wide impact of these changes (eg, on academic performance, school budget, traffic patterns, teacher retention).

RECOMMENDATIONS

1. Pediatricians should educate adolescents and parents regarding the optimal sleep amount teenagers need to match physiologic sleep needs (8.5–9.5 hours). Although napping, extending sleep on weekends, and caffeine consumption can temporarily counteract sleepiness, these measures do not restore optimal alertness and are not a substitute for regular sufficient sleep.
2. Health care professionals, especially those working in school-based clinics or acting in an advisory capacity to schools, should be aware of adolescent sleep needs. They should educate parents, teenagers, educators, athletic coaches, and other stakeholders about the biological and environmental factors, including early school start times, that contribute to widespread chronic sleep deprivation in America's youth.

3. Educational interventions for parents and adolescents as well as the general public should be developed and disseminated by the American Academy of Pediatrics and other child and sleep health advocacy groups. Content should include the potential risks of chronic sleep loss in adolescents, including depressed mood, deficits in learning, attention and memory problems, poor impulse control, academic performance deficits, an increased risk of fall-asleep motor vehicle crashes, and an elevated risk of obesity, hypertension, and long-term cardiovascular morbidity. Information should also be included about the potential utility of systemic countermeasures, including delaying school start times, in mitigating these effects. Finally, educational efforts should also emphasize the importance of behavior change on the individual level and the personal responsibility that families and students themselves have in modifying their sleep habits.
4. Pediatricians and other pediatric health care providers (eg, school physicians, school nurses) should provide scientific information, evidence-based rationales, guidance, and support to educate school administrators, parent-teacher associations, and school boards about the benefits of instituting a delay in start times as a potentially highly cost-effective countermeasure to adolescent sleep deprivation and sleepiness. In most districts, middle and high schools should aim for a starting time of no earlier than 8:30 AM. However, individual school districts also need to take average commuting times and other exigencies into account in setting a start time that allows for adequate sleep opportunity for students. Additional information regarding opportunities, challenges, and potential solutions involved in changing school start times may be found at: http://www.sleepfoundation.org/article/sleep-topics/school-start-time-and-sleep; http://schoolstarttime.org.
5. Pediatricians should routinely provide education and support to adolescents and families regarding the significance of sleep and healthy sleep habits as an important component of anticipatory guidance and well-child care. In particular, pediatricians should endorse parental involvement in setting bedtimes and in supervising sleep practices, such as social networking and electronic media use in the bedroom; for example, pediatricians could recommend to parents that they establish a "home media use plan" and enforce a "media curfew." Adolescents should be regularly queried regarding sleep patterns and duration and counseled about the risks of excessive caffeine consumption, misuse of stimulant medications as a countermeasure to sleepiness, and the dangers of drowsy driving.

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REFERENCES

1. US Department of Health and Human Services. Healthy People 2020 sleep health objectives. Available at: www.healthypeople.gov/2020/topicsobjectives2020/objectiveslist.aspx?topicId=38. Accessed June 26, 2013

2. Chen MY, Wang EK, Jeng YJ. Adequate sleep among adolescents is positively associated with health status and health-related behaviors. *BMC Public Health*. 2006;6:59
3. Eaton DK, McKnight-Eily LR, Lowry R, Perry GS, Presley-Cantrell L, Croft JB. Prevalence of insufficient, borderline, and optimal hours of sleep among high school students —United States, 2007. *J Adolesc Health*. 2010;46(4):399–401
4. Frey S, Balu S, Greusing S, Rothen N, Cajochen C. Consequences of the timing of menarche on female adolescent sleep phase preference. *PLoS ONE*. 2009;4(4): e5217
5. Carskadon MA, Acebo C, Jenni OG. Regulation of adolescent sleep: implications for behavior. *Ann N Y Acad Sci*. 2004;1021:276–291
6. Carskadon MA. Sleep in adolescents: the perfect storm. *Pediatr Clin North Am*. 2011; 58(3):637–647
7. Crowley SJ, Acebo C, Fallone G, Carskadon MA. Estimating dim light melatonin onset (DLMO) phase in adolescents using summer or school-year sleep/wake schedules. *Sleep*. 2006;29(12):1632–1641
8. Carskadon MA, Acebo C, Richardson GS, Tate BA, Seifer R. An approach to studying circadian rhythms of adolescent humans. *J Biol Rhythms*. 1997;12(3):278–289
9. Jenni OG, Achermann P, Carskadon MA. Homeostatic sleep regulation in adolescents. *Sleep*. 2005;28(11):1446–1454
10. Taylor DJ, Jenni OG, Acebo C, Carskadon MA. Sleep tendency during extended wakefulness: insights into adolescent sleep regulation and behavior. *J Sleep Res*. 2005; 14(3):239–244
11. Carskadon MA. The second decade. In: Guilleminault C, ed. *Sleeping and Waking Disorders: Indications and Techniques*. Menlo Park, CA: Addison Wesley; 1982:99–125
12. Carskadon MA, Acebo C, Seifer R. Extended nights, sleep loss, and recovery sleep in adolescents. *Arch Ital Biol*. 2001;139(3):301–312
13. Roenneberg T, Kuehnle T, Pramstaller PP, et al. A marker for the end of adolescence. *Curr Biol*. 2004;14(24):R1038–R1039
14. Cain N, Gradisar M. Electronic media use and sleep in school-aged children and adolescents: a review. *Sleep Med*. 2010;11 (8):735–742
15. Knutson KL, Lauderdale DS. Sociodemographic and behavioral predictors of bed time and wake time among US adolescents aged 15 to 17 years. *J Pediatr*. 2009;154(3): 426–430, 430.e1
16. Wolfson AR. Bridging the gap between research and practice: what will adolescents' sleep-wake patterns look like in the 21st century? In: Carskadon MA, ed. *Adolescent Sleep Patterns: Biological, Social, and Psychological Influences*. New York, NY: Cambridge University Press; 2002:198–219
17. Fredriksen K, Rhodes J, Reddy R, Way N. Sleepless in Chicago: tracking the effects of adolescent sleep loss during the middle school years. *Child Dev*. 2004;75(1):84–95
18. Dahl RE, Carskadon MA. Sleep and its disorders in adolescence. In: Ferber R, Krieger MH, eds. *Principles and Practices of Sleep Medicine in the Child*. Philadelphia, PA: WB Saunders Co; 1995:19–27
19. Carskadon MA, Wolfson AR, Acebo C, Tzischinsky O, Seifer R. Adolescent sleep patterns, circadian timing, and sleepiness at a transition to early school days. *Sleep*. 1998;21(8):871–881
20. National Sleep Foundation. 2006 Teens and sleep. Available at: www.sleepfoundation.org/article/sleep-america-polls/2006-teens-and-sleep. Accessed June 26, 2013
21. O'Brien EM, Mindell JA. Sleep and risk-taking behavior in adolescents. *Behav Sleep Med*. 2005;3(3):113–133
22. Giedd JN. Linking adolescent sleep, brain maturation, and behavior. *J Adolesc Health*. 2009;45(4):319–320
23. Holm SM, Forbes EE, Ryan ND, Phillips ML, Tarr JA, Dahl RE. Reward-related brain function and sleep in pre/early pubertal and mid/late pubertal adolescents. *J Adolesc Health*. 2009;45(4):326–334
24. Moore M, Kirchner HL, Drotar D, et al. Relationships among sleepiness, sleep time, and psychological functioning in adolescents. *J Pediatr Psychol*. 2009;34(10):1175–1183
25. Pasch KE, Laska MN, Lytle LA, Moe SG. Adolescent sleep, risk behaviors, and depressive symptoms: are they linked? *Am J Health Behav*. 2010;34(2):237–248
26. Soffer-Dudek N, Shahar G. Daily stress interacts with trait dissociation to predict sleep-related experiences in young adults. *J Abnorm Psychol*. 2011;120(3):719–729
27. Curcio G, Ferrara M, De Gennaro L. Sleep loss, learning capacity and academic performance. *Sleep Med Rev*. 2006;10(5):323–337
28. Pagel JF, Forister N, Kwiatkowki C. Adolescent sleep disturbance and school performance: the confounding variable of socioeconomics. *J Clin Sleep Med*. 2007;3 (1):19–23
29. Wolfson AR, Carskadon MA. Understanding adolescents' sleep patterns and school performance: a critical appraisal. *Sleep Med Rev*. 2003;7(6):491–506
30. Wolfson AR, Spaulding NL, Dandrow C, Baroni EM. Middle school start times: the importance of a good night's sleep for young adolescents. *Behav Sleep Med*. 2007; 5(3):194–209
31. Alfano CA, Zakem AH, Costa NM, Taylor LK, Weems CF. Sleep problems and their relation to cognitive factors, anxiety, and depressive symptoms in children and adolescents. *Depress Anxiety*. 2009;26(6): 503–512
32. Lofthouse N, Gilchrist R, Splaingard M. Mood-related sleep problems in children and adolescents. *Child Adolesc Psychiatr Clin N Am*. 2009;18(4):893–916
33. Regestein Q, Natarajan V, Pavlova M, Kawasaki S, Gleason R, Koff E. Sleep debt and depression in female college students. *Psychiatry Res*. 2010;176(1):34–39
34. Gromov I, Gromov D. Sleep and substance use and abuse in adolescents. *Child Adolesc Psychiatr Clin N Am*. 2009;18(4):929–946
35. Bryant Ludden A, Wolfson AR. Understanding adolescent caffeine use: connecting use patterns with expectancies, reasons, and sleep. *Health Educ Behav*. 2010;37(3):330–342
36. Dahl RE. Biological, developmental, and neurobehavioral factors relevant to adolescent driving risks. *Am J Prev Med*. 2008; 35(suppl 3):S278–S284
37. Hutchens L, Senserrick TM, Jamieson PE, Romer D, Winston FK. Teen driver crash risk and associations with smoking and drowsy driving. *Accid Anal Prev*. 2008;40(3): 869–876
38. Verhulst SL, Schrauwen N, Haentjens D, et al. Sleep duration and metabolic dysregulation in overweight children and adolescents. *Arch Dis Child*. 2008;93(1):89–90
39. Gangwisch JE, Malaspina D, Babiss LA, et al. Short sleep duration as a risk factor for hypercholesterolemia: analyses of the National Longitudinal Study of Adolescent Health. *Sleep*. 2010;33(7):956–961
40. Hasler G, Buysse DJ, Klaghofer R, et al. The association between short sleep duration and obesity in young adults: a 13-year prospective study. *Sleep*. 2004;27(4):661–666
41. Cappuccio FP, Taggart FM, Kandala NB, et al. Meta-analysis of short sleep duration and obesity in children and adults. *Sleep*. 2008; 31(5):619–626
42. Dexter D, Bijwadia J, Schilling D, Applebaugh G. Sleep, sleepiness and school start times: a preliminary study. *WMJ*. 2003;102(1): 44–46
43. Hansen M, Janssen I, Schiff A, Zee PC, Dubocovich ML. The impact of school daily schedule on adolescent sleep. *Pediatrics*. 2005;115(6):1555–1561

44. Carrell SE, Maghakian T, West JE. A's from Zzzz's? The causal effect of school start time on the academic achievement of adolescents. *Am Econ J Economic Policy*. 2011;3(3):62–81
45. Edwards F. Early to rise: the effect of daily start times on academic performance. Working Paper, University of Illinois at Urbana-Champaign; 2010. Available at: http://ssrn.com/abstract=1628693. Accessed June 26, 2013
46. Hinrichs P. When the bell tolls: the effects of school starting times on academic achievement. *Educ Finance Policy*. 2011;6(4):1–22
47. Epstein R, Chillag N, Lavie P. Starting times of school: effects on daytime functioning of fifth-grade children in Israel. *Sleep*. 1998;21 (3):250–256
48. Lufi D, Tzischinsky O, Hadar S. Delaying school starting time by one hour: some effects on attention levels in adolescents. *J Clin Sleep Med*. 2011;7(2):137–143
49. US Department of Education, National Center for Education Statistics, Schools and Staffing Survey. Public School Data File, 2011–12. Available at: http://nces.ed.gov/surveys/sass/tables/sass1112_201381_s1n.asp. Accessed July 14, 2014
50. Wahlstrom K. Changing times: findings from the first longitudinal study of later high school start times. *NASSP Bull*. 2002;286(633):3–21
51. Wahlstrom K. Accommodating the sleep patterns of adolescents within current educational structures: an uncharted path. In: Carskadon M, ed. *Adolescent Sleep Patterns: Biological, Social, and Psychological Influences*. New York, NY, and Cambridge, England: Cambridge University Press; 2002:72–197
52. Danner F, Phillips B. Adolescent sleep, school start times, and teen motor vehicle crashes. *J Clin Sleep Med*. 2008;4(6):533–535
53. Owens JA, Belon K, Moss P. Impact of delaying school start time on adolescent sleep, mood, and behavior. *Arch Pediatr Adolesc Med*. 2010;164(7):608–614
54. Wahlstrom K, Dretzke B, Gordon M, Peterson K, Edwards K, Gdula J. *Examining the Impact of Later School Start Times on the Health and Academic Performance of High School Students: A Multi-Site Study. Center for Applied Research and Educational Improvement*. St Paul, MN: University of Minnesota; 2014
55. Htwe ZW, Cuzzone D, O'Malley MB, O'Malley EB. Sleep patterns of high school students before and after delayed school start time. *J Sleep Disord Res*. 2008;31(suppl):A74–A75
56. Cortes KE, Bricker J, Rohlfs C. The role of specific subjects in education production functions: Evidence from morning classes in Chicago public high schools. *The BE Journal of Economic Analysis & Policy*. 2010;12(1)
57. Hoyland A, Dye L, Lawton CL. A systematic review of the effect of breakfast on the cognitive performance of children and adolescents. *Nutr Res Rev*. 2009;22(2):220–243
58. Boergers J, Gable CJ, Owens JA. Later school start time is associated with improved sleep and daytime functioning in adolescents. *J Dev Behav Pediatr*. 2014;35 (1):11–17
59. Fitzgerald CT, Messias E, Buysse DJ. Teen sleep and suicidality: results from the youth risk behavior surveys of 2007 and 2009. *J Clin Sleep Med*. 2011;7(4):351–356
60. Knipling R, Wang J. *Crashes and Fatalities Related to Driver Drowsiness/Fatigue*. Washington, DC: National Highway Traffic Safety Administration; 1994. Available at: http://ntl.bts.gov/lib/jpodocs/repts_te/1004.pdf. Accessed June 26, 2013
61. Vorona RD, Szklo-Coxe M, Wu A, Dubik M, Zhao Y, Ware JC. Dissimilar teen crash rates in two neighboring southeastern Virginia cities with different high school start times. *J Clin Sleep Med*. 2011;7(2): 145–151
62. Wolfson AR, Carskadon MA. A survey of factors influencing high school start times. *NASSP Bull*. 2005;89(642):47–66
63. Jacob BA, Rockoff JE. *Organizing Schools to Improve Student Achievement: Start Times, Grade Configurations, and Teacher Assignments. The Hamilton Project. Brookings Institute Discussion Paper*. Washington, DC: Brookings Institute; 2011. Available at www.brookings.edu/research/papers/2011/09/organization-jacob-rockoff. Accessed June 26, 2013

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Setting Adolescents Up for Success: Promoting a Policy to Delay High School Start Times

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ABSTRACT

BACKGROUND: A unique biological shift in sleep cycles occurs during adolescence causing later sleep and wake times. This shift is not matched by a concurrent modification in school start times, resulting in sleep curtailment for a large majority of adolescents. Chronic inadequate sleep is associated with poor academic performance including executive function impairments, mood, and behavioral issues, as well as adverse health outcomes such as an increased risk of obesity, hypertension, and cardiovascular disease. In order to address sleep deficits and the potential negative outcomes associated with chronic sleep deprivation, the American Academy of Pediatrics (AAP) and US Centers for Disease Control and Prevention (CDC) support delaying school start times for middle and high school students.

METHODS: We summarize current evidence, explicate the need for policy change, and urge school districts to put adolescent students' health as top priority and implement school start times consistent with their developmental needs.

RESULTS: Whereas substantial evidence illustrating adverse consequences of inadequate sleep on psychological and physical health, and recommendations exist to adapt daytime school schedules to match sleep needs have been released, actual implementation of these recommendations have been limited.

CONCLUSIONS: This is a call to action for the implementation of AAP/CDC recommendations across the state and nation.

Keywords: adolescence; sleep; school start times; sleep deprivation; development; school health policy.

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Sleep is essential to human growth and development across all functional domains.[1] Sleep needs and patterns shift across the lifespan, with the most notable shift occurring in adolescence.[1] By mid-puberty, delays in the circadian nocturnal melatonin secretion increase the time required to fall asleep.[2] The melatonin secretion also turns off later in the morning, making it more difficult to wake up early.[3] Unfortunately, the current school schedule does not facilitate later wake times. The ''mismatch'' results in an estimated 2-hour sleep restriction and circadian rhythm disruption.[2] One could argue that less disruptive interventions may be just as effective for preventing sleep deprivation (eg, reducing all night lighting, avoiding caffeine, stimulants, exercise, eating, screen time before bed, napping). However, even with the implementation of sleep hygiene interventions, sleep hygiene does not address the physiological shift in melatonin secretion. As such, the synchronization of the school schedule with adolescent sleep patterns is a key to reducing sleep deprivation and associated outcomes in teens. Reducing adolescent sleep deprivation via delayed school start times may have profound effects on cognitive function, feeding behaviors, physical activity, and overall health.[1] We emphasize the potential impact of longer sleep duration/later start times

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for adolescents on cognitive function, and more specifically executive function, in addition to overall health outcomes.

SLEEP AND SCHOOL ACHIEVEMENT

The American Academy of Pediatrics (AAP) recommends 8.5 to 9.5 hours of sleep per night for adolescents.[2] However, a large proportion of adolescents reports getting less than 8 hours of sleep.[1] Estimates suggest that 26% of adolescents get less than 6.5 hours on school nights leading to consequences across several functional domains.[2,4] Sleep duration is inversely associated with absenteeism, academic achievement, and school readiness across middle school, high school, and college level adolescents.[5-8] Up to 28% of adolescents report falling asleep in school and 1 in 5 fall asleep doing homework at least once per week.[4] Sleep deficits impact cognitive function including decision-making, attention span, working memory, and impulse control.[9-11] Sleep-related cognitive deficits can also lead to increased emotional and behavioral difficulties.[12,13] Additionally, deficits in working memory increase the likelihood of risky behaviors (sex, drug and alcohol use, safety violations, and increased violence).[13] The negative impact of sleep deprivation on cognitive function, emotional well-being, and in turn both academic and social outcomes, highlights the importance of targeting adolescent sleep via delayed school start times.

SLEEP AND ADOLESCENT METABOLIC HEALTH

Although not directly related to educational performance, in addition to inducing adverse psychosocial outcomes as a consequence of sleep deprivation, adolescents' physiologic health is also impacted, specifically through increased obesity and associated metabolic disease risk.

A number of biological mechanisms have been proposed to link sleep duration and obesity.[14] Figure 1 illustrates these obesogenic pathways. Sleep restriction has been linked to decreased serum leptin and increased ghrelin, which are both associated with increased hunger, appetite, desire to eat, and actual food intake.[14-16] It has also been suggested that, short sleep duration may increase obesity risk via eating patterns that cumulatively increase energy intake.[17-19] It is hypothesized that increased energy intake is not compensated by commiserate energy expenditure with research indicating that decreased physical activity follows sleep deprivation.[20] Adolescents with shorter sleep duration had a 58% higher risk for overweight or obesity, and children with shortest sleep duration had an even higher risk (92%) when compared with children having longer sleep duration. For each hour increase in sleep, the risk of overweight/obesity was reduced on average by 9%.[21] In addition to the cognitive impairments associated with sleep deprivation, obesity has also been linked to cognitive impairments in the areas of executive function and working memory.[22] As both sleep and obesity share overlapping cognitive deficits, and sleep has been associated with increased risk for obesity, improving sleep quantity may help in a 2-fold manner by both reducing weight and ensuring that brain function and structure are protected even in the presence of excess weight.

AAP POLICY RECOMMENDATIONS

Originally, school schedules were implemented to coincide with school budgets, transportation logistics, parental work schedules, athletic programs, and staff commutes as opposed to adolescent needs.[11] In 2014, the AAP published a policy statement recommending that middle and high schools delay start times to 8:30 AM or later.[2] Following this statement, several school districts in the United States (US) explored to option of delaying school start times to improve physiologic and psychological health of students; however, only a small proportion have actually implemented the recommended later schedules.[11,23] According to the AAP, 85% of high schools in the US start before 8:30 AM with half of these schools starting before 8:00 AM. The median middle school start time is 8 AM, and more than 20% of middle schools starting at 7:45 AM or earlier.[2] As melatonin secretion begins later at night and turns off later in the morning during adolescence, a majority of teens are starting school when they are still under biologically mediated sleep reinforcers.[3] As empirical data emphasizes the benefits of adequate sleep duration and sleep patterns during adolescence, more middle and high schools should

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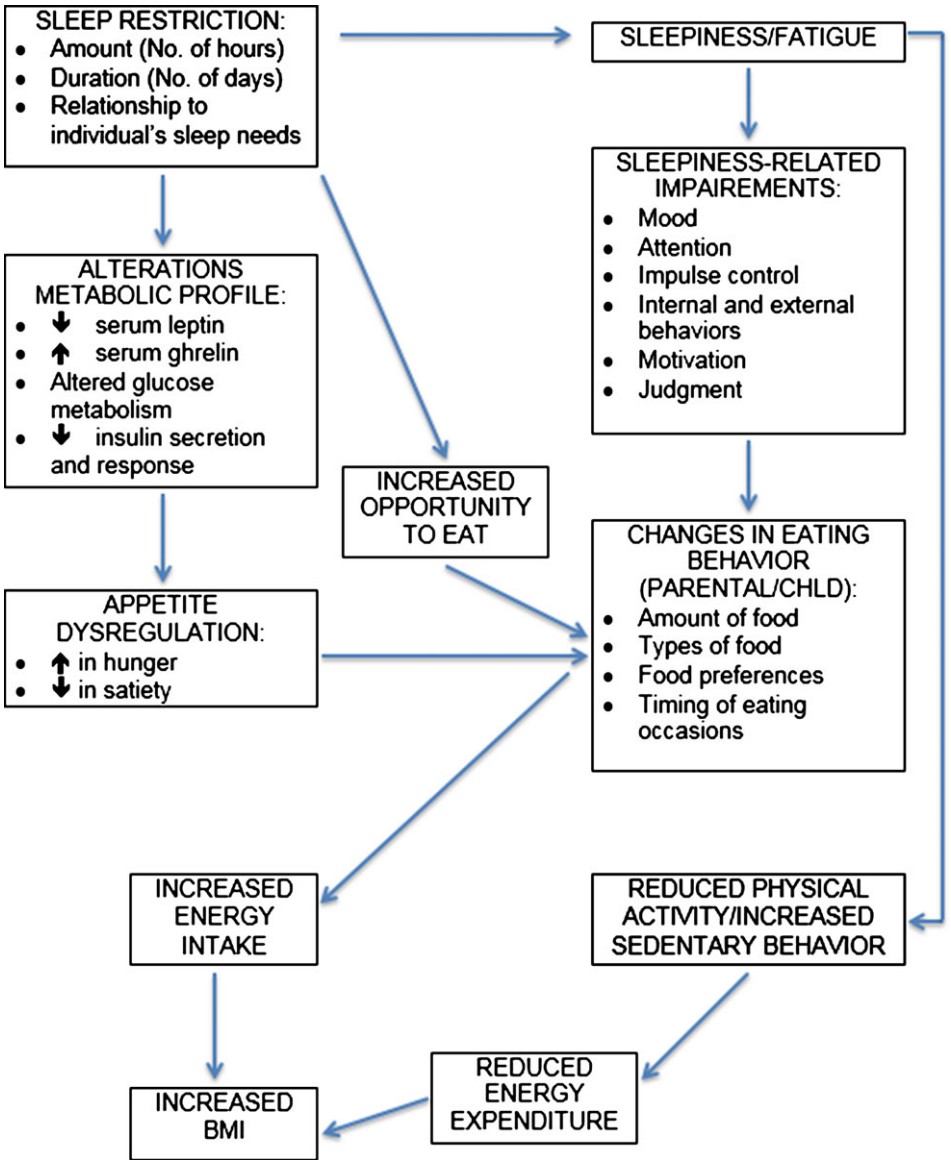
Figure 1. **Potential Mechanistic Pathways That May Increase Risk of Obesity With Sleep Restriction (adapted from Taheri[14]).**



adopt later schedules to improve the overall health and well-being of their students.[2,11]

EXPERIENTIAL EVIDENCE TO DATE

In 2 seminal US studies, adolescents experienced positive outcomes related to sleep, mood, caffeine intake, and healthcare use.[11,24] In the initial study conducted by Owens et al[24] school start time was delayed from 8:00 AM to 8:30 AM in an independent private high school serving adolescents from 9th to 12th grade. After implementing delayed school start times, self-reported mean school night sleep duration increased by 45 minutes, and average bedtime advanced by 18 minutes.[24] The percentage of students getting less than 7 hours of sleep decreased by 79.4%, and those reporting at least 8 hours of sleep increased from 16.4% to 54.7%. Using a validated measure of sleep quality, students reported significantly more satisfaction with sleep and improved motivation to complete daily tasks. Daytime sleepiness, fatigue, and ability to function throughout the day were all significantly improved (Table 1). Health center visits for fatigue-related complaints, depressed mood, and class attendance also improved suggesting that the impact of a 30-minute shift in school start time may have far-reaching impacts on adolescent well-being beyond those directly related to sleep duration.[24] It is possible that with the later start times and associated increased sleep, students were better prepared to

Table 1. **Percentage of Students Reporting Daytime Sleepiness-Related Behaviors in the Past Week at Surveys 1 and 2 (N = 201; adapted from Owens et al[24])**

Reported Behavior	% Change From Baseline†
Daytime sleepiness (at least more than a little)	−29.1*
Struggled to stay awake, fell asleep, or both during class	−24.6*
At least somewhat bothered by feeling too tired to do homework	−23.8*
Fell asleep during morning class (at least once)	−20.9*
Arrived late (at least once)	−14.1*
Takes naps at least sometimes	−16.1*
Required assistance to wake up in the morning	−7.6*

*Significantly different at ≤ .001.
†Percentage change reflects difference in percentage of students endorsing behavior from preintervention to postintervention.

attend class, pay attention to academic tasks, and perform academically which in turn may have led to improvements in mood and somatic complaints.

In the second study conducted by Boergers et al,[25] school start time at a similarly structured independent high school was delayed from 8:00 to 8:25. Delayed start times resulted in significant increases in sleep duration on school nights by an average of 29 minutes with the percentage of students receiving 8 or more hours of sleep on school nights increasing from 18% to 44%. Significant reductions in daytime sleepiness, depressed mood, and caffeine intake were also reported. Of note, when the 8:00 AM school start time was reinstituted, sleep duration reverted to baseline levels.[25] It is notable that gains in sleep time were documented both through an early bedtime and a later wake time, as opposed to just a later wake time.

INITIATING HEALTH BENEFITS

Changes in weight status and other metabolic parameters have not been experimentally evaluated in regards to delayed school start times. However, the Owens et al,[24] study did include an assessment of the types and numbers of foods consumed during breakfast for adolescents prior to and after the changed schedule. After delaying school start times, school food services reported a significant increase in the amount of hot breakfast foods consumed from December to February (35 vs 83 servings per month). Because both December and February are winter months, the authors suggest that the change in school start times may have been associated with an increase in breakfast consumption for the adolescents. Longitudinal research with outcomes specifically related to obesity and metabolic shifts is needed to assess the impact of delaying school start times on adolescents' dietary habits, weight and metabolic health. However, this requires schools to adopt later start times to demonstrate potential benefits.

The National Sleep Foundation has identified potential barriers to implementing delayed school start times for adolescents including transportation, after school activities, impact on younger students and community programs, reduced time to access public resources, teacher impact, increased family stress, community objection, and student resistance.[2,4] We present specific barriers and possible solutions in Table 2.

ALABAMA RESPONDS

Two school districts (PC and DC) in Alabama have responded to the US Centers for Disease Control and Prevention and AAP endorsements for delayed school start times for adolescents. Beginning in the 2014-2015 school year, PC public schools delayed start times from 7:45 AM until 9:00 AM for students in grades 8-12 and advanced start times for students in grades 6-7 from 8:30 AM to 7:45 AM. Elementary school students start at 8:00 AM. To ensure a smooth transition to the new schedule, PC identified and addressed barriers ahead of implementation including the need to reroute buses and provide extended childcare coverage for parents and teachers in both the morning and afternoons. Preliminary evaluations based on individual school data indicate that tardiness and late check-ins for high school students have decreased. Additionally, the new schedule did not increase costs to the district. A second district in Alabama (DC) also pushed back middle and high school start times from 7:45 AM until 8:30 AM and advanced elementary school start times from 8:30 AM to 7:45 AM. Initial report from the district superintendent indicated that the new schedule saved the district money on transportation and decreased tardiness. Taken together, the preliminary evidence in conjunction with published studies supports efforts to adopt new policy among other regional and national districts to implement similar schedules.[24,25]

IMPLICATIONS FOR SCHOOL HEALTH

Given the existing research about the prevalence of adolescent sleep deprivation and the risks it poses to adolescent health and well-being, current recommendations support school start time delays as an important public health measure.[2,4] Advocacy should be aimed at providing evidence-based research to educate school administrators and school boards about the benefits of instituting a delay in school start times as a means of counteracting adolescent sleep restriction.[2] The AAP urges middle and high schools to aim for school start times that are consistent with adolescents' sleep patterns and that would allow students to receive 8.5 to 9.5 hours of sleep a night.[2,4] Vital to the design and implementation

Table 2. **National Sleep Foundation's Barriers and Solutions to Later School Start Times**

Barrier	Solution 1	Solution 2	Concerns
Transportation	Flip school elementary and high school start times	Shift to public transportation for high school routes	Traffic congestion for both students and teachers at later times
Extracurriculars	Reschedule practice and games for later in the day	Install extra lighting for later extracurriculars	Students who have after school jobs or those who have non-school-directed activities
Impact on other students/programs	Advance morning childcare schedules	Assign parents on rotating schedule as neighborhood bus stop supervisors	May require additional planning for special education students and career centers
Reduced time to access public resources	No solutions offered though it is hypothesized that students with better sleep may be more efficient workers and thus this will not be as much of a concern		
Teachers	Alter "planning time" to early morning so that teacher schedules do not change	Implement early morning childcare at schools as needed	Teachers with students whose schedules may no longer match their own
Family stress	Involve families in schedule planning ahead of implementation of new school start times	Implement hotlines, message boards, and meetings to increase communication and problem-solving	Most families schedules are finely turned and thus a disruption can be overwhelming. Community involvement is key
Uneducated community	Campaign in local community to increase awareness of changes and reasons behind the change	Educate community about negative outcomes related to sleep deprivation, not just for students but for everyone	Lack of knowledge in the community may decrease community buy-in
Student resistance	Educate students about benefits of new start time. Can be done in relevant classes	Include students in early discussions to gain support	Students can be resistant to change even if beneficial

of systemic policy changes supporting delayed school start time is public education, including the students, parents, school personnel, and the general public about chronic sleep deprivation and the associated health outcomes, including depressed mood, deficits in learning, attention and memory problems, poor impulse control, poor academic performance, and an increased risk of obesity, hypertension, and long-term cardiovascular morbidity.[2] While the National Sleep Foundation and the AAP have made these recommendations for policy change, there is a lack of implementation. States and local school districts should evaluate current school schedules, community needs, resources and financial concerns, in order to develop an implementation plan to align local schools with recommended practices. As Table 2 shows, this implementation should be a joint effort between local school districts and key community stakeholders whereby the involved parties identify, discuss, and find solutions to barriers that may impede the implementation of delayed school start times for middle and high schools. Whereas general solutions and implementation strategies may be offered as in Table 2, individual district implementation plans will vary as a function of the communities they serve. To facilitate widespread adoption of delayed school start times, implementation plans should be documented and disseminated in school association and education-focused forums so that strategies can be shared with other school districts and/or policymakers on a national scale.

REFERENCES

1. Burns CE, Dunn AM, Brady MA, Starr NB, Blosser CG. *Pediatric Primary Care*. 5th ed. Philadelphia, PA: Elsevier Saunders; 2013.
2. American Academy of Pediatrics. School start times for adolescents. *Pediatrics*. 2014;134(3):642-649.
3. Carskadon MA, Wolfson AR, Acebo C, Tzischinsky O, Seifer R. Adolescent sleep patterns, circadian timing, and sleepiness at a transition to early school days. *Sleep*. 1998;21:871-881.
4. National Sleep Foundation. Teens and sleep. 2006. Available at: www.sleepfoundation.org/article/sleep-america-polls/2006-teensand-sleep. Accessed February 18, 2014.
5. Curcio G, Ferrara M, De Gennaro L. Sleep loss, learning capacity and academic performance. *Sleep Med Rev*. 2006;10(5):323-333.
6. Fredriksen K, Rhodes J, Reddy R, Way N. Sleepless in Chicago: tracking the effects of adolescent sleep loss during the middle school years. *Child Dev*. 2004;75(1):84-95.
7. Wolfson AR, Spaulding NL, Dandrow C, Baroni EM. Middle school start times: the importance of a good night's sleep for young adolescents. *Behav Sleep Med*. 2007;5(3):194-209.
8. Wolfson AR, Carskadon MA. Understanding adolescents' sleep patterns and school performance: a critical appraisal. *Sleep Med Rev*. 2003;7(6):491-506.
9. Beebe DW. Cognitive, behavioral, and functional consequences of inadequate sleep in children and adolescents. *Pediatr Clin North Am*. 2011;58:649-665.
10. Harrison Y, Horne JA. The impact of sleep deprivation on decision making: a review. *J Exp Psychol Appl*. 2000;6:236-249.
11. Owens J, Lewin D, Drobnich D, Baylor A. School start time change: an in-depth examination of school districts in the United States. *Mind, Brain Educ*. 2014;8(4):182-213.
12. Smaldone A, Honig JC, Byrne MW. Sleepless in America: inadequate sleep and relationships to health and well-being of our nation's children. *Pediatrics*. 2007;119(Suppl 1):S29-S37.
13. Thomas AG, Monahan KC, Lukowski AF, Cauffman E. Sleep problems across development: a pathway to adolescent risk taking through working memory. *J Youth Adolesc*. 2015;44:447-464.

14. Taheri S. The link between short sleep duration and obesity: we should recommend more sleep to prevent obesity. *Arch Dis Child*. 2006;91(11):881-884.
15. Spiegel K, Leproult R, L'Hermite-Baleriaux M, et al. Leptin levels are dependent on sleep duration: relationships with sympathovagal balance, carbohydrate regulation, cortisol, and thyrotropin. *J Clin Endocrinol Metab*. 2004;89:5762-5771.
16. Wren AM, Seal LJ, Cohen MA, et al. Ghrelin enhances appetite and increases food intake in humans. *J Clin Endocrinol Metab*. 2001;86:5992.
17. Beebe DW, Simon S, Summer S, Hemmer S, Strotman D, Dolan LM. Dietary intake following experimentally restricted sleep in adolescents. *Sleep*. 2013;36(6):827-834.
18. Gupta NK, Mueller WH, Chan W, Meininger JC. Is obesity associated with poor sleep quality in adolescents? *Am J Hum Biol*. 2002;14(6):762-768.
19. Weiss A, Xu F, Storfer-Isser A, Thomas A, Ievers-Landis CE, Redline S. The association of sleep duration with adolescents' fat and carbohydrate consumption. *Sleep*. 2010;33(9): 1201-1209.
20. Hart CN, Cairns A, Jelalian E. Sleep and obesity in children and adolescents. *Pediatr Clin North Am*. 2011;58(3):715-733.
21. Chen X, Beydoun MA, Wang Y. Is sleep duration associated with childhood obesity? A systematic review and meta-analysis. *Obesity*. 2008;16(2):265-274.
22. Lokken KL, Boeka AG, Austin HM, Gunstad J, Harmon CM. Evidence of executive dysfunction in extremely obese adolescents: a pilot study. *Surg Obes Relat Dis*. 2009;5:547-552.
23. Healthcanal. Support for sleeping in? Half of parents favor later school start times for teens. 2015. Available at: http://www.healthcanal.com/disorders-conditions/sleep/60281-support-for-sleeping-in-half-of-parents-favor-later-school-start-times-for-teens.html. Accessed February 20, 2015.
24. Owens JA, Belon K, Moss P. Impact of delaying school start time on adolescent sleep, mood, and behavior. *Arch Pediatr Adolesc Med*. 2010;164:608-614.
25. Boergers J, Gable CJ, Owens JA. Later school start time is associated with improved sleep and daytime functioning in adolescents. *J Dev Behav Pediatr*. 2014;35:11-17.

Examining the Impact of Later High School Start Times on the Health and Academic Performance of High School Students: A Multi-Site Study

Final Report
February 2014

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Examining the Impact of Later High School Start Times on the Health and Academic Performance of High School Students: A Multi-Site Study

Final Report

Major findings: *The results from this three-year research study, conducted with over 9,000 students in eight public high schools in three states, reveal that high schools that start at 8:30 AM or later allow for more than 60% of students to obtain at least eight hours of sleep per school night. Teens getting less than eight hours of sleep reported significantly higher depression symptoms, greater use of caffeine, and are at greater risk for making poor choices for substance use. Academic performance outcomes, including grades earned in core subject areas of math, English, science and social studies, plus performance on state and national achievement tests, attendance rates and reduced tardiness show significantly positive improvement with the later start times of 8:35 AM or later. Finally, the number of car crashes for teen drivers from 16 to 18 years of age was significantly reduced by 70% when a school shifted start times from 7:35 AM to 8:55 AM.*

INTRODUCTION

High school students often seem to stay up too late at night and then have difficulty getting out of bed the next morning. Although there might be social and environmental factors that influence adolescents' sleep behavior, recent research on the sleep-wake cycle of teens has identified changes in specific biological processes that occur with the onset of puberty that cause adolescents not only to need more sleep but also to feel sleepy at a later time (e.g., Crowley, Acebo, & Carskadon, 2007). Because the sleep-wake cycle changes as children grow into adolescents, early high school start time has been identified as an important external factor that could restrict sleep and negatively affect academic learning (e.g., Owens, Belon, & Moss, 2010).

STUDY OVERVIEW

This research project examined whether or not a delay in start time for high school students had an impact on their overall health and academic performance. Data were collected in

eight public high schools in five school districts in three states—Minnesota, Colorado, and Wyoming. The population was ethnically and socio-economically diverse. Percentages of white students ranged from 60% to 90%, the free/reduced lunch rate ranged from 34% to 10%, and the graduation rates ranged from 81% to 97%.

The research study consisted of three parts. Part 1 of the study involved collecting survey data from over 9,000 students across eight high schools in five school districts. Students were individually surveyed about their daily activities, substance use, and sleep habits. We examined various health factors post-start time delay, plus we compared them with national average data from other studies. In Part 2 of the study, we collected data regarding students' academic performance, such as grades earned, attendance, tardiness, and performance on state and national tests. We also examined car crash data for the communities involved in this project. Part 3 of the research included an examination of the processes by which local school districts made the decision to change to a later start time. Interviews with key players who were active participants in the discussions and in the decisions for each of the five districts identified both the barriers and facilitative aspects in making such a policy change.

RESEARCH QUESTIONS

The major research questions addressed by this study are:

1. What are the health outcomes for high school students in schools that have shifted to a later start time, including: bedtimes and wake times, sleepiness in class, emotional and physical well-being, depressive feelings, and car crash rates?
2. What are the pre-post start time delay differences in academic outcomes such as grade point average, standardized test scores, school attendance, and tardiness? What is the relationship between participation in activities outside of school and grades earned?
3. What actions are taken and what information is used by school district and community leaders as they engage in policy discussions and make an eventual decision to shift to a later high school start time?

The literature review included in this research report is intended to be an overview of many key studies across a range of topics associated with teens and sleep. Because the range of topics embedded within the design of this study is so wide, we have touched on the topics that have relevance for this investigation, citing literature for each one. To that end, the findings of this research can be framed within what we already know and what is still to be investigated or confirmed.

Overview of Factors Related to Sleep in Adolescence

While all of the benefits of sleep are not yet clear, the fact that all animals do sleep indicates its importance (Tononi & Cirelli, 2013; Tononi & Cirelli, 2005). Sleep appears to help with the encoding of memories and learning (Carskadon, 2011a; Payne, 2011; Tononi & Cirelli, 2013; Tononi & Cirelli, 2006), ability to pay attention (Beebe, 2011; Beebe, Rose, & Amin, 2010), emotional regulation (Dahl, 1999) and other health benefits such as lower prevalence of mood disorders (Harvey, Alfano & Clarke, in press). Additionally, evidence of higher sleep amounts in younger animals suggests that sleep plays an important role during the maturational process (Dahl, 1999). Given that adolescence is a time of great biological change, it is necessary to consider the importance of getting enough sleep in this developmental period.

Although many believe that the amount of sleep needed decreases as a child enters adolescence, research has shown that adolescents still need the same amount of sleep or more (Carskadon, 2013; Carskadon, Acebo, & Jenni, 2004). While an estimated 9 hours 20 minutes may be ideal for adolescents (Carskadon, 2013), results from many studies have found that, on average, adolescents report sleeping less than 8 hours on school nights (Carskadon, 2011b; Carskadon, Wolfson, Acebo, Tzischinsky, & Seifer, 1998; Dexter, 2003; Eliasson, Eliasson, King, Gould, & Eliasson, 2002; National Sleep Foundation, 2006; Wahlstrom, 2002). While students tend to report longer amounts of sleep on weekends, typically believed to be due to attempting to "catch up" from inadequate sleep during the school week, there are still detrimental effects due to the insufficient sleep on school nights (Andrade, Benedito-Silva, Domenice, Arnhold & Menna-Barreto, 1993; Dahl & Lewin, 2002; Wahlstrom, 2002). Given the negative effects, it is important to consider why adolescents tend to be sleep deprived.

Factors Influencing Amount of Sleep

Adolescence brings changes in a child's life due to a number of biological changes and psychosocial factors. Not only are children going through puberty, they are also experiencing more independence through choice of after school activities, driving, after school jobs, and other responsibilities, as well as more peer influence on their thoughts and behavior.

Biological changes. Aside from physiological changes associated with puberty, changes in natural sleep time preference occurs in adolescence (Crowley, Acebo, & Carskadon, 2007; Hagenauer, Perryman, Lee, & Carskadon, 2009). As children reach more advanced stages of physical puberty, the changes in the sleep patterns become more pronounced (Carsdakon, 1999). Sleep patterns are influenced by two competing, yet compatible processes known as the circadian rhythm (Process C) and homeostasis (Process S) (Crowley, Acebo, & Carskadon, 2007; Hagenauer, Perryman, Lee, & Carskadon, 2009).

Process S can be thought of as a measure of sleep pressure. That is, when one has been awake for a while, the pressure to sleep becomes greater; however, if one has been sleeping for some time, the pressure to sleep lessens. Process C, on the other hand, can be thought of more as a biological clock that lets us know when sleep should occur. This feeling of when sleep should occur is related to when the body is exposed to light as well as when secretion of a chemical known as melatonin occurs. As children mature, the timing of melatonin secretion becomes later in the evening (Tarokh & Carskadon, 2009), known as a phase delay.

It has been shown that the pressure to fall asleep tends to become lower as a child enters adolescence (Carskadon, Acebo, & Jenni, 2004; Carskadon, 2011b). This, in combination with the natural phase delay in the circadian rhythm can help to explain why sleeping patterns change with puberty. This phase delay has been seen in other types of mammals at puberty, which provides further evidence of the shift in circadian phase seen in humans being purely biological (Hagenauer et al., 2009). However, the reason adolescents tend to have insufficient sleep is not solely due to their body's natural changes, but also due to an interaction with societal expectations and norms.

Societal expectations. One of the most commonly cited and researched societal factors influencing adolescent sleep is that of school start times. In the United States in particular, as students get older, school start times tend to be earlier (Wolfson & Carskadon, 2005). However, this pattern of earlier morning obligations is in direct opposition to the students' natural sleep patterns. It has repeatedly been shown that when middle or high school start times are pushed later, students still tend to go to bed about the same time, but, due to waking up later, increase their sleep (Carskadon et al., 1998; Vedaa, Saxvig & Wilhelmsen-Langeland, Wahlstrom, 2002).

While the benefits to later school start times are undeniable regarding amount of sleep students get, there are many other factors which must be considered. When schools change their schedules, transportation to and from school and school activities can be affected in a variety of ways. For instance, many school districts use the same buses to serve multiple schools. If the start times of some schools are delayed, it is possible that the change would force other schools to start earlier in order to allow for all necessary busing to occur. Typically, this would mean that younger students would have to catch the bus at an earlier time, which may mean more time spent waiting in the dark (Wrobel, 1999; Wahlstrom, 2002; Wolfson & Carskadon, 2005). If the younger children are also beginning earlier than the adolescents, this can mean that older children are no longer available for after school care for their younger siblings. A similar problem with parent work schedules and providing transportation and child care could occur with a change in school start times (Wrobel, 1999).

Delaying the start time of schools may affect after school activities, such as sports, because school end times are delayed as well. With sports schedules dependent on other school schedules, more time in the afternoon classes may have to be missed by some students in order to allow them to participate in sports games. The amount of time that students would have available for after school jobs may also become less, which could be problematic for families that rely on adolescent income for everyday living (Wolfson & Carskadon, 2005; Wrobel, 1999). That said,

the study by Wahlstrom (2002) found there was no negative impact on after school employment of high school students whose schools shifted to later start times because all employers who were interviewed indicated that their need for additional staff did not occur until 4:00 PM or later.

While changing school start times can negatively impact ability to participate in after school activities, the increased need for social activities in adolescence may be related to insufficient sleep as well. Students not only want to participate in social activities, but also must complete daily homework assignments. Some students may sacrifice sleep in order to be able to complete both types of activities.

Use of technology. In adolescence, there is increased reliance on technology for social interactions as well as increased availability of technology (National Sleep Foundation, 2006). Negative effects of nighttime use of computers or watching TV, such as difficulty falling asleep (Polos et al., 2010; Shochat, Flint-Bretler, & Tzischinsky, 2010), as well as problems with mood, behavior, and cognitive functioning during the day have been reported (Polos et al., 2010). Many students with technology in their bedrooms report frequent awakening at night due to receiving a text, phone call, or email (Harvey et al., in press).

Light exposure. As mentioned above, the circadian rhythm is influenced in part by exposure to light. This light can either be natural, as from the sun, or artificial, as from electronics such as a computer or TV. Thus, adolescents who report using an electronic device which emits light, in particular blue light, shortly before bed may be artificially affecting their bodies' natural sleep rhythm (Calamaro et al., 2009; Carskadon, 2013). While light exposure in the morning helps adults to awaken more easily, there is some evidence that this facilitating factor is diminished in adolescence (Hansen et al., 2005) while the effect of evening light exposure inhibiting sleep may be enhanced (Carskadon, Acebo, & Jenni, 2004).

Caffeine. Another known inhibiter of sleep is the consumption of caffeine. Not only is drinking soda prevalent in adolescence, energy drinks high in caffeine content, as well as coffee and tea, are also consumed (Calamaro, Mason, & Ratcliffe, 2009; Ludden & Wolfson, 2009; Pollak & Bright, 2003). Because caffeine is known to reduce sleep pressure, it is no surprise that studies looking at adolescent consumption find that students who have more caffeinated drinks slept less overall (Ludden & Wolfson, 2009; Pollak & Bright, 2003) and tend to have a harder time staying awake at school (Calamaro et al., 2009; Ludden & Wolfson, 2009).

Consequences of Not Enough Sleep

Mental health and behavioral outcomes. Sleep problems in childhood are known to be predictive of the development of anxiety and depressive symptoms as the child matures (Beebe, 2011). This negative effect of sleep problems appears to carry on into adolescence, where teens are more likely to have lower self-esteem (Frediksen, Rhodes, Reddy & Way, 2004), have a more negative attitude towards life (Perkinson-Gloor, Lemola, & Grob, 2013), more problems regulating their emotions (Dahl, 1999; Dahl & Lewin, 2002), higher rates of mood disorders (Harvey et al., in press), and thoughts of suicide (Fitzgerald, Messias, & Buysse, 2011).

However, mood disorders such as depression or bipolar disorder are considered to have a bidirectional causal influence with sleep (Harvey et al., in press). That is, people with depression tend to have more sleep problems, but people with more sleep problems also tend to be more likely to be depressed. A bidirectional causal relationship between sleep and suicidality may also exist (Fitzgerald et al., 2011; Gau et al., 2007), revealing the difficulty of interpreting the interaction between sleep, depressive symptoms, and thoughts of suicide.

High risk behaviors. Many people who have mood disorders such as depression also tend to use drugs and alcohol more (Harvey et al., in press). Teens who report having insufficient sleep have been found to be more likely to smoke cigarettes, use marijuana, engage in sexual activity, and drink alcohol (McKnight-Eily et al., 2011; Dahl & Lewin, 2002). Furthermore, older adolescents and college students who are at the late end of the morningness-eveningness continuum are more likely to habitually use drugs and alcohol (Gau et al., 2007; Onyper, Tacher, Gilber, & Gradess, 2012).

Attention problems. Ability to focus is important not only for learning of new information, but also for safe completion of activities such as driving. The level of inattentive behavior has been found to be higher for students who have had less sleep (Beebe et al., 2010; Lufi, Tzischinsky, & Hadar, 2011). Additionally, reaction times improve in students who have had more sleep (Lufi et al., 2011; Vedaa et al., 2012). Given that reaction time is an important factor when driving in order to avoid having an accident, it is no surprise that there is a high prevalence of teen automobile accidents.

Lower quality sleep has been shown to be associated with higher prevalence of self-reported accidents among teen drivers (Pizza et al., 2010), as well as lower quantity (Danner & Phillips, 2008). A study that used DMV records of teen automobile accidents found that adolescent automobile accidents occurred at a higher rate in a city which had an earlier high school start time than its neighboring, but demographically similar city (Vorona et al., 2011). Because of the extensive research indicating that students who start school later get more sleep, it may be reasonable to assume that this difference in crash rates is in part due to differences in sleep amounts for teens in the two cities.

Academics. While the evidence pertaining to consequences of not enough sleep in adolescents as related to academic outcomes (grades, test scores, attendance) is still emerging, the general consensus of research indicates that good sleep has a positive relationship with academic outcomes for students in middle school all the way through college (Wolfson & Carskadon, 2003; Edwards, 2012; Wahlstrom, 2002; Carrell, Maghakian, & West, 2011). Additionally, if students do not obtain enough sleep before beginning their school day, they will have more difficulty understanding material taught that day and struggle to complete an assignment or test, regardless of the amount of time spent studying (Gillen-O'Neel, Huynh, & Fuligni, 2013).

Studies have shown when school start times are pushed back, an increase in amount of sleep, as well as attendance and decrease in tardies to first period are observed (Drake et al., 2003; Wahlstrom, 2002). While some studies do not report a significant relationship between

grade point average (GPA) and amount of sleep (Eliasson et al., 2002; Wahlstrom, 2002; Fredriksen et al., 2004), studies where the variables in the methodology could be adequately controlled do show a relationship between amount of sleep and GPA (Carrell et al., 2011; Perkinson-Gloor et al., 2013). In studies that examined subject areas independently, mathematics grades appear to be more related to amount of sleep obtained than other core courses (Ng, Ng, & Chan, 2009). As with grades, there are inconsistent results in studies that examined changes in test scores related to more sleep, with some reporting a positive effect (Edwards, 2012; Carrell, 2011) and others reporting no effect (Hinrichs, 2012). However, as with the studies looking at grades, those which found significant, positive relationships used stronger and more valid methodology to assess the relationship between sleep and test scores.

It is known that people who consider themselves as "morning people" show their best performance earlier in the day, with performance decreasing as the day continues. On the other hand, evening types tend to show greater performance throughout the day (Anderson et al., 1991). One possible explanation for the lack of academic effects found in some studies is that most adolescents tend to shift towards being evening types (Randler & Frech, 2009) and tend to show optimal performance on tasks later in the day (Hansen et al., 2005; Kirby, Maggi, & D'Angiulli, 2011). Therefore, studies which look at differences in academic tests such as the ACT which are typically given in the morning (e.g., Hinrichs, 2011) may not be controlling for the confounding factor of the time of day that the assessment is given.

To summarize, sleep plays an important role in all aspects of an adolescent's life. Insufficient sleep can be related to attention problems both in and out of school, general cognitive functioning, emotional regulation, mood disorders, engaging in risky behaviors, and academic outcomes. Therefore, it is important that school personnel, parents, and students alike understand and make choices using the knowledge that we have about sleep both as a framework and a lens.

Final Report Summary and Conclusions

Despite the strong medical evidence of the need for adolescents to obtain at least 8, and preferably 9, hours of sleep every night to maximize their neural development, a strong resistance to a delayed high school start time exists in many localities across the U.S. School districts are very complex organisms that link bureaucratic structures with community norms and family life patterns, and where homeostasis or maintenance of the status quo is probably the strongest force against adopting a later start time for high schools.

However, given the analyses summarized here, there are clear benefits for students whose high schools start at 8:30 AM or later. This would include, for teens who reported they got at least 8 hours of sleep per night, that they were more likely to say they have good overall health and were less likely to report being depressed or using caffeine and other substances (e.g., alcohol, tobacco, other drugs). Other positive findings include a significant reduction in local car crashes, less absenteeism, less tardiness, as well as higher test scores on national achievement tests. Most of the research completed prior to the study being reported here has been conducted in single districts, with none examining multiple school districts in multiple locations across the U.S., *using identical metrics* to assess changes. Replications of this study would go a long way in confirming what appear to be substantive findings.

Finally, conducting research in school districts has more challenges than anyone might imagine. Hurdles include such things as gaining access to the students for conducting a survey, administering student surveys prior to the start time delay so that pre-post analyses can be carried out, obtaining reliable comparative academic performance data, gaining IRB approval from the local school district to conduct the study, locating several districts who are willing to have their experiences thrust into public view, and so forth. Despite those hurdles, the findings of this research study reveal that there are empirically-based positive outcomes for adolescents whenever the start time of their high school is moved to a later time—with the starting time of 8:30 AM or later clearly showing the most positive results.

School Start Time Change: An In-Depth Examination of School Districts in the United States

The Children's National Medical Center's Blueprint for Change Team

April 15, 2014

I. Executive Summary

In response to the scientific evidence documenting both profound changes in sleep and circadian rhythms during adolescence and the myriad of negative health, performance and safety outcomes associated with chronic sleep loss, some 70 school districts in the United States (U.S.), representing approximately 1,000 schools, have successfully implemented a delay in high school start times. However, despite the compelling evidence supporting school start time (SST) change as a key strategy in addressing the epidemic of adolescent sleep loss in the U.S., there are still many school districts across the country with early high school start times that have either not considered this option or have failed in their efforts to implement later bell schedules. In addition, while the scientific literature has clearly documented the positive *outcomes* associated with delayed high school start times, these studies contain limited information regarding the *process* by which school districts consider, approve and implement bell schedule changes. This can, in fact, be extremely challenging, as bell changes impacts not only the obvious stakeholders in the community (e.g., parents, students, teachers, school personnel) but also those citizens who may not have direct involvement in the school system (e.g., employers of adolescents, community members using school facilities).

Therefore, an in-depth examination of those school districts that have been successful in changing their bell schedules can be highly instructive to other districts at various stages of contemplating this measure. However, because there is no comprehensive national repository of information regarding start time change, a comprehensive summary necessitates the use of a multi-pronged approach to accessing relevant information in as comprehensive and up-to-date manner as is possible. Thus, in order to create this summary document, we identified and reviewed relevant scientific literature and existing information from a variety of sources, including online and print media articles, school reports, and case studies from other organizations, as well as personal notes of discussions with sleep experts, parents, and district officials conducted over the years. We also administered a brief web-based national survey to a select number of school districts that have successfully changed their school start times to obtain more specific information on methods and the process used to change schedules and gain community support. Finally, we conducted in-depth telephone interviews with personnel and stakeholders in several school districts to further identify and discuss challenges, opportunities and lessons learned in more detail.

The outcomes of this review process are presented as follows: 1) a summary grid of selected schools that have delayed start times with demographics, change strategies employed and additional comments, 2) results of the national school start times survey, and 3) in-depth case studies. An historical timeline of school start time change and advances in knowledge of sleep and circadian biology is included in the Appendix.

Finally, after reviewing all of the available information on the process of school start time change from a wide variety of sources as described above, we developed an integration and summary of the most common and salient points likely to best inform other school districts. While not necessarily exhaustive, as each school district has both unique challenges and solutions, the ten key messages, categorized according to major content themes, represent principles that have a basic foundation in successful implementation of start time change and are those that are most applicable to the majority of school districts, no matter their size or complexity of issues. It is our hope that this information will not only assist Fairfax County Public Schools in charting a course forward but will also be a useful tool for other school districts looking to protect the health, safety and academic opportunities of their students.

II. Introduction

Many studies have documented that the average adolescent in the United States is chronically sleep deprived and pathologically sleepy. As a result, many high school students are at risk for adverse consequences of insufficient sleep including impairments in mood, affect regulation, attention, memory, behavior control, executive function, and impulse control. In particular, many studies have shown an association between decreased sleep duration and lower academic achievement at the middle school, high school, and college levels, as well as higher rates of absenteeism and tardiness, and decreased motivation to learn (1,2). Other documented health-related effects of sleep loss in adolescents include increased use of stimulants (e.g., caffeine, prescription medications) to counter the effects of chronic sleepiness, which in turn may increase the risk of substance use later in adolescence and early adulthood (3). Adolescents are also at greater risk for drowsy driving-related crashes, as well as athletic and other injuries, due to insufficient sleep (4). Chronic sleep restriction increases subsequent risk of both cardiovascular disease and metabolic dysfunction such as type 2 diabetes (5). An association between short sleep duration and obesity in children and adolescents has been demonstrated in several cross-sectional and prospective studies, underscoring how chronic sleep restriction can undermine the health of our nation's youth (6).

While a number of factors, including biological changes in sleep, lifestyle choices and academic demands impact upon sleep in students, the evidence strongly supports that early school start times (i.e., before 8:00 am) are a key contributor to sleep loss in high school students (7-9). Numerous studies have demonstrated that early start times significantly impede high school students' abilities to obtain sufficient sleep (10, 11).

From a biological perspective, at about the time of the onset of puberty, adolescents begin to experience a sleep-wake "phase delay" (later sleep onset and wake times), as a result of well-documented changes in circadian rhythms. This is manifested as a shift in the fall-asleep time to about two-hours later relative to middle childhood. At the same time, adolescent sleep *needs* do not decline significantly from pre-adolescent levels, and optimal sleep amounts remain in the range of 8.5 to 9.5 hours per night for most teens (12). On a practical level, this means that the average adolescent cannot fall asleep before 11 pm and has significant difficulty in waking before 8 am (13).

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 for students in regard to physical and mental health, safety, and academic achievement. Studies comparing high schools with start times even just 30 minutes earlier to those with later start times demonstrate adverse consequences such as shorter sleep duration, increased sleepiness, difficulty concentrating, behavior problems, and more school absences (14-16). Scientific literature has confirmed that delaying high school start times results in increased total sleep time, decreased tardiness rates and absenteeism, improved performance on standardized tests, reduced self-reported depression, and fewer automobile crashes (17, 18).

A precise tally of public high schools that have delayed school start times nationwide is not available, partly due to the fact that this tends to be a moving target, as more schools and districts make the decision to implement bell time changes. To the best of our knowledge, approximately 1,000 schools in some 70 school districts have taken this step. Importantly, only a handful of schools have subsequently returned to the original earlier bell time.

It is an important but under-appreciated fact that early high school start times are a relatively recent phenomenon that evolved as a result of factors, which had little to do with academics or what is best for the health and well-being of students. The overwhelming majority of modern day bell schedules in American public high schools are historically based on such "adult" considerations as school budgets, transportation logistics, parent work schedules, athletics, staff commute times, and

community use of fields and facilities. By and large, districts did not take into consideration the evolving scientific literature on biologically-based changes in sleep patterns and circadian rhythms associated with puberty and the evidence linking early school start times with detriments in the health, safety and well-being of students. While there are no systematic national databases of school start times, historical and media sources suggest that school districts in the U.S. began advancing school start times, especially at the high school level, first in the late 1950's and 1960's and then increasingly so during the 1970's. The move to earlier start times was likely in reaction to a number of increasing pressures (e.g., fiscal, political, sociological) faced by school districts to cut costs, to close neighborhood schools in favor of larger "feeder" schools, and basically to "do more with less" (a short summary timeline of public school bell schedule changes, contributing factors and the relationship to scientific advances in our understanding of sleep and circadian biology is included in Appendix A).

However, it should be noted that there are many school districts in the U.S. which have never succumbed to the same political, budgetary and social pressures described above and have maintained healthy start times for their high school students. For example, Loudon County, Virginia has had the same bell schedule since 1954, with high schools starting at 9:00 am, middle schools at 8:30 am and elementary schools at 7:50 am. Similarly, some large Texas districts, such as Dallas and Austin, have started their high schools at 9:00 am or later since the early 1990's. According to the U.S. Department of Education's National Center for Education Statistics, a majority (60%) of the 19,000 public high school in the US currently start at 8 am or later, with 45% starting between 8 and 8:30 a.m., and 15% starting 8:30 a.m. or later (19).

Fairfax County in Virginia, the 11th largest school district in the country and one of the most socioeconomically and ethnically diverse, has been wrestling with the issue of delaying high school start time for more than a decade. The current high school start time of 7:20 am makes it virtually impossible for high school students in Fairfax County to obtain enough sleep to allow them function at minimally acceptable levels, given adolescents' biologically-based delayed sleep/wake preferences. In fact, in the Fairfax County Youth Survey of 8th, 10th, and 12th grade students found that two-thirds of respondents reported sleeping seven hours or less on an average school night, more than two hours short of their sleep needs. Recognizing the need to address this issue and in keeping with Fairfax County Public Schools (FCPS) long-standing interest in improving the health, safety and academic and athletic opportunities of its student body, the school board adopted a resolution on April 12, 2012 targeting a goal of starting high schools in the FCPS system after 8:00 am.

Shortly afterward, the district engaged Children's National Medical Center's (CNMC) Division of Sleep Medicine to develop a "Blueprint for Change" to accomplish this task. As part of the development of a "Blueprint for Change," the CNMC team evaluated other school districts across the U.S., with a specific focus on those schools that have successfully implemented start time change, in order to fully explore and utilize any "lessons learned" by our predecessors. While FCPS is unique in many ways (e.g., size, diversity, community use of school facilities), an examination of strategies employed by other school districts to identify and address potential roadblocks as well as to develop creative and innovative approaches can contribute valuable information regarding the process of start time change and inform the development of targeted approaches applicable to Fairfax County. A summary of the key findings and a set of resulting "take home points" are the subject of this report. It is our hope that this information will not only assist Fairfax County Public Schools in charting a course forward but will also be a useful tool for other school districts looking to protect the health, safety and academic opportunities of their students.

IX. Appendices

A. History of School Start Times and Sleep Research on Adolescents in the United States

Historically, public school bell times across the nation evolved as a result of economic, social, legal and political pressures on school districts and municipalities – not from sleep science pertaining to adolescents (which essentially did not exist until the 1970's) or concerns about the health, safety and academic performance of students. Below is an overview of the interplay between influential factors in the development of public education and its transportation systems as well as major milestones in science of sleep and circadian biology.

1800s

Until the 1840s, the educational system is highly localized and largely accessible only to certain privileged groups (i.e., the wealthy, whites, males).

Mid 1800s

Educational reform movement led by Horace Mann and Henry Barnard leads to free public education at the elementary level for all American children.

Late 1800s

17 states had operable public school transportation programs, starting with Massachusetts in 1869 (e.g., horseback, wagon).

At the end of the nineteenth century, 93% of the highways in the country are dirt roads. Horse-drawn carriages and the railroad are the leading means of transportation. Automobiles first came into use in the 1890s, and the first auto arrived in Seattle in 1900. By the 1950s, the "Age of the Automobile" had come into its own and there is great pressure to create an improved transportation infrastructure; i.e., to build more and better roads that link new houses being built outside cities and jobs that still exist mostly in urban centers.

1900s

1915—Navistar manufactures the first "school bus" for Ravinia School District in South Dakota.

By 1918, all states have passed laws requiring children to attend at least elementary school.

1919—All 48 states have laws allowing the use of public funds for transporting children to and from school.

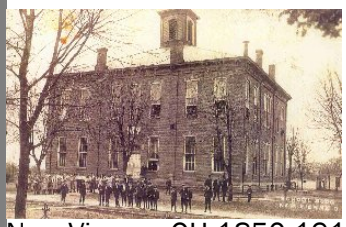
1920s

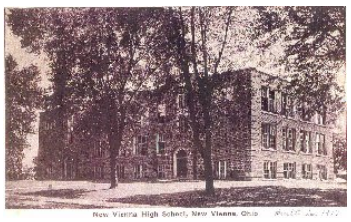
Dr. Nathaniel Kleitman, one of the earliest and most influential sleep researchers, begins to study the regulation of sleep and wakefulness at the University of Chicago.

1925—Supreme Court rules in *Pierce v. Society of Sisters* that states cannot compel children to attend public schools and that children can instead attend private schools.

As the 20th century progresses, most states enact legislation extending compulsory education to age 16.

The availability of and access to affordable motor vehicle transportation helps transport children from more rural and remote areas and helps lead to the consolidation and modernization of schools.


New Vienna, OH 1850-1917


New Vienna, OH 1917-1963

1939—Dr. Nathaniel Kleitman publishes his seminal book *Sleep and Wakefulness.*

1940s
In the 1940s, responsibility for financing public education becomes more regionalized at the state, district and municipality levels. In 1940, local property taxes finance 68% of public school expenses, while state governments contribute 30%. By 1990, local districts and states each contribute 47% to public school revenues. The federal government provides most of the remaining funds.

1941-1945—U.S. in World War II: Industrialization and a post-war economic boom dramatically change the prosperity of Americans and they buy more houses, automobiles and start families, which will become the "baby boomers."

By the middle of the 20th century, most states take a more active regulatory role in public education than in the past. Many states consolidate school districts into larger units. In 1940, there are over 117,000 school districts in the United States, but by 1990 the number decreases to just over 15,000. This regionalization often results in transporting a greater number of students over longer distances.

1950s
All in all, new highways, faster & cheaper vehicles, and economic prosperity stimulate a tremendous urban sprawl and the "suburbanization of America" from the 50s to present day.

1950s-1960s—"Baby boomers" begin to reach school age. More than 50% of today's schools are built during this period.

1953—Dr. Nathaniel Kleitman and his graduate student, Eugene Aserinsky, make the landmark discovery of rapid eye movement (REM) during sleep. Shortly afterwards, their student, Dr. William Dement describes the "cyclical" nature of sleep and the relationship between REM and dreaming.

1954—*Brown v. Board of Education* outlaws "separate but equal" facilities. "White flight" from urban centers begins, leading to the rapid development of suburban school districts. In many regions of the country, children are bused longer distances to assist in integrating schools.

1956—President Dwight D. Eisenhower signs the Interstate and Defense Highways Act and helps accelerate the suburbanization of America. 47,000 miles of federal highway are built.

1960s

By the early 1960s, there is a rapid increase in the school population due to the consolidation of remaining schools—larger and more complicated school districts are created. Educators begin looking for new ways to deal with the problem of overcrowding, which leads to staggered start times being considered and implemented in some school districts. With little or no sleep science available to guide decision-making, high school start times are typically placed earlier than elementary schools.

1961—Fairfax joins Montgomery and Prince Georges Counties in MD in staggering start times for elementary and secondary schools to reduce operating costs. All high schools except Herndon and Luther Jackson start at 8:15 am.

1970s

During the 1970s, recession, inflation, increasing fuel costs and budget cuts further contribute to a "do more with less" mentality in school systems and in state and local governments. As a result of waning enrollment and decreasing property tax revenues, many school districts look for ways to cut transportation costs and adopt tiered bell schedules so that they could move the same number of students with fewer buses.

1970—Court-ordered busing begins to help integrate schools, but in some regions of the country, this leads to an even greater exodus from urban centers. The further consolidation of schools and the creation of still larger school districts result in longer commutes for some students.

Dr. William Dement, "the father of sleep medicine," founds the first sleep research center at Stanford University.

1972—Animal studies lead to the discovery of the suprachiasmatic nuclei in the hypothalamus is the center of the "biologic (or circadian) clock" in the human brain.

The Fairfax County School Board adopts ½ Mondays in elementary schools to allow for planning time for teachers.

1973-1974—Stock market crash causes inflation and devaluation of the dollar.

U.S. experiences an energy crisis due to an oil boycott by the Organization of Arab Petroleum Exporting Countries (OAPEC). President Nixon asks the nation to adopt measures to conserve energy. School districts lower thermostats, consider shorter days and many adopt tiered-busing to save fuel, which will more than double in price by the end of the decade.

1974—Daylight Saving Time is expanded to more states and for a more extended time period, which leads to concerns regarding younger students waiting for the bus in the dark.

1976—Using a standardized protocol (the Multiple Sleep Latency Test), Dr. Mary Carskadon establishes sleep latency (time to fall asleep) as a physiologic measurement of sleep propensity (likelihood of falling asleep). This allows researchers to objectively measure the extent of daytime sleepiness resulting from acute and chronic sleep loss and begin to quantify the impact of sleep loss on daytime performance.

1975-1976—The Fairfax County School Board cancels plans to buy 80 new replacement busses and instead adjusts bell schedules earlier by 10-15 minutes and adds a fourth tier to its busing schedule.

Late 1970s—Dr. Mary Carskadon at Brown University and others conduct initial research on normal biological and circadian changes in adolescent sleep.

1979—Second energy crisis hits the nation following the Iranian revolution; increasing pressure on school districts and municipalities to lower transportation costs.

1979—1986 – During the next decade, Fairfax County Public Schools moves its high school start times from 8:00-8:15 am to 7:40 am.

After peaking in 1970, total school enrollment falls during the 1970s and early 1980s.

1980s

During the 1980s, an increase in the birth rate and new immigration contributes to the growth of the nation's student population, adding pressure on many school systems.

Starting in the 1980s, important research on adolescent sleep needs and sleep schedules is conducted by Dr. Carskadon and others.

1982—Researchers develop a hypothesis about how sleep may play a key role in learning and memory consolidation.

1986—Dr. Charles Czeisler and colleagues describe for the first time how bright light influences the human biological clock.

1987—Fairfax County Pubic Schools' high schools move start times earlier by 10 minutes to 7:30 am.

1988—U.S. Congress appoints Dr. William Dement as Chair of the National Commission on Sleep Disorders Research to study the prevalence of sleep deprivation and sleep disorders and their impact on the health of all Americans.

1990s

Sleep researchers begin to describe delayed phase preference in teenagers and the impact of school schedules and employment on their sleep. Researchers also begin to study sleep disorders and the relationship between sleep loss and depression in adolescents.

1990—Fairfax County Public Schools increases its secondary school day by 30 minutes by adopting a 7-period day, with high schools going from 7:30 am to 2:20 pm.

1992—The National Commission on Sleep Disorders Research issues its report and declares, "America is seriously sleep-deprived with disastrous consequences."

1993—The Minnesota Medical Association adopts a resolution calling on local school districts to eliminate early start times for adolescents.

The National Center for Sleep Disorders Research (NCSDR) is established at the National Institutes of Health; its mission is to coordinate research and national educational efforts about sleep and sleep disorders.

1994—The CLOCK gene is discovered, which both demonstrates the genetic influence on normal human circadian functioning and emphasizes the importance of circadian regulation on health and disease.

1996—Edina, Minnesota becomes the nation's first school district to delay start times for high school students based on sleep research showing the impact of sleep loss on young people.

High school start time in Fairfax County is adjusted 10 minutes earlier to 7:20 am, where it currently remains.

1997—The National Institutes of Health (NIH) declares that adolescents and young adults (ages 12 to 25 years) are a population at high risk for problem sleepiness based on "evidence that the prevalence of problem sleepiness is high and increasing with particularly serious consequences."

1997—As a means of mitigating after-school criminal activity by unsupervised teenagers, Congresswomen Zoe Lofgren introduces Concurrent Resolution 227 (ZZZ's to As Act) expressing the "sense of Congress that secondary schools should begin the school day no earlier than 9:00."

1998—Dr. Kyla Wahlstrom and colleagues publish the preliminary findings of their research on the impact of changing start times in 3 Minneapolis high schools.

1999—Congresswoman Zoe Lofgren introduces H.R. 1267, "Zs to As Act." The bill provides grants up to $25,000 to local educational institutions that agree to begin school for secondary students after 9:00 am. This time, the bill focuses on the sleep needs of adolescents. It does not pass, but gains significant media attention and helps spur a "national conversation" about the issue.

1999—The National Research Council holds *Sleep Needs, Patterns and Difficulties of Adolescents Workshop,* which raises awareness amongst federal agencies and other health professionals about more than two decades of sleep research on teens. Dr. William Dement declares, "Adolescence is the time of greatest vulnerability from the standpoint of sleep."

Dr. Eve Van Cauter and her colleagues describe the effects of sleep debt in young adults, establishing an association between sleep loss and metabolic and hormonal function. The research later leads to findings linking sleep loss with an increased risk of obesity.

2000s

Sleep researchers increasingly focus on cultural and international differences in sleep habits, including public policies related to work and school hours and their impact on sleep, etc. There is also emerging evidence that puberty-related changes in sleep patterns may affect middle school students as well, thus highlighting the importance of considering later start times in this population as well.

2000—The National Sleep Foundation releases an *Adolescent Sleep Research Report and Resource Guide* at a press conference on Capitol Hill with Congresswomen Zoe Lofgren in order to draw national media attention to the consequences of early start times on the health and safety of adolescents.

2001—A state senator in Connecticut introduces the first statewide legislation to change school start times in the nation, but it does not pass.

2002—Dr. Kyla Wahlstrom publishes *Changing times: Findings from the first longitudinal study of high school start times*, the nation's first major study that details the positive impacts of later school start times.

2002—A bill is introduced in the Connecticut Senate that bans administering state tests before 9:00, but does not pass.

2003—Stickgold and colleagues at Harvard Medical School publish evidence of the relationship between sleep and memory and learning.

2004—The State of Connecticut passes legislation that allows districts to administer the tenth grade mastery test as early as 8:30.

2006—The National Sleep Foundation issues its annual "Sleep in America" poll. The national poll is the first of its kind, detailing the findings of telephone interviews from a random sample of 1,602 caregivers and their adolescent children about the student's sleep and sleep habits. It finds that only 9% of high school-aged respondents get the amount of sleep recommended by physicians on school nights.

2009—The Centers for Disease Control and Prevention (CDC) releases data from a national survey used to assess the prevalence of unhealthy sleep behaviors in 12 states and declares "insufficient sleep is a public health epidemic."

1900-2010—The percentage of teenagers who graduate from high school increases from about 6% in 1900 to about 85% in 1996, and then declines over the next decade and a half to 75% in 2010.

2010s

2010—The Department of Health and Human Services releases Healthy People 2020, which for the first time gives sleep it's own focus area and sets the objective of increasing "the proportion of students in grades 9 through 12 who get sufficient sleep."

2010—The American Medical Association (AMA) adopts Resolution 503, "Insufficient Sleep in Adolescents," – sponsored by the American Sleep Apnea Association – which confirms "adolescent insufficient sleep and sleepiness as a public health issue" and supports "education about sleep health as a standard component of care for adolescent patients."

2011—Vorona et al publish findings on adolescent automobile crash rates in Virginia Beach and Chesapeake, Virginia showing a significant increase in crashes in the district with earlier high school start times.

The Brookings Institute issues its report, *Organizing Schools to Improve Student Achievement: Start Times, Grade Configurations, and Teacher Assignments*, identifying high school start time delay as one of the 3 most important strategies to improve America's schools and projecting a potential benefit-to-cost ratio of 9:1.

The CDC publishes an epidemiological study showing that almost 70% of high school students are not getting sufficient sleep and sleep loss is associated with 10 at-risk behaviors including smoking, alcohol and marijuana use, sexual activity, feelings of sadness, and thoughts of suicide.

2012—The Florida Chapter of the American Academy of Pediatrics issues a position statement supporting, "considerations to policy changes where students' physical and mental health is promoted. The FCAAP/FPS supports efforts to change high school start times after 8:00 a.m."

2013—U.S. Department of Education Secretary Arne Duncan tweets, "Common sense to improve student achievement that too few have implemented: let teens sleep more, start school later.

Virginia Chapter of the American Academy of Pediatrics issues a statement supporting later school start times for all Virginia high schools.

2014—Dr. Kyla Wahlstrom, with funding from the CDC, publishes the findings from a 3-year research study looking at the impacts of later start times in 8 public high schools in 3 states. The study finds that later start times improve sleep, academic performance and reduce motor vehicle crashes.

The Children, Youth, & Families Office of the American Psychological Association

Later School Start Times Promote Adolescent Well-Being

Moving high school start times can improve student performance and general well-being.

Delaying Start Times

Though comprehensive national statistics on school start times are not available, it is common for American public high schools to begin their instructional day between 7:00-8:00AM. Research has shown that these early bell times are responsible for the discrepancy between how much sleep teens need and how much sleep they get.[9] When school systems have moved to later start times, they have found that their students get more sleep.[4,19-20] Numerous studies have been done with schools that have shifted to later start times; while individual differences in communities and research methodology have led to different outcomes, results are almost always positive. Benefits observed from later high school start times include: [4, 6,9-14, 16, 19-21]

- Increased attendance rates
- Decrease in disciplinary action
- Decrease in student-involved car accidents
- Increase in student GPA
- Increase in state assessment scores
- Increase in college admissions test scores
- Increase in student attention
- Decrease in student sleeping during instruction
- Increase in quality of student-family interaction

These benefits are from studies of delayed start times in schools and districts across the country in Colorado, Connecticut, Kentucky, Minnesota, Missouri, Rhode Island, Virginia, & Wyoming. They have been done with schools in a broad range of developed environments–urban, suburban, and rural.

Sleeping in Adolescence

The optimal amount of sleep for adolescents is approximately 9 ¼ hours nightly.[2] Surveys show that, while younger children generally get enough sleep, by early adolescence, most do not; this trend continues to worsen throughout the teenage years (See Figure 1). More than half of teens age 15-17 sleep for 7 or fewer hours per school night.

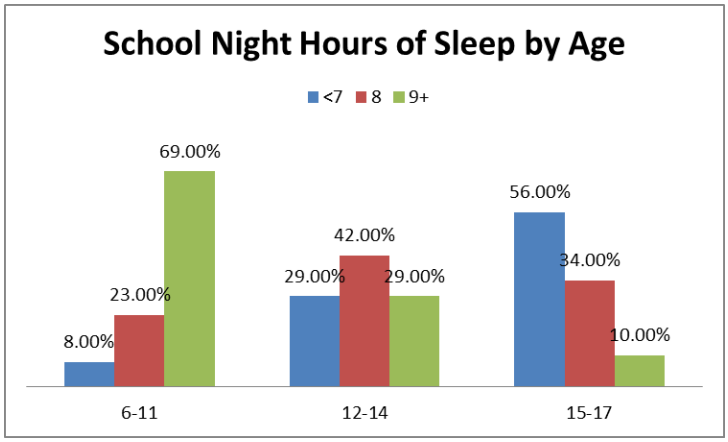


Figure 1: *School Night Hours of Sleep by Age Group. While 69% of kids age 6-11 get approximately enough sleep, just 1 in 10 15-17 year olds are. Source: National Sleep Foundation, 2014..*

Teens are notorious night owls – generally, they go to bed late in the evening and, when given the opportunity, wake up late in the morning. This tendency has biological and physiological roots. The sleep-wake cycle is governed by both the homeostatic drive for sleep (Process S) and the circadian rhythm (Process C).[5,8]

- Process S builds during wakefulness and makes you feel tired. This process weakens during adolescence.[1,3]
- Process C helps the body determine when the right time for sleep is. It naturally shifts later during adolescence. This is called Delayed Phase Preference.[18]

Process S and Process C heavily influence mood and learning abilities.[17] While they are interconnected, fixing an issue with one does not mean that an issue with the other will be resolved. That is, simply going to bed earlier does not necessarily make someone less tired in the early morning hours.[9]

Benefits of Sleep

Scientists are still discovering new benefits of sleep. Research has suggested that sleep is vital to almost all areas of human functioning. Some benefits of sleep are listed below.[6,7,9,16,21]

Sleep leads to increases in/benefits to:

- Memory & learning
- Attention
- Emotional regulation
- Mental health & well-being
- Weight control/Body Mass Index (BMI)

Loss of sleep leads to decreases in/problems with:

- Information retention & cognition
- Student behavior and classroom conflict
- Attendance issues
- Mood regulation

Concerns

Concerns about delayed start times have generally focused less on academic/social/cognitive outcomes and more on logistical complications. Some considerations include:[9]

- Increased cost, congestion, & delays associated with having busses on the road later in the morning
- Inability of parents to rely on older children for afternoon childcare, as the lower schools would have effectively switched schedules with the upper schools.
- Scheduling conflicts for intervarsity/interscholastic events with neighboring jurisdictions that have earlier dismissal.

These issues are surmountable, and, with adequate planning, can be minimized or completely eliminated.

Conclusion

While implementation may be complex, particularly when a change would bring a school's schedule out of sync with neighboring systems, delaying school start times so that adolescents begin their instructional day later provides numerous benefits to the students and their broader community alike.

References

1. Carskadon, M. A. (2011). Sleep in adolescents: The perfect storm. *Pediatrics Clinics of North America*, *58*, 637-647.
2. Carskadon, M. A. (2013). Optimal sleep habits in adolescents. In H. P. A. Van Dongen & G. A. Kerkhof (Eds.),*Encyclopedia of Sleep*, *190,* 86-87.
3. Carskadon, M. A., Acebo, C., & Jenni, O. G. (2004). Regulation of adolescent sleep: Implications for behavior. *Annals of the New York Academy of Sciences, 1021*, 276-291.
4. *Center for Applied Research and Educational Improvement*. (1998).School start time study. Technical report: Vol. II. Analysis of student survey data.
5. Crowley, S. J., Acebo, C., & Carskadon, M. A. (2007). Sleep, circadian rhythms, and delayed phase in adolescence. *Sleep Medicine, 8*, 602–612
6. Davison, C. M., Newton, L., Brown, R. S., Freeman, J., Ufholz, L. A., & Smith, J. D. (2012). Systematic Review Protocol: Later School Start Times for Supporting the Education, Health and Well-being of High School Students. *The Campbell Collaboration.*
7. El-Sheikh, M., Bagley, E. J., Keiley, M. K., & Erath, S. A. (2014). Growth in Body Mass Index From Childhood Into Adolescence: The Role of Sleep Duration and Quality. *The Journal of Early Adolescence.*
8. Hagenauer, M. H., Perryman, J. I., Lee, T. M., & Carskadon, M. A. (2009). Adolescent changes in the homeostatic and circadian regulation of sleep. *Developmental Neuroscience, 31*, 276-284.
9. Kirby, M., Maggi, S., & D'Angiulli, A. (2011). School start times and the sleep-wake cycle of adolescents: A review and critical evaluation of available evidence. *Educational Researcher. 40(2),* 56-61
10. *National Sleep Foundation*. (2005a). Changing school start times: Arlington, Virginia
11. *National Sleep Foundation*. (2005b). Changing school start times: Denver, Colorado
12. *National Sleep Foundation.* (2005c). Changing school start times: Fayette County, Kentucky
13. *National Sleep Foundation*. (2005d). Changing school start times: Jessamine County, Kentucky
14. *National Sleep Foundation.* (2005e). Changing school start times: Wilton, Connecticut
15. *National Sleep Foundation.* (2014). 2014 Sleep In America ® poll - Sleep in the modern family: Summary of findings.
16. Owens JA, Belon K, Moss P. (2010). Impact of delaying school start time on adolescent sleep, mood, and behavior. *Archives of Pediatric & Adolescent Medicine, 164*(7), 608–14
17. Schmidt, C., Collette, F., Cajochen, C., & Peigneux, P. (2007). A time to think: Circadian rhythms in human cognition. *Cognitive Neuropsychology, 24*, 755–789.
18. Tarokh, L., & Carskadon, M. A. (2009). Sleep in adolescents. In Squire, L.R. (Ed.). *Encyclopedia of Neuroscience, 8*, Oxford Academic Press, 1015-1022
19. Vedaa, Ø., Saxvig, I. W., & Wilhelmsen-Langeland, A. (2012). School start time, sleepiness and functioning in Norwegian adolescents. *Scandinavian Journal of Educational Research,* 56, 55-67
20. Wahlstrom, K. (2002). Changing times: Findings from the first longitudinal study of later high school start times. *NASSP Bulletin, 86*(633) , 3–21.
21. Wahlstrom, K., Dretzke, B., Gordon, M., Peterson, K., Edwards, K., & Gdula, J. (2014). 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.*

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Young and Sleep Deprived

Psychologists' research supports later school start times for teens' mental health.

By Karen Weintraub

Many American teenagers stumble into classrooms before the sun has crested the horizon. Some have forgotten their homework, will fall asleep in class and act as beastly to their friends as to their parents.

Most of these teens just aren't sleeping enough.

A National Sleep Foundation panel concluded last year that adolescents need eight to 10 hours of sleep a night, yet nearly two-thirds of 17-year-olds report sleeping less than seven hours a night, according to a policy statement from the American Academy of Pediatrics (AAP) in 2014.

The potential consequences are huge. Per the report, which was published in Pediatrics, adolescents who get less sleep than they need are at higher risk for depression, suicide, substance abuse and car crashes. They don't perform as well in school. Evidence also links short sleep duration with obesity and a weakened immune system.

One way to help, according to an August 2015 report from the Centers for Disease Control and Prevention, would be to roll back middle and high school start times to 8:30 a.m. or later, per AAP recommendations.

Yet fewer than one in five American middle and high schools begin their days then. The average start time across the U.S. is 8:03 a.m. In some states, 75 percent to 100 percent of schools start before 8:30.

A growing number of psychologists, among other professionals, have felt so strongly about the data that they've started leading efforts to push back middle and high school start times. They want teens to be able to roll out of bed closer to their natural wake-up time of 8 a.m.

"We are robbing adolescents of sleep," said Lisa J. Meltzer, PhD, a sleep researcher and clinician in the department of pediatrics at National Jewish Health in Denver, who lobbies for later start times. "We are requiring them to wake up at a time when their brain would otherwise be asleep. … I don't think we're giving adolescents the opportunity to be the best they can be."

MORNING IN AMERICA

Mary A. Carskadon, PhD, a professor of psychiatry and human behavior at Brown University, was the first to show that as kids go through puberty, their circadian rhythms change, making it easier for them to stay up later. In contrast with children, whose circadian rhythms push them to fall asleep early- to mid-evening, adolescents' sleep drive doesn't kick in until later in the evening.

Paul Kelley, PhD, who researches sleep and circadian rhythms at the University of Oxford, and colleagues wrote that schools shouldn't start until after 10 a.m. to fully accommodate what research says may be shifts of up to three hours in adolescent sleep patterns (Learning, Media, and Technology, 2015). Those shifts are "not understood by most educators," the review said. A common misbelief is that adolescents are tired, irritable or uncooperative "because they choose to stay up too late, or are difficult to wake in the morning because they are lazy."

Carskadon says one study really changed her own mind about school start times. She was following students who went from ninth grade in a late-start middle school to 10th grade in an early-start high school. She'd assumed that exposure to early morning light would allow them to quickly adjust to the earlier start time. But they didn't.

In tests at 8:30 a.m., she'd turn off the lights and the students wouldn't be able to stay awake for more than three minutes. "It was like they developed narcolepsy," she says. "And they'd go right into REM [rapid eye-movement] sleep, which is not what you'd do if you're healthy and on the right schedule and not suffering from narcolepsy."

She says it's also been striking to see how much student mood improves with later start times. "Everybody was happier" before the shift, Carskadon says, including teachers. "Teachers have to work really, really hard at 7:30 in the morning with teenagers — they're not in the moment."

She says she started off as an objective researcher, keeping her distance from policy decisions. But at a certain point, she decided the data were too conclusive to ignore. "Now, in the last decade, I've been going to school committees if they call."

ZONED OUT IN CLASS

To get to high school by the time her first class starts at 7:35 a.m., sophomore Hannah Bruce of Sherborn, Massachusetts, has to set her alarm for 6 a.m. "although snooze happens quite a lot." Her bus comes at 7. Her swim practice ends at 10 p.m. — a complex yet common problem for teens who do extracurricular activities in the evening. Even if she's already finished her homework, she says it's nearly impossible to wind down enough to fall asleep before 11.

Bruce, 16, admits she struggles to pay attention in class, and has nodded off more than once.

Studies have shown a tight link between school performance and sleep. For one, sleep deficiency increases the risk of attention problems, says Charles Czeisler, MD, PhD, who directs the Division of Sleep Medicine at Harvard Medical School and chairs the board of the National Sleep Foundation.

Though it's not a panacea for the academic and other demands facing teens, moving start times appears to help them perform better. When a Jackson Hole, Wyoming, high school pushed its start time back from 7:35 to 8:55, students' grades in their first-period classes improved significantly, according to a 2014 report by Kyla L. Wahlstrom, PhD, a leading researcher who directs the Center for Applied Research and Educational Improvement in the College of Education and Human Development at the University of Minnesota. The study, which reviewed 9,000 students in three states, also found that delaying start times led to a significant drop in tardiness and absences.

Critics — including some parents and teachers' unions — say that later start times will mean kids will simply go to bed later, but research doesn't bear out that concern. Pushing back school start times by 75 minutes yields as much as 50 minutes more sleep for the average middle schooler, according to a study of 205 students by psychologist Amy R. Wolfson, PhD, in Behavioral Sleep Medicine (2007), and — depending on the study and the amount of delay — 15 to 45 minutes extra sleep for the average high schooler. In schools that start at 8:30 or later, 60 percent of students sleep at least eight hours on school nights, the University of Minnesota review found.

That added sleep can have profound benefits. In Jackson Hole, teen car crashes fell by 70 percent after the shift in start times.

"Plus, the data show a clear trend: The later the start, the more the positive outcomes emerge," says Wahlstrom. "Even though it is difficult for the school community to make the change to a later high school start time, the emerging benefits for the well-being and the academic gains for teenagers make the decision to do so very compelling."

According to the advocacy group Start School Later, hundreds of schools in the U.S. have shifted start times thanks to sleep research. A number of legislators have introduced related bills, including Rep. Zoe Lofgren (D-Calif.) whose ZZZ's to A's Act asks the secretary of education to conduct a comprehensive review of sleep times and health and issue a formal recommendation.

But shifting school start times is complicated. For example, while research from Matthew Milewski, MD, of Connecticut Children's Medical Center, and colleagues shows that a chronic lack of sleep is associated with a greater risk of injuries for school athletes (Journal of Pediatric Orthopaedics, 2014), some coaches argue that later start times push practices into the afternoon dark, when it's impossible to see balls. Installing field lights would cost millions.

Hannah Bruce says that many parents in her high-achieving district don't want a later start time because it would cut down on the time their children have to participate in afternoon enrichment activities, clubs and sports.

Some teachers' unions have objected, too, including one in Montgomery County, Maryland. In a recent survey, some teachers argued that the proposed half-hour shift wouldn't be enough to make a difference in kids' sleep.

Others said they didn't want their schedules disrupted, or worried about extra costs and commute times.

Another concern is bus schedules: Many districts have just one fleet of buses to get both high school and elementary school students to school, so if high school students start later, how will that affect elementary school children? Montgomery County moved its high school starting time back 20 minutes, and while parents of teenagers generally welcomed the change, some of those with younger children, many of whom now begin school at 9:25, complained of issues finding child care to fill the new early-morning gap.

For the 2014 school year, Falls Church, Virginia, moved the start of its middle school from 7:30 a.m. to 8:10 a.m. Superintendent Toni Jones said parents had pushed for the switch based on the research and the trouble they had getting their young teens to school so early. She couldn't move the start time back any later because of busing issues — buses have to be finished with their routes before the D.C. rush-hour begins, or they will be stuck in gridlock for hours, she says.

A few teachers opposed the switch at first because of scheduling conflicts with their own kids, but the district saw no organized opposition, and parents and students were happy with the change, Jones says. And more school systems are embracing later start times. In November, Seattle Public Schools voted to delay high school starting times to 8:45 a.m. Seattle is so far the largest school system to make the change.

TIME FOR ACTION

Psychologist Beth Hall, PhD, EdD, of Westborough, Massachusetts, is among the growing number of psychologists advocating for later start times. She drops her daughter off at high school at 6:30 on band practice mornings, and says she's constantly reminded of the downside of such early start times.

"Look at them. They're exhausted," says Hall, pointing to high schoolers. "Adults know how it feels to be really sleep deprived and we're asking kids day in and day out to do this."

Hall routinely asks her clients about their sleep habits, and often has them keep a sleep log. She also involves parents, encouraging them to be good role models for their children by developing healthy sleep habits themselves.

Of course, school start times aren't the only reason kids are sleep-deprived. Teens bear some responsibility for their sleep habits. They don't want to hear Mom and Dad telling them to go to bed anymore. They don't want to disconnect from friends on social media — and research by Mariana Figueiro, PhD, of the Lighting Research Center at Rensselaer Polytechnic Institute has found that the blue light used in cellphones, laptops and tablets counters the body's melatonin signals and can make it harder to fall asleep, especially for adolescents (Lighting Research and Technology, 2015).

"I think improvements could be made," Hannah Bruce admits about her own sleep schedule.

Parents also have a role to play in setting bedtimes and other limits. In families where parents don't enforce a typical bedtime of about 10 p.m., researchers found that their high schoolers have an increased risk of depression and suicidal thinking (Sleep, 2010).

Another major factor in adolescent sleep deprivation is the stress parents and society put on teens to get good grades, play sports, volunteer, get jobs, get into college and more.

"Something has to give," Meltzer says, "and usually, it's sleep."

There is one consolation for teenagers: Life is likely to get better soon. Once adolescents reach their late teens, their need for sleep declines a bit, according to the National Sleep Foundation's recommendations, and they start getting a little more shut-eye. As many as 40 percent of 19-year-olds sleep more than seven hours a night, the new Pediatrics study found.

Karen Weintraub is a journalist in Cambridge, Massachusetts.

Student Health
School Start Times
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Later Education Start Times in Adolescence: Time for Change

By Paul Kelley and Clark Lee

School start times for adolescents in the United States are typically too early to be healthy for this age group. There is significant evidence from the research literature that early starts have serious negative impacts on students. In particular, early education start times in adolescence cause chronic sleep deprivation, which damages both adolescents' education and health. Fortunately, chronic sleep deprivation is one of the more preventable public health issues facing the nation. This briefing paper summarizes the latest research on the subject, explores policy options to address this education and public health issue, and sets forth the recommendation that education start times be adjusted appropriately for U.S. adolescents.

Research

Adolescence starts with the onset of puberty and ends in the early 20s. During this period, adolescents are driven to later wake/sleep times by their biological clock (see The Adolescent Biological Clock sidebar). Because education start times do not adjust for this change, early school start times effectively limit sleep in adolescents. Researchers have found that students lose as much as an average of 2.7 hours of sleep on school days.[1] This is why sleep loss in adolescence is greater than at any period in our lives.

Sleep loss associated with early school start times can damage adolescents' learning and health. Later starting times, by contrast, are associated with longer sleep, better learning and reduced health risks. Research from the past 20 years has consistently supported these findings.

The Adolescent Biological Clock

Our biological timing systems are determined by genes throughout the body. These timing systems are largely outside our control. A small group of cells, the suprachiasmatic nucleus (SCN), is the master clock in the human brain.

The SCN is our circadian (daily) pacemaker, controlling the timing of most 24-hour behavioral and physiological rhythms. These daily rhythms include the sleep-wake cycle, alertness and performance rhythms, hormone production, core body temperature regulation and metabolism. These natural rhythms cannot be trained to suit modern society. Despite all our technologies and timetables, our bodies continue to run on sun time, not clock time.

This biological clock changes our sleep patterns from the onset of puberty, slowly moving to later sleep/wake times until 20 or 21 years of age. During our late teens and early 20s, this biologically driven delay in our natural sleep/wake patterns reaches almost three hours. At that point, students in our schools and colleges can be losing two to three hours of sleep every night. This is why education start times requiring waking at 7 a.m. or earlier – which is like adults waking at 4 a.m. every day – cause chronic sleep loss. Losing sleep through the week on this scale leads to poorer academic achievement and increased health risks.

Research from a variety of fields on different stages of adolescence consistently shows the positive effects of later starts. Recently, economists looking at existing school data where start times were changed for administrative reasons found similar positive improvements. Research found clear test gains in middle school students (grades 6 to 8) when they had later start times, and the positive effect in 8th grade scores remained two years later in 10th grade.[2] Additional research examined data from the United States Air Force Academy and found that the earlier students had to start classes, the worse they did in those classes.[3] Moreover, the earlier students had their first class, the lower their achievement in all classes taken on the same day. Taken together, these two studies alone involved more than 10,000 students, and findings in both studies were consistent over a number of years.

Later school times also are associated with other positive social outcomes. In the Minneapolis School District high schools study of later start times, parents were very positive about the later start time, with 92 percent liking the change. Parents also reported that their children were "easier to live with" and that families had "more conversation time."[4]

Sleep deprivation not only impacts learning but also increases risks of accidents and injuries and affects hormones and metabolism. Changing to later school start times has been shown to reduce car accidents involving adolescent drivers. There is also clinical evidence that sleep deprivation is a contributing factor to obesity, depressive illness and sleep disorders.

From our personal experience, we understand that several hours of sleep deprivation over several nights would impact anyone's alertness and performance. These perceptions are clearly supported by scientific research. Even relatively moderate sleep restriction can seriously impair learning in healthy adolescents. For example, a 2013 study found that subjects restricted to six hours or less sleep per night produced cognitive performance deficits equivalent to up to two nights of total sleep deprivation.[5] Adequate sleep is particularly important in adolescent development. It is also important when adolescents are trying to form long-term memories because key memory processes occur during sleep. These are some of the reasons good sleep improves in-class attention, academic performance and test results in adolescents.

Sleep deprivation not only impacts learning but also increases risks of accidents and injuries and affects hormones and metabolism. Changing to later school start times has been shown to reduce car accidents involving adolescent drivers. There is also clinical evidence that sleep deprivation is a contributing factor to obesity, depressive illness and sleep disorders. Sleep-deprived adolescents (and adults) are more likely to resort to potentially risky behaviors to control sleep that include using sleep medications and depressants (including alcohol) at night and stimulants during the day (including coffee, high caffeine drinks and smoking).

There is clear evidence that sleep deprivation poses health risks for millions of young adults and adolescents. In a study of 1.3 million cases starting from 16 years of age, research found short sleep duration per night was significantly associated with increased health risks.[6] The study concluded that modifications of working environments to allow sufficient sleep were highly desirable.

Given that many adolescents routinely lose more than two hours of sleep a night through early start times, it can be argued that adolescents are a particularly high-risk population for the numerous negative health outcomes associated with chronic sleep deprivation. For example, recent analysis based on July 2006 Census data estimated that more than 3 million adolescents and adults younger than 24 years of age are Delayed Sleep Phase types (as defined by the International Classification of Sleep Disorders).

There is virtually unanimous agreement in the research community that later start times in adolescent education would produce a positive change in adolescent learning, health and safety. Leading researchers in sleep medicine and sleep neuroscience have frequently called for this change in education start times to improve learning and reduce health risks. Few, if any, educational interventions are so strongly supported by research evidence from so many different disciplines and experts in the field.

Considering Options for Change

Despite the substantial body of evidence from scientific, medical and education research supporting later school starts, almost all adolescent education in the United States currently has early start times. This leaves states, school districts and other responsible bodies in the untenable position of defending a current practice that has been demonstrated to be detrimental to student learning, health and safety. It seems prudent for these parties to demonstrate a greater awareness of the issues, engage with other stakeholders and consider some of the options for reasonable and appropriate changes.

There are undoubtedly pragmatic reasons to avoid change. Changing community habits based on conventional wisdom can be difficult and needs to be handled confidently. Current early start times have determined timing of other activities (bus transportation and student athletics, for example), and organizers of these activities may resist change. Although most students (and increasingly parents) would support change, there will remain some who are opposed to it. These are not reasons, however, for stakeholders to avoid considering options for reasonable and appropriate changes to school start times.

There is a major shift in public knowledge and attitudes toward later start times. School districts are increasingly finding themselves compared to districts with later start times, and this has fuelled calls to take action in many communities.

There is a major shift in public knowledge and attitudes toward later start times. School districts are increasingly finding themselves compared to districts with later start times, and this has fuelled calls to take action in many communities. Enhancing public knowledge and securing the acknowledgement of key stakeholders on the demonstrated benefits of later school start times may be a prudent approach to keeping the issue in the forefront of the public's conscience. Normal risk management of change, including planning and implementation preparation, needs to be in place in due course.

Another possible strategy is to simply act decisively to improve public schools by moving to later starts. Altering education times can be legitimately presented as a strategy to both improve learning and reduce health risks. This message, especially the potential reduction of risk for children, can be powerful for families. Indeed, evidence of consultations with families has shown positive responses from families and students once a change to later start times is implemented.

Finally, in an increasingly accountable education environment, a powerful means to increase test scores, reduce health risk and improve faster than other states or districts must have at least some appeal.

Emerging Legal Risks[7]

There appears to be no argument for keeping early start times that is supported by scientific or medical studies, and this may make it difficult to defend current practice. The mere existence of more than 3 million adolescents and young adults younger than 24 with delayed sleep phase

disorders indicates the scale of potential problems arising from negligence suits (given that states already spend millions of dollars on settlements and judgements from injuries to students).

Education start times are the responsibility of education bodies and institutions, and thus it could be argued they have full responsibility for any foreseeable negative impact of early start times. Education bodies and institutions have an affirmative duty to provide a reasonable standard of care to their students, in part because of the compulsory nature of education. This duty of care may include warning of known risks or dangers and providing a safe environment (this may be taken to include the temporal environment). These considerations, taken as a whole, suggest that consideration of legal risks involved in keeping early start times may be advisable.

Education Policy on Starting Times

While start times are typically set at the local level, leaders can help raise awareness of the overwhelming evidence that later starts are beneficial.

State support could take the form of briefing papers such as this one, or through sharing examples of successful approaches to the management of change. There are other preliminary steps that can be taken, for example giving advice on improving the quality of sleep to students. Although biological drivers determine the extent of the shift to later wake/sleep times in adolescence, the impact on sleep can be made worse by use of screen technologies in the last hour before sleep (such as televisions, computers and phones). Sleep can be enhanced when bedroom temperatures are lower, and there are other ways to contribute to better quality sleep.

The current context is one in which there is a growing pressure to change to later start times for adolescent students (see Political and Legislative Context in sidebar). Of particular note is the House Concurrent Resolution calling for secondary schools to begin the school day no earlier than 9 a.m. Already, schools in the United Kingdom and New Zealand start at 10 a.m. or later for older adolescents, with strong positive impacts on achievement and behaviors. Many colleges already start at these times both in the United States and internationally.

The cost of implementing policies related to later start times is negligible. Later school start times can improve learning and reduce health risks. It is a change that is in the best interests of our students, families, communities and nation.

Political and Legislative Context

Public interest is growing in later school starts with organizations including the National Sleep Foundation and campaigns such as Start School Later taking a consistent line that change is necessary.

Legislative and policy proposals are increasing. Virginia and Massachusetts have considered new laws, and Maryland passed legislation related to later school start times recently. Action on a national level includes the House Concurrent Resolution 176 (2009): Expressing the sense of the Congress that secondary schools should begin the school day no earlier than 9 a.m.

The U.S. Secretary of State for Education in 2013 tweeted “let teens sleep, start school later.” He was no doubt aware the statement already had wider research and political support.

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Endnotes

[1] Hansen et al. 2005 http://pediatrics.aappublications.org/content/115/6/1555.long; Jenni et al. 2005 http://www.journalsleep.org/Articles/281116.pdf; Foster et al. 2013 http://www.ncbi.nlm.nih.gov/pubmed/23899602

[2] Edwards, F. 2012. http://eric.ed.gov/?id=EJ989056

[3] Carrell et al. 2011 http://old.econ.ucdavis.edu/faculty/scarrell/sleep.pdf

[4] Center for Applied Research and Educational Improvement (CAREI). 2002. School start time study: Final Report Summary. (University of Minnesota).

[5] Möller-Levet et al., 2013 http://www.pnas.org/content/110/12/E1132

[6] Cappuccio et al. 2010. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2864873/.

[7] None of the contents in this briefing or discussion of risk should be construed as formal legal advice to any person or organization and should be used strictly for informational purposes only. Please consult with appropriate legal counsel for formal legal advice.

Do Schools Begin Too Early?

The effect of start times on student achievement

What time should the school day begin? School start times vary considerably, both across the nation and within individual communities, with some schools beginning earlier than 7:30 a.m. and others after 9:00 a.m. Districts often stagger the start times of different schools in order to reduce transportation costs by using fewer buses. But if beginning the school day early in the morning has a negative impact on academic performance, staggering start times may not be worth the cost savings.

Proponents of later start times, who have received considerable media attention in recent years, argue that many students who have to wake up early for school do not get enough sleep and that beginning the school day at a later time would boost their achievement. A number of school districts have responded by delaying the start of their school day, and a 2005 congressional resolution introduced by Rep. Zoe Lofgren (D-CA) recommended that secondary schools nationwide start at 9:00 or later. Despite this attention, there is little rigorous evidence directly linking school start times and academic performance.

In this study, I use data from Wake County, North Carolina, to examine how start times affect the performance of middle school students on standardized tests. I find that delaying school start times by one hour, from roughly 7:30 to 8:30, increases standardized test scores by at least 2 percentile points in math and 1 percentile point in reading. The effect is largest for students with below-average test scores, suggesting that later start times would narrow gaps in student achievement.

The primary rationale given for start times affecting academic performance is biological. Numerous studies, including those published by Elizabeth Baroni and her colleagues in 2004 and by Fred Danner and Barbara Phillips in 2008, have found that earlier start times may result in fewer hours of sleep, as students may not fully compensate for earlier rising times with earlier bedtimes. Activities such as sports and work, along with family and social schedules, may

By FINLEY EDWARDS

PHOTO / GETTY IMAGES / PLATTFORM

make it difficult for students to adjust the time they go to bed. In addition, the onset of puberty brings two factors that can make this adjustment particularly difficult for adolescents: an increase in the amount of sleep needed and a change in the natural timing of the sleep cycle. Hormonal changes, in particular, the secretion of melatonin, shift the natural circadian rhythm of adolescents, making it increasingly difficult for them to fall asleep early in the evening. Lack of sleep, in turn, can interfere with learning. A 1996 survey of research studies found substantial evidence that less sleep is associated with a decrease in cognitive performance, both in laboratory settings and through self-reported sleep habits. Researchers have likewise reported a negative correlation between self-reported hours of sleep and school grades among both middle- and high-school students.

I find evidence consistent with this explanation: among middle school students, the impact of start times is greater for older students (who are more likely to have entered adolescence). However, I also find evidence of other potential mechanisms; later start times are associated with reduced television viewing, increased time spent on homework, and fewer absences. Regardless of the precise mechanism at work, my results from Wake County suggest that later start times have the potential to be a more cost-effective method of increasing student achievement than other common educational interventions such as reducing class size.

Wake County

The Wake County Public School System (WCPSS) is the 16th-largest district in the United States, with 146,687 students in all grades for the 2011–12 school year. It encompasses all public schools in Wake County, a mostly urban and suburban county that includes the cities of Raleigh and Wake Forest. Start times for schools in the district are proposed by the transportation department (which also determines bus schedules) and approved by the school board.

Wake County is uniquely suited for this study because there are considerable differences in start times both across schools and for the same schools at different points in time. Since 1995, WCPSS has operated under a three-tiered system. While there are some minor differences in the exact start times, most Tier I schools begin at 7:30, Tier II schools at 8:15, and Tier III at 9:15. Tiers I and II are composed primarily of middle and high schools, and Tier III is composed entirely of elementary schools. Just over half of middle schools begin at 7:30, with substantial numbers of schools beginning at 8:00 and 8:15 as well. The school day at all schools is the same length. But as the student population has grown, the school district has changed the start times for many individual schools in order to maintain a balanced bus schedule, generating differences in start times for the same school in different years.

For students who have entered adolescence, later start times have the potential to be a more cost-effective method of increasing achievement than other common education interventions such as reducing class size.

The only nationally representative dataset that records school start times indicates that, as of 2001, the median middle-school student in the U.S. began school at 8:00. More than one-quarter of students begin school at 8:30 or later, while more than 20 percent begin at 7:45 or earlier. In other words, middle school start times are somewhat earlier in Wake County than in most districts nationwide. The typical Wake County student begins school earlier than more than 90 percent of American middle-school students.

Data and Methods

The data used in this study come from two sources. First, administrative data for every student in North Carolina between 2000 and 2006 were provided by the North Carolina Education Research Data Center. The data contain detailed demographic variables for each student as well as end-of-grade test scores in reading and math. I standardize the raw test scores by assigning each student a percentile score, which indicates performance relative to all North Carolina students who took the test in the same grade and year. The second source of data is the start times for each Wake County public school, which are recorded annually and were provided by the WCPSS transportation department.

About 39 percent of WCPSS students attended magnet schools between 2000 and 2006. Since buses serving magnet

schools must cover a larger geographic area, ride times tend to be longer for magnet school students. As a result, almost all magnet schools during the study period began at the earliest start time. Because magnet schools start earlier and enroll students who tend to have higher test scores, I exclude magnet schools from my main analysis. My results are very similar if magnet school students are included.

The data allow me to use several different methods to analyze the effect of start times on student achievement. First, I compare the reading and math scores of students in schools that start earlier to the scores of similar students at later-starting schools. Specifically, I control for the student's race, limited English status, free or reduced-price lunch eligibility, years of parents' education, and whether the student is academically gifted or has a learning disability. I also control for the characteristics of the school, including total enrollment, pupil-to-teacher ratio, racial composition, percentage of students eligible for free lunch, and percentage of returning students. This approach compares students with similar characteristics who attend schools that are similar, except for the fact that some schools start earlier and others start later.

The results produced by this first approach could be misleading, however, if middle schools with later start times differ from other schools in unmeasured ways. For example, it could be the case that more-motivated principals lobby the district to receive a later start time and also employ other strategies that boost student achievement. If that were the case, then I might find that schools with later start times have higher test scores, even if start times themselves had no causal effect.

To deal with this potential problem, my second approach focuses on schools that changed their start times during the study period. Fourteen of the district's middle schools changed their start times, including seven schools that changed their start times by 30 minutes or more. This enables me to compare the test scores of students who attended a particular school to the test scores of students who attended the same school in a different year, when it had an earlier or later start time. For example, this method would compare the test scores of students at a middle school that had a 7:30 start time from 1999 to 2003 to the scores of students at the same school when it had an 8:00 start time from 2004 to 2006. I still control for all of the student and school characteristics mentioned earlier.

As a final check on the accuracy of my results, I perform analyses that compare the achievement of individual students to their own achievement in a different year in which the middle school they attended started at a different time. For example, this method would compare the scores of 7th graders at a school with a 7:30 start time in 2003 to the scores of the same students as 8th graders in 2004, when the school had a start time of 8:00. As this suggests, this method can only be used for the roughly 28 percent of students in my sample whose middle school changed its start time while they were enrolled.

Results

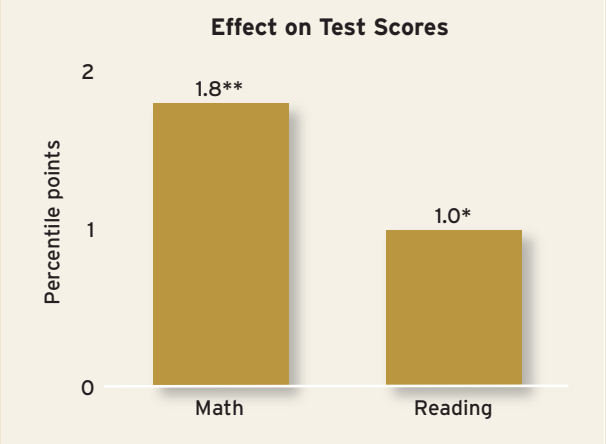
My first method compares students with similar characteristics who attend schools that are similar except for having different start times. The results indicate that a one-hour delay in start time increases standardized test scores on both math and reading tests by roughly 3 percentile points. As noted above, however, these results could be biased by unmeasured differences between early- and late-starting schools (or the students who attend them).

Using my second method, which mitigates this bias by following the same schools over time as they change their start times, I find a 2.2-percentile-point improvement in math scores and a 1.5-point improvement in reading scores associated with a one-hour change in start time.

My second method controls for all school-level characteristics that do not change over time. However, a remaining concern is that the student composition of schools may change. For example, high-achieving students in a school

Better Later (Figure 1)

Test scores rise for students attending schools that move their start times later.



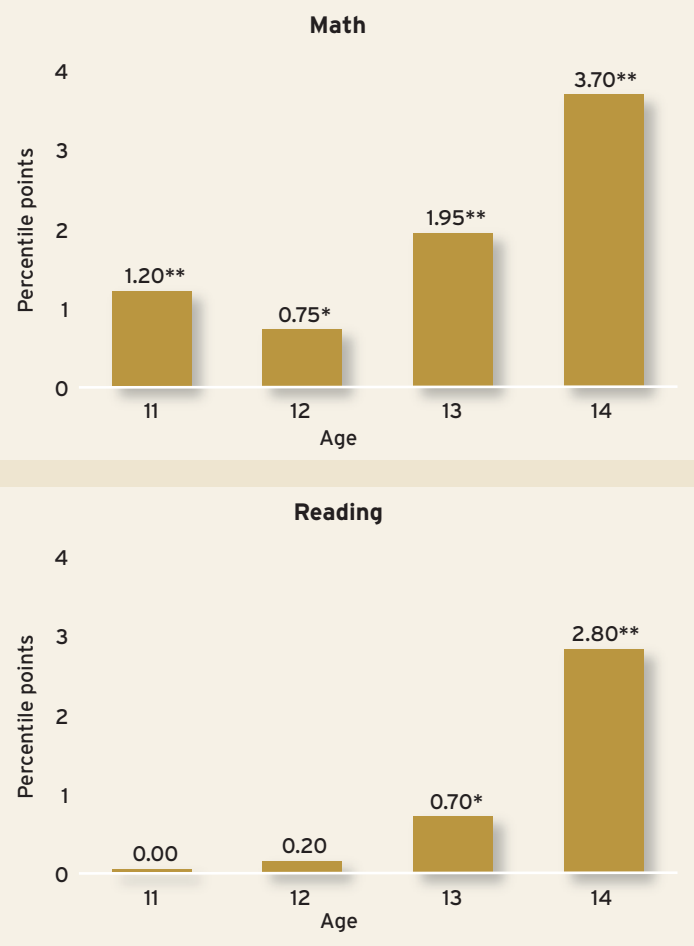
** (*) indicates that the effect is statistically significant at the 99 (95) percent confidence level.

Note: Estimated effects on test scores of starting school one hour later are based on a fixed-effect analysis that compares individual students only to themselves at different points in time while controlling for school and grade.

SOURCE: Author's calculations

A Teen Effect (Figure 2)

In both reading and math, the test-score effects of later start times increase as students age.



** (*) indicates that the effect is statistically significant at the 99 (95) percent confidence level.

Note: Estimated effects on test scores of starting school one hour later are based on a fixed-effect analysis that compares individual students only to themselves at different points in time while controlling for school and grade. Age is as of January 1 of the relevant school year.

SOURCE: Author's calculations

that changed to an earlier start time might transfer to private schools. To address this issue, I estimate the impact of later start times using only data from students who experience a change in start time while remaining in the same school. Among these students, the effect of a one-hour later start time is 1.8 percentile points in math and 1.0 point in reading (see Figure 1).

These estimated effects of changes in start times are large enough to be substantively important. For example, the effect of a one-hour later start time on math scores is roughly 14 percent of the black-white test-score gap, 40 percent of the gap between those eligible and those not eligible for free or reduced-price lunch, and 85 percent of the gain associated with an additional year of parents' education.

The benefits of a later start time in middle school appear to persist through at least the 10th grade. All students in North Carolina are required to take the High School Comprehensive Test at the end of 10th grade. The comprehensive exam measures growth in reading and math since the end of grade 8 and is similar in format to the end-of-grade tests taken in grades 3–8. Controlling for the start time of their high school, I find that students whose middle school started one hour later when they were in 8th grade continue to score 2 percentile points higher in both math and reading when tested in grade 10.

I also looked separately at the effect of later start times for lower-scoring and higher-scoring students. The results indicate that the effect of a later start time in both math and reading is more than twice as large for students in the bottom third of the test-score distribution than for students in the top third. The larger effect of start times on low-scoring students suggests that delaying school start times may be an especially relevant policy change for school districts trying to meet minimum competency requirements (such as those mandated in the No Child Left Behind Act).

Why Do Start Times Matter?

The typical explanation for why later start times might increase academic achievement is that by starting school later, students will get more sleep. As students enter adolescence, hormonal changes make it difficult for them to compensate for early school start times by going to bed earlier. Because students enter adolescence during their middle-school years, examining the effect of start times as students age allows me to test this theory. If the adolescent hormone explanation is true, the effect of school start times should be larger for older students, who are more likely to have begun puberty.

I therefore separate the students in my sample by years of age and estimate the effect of start time on test scores separately for each group. In both math and reading, the start-time effect is roughly the same for students age 11 and 12, but increases for those age 13 and is largest for students age 14 (see Figure 2). This pattern is consistent with the adolescent hormone theory.

To further investigate how the effect of later start times varies with age, I estimate the effect of start times on upper elementary students (grades 3–5). If adolescent hormones are the mechanism through which start times affect academic performance, preadolescent elementary students should not be affected by early start times. I find that start times in fact had no effect on elementary students. However, elementary schools start much later than middle schools (more than half of elementary schools begin at 9:15, and almost all of the rest begin at 8:15). As a result, it is not clear if there is no effect because start times are not a factor in the academic performance of prepubescent students, or because the schools start much later and only very early start times affect performance.

Of course, increased sleep is not the only possible reason later-starting middle-school students have higher test scores. Students in early-starting schools could be more likely to skip breakfast. Because they also get out of school earlier, they could spend more (or less) time playing sports, watching television, or doing homework. They could be more likely to be absent, tardy, or have behavioral problems in school. Other explanations are possible as well. While my data do not allow me to explore all possible mechanisms, I am able to test several of them.

I find that students who start school one hour later watch 12 fewer minutes of television per day and spend 9 minutes more on homework per week, perhaps because students who start school later spend less time at home alone. Students who start school earlier come home from school earlier and may, as a result, spend more time at home alone and less time at home with their parents. If students watch television when they are home alone and do their homework when their parents are home, this behavior could explain why students who start school later have higher test scores. In other words, it may be that it is not so much early start times that matter but rather early end times.

Previous research tends to find that students in early-starting schools are more likely to be tardy to school and to be absent. In Wake County, students who start school one hour later have 1.3 fewer absences than the typical student—a reduction of about 25 percent. Fewer absences therefore may also explain why later-starting students have higher test scores: students who have an early start time miss more school and could perform worse on standardized tests as a result.

Conclusion

Later school start times have been touted as a way to increase student performance. There has not, however, been much empirical evidence supporting this claim or calculating how large an effect later start times might have. My results indicate that delaying the start times of middle schools that currently open at 7:30 by one hour would increase math and reading scores by 2 to 3 percentile points, an impact that persists into at least the 10th grade.

Students who start school one hour later have 1.3 fewer absences than the typical student—a reduction of about 25 percent.

These results suggest that delaying start times may be a cost-effective method of increasing student performance. Since the effect of later start times is stronger for the lower end of the distribution of test scores, later start times may be particularly effective in meeting accountability standards that require a minimum level of competency.

If elementary students are not affected by later start times, as my data suggest (albeit not definitively), it may be possible to increase test scores for middle school students at no cost by having elementary schools start first. Alternatively, the entire schedule could be shifted later into the day. However, these changes may pose other difficulties due to child-care constraints for younger students and jobs and afterschool activities for older students.

Another option would be to eliminate tiered busing schedules and have all schools begin at the same time. A reasonable estimate of the cost of moving start times later is the additional cost of running a single-tier bus system. The WCPSS Transportation Department estimates that over the 10-year period from 1993 to 2003, using a three-tiered bus system saved roughly $100 million in transportation costs. With approximately 100,000 students per year divided into three tiers, it would cost roughly $150 per student each year to move each student in the two earliest start-time tiers to the latest start time. In comparison, an experimental study of class sizes in Tennessee finds that reducing class size by one-third increases test scores by 4 percentile points in the first year at a cost of $2,151 per student per year (in 1996 dollars). These calculations, while very rough, suggest that delaying the beginning of the school day may produce a comparable improvement in test scores at a fraction of the cost.

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EDUCATION WEEK

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COMMENTARY

Push Back High School Start Times

By Terra Ziporyn Snider

Since the late 1990s, school boards across the United States have been asked repeatedly to delay predawn school start times and bus schedules, and some—including schools in Decatur, Ga., and Amherst, Mass.—appear poised to move in that direction. Just last month, the Fairfax County, Va., school board set a goal of starting its high schools no earlier than 8 a.m. to promote student sleep and health.

These recent developments, while encouraging, are baby steps on a road marked by considerable idling and even reversals. They join a plethora of both new and decades-old campaigns, including ones championed by a Florida pediatrician; a Wisconsin research librarian; district superintendents in Louisiana and Massachusetts; students in California, New Hampshire, and Missouri; and parents in Washington state and my own state of Maryland.

Most of these efforts fail, primarily for systemic reasons. The science is there; the will to change is not. Today you'd be hard-pressed to find a health professional, sleep scientist, or educator who would defend starting high schools in the 7 a.m. hour, now the norm for many U.S. high schools, as good for physical or mental health, safety, or learning. But politics and human nature typically keep schools from prioritizing student health and well-being when they draw up the academic schedule.

Given the science, the idea of starting high schools later is a no-brainer. Waking before sunrise means teens must be asleep by about 8:30 p.m. to get the approximately nine hours of sleep per night their growing brains and bodies require. Even disregarding homework, extracurriculars, and electronics, physiologic changes mean most adolescents can't fall asleep before 11 p.m. Shifted circadian rhythms make 7 a.m. in teens (and younger teachers) equivalent to 4 a.m. in their parents.

The federal Centers for Disease Control and Prevention's, or CDC's, 2011 **Youth Risk Behavior Survey** estimated that 70 percent of U.S. teens are sleep-deprived, with nearly 40 percent getting six or fewer hours of sleep per night—setting them up for a sobering litany of health and learning problems.

Safety is an issue, too. With bus runs starting in the 5 a.m. hour, students wait in the pitch black, often with no sidewalks or even shoulders of the road, or they drive themselves drowsily to school. Because these early-start school days end around 2 p.m., teenagers come home to hours of unsupervised time, which, together with sleep deprivation, predisposes them to risk-taking and delinquent behavior.

Many state and local medical societies have advocated later start times in the past two decades. CDC researchers have confirmed that delaying school start times is a demonstrated strategy to promote sufficient sleep among adolescents. A Harvard School of Public Health forum on **America's sleep deficit**, held in March, emphasized the need to start schools later, and the American Academy of Pediatrics is developing a **policy statement** about safe and healthy start times for middle and high schools.

Aligning start times with student body clocks decreases dropout rates, truancy, moodiness, car crashes, depression, and related medication needs, and it improves school performance and increases the amount of sleep students get per night. Brookings Institution economists **recently showed** that early school start times reduce performance among disadvantaged students by an amount equivalent to having a highly ineffective teacher. They estimated that delaying middle and high school start times from 8 a.m. to 9 a.m. would increase academic achievement by 0.175 standard deviations, with a corresponding increase in student lifetime earnings of approximately $17,500—a benefit-to-cost ratio of at least 9-to-1.

Ironically, the widespread push several decades ago toward what sleep scientists have called deleterious, cruel, and even abusive start times coincided with growing understanding of adolescent sleep requirements, circadian rhythms, and the critical function of sleep itself. Data about school start times (and bus runs) are poor, but in many communities the change was implemented gradually and without public input, primarily to save money by reusing buses to ferry students to schools with different opening times. The change may also, in part, be related to an expansion of business hours. Today we have a much more 24/7 view of life than we used to have, and the concept of 9 to 5 as "normal" work hours seems to be going the way of family dinners and nonworking vacations.

"We must start regarding 7 a.m. start times as just as unacceptable as refusing to heat schools when the temperature drops."

Whatever the explanation, returning to more traditional 9 a.m. school bells is now virtually impossible in many districts. Even the best-organized reform efforts fall to entrenched interests that have adapted to early hours, as well as the human tendency to make a virtue of (perceived) necessity. Because communities revolve around school schedules, too, there is inevitably outcry that later start times will wreak havoc on life as we know it. This outcry typically includes kneejerk and misinformed reactions, some reflecting our society's disregard for sleep itself.

Tellingly, identical objections arise no matter what the existing or proposed school hours, and recur even when superintendents propose making changes to save money on transportation. It's not so much the new start time that people fear, but change itself.

Communities with the will to change have found ways to do so as shown in the rare, but revealing, success stories in districts including Wilton, Conn.; Edina, Minn., and Minneapolis; and Palo Alto, Calif. Concerns about the impact on sports, jobs, day care, and so forth turn out to be groundless; everything in the community adjusts to the new school times, just as when schools or families change start times for other reasons.

Red herrings or not, community concerns remain a powerful force. A superintendent or school board member who suggests, or even supports, later start times has to be almost suicidal because merely raising the issue mobilizes opposition. By the time communities have been familiarized with the ever-growing literature on the topic, the cohort of kids in question has graduated.

If we genuinely believe the research about the impact of our extremely early school hours and associated sleep deprivation, continuing to throw this issue back to lay school boards and administrators is nothing short of negligent. Tolerating baby steps is equally negligent, given that we're dealing with human lives. We need a sea change in our approach, and, as several leading public-health experts have noted, this will require collective action on a scale much larger than the local school system.

We must start regarding 7 a.m. start times as just as unacceptable as refusing to heat schools when the temperature drops or as exposing children to secondhand smoke. This may take federal, state, and/or local laws or regulations to ensure safe, healthy school hours for all students, in much the same way that federal regulations already restrict times school lunch can be served.

Specific school hours must be determined at the community level. But setting reasonable parameters is a matter of public health and safety and will make it easier for local districts to prioritize the health and well-being of students and communities alike when they set their particular schedules.

Terra Ziporyn Snider is a medical writer and historian and a former associate editor of JAMA, *The Journal of the American Medical Association, and the author of numerous popular health and medical publications, including* The New Harvard Guide to Women's Health. *She is the co-founder and co-director of Start School Later (**startschoollater.net**), a coalition dedicated to increasing public awareness about the relationship between sleep and school hours.*

Vol. 31, Issue 31, Pages 25,27

RELATED STORIES

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School Start Times for Middle School and High School Students — United States, 2011–12 School Year

Anne G. Wheaton, PhD[1]; Gabrielle A. Ferro, PhD[1]; Janet B. Croft, PhD[1]

Adolescents who do not get enough sleep are more likely to be overweight (*1*); not engage in daily physical activity (*2*); suffer from depressive symptoms (*2*); engage in unhealthy risk behaviors such as drinking, smoking tobacco, and using illicit drugs (*2*); and perform poorly in school (*3*). However, insufficient sleep is common among high school students, with less than one third of U.S. high school students sleeping at least 8 hours on school nights (*4*). In a policy statement published in 2014, the American Academy of Pediatrics (AAP) urged middle and high schools to modify start times as a means to enable students to get adequate sleep and improve their health, safety, academic performance, and quality of life (*5*). AAP recommended that "middle and high schools should aim for a starting time of no earlier than 8:30 a.m." (*5*). To assess state-specific distributions of public middle and high school start times and establish a pre-recommendation baseline, CDC and the U.S. Department of Education analyzed data from the 2011–12 Schools and Staffing Survey (SASS). Among an estimated 39,700 public middle, high, and combined schools* in the United States, the average start time was 8:03 a.m. Overall, only 17.7% of these public schools started school at 8:30 a.m. or later. The percentage of schools with 8:30 a.m. or later start times varied greatly by state, ranging from 0% in Hawaii, Mississippi, and Wyoming to more than three quarters of schools in Alaska (76.8%) and North Dakota (78.5%). A school system start time policy of 8:30 a.m. or later provides teenage students the opportunity to achieve the 8.5–9.5 hours of sleep recommended by AAP (*5*) and the 8–10 hours recommended by the National Sleep Foundation (*6*).

Every few years, the U.S. Department of Education conducts SASS, which provides data on the condition of elementary and secondary education in the United States. SASS consists of several questionnaires, including those tailored to schools, teachers, principals, school districts, and library media centers. SASS is a mail-based survey, with telephone and field follow-up, and uses a stratified probability sample design.† For the 2011–12 school year, the sample included about 10,250 traditional public schools and 750 public charter schools, with a unit response rate for public schools of 72.5%. As part of the school questionnaire in the 2011–12 school year, respondents were asked, "At what time do most of the students in

* Middle schools include any schools with no grade lower than 5 and no grade higher than 8. High schools include any school with no grade lower than 7 and at least one grade higher than 8. Combined schools include any schools with at least one grade lower than 7 and at least one grade higher than 8, or with all students in ungraded classrooms.

† Additional information available at http://nces.ed.gov/surveys/sass/overview.asp and http://nces.ed.gov/statprog/handbook/sass_surveydesign.asp. Questions about SASS can be directed to Chelsea Owens at chelsea.owens@ed.gov.

INSIDE

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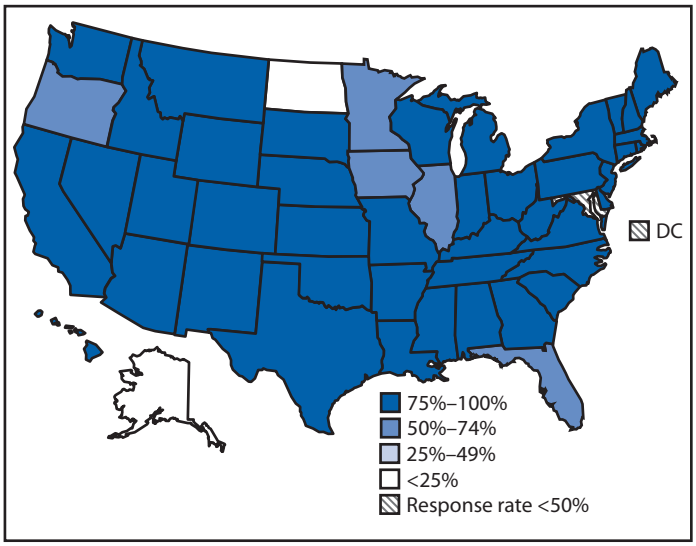
this school begin the school day?" Because AAP recommends school start times of 8:30 a.m. or later for both middle schools and high schools, the analyses in this report include public middle schools, high schools, and schools with combined grades. Average start time (with standard error) and percentage distribution of start times were calculated by school level and state. Results are weighted to reflect the complex sample design and to account for nonresponse and other adjustments.

Among an estimated 39,700 U.S. public middle, high, and combined schools (with an estimated total enrollment of 26.3 million students), the average start time was 8:03 a.m. Forty-two states reported that 75%–100% of their public schools had early start times (before 8:30 a.m.) (Figure). Overall, only 17.7% of public schools (with an estimated total enrollment of 4.2 million students), started school at 8:30 a.m. or later (Table). The proportion was lowest for high schools (14.4%) and highest for combined schools (23.4%). The percentage of schools that started at 8:30 a.m. or later varied greatly by state, ranging from 0% in Hawaii, Mississippi, and Wyoming to 76.8% in Alaska and 78.5% in North Dakota. North Dakota and Alaska also reported the latest average school start times (8:31 a.m. and 8:33 a.m., respectively), whereas Louisiana reported the earliest average school start time (7:40 a.m.) and the largest percentage of schools starting before 7:30 a.m. (29.9%).

FIGURE. Percentage of public schools* with early school start times (before 8:30 a.m.), by state — Schools and Staffing Survey, United States, 2011–12 school year



Source: U.S. Department of Education, National Center for Education Statistics, Schools and Staffing Survey, public school data file, 2011–12. Additional information available at http://nces.ed.gov/surveys/sass/overview.asp.

* Includes middle, high, and combined schools. Middle schools include any schools with no grade lower than 5 and no grade higher than 8. High schools include any school with no grade lower than 7 and at least one grade higher than 8. Combined schools include any schools with at least one grade lower than 7 and at least one grade higher than 8, or with all students in ungraded classrooms.

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TABLE. Average start time and percentage distribution of start times for public middle, high, and combined schools,* by school level and state — Schools and Staffing Survey 2011–12 school year

School level and state	Estimated no. of public middle, high, and combined schools		Estimated no. of students in public middle, high, and combined schools		Average start time (a.m.)¶		Percentage distribution† of public middle, high, and combined school start times							
					Before 7:30 a.m.		7:30 a.m. to 7:59 a.m.		8:00 a.m. to 8:29 a.m.		8:30 a.m. or later		8:30 a.m. or later	
	No.	(SE)	No.	(SE)	Time	(SE)§	%	(SE)	%	(SE)	%	(SE)	%	(SE)
Total	**39,700**	**(390)**	**26,284,000**	**(613,100)**	**8:03**	**(1)**	**6.7**	**(0.4)**	**31.9**	**(0.8)**	**43.7**	**(0.8)**	**17.7**	**(0.7)**
School level														
Middle	13,990	(169)	8,674,000	(135,800)	8:04	(1)	4.8	(0.7)	35.9	(1.3)	40.4	(1.1)	18.9	(1.0)
High	18,360	(434)	14,995,000	(413,600)	7:59	(1)	9.5	(0.6)	33.0	(1.1)	43.1	(1.1)	14.4	(0.9)
Combined	7,350	(571)	2,615,000	(300,600)	8:08	(3)	3.5	(0.7)	21.6	(2.2)	51.5	(2.6)	23.4	(2.7)
State														
Alabama	680	(39)	344,000	(31,100)	7:49	(2)	6.4	(2.2)††	57.8	(4.4)	34.0	(5.3)	—**	—
Alaska	—**	—	—**	—	8:33	(8)	0.0	—§§	11.6	(3.8)††	11.6	(4.8)††	76.8	(7.8)
Arizona	860	(159)	506,000	(53,100)	8:03	(3)	8.1	(2.9)††	23.3	(6.6)	47.3	(5.8)	21.3	(5.0)
Arkansas	450	(28)	292,000	(30,300)	8:01	(1)	—**	—	29	(4.7)	63.0	(4.7)	7.3	(2.0)
California	3,880	(219)	3,303,000	(146,300)	8:07	(2)	3.5	(0.9)	27.7	(3.1)	47.6	(3.3)	21.2	(2.9)
Colorado	730	(84)	527,000	(51,700)	7:54	(2)	16.9	(5.1)	31.3	(6.6)	40.9	(5.1)	10.9	(2.6)
Connecticut	380	(24)	260,000	(23,900)	7:46	(2)	13.8	(2.9)	57.4	(4.2)	24.0	(3.8)	4.8	(2.1)††
Delaware	090	(4)	63,000	(4,900)	7:42	(3)	24.0	(5.3)	51.9	(6.3)	16.6	(4.6)	7.5	(3.0)††
District of Columbia	—**	—	—**	—	—**	—	—**	—	—**	—	—**	—	—**	—
Florida	1,570	(100)	1,406,000	(111,400)	8:17	(3)	19.5	(2.5)	18.6	(2.4)	19.3	(2.9)	42.6	(3.8)
Georgia	1,030	(24)	955,000	(77,500)	8:09	(2)	—**	—	28.7	(4.3)	43.9	(4.6)	24.0	(3.4)
Hawaii	—**	—	—**	—	8:03	(3)	0.0	—§§	42.5	(17.3)††	57.5	(17.3)††	0.0	—§§
Idaho	370	(182)	157,000	(40,300)	8:13	(28)	0.0	—§§	20.9	(7.5)††	58.3	(14.5)	—**	—
Illinois	1,590	(48)	1,008,000	(145,200)	8:13	(3)	—**	—	19.7	(3.4)	48.7	(5.5)	28.4	(6.0)
Indiana	740	(27)	559,000	(43,800)	7:58	(2)	—**	—	41.8	(3.2)	45.1	(4.0)	10.2	(2.7)
Iowa	550	(35)	249,000	(31,300)	8:23	(6)	0.0	—§§	6.3	(2.0)††	66.3	(7.2)	27.4	(7.6)
Kansas	540	(20)	204,000	(20,000)	8:00	(1)	—**	—	26.5	(3.5)	71.5	(3.7)	—**	—
Kentucky	710	(32)	358,000	(33,100)	8:03	(4)	8.6	(4.2)††	24.8	(4.0)	49.0	(5.8)	17.5	(4.0)
Louisiana	630	(32)	316,000	(33,100)	7:40	(2)	29.9	(4.8)	53.1	(4.9)	12.1	(3.5)	—**	—
Maine	240	(5)	105,000	(5,500)	7:53	(3)	6.6	(1.9)	53.1	(5.1)	32.8	(4.8)	7.5	(3.6)††
Maryland	—**	—	—**	—	—**	—	—**	—	—**	—	—**	—	—**	—
Massachusetts	700	(58)	527,000	(48,600)	7:53	(4)	8.0	(3.6)††	53.3	(6.1)	27.2	(5.1)	11.5	(5.4)††
Michigan	1,540	(47)	891,000	(59,100)	7:54	(2)	9.5	(2.1)	43.6	(3.6)	39.0	(3.5)	7.9	(2.2)
Minnesota	1,100	(58)	522,000	(43,100)	8:18	(3)	0.9	(0.4)††	18.8	(2.6)	46.7	(3.7)	33.6	(3.5)
Mississippi	570	(23)	272,000	(18,600)	7:47	(2)	12.4	(3.7)††	58.3	(4.3)	29.3	(4.3)	0.0	—§§
Missouri	900	(37)	530,000	(28,700)	7:54	(1)	6.7	(1.7)	39.0	(3.9)	51.0	(3.9)	3.2	(1.4)††
Montana	220	(15)	78,000	(8,200)	8:13	(2)	0.0	—§§	5.8	(2.1)††	80.9	(6.1)	13.4	(5.5)††

See table footnotes on next page.

Discussion

Obtaining adequate sleep is important for achieving optimal health. Among adolescents, insufficient sleep has been associated with adverse risk behaviors (*2*), poor health outcomes (*1*), and poor academic performance (*3*). In view of these negative outcomes, the high prevalence of insufficient sleep among high school students is of substantial public health concern. *Healthy People 2020* includes a sleep objective for adolescents: to "increase the proportion of students in grades 9 through 12 who get sufficient sleep (defined as 8 or more hours of sleep on an average school night)."§ However, the proportion of students who get enough sleep has remained approximately 31% since 2007 (*4*), the first year that the national Youth Risk Behavior Survey included a question about sleep, meaning that more than two thirds of high school students do not get enough sleep. Multiple contributors to insufficient sleep in this population might exist. In puberty, biological rhythms commonly shift so that adolescents become sleepy later at night and need to sleep later in the morning (*7*). These biological changes are often combined with poor sleep hygiene (including irregular bedtimes and the presence of televisions, computers, or mobile phones in the bedroom) (*8*). During the school week, the chief determinant of wake times is school start time (*9*). The combination of delayed bedtimes and early school start times results in inadequate sleep for a large portion of the adolescent population.

Citing evidence of the benefits of delayed school start times for adolescents, AAP released a policy statement in 2014 that encouraged middle and high schools to modify start times to enable students to get sufficient sleep and subsequently improve their health, safety, academic performance, and quality of

§ Information on *Healthy People 2020* sleep objectives is available at http://www.healthypeople.gov/2020/topics-objectives/topic/sleep-health.

TABLE. (*Continued*) Average start time and percentage distribution of start times for public middle, high, and combined schools,* by school level and state — Schools and Staffing Survey 2011–12 school year

School level and state	Estimated no. of public middle, high, and combined schools		Estimated no. of students in public middle, high, and combined schools		Average start time (a.m.)¶		Percentage distribution† of public middle, high, and combined school start times							
					Before 7:30 a.m.		7:30 a.m. to 7:59 a.m.		8:00 a.m. to 8:29 a.m.		8:30 a.m. or later		8:30 a.m. or later	
	No.	(SE)	No.	(SE)	Time	(SE)§	%	(SE)	%	(SE)	%	(SE)	%	(SE)
Nebraska	370	(26)	150,000	(19,200)	8:07	(1)	0.0	—§§	8.0	(2.5)††	88.9	(2.4)	3.0	(1.4)††
Nevada	260	(12)	276,000	(20,900)	7:51	(3)	18.0	(3.0)	30.7	(5.5)	38.2	(6.0)	13.1	(3.6)
New Hampshire	180	(18)	116,000	(7,800)	7:46	(2)	11.6	(3.2)	64.4	(5.7)	19.7	(4.4)	—**	—
New Jersey	870	(52)	698,000	(45,200)	8:00	(2)	6.7	(2.0)	37.2	(4.5)	41.2	(4.7)	14.9	(3.6)
New Mexico	310	(99)	151,000	(47,000)	8:10	(3)	1.6	(0.7)††	24.1	(5.8)	53.9	(10.2)	20.4	(5.9)
New York	2,070	(108)	1,670,000	(149,100)	7:59	(2)	7.7	(3.1)††	31.6	(2.9)	49.6	(3.4)	11.0	(2.5)
North Carolina	1,120	(35)	768,000	(88,900)	8:03	(2)	—**	—	36.6	(5.0)	45.3	(5.4)	15.2	(4.2)
North Dakota	220	(9)	67,000	(5,000)	8:31	(1)	0.0	—§§	2.8	(1.2)††	18.7	(3.2)	78.5	(3.4)
Ohio	1,640	(73)	1,061,000	(60,800)	7:52	(2)	13.1	(2.0)	45.3	(4.3)	29.3	(3.7)	12.3	(3.0)
Oklahoma	700	(27)	356,000	(29,000)	8:10	(2)	0.0	—§§	12.0	(2.8)	77.6	(3.9)	10.4	(2.8)
Oregon	480	(25)	282,000	(21,100)	8:14	(3)	—**	—	25.2	(3.8)	45.0	(4.1)	28.9	(4.2)
Pennsylvania	1,280	(145)	1,001,000	(189,700)	7:48	(2)	13.0	(3.0)	51.3	(6.6)	32.6	(7.9)	3.1	(1.3)††
Rhode Island	100	(10)	68,000	(6,200)	7:50	(4)	24.8	(6.1)	27.5	(7.9)	40.3	(9.2)	—**	—
South Carolina	500	(9)	411,000	(26,400)	8:03	(2)	—**	—	35.3	(6.5)	50.9	(6.8)	12.3	(3.7)
South Dakota	230	(11)	78,000	(5,200)	8:13	(2)	—**	—	6.6	(2.7)††	77.7	(4.2)	14.8	(4.9)††
Tennessee	760	(47)	533,000	(31,000)	7:57	(3)	13.3	(3.4)	29.4	(4.7)	40.0	(5.1)	17.2	(3.5)
Texas	3,940	(183)	2,556,000	(254,700)	8:05	(2)	3.1	(1.2)††	28.3	(3.4)	46.3	(3.5)	22.4	(2.7)
Utah	410	(22)	297,000	(45,200)	8:05	(3)	0.0	—§§	33.1	(5.3)	49.6	(5.9)	17.3	(5.9)††
Vermont	100	(2)	46,000	(2,600)	8:05	(2)	—**	—	34.1	(5.1)	48.0	(4.8)	15.1	(3.0)
Virginia	850	(17)	555,000	(37,700)	8:04	(2)	10.0	(2.6)	26.6	(4.4)	42.6	(4.4)	20.8	(3.6)
Washington	930	(35)	526,000	(42,300)	8:08	(2)	6.4	(1.9)††	24.2	(3.8)	50.2	(4.6)	19.3	(3.5)
West Virginia	300	(5)	160,000	(7,000)	7:54	(2)	11.1	(2.0)	33.9	(3.3)	47.9	(4.0)	7.1	(2.3)††
Wisconsin	860	(37)	423,000	(44,200)	7:59	(3)	2.3	(1.0)††	48.2	(5.4)	39.1	(4.3)	10.4	(4.4)††
Wyoming	130	(8)	50,000	(4,300)	7:59	(1)	0.0	—§§	41.1	(5.2)	58.9	(5.2)	0.0	—§§

Source: U.S. Department of Education, National Center for Education Statistics, Schools and Staffing Survey (SASS), "Public School Data File," 2011–12.
Abbreviation: SE = standard error.
* Middle schools include any schools with no grade lower than 5 and no grade higher than 8. High schools include any school with no grade lower than 7 and at least one grade higher than 8. Combined schools include any schools with at least one grade lower than 7 and at least one grade higher than 8, or with all students in ungraded classrooms.
† Detail may not sum to totals because of rounding and because some data are not shown.
§ SE of average start time is expressed in minutes.
¶ Schools with afternoon start times were not included in analysis.
** Reporting standards not met. Relative standard error ≥0.5 or the response rate <50%.
†† Interpret data with caution. 0.3 ≤ relative standard error < 0.5.
§§ Rounds to zero. SE is not applicable.

life (*5*). AAP recommended that schools start at 8:30 a.m. or later (*5*), but this was the case in only one in six U.S. public middle and high schools, with substantial variation by state. Because school start times are determined at the district or even individual school level, local stakeholders have the most influence on whether start times change in their communities.

Groups seeking to delay school start times in their district often face resistance. Common barriers to delaying school start times include concerns about increased transportation costs because of changes in bus schedules; potential for traffic congestion for students and faculty; difficulty in scheduling after-school activities, especially athletic programs; and lack of education in some communities about the importance of sleep and school start times.¶ Advocates for delayed start times might benefit from 1) becoming familiar with research about the negative impact of insufficient sleep and early start times on adolescents' health, well-being, and academic performance; 2) identification of persons who might be impacted by the decision to delay start times, including parties involved in transportation and school athletic programs, as well as students, teachers, and school staff; and 3) preparing responses to common arguments against delaying start times. Many school systems have successfully overcome barriers to delay start times.**

Among the possible public health interventions for increasing sufficient sleep among adolescents, delaying school start times has the potential for the greatest population impact by changing the environmental context for students in entire

¶ A discussion of common barriers faced by proponents of delayed school start times is available at http://sleepfoundation.org/sleep-news/eight-major-obstacles-delaying-school-start-times.

** Several case studies that describe how this was done were compiled by the National Sleep Foundation and are available at http://www.startschoollater.net/case-studies.html.

Summary

What is already known on this topic?

The American Academy of Pediatrics (AAP) has urged middle and high schools to modify school start times to enable adolescent students to get sufficient sleep and improve their health, safety, academic performance, and quality of life. AAP recommends that schools aim to start no earlier than 8:30 a.m.

What is added by this report?

During the 2011–12 school year, before publication of the new AAP recommendations, only 17.7% of public middle and high schools in the United States started school at 8:30 a.m. or later. The percentage varied greatly by state, ranging from 0% in Hawaii, Mississippi, and Wyoming to more than three quarters of schools in Alaska (76.8%) and North Dakota (78.5%).

What are the implications for public health practice?

School start time policies are established at the district and individual school levels. Educating parents and school system decision-makers about the impact of sleep deprivation on adolescent health and academic performance might lead to adoption of later start times.

school districts. However, a late school start time does not preclude the need for other interventions that have the potential to improve the sleep of adolescents. Health care providers who treat adolescents, both in and outside of school settings, should educate patients and parents about the importance of adequate sleep, as well as factors that contribute to insufficient sleep among adolescents. Parents can help their children practice good sleep hygiene (i.e., habits that help promote good sleep). A regular bedtime and rise time, including on weekends, is recommended for everyone, whether they are children, adolescents, or adults.[††] In addition, adolescents with parent-set bedtimes usually get more sleep than those whose parents do not set bedtimes (*8*). Adolescents who are exposed to more light (such as room lighting or from electronics) in the evenings are less likely to get enough sleep (*8*). Technology use (e.g., computers, video gaming, or mobile phones) might also contribute to late bedtimes (*8*) and parents might consider implementing a "media curfew" or removing these technologies from the bedroom. Finally, parents might benefit themselves and their children by setting a good example. Adolescent sleep habits tend to reflect their parents' sleep habits (*10*).

[††] Information on healthy sleep habits, often referred to as good "sleep hygiene", is available at http://sleepfoundation.org/sleep-tools-tips/healthy-sleep-tips.

[1]Division of Population Health, National Center for Chronic Disease Prevention and Health Promotion, CDC.

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References

1. Lowry R, Eaton DK, Foti K, McKnight-Eily L, Perry G, Galuska DA. Association of sleep duration with obesity among US high school students. J Obes 2012;2012:476914.
2. McKnight-Eily LR, Eaton DK, Lowry R, Croft JB, Presley-Cantrell L, Perry GS. Relationships between hours of sleep and health-risk behaviors in US adolescent students. Prev Med 2011;53:271–3.
3. Perez-Lloret S, Videla AJ, Richaudeau A, et al. A multi-step pathway connecting short sleep duration to daytime somnolence, reduced attention, and poor academic performance: an exploratory cross-sectional study in teenagers. J Clin Sleep Med 2013;9:469–73.
4. Basch CE, Basch CH, Ruggles KV, Rajan S. Prevalence of sleep duration on an average school night among 4 nationally representative successive samples of American high school students, 2007–2013. Prev Chronic Dis 2014;11:E216.
5. Adolescent Sleep Working Group; Committee on Adolescence; Council on School Health. School start times for adolescents. Pediatrics 2014;134:642–9.
6. Hirshkowitz M, Whiton K, Albert SM, et al. National Sleep Foundation's sleep time duration recommendations: methodology and results summary. Sleep Health 2015;1:40–3.
7. Crowley SJ, Acebo C, Carskadon MA. Sleep, circadian rhythms, and delayed phase in adolescence. Sleep Med 2007;8:602–12.
8. Bartel KA, Gradisar M, Williamson P. Protective and risk factors for adolescent sleep: a meta-analytic review. Sleep Med Rev 2014;21:72–85.
9. Knutson KL, Lauderdale DS. Sociodemographic and behavioral predictors of bed time and wake time among US adolescents aged 15 to 17 years. J Pediatr 2009;154:426–30, 30 e1.
10. Fuligni AJ, Tsai KM, Krull JL, Gonzales NA. Daily concordance between parent and adolescent sleep habits. J Adolesc Health 2015;56:244–50.

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BRIEF

Prevalence of Sleep Duration on an Average School Night Among 4 Nationally Representative Successive Samples of American High School Students, 2007–2013

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PEER REVIEWED

Abstract

Consistency, quality, and duration of sleep are important determinants of health. We describe sleep patterns among demographically defined subgroups from the Youth Risk Behavior Surveillance System reported in 4 successive biennial representative samples of American high school students (2007 to 2013). Across the 4 waves of data collection, 6.2% to 7.7% of females and 8.0% to 9.4% of males reported obtaining 9 or more hours of sleep. Insufficient duration of sleep is pervasive among American high school students. Despite substantive public health implications, intervention research on this topic has received little attention.

Objective

Recent research provides evidence for conventional wisdom that consistency, quality, and duration of sleep are important determinants of health. Among adults, insufficient quality or duration of sleep is associated with obesity and diabetes (1), cardiovascular disease (1,2), and all-cause mortality (3). In early childhood (4) and among adolescents (5,6) and adults (7), sleep affects cognition. Sleep is essential for the health of the human brain (5). Despite the importance of sleep for cognition, development, and well-being, we did not find any studies describing duration of sleep among demographic subgroups of high school students in the United States during the past decade. We, therefore, used data from 4 successive biennial samples from the Youth Risk Behavior Surveillance System (YRBSS), representative of American high school students, to describe sleep patterns among demographically defined subgroups.

Methods

We conducted secondary analyses of YRBSS data, weighted to align with national population proportions and collected in 2007, 2009, 2011, and 2013. We focused on the sleep duration item; added in 2007, the question was identical over time, "On an average school night, how many hours of sleep do you get?" We summarized the percentages of respondents by sex, grade, and race/ethnicity as 5 hours or less, 6 hours, 7 hours, 8 hours, or 9 hours or more. Data on participants with missing responses (<5%) were excluded. The number of respondents (and overall response rate [school response rate × student response rate]) for each year was 12,154 (68%) in 2007; 14,782 (71%) in 2009; 12,198 (71%) in 2011; and 13,584 (68%) in 2013. We assessed significant differences between percentages by using 95% confidence intervals (CIs). (CIs are available upon request from the authors.) Data were cleaned in Perl version 5.12.3 (www.perl.org) and analyzed using Matlab (MathWorks). This study was approved by the institutional review boards at Teachers College, Columbia University; William Paterson University; and New York University Langone Medical Center.

Results

Across the 4 waves of data collection, 6.2% to 7.7% of females and 8.0% to 9.4% of males reported obtaining 9 or more hours of sleep. For all females across the 4 waves, we found a consistent pattern in which the percentage who reported obtaining 9 or more hours of sleep decreased as grade level increased (Table 1). This pattern was generally consistent when the data were disaggregated for white females, Hispanic females, and black females (Table 1). We found the same general pattern for males (Table 2). Without exception, compared with 9th graders, a significantly lower percentage of 11th and 12th graders reported obtaining 9 or more hours of sleep and, except in 2009 and 2013, a significantly higher percentage of 11th and 12th graders reported obtaining 5 or fewer hours of sleep.

For each year, a significantly greater percentage of black females than white females reported obtaining 5 or fewer hours of sleep per school night (Table 1). These differences were also found between white males and black males. For each year, more than 1 in 5 black females and 1 in 5 black males reported obtaining 5 or fewer hours of sleep. At least 15% of Hispanic females and white females and at least 12% of Hispanic males and white males reported obtaining 5 or fewer hours of sleep. In contrast, a significantly higher percentage of black females than white females reported obtaining 9 or more hours of sleep on school nights in 3 of the study years (2007, 2009, and 2013). Nevertheless, only 7.9% to 11.4% of black females reported obtaining 9 or more hours of sleep per school night in any year. Among black males, Hispanic males, and white males (Table 2), we found only one significant difference in the percentage that obtained 9 or more hours of sleep: in 2007, a larger percentage of Hispanic males (11.7%; 95% CI, 9.7%–13.8%) than white males (7.9%; CI, 7.0%–8.7%) reported obtaining 9 or more hours of sleep. Across all 4 waves of data collection, a small (<10%) overall percentage of females and males reported obtaining 9 or more hours of sleep. In 3 years (2007, 2009, and 2013), we found among females (compared with males) both a higher percentage who obtained 5 or fewer hours of sleep and a lower percentage who obtained 9 or more hours of sleep.

Discussion

The Centers for Disease Control and Prevention recommends that adolescents obtain 9 or 10 hours of sleep each day (8). In our study, a large majority of American high school students did not meet this recommendation. Among 12th graders, approximately 95% of males and females did not meet this recommendation. Data on students that report sleeping 7 hours or fewer on an average school night show that a substantial proportion of American high school students are not even close to obtaining the recommended amount of sleep.

Consistent with prior reports (6), our study shows that the percentage of students obtaining an insufficient amount of sleep increased as students progressed from grades 9 to 12. These findings indicate a need for early intervention, both before and during high school. Although a higher percentage of females than males, especially black females, reported receiving 5 or fewer hours of sleep, the data show a need for universal interventions — those directed toward all students. For example, the American Academy of Pediatrics has encouraged school districts to establish start times that optimize students' sleep (9). Unfortunately, intervention research directed toward high school populations has received little attention.

Although the important role of sleep in memory was recognized more than a century ago (5), more recent research has clarified the causal mechanisms through which sleep benefits memory, namely by active consolidation of memories through the reactivation of newly encoded memory representations that become incorporated into long-term knowledge (5,10). These insights, coupled with research demonstrating the importance of sleep for emotional self-regulation (6,10), obesity, safety, and attention to on-task learning (6) and the effect of sleep on chronic disease risk factors such as glucose metabolism (11), hypertension (1), inflammatory markers (1,12), and impaired immune response (12), suggest that adequate sleep has implications for academic achievement and the prevention of chronic disease (9). Attention is needed to develop feasible and effective interventions to increase sleep among American high school students.

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Stacy Simera

Still Sleepless in America: The paradox of local control in education

Adolescent sleep loss is a growing concern around the world, and one of the more complicated barriers to addressing this public health issue in America is the paradox of local control.

Experts across the US, most notably the American Academy of Pediatrics, have called for middle and high school start times after 8:30am. Other US groups to support later start times include the American Academy of Child and Adolescent Psychiatry, the National Association of School Nurses, the Society of Pediatric Nurses, and the National Education Association as well as myriad state and local organizations.

There is a body of evidence linking early school start times with chronic adolescent sleep deprivation. Chronic sleep loss is linked with a host of concerns including diabetes, heart disease, more aggressive forms of cancer, car crashes, depression, suicide, substance abuse, aggression, poorer academic functioning, and more.

In regards to academic success, the non-partisan Education Commission of the States released a policy brief last year titled 'Later Education Start Times in Adolescence: Time for Change' that concluded: "Few, if any, educational interventions are so strongly supported by research evidence from so many different disciplines and experts in the field." (Kelley and Lee, 2014, pg 3)

Why, then, do schools in the US continue to run at unhealthy hours when the support is so strong and the science is so overwhelming?

Education and Health ran an editorial in 2012 titled "Sleepless in America: School Start Times" that featured examples of two Americans who were using the evidence to promote healthy school start times: California attorney Dennis Nolan who created the website SchoolStartTime.org, and me. I have been working to raise awareness in Ohio since 2009, and now serve as chair of the Sleep Committee for the Ohio Adolescent Health Partnership and serve on the Executive Board of the national non-profit Start School Later.

Editor David McGeorge contacted me and asked if I could write this follow-up to the 2012 editorial, updating the rest of the world about the progress in Ohio and the US in protecting adolescent sleep. My initial response was that the news is not entirely positive. Awareness is raised, and some communities have acted, but unfortunately the great majority of schools in America have failed to respond to the science. Some schools, in fact, have chosen to shift to even earlier start times - primarily to accommodate bus scheduling.

This article is meant to shed light on the limitations of local control in a key public health issue that exists not only in the United States, but in other countries around the world. A documentary crew from EBS TV in Korea came to visit me last year to talk about the topic, and I heard the same stories of Korean teen sleep and stress that I hear in my own Ohio counselling practice.

Transportation: The tail that wags the dog

Transportation is an oft-cited barrier to adopting school schedules that are healthiest for the students. Former school superintendent, and now professor at Fredonia State College, Dr. Charles Stoddard famously stated: "The tail of transportation wags the dog of the educational system" (Creel, 2010).

Health professionals are very concerned about this trend. Research consistently shows that adolescents experience a later shift in sleep cycle and need adequate sleep for health, yet we have consistently inched school start times earlier and earlier to accommodate bus schedules. Florida, for example, boasts some of the earliest bus runs in the country - including 5:05am bus pick-ups in Orange County (Maxwell, 2015).

Florida state representative Matt Gaetz proposed a state-wide bill in 2013 prohibiting high school start times before 8am, saying: "If local school districts are so caught up in the bus schedule they cannot see the forest for the trees, I think the state has the responsibility to set guidelines. At what point does the bus ride become more important than what happens at the school?" (Trimble, 2013) The bill failed, with some people arguing that the state should not impose upon 'local control'.

In America we often value local control to the point where public health is compromised and where 'control', paradoxically, is limited or lost. My state of Ohio is an example of good intentions gone bad.

Ohio: A case study of the paradox of local control

Ohio, with a population of about 11.5 million, is considered a microcosm of the United States – representing nearly all types of US industry, religions, ethnicities, political views, and geography. Ohio is also the epitome of 'local control' in education – with over 600 sovereign public school districts with its own superintendent and school board. Such localized control could lead one to assume that change is therefore easier, however it is often the opposite – and primarily due to transportation issues.

If an Ohio student chooses to attend a private or STEM school instead of his/her local public school, the public school must, in most instances, provide the student with transportation to the school of choice. Public schools also often band together to create vocational schools or 'compacts' in which 5 to 15 local schools send select students to a different facility to learn a trade while completing high school. In addition, the scheduling of athletic events or other extra-curricular activities requires a level of cooperation between schools in the same athletic conference.

Thus if a public school wishes to adopt later start times without cooperation from nearby schools, the resulting upheaval in transportation schedules can be daunting and possibly create an economic burden if the school must create separate bus runs for literally one or two STEM or charter school students. Because of localized control, neighbouring schools are not answerable to each other, and regional attempts at change can be thwarted by one stubborn school board. Local control has become, in this instance, the reason that local school boards have limited control over their ability to act on the recommendations of the nation's pediatricians. Local control becomes 'local lack of control'.

This paradox, and of course the overwhelming scientific evidence, is why many experts are calling for the states to step in to set healthy boundaries for school start times.

Legislation: Protecting children by setting healthy parameters

State and federal regulations to protect children are common - such as seat belt usage, graduated driver's licenses, school lunch requirements, and child labor laws. The lack of state and federal intervention on school start times, therefore, baffles most experts.

In America we pride ourselves on our child labour laws, yet look the other way when children rise in the 4 or 5 o'clock hour and walk to school or the bus stop in the dark. Given the approximately 90-minute later shift in sleep cycle experienced during puberty, and given that adolescents require approximately 90 minutes more sleep than adults – a compulsory wake time of 5am for teens is biochemically similar to a compulsory wake time of 2am for all adults – something few Americans would tolerate. In recent decades, for example, changes to the regulations surrounding the work schedules of air traffic controllers, pilots, train conductors, truck drivers, and naval submarine crews have been made to further protect the sleep of working adults.

Many people have stated that early school start times 'prepare kids for the real world' – however when it comes to sleep, American adults appear to have better protection than children.

Children will also be better prepared for the 'real world' if they can make it through puberty intact. Davis et al (2013) found that 14 and 15

year olds who were sleep-restricted experienced 50% more 'hits' and 'close calls' in virtual cross-walk situations. Milewski et al (2013) found that teens who obtained less than 8 hours of sleep per night experienced 68% more sports injuries than their peers who slept more. And Walhstrom et al (2014) found that teen drivers in school districts that adopted later school start times experienced 65% and 70% fewer car crashes. Space limits me from citing the research on the links between chronic sleep disruption and diabetes, multiple sclerosis, depression, and other conditions that limit our American goals of life, liberty, and the pursuit of happiness. To sum: later school start times can literally save lives.

Local Success: The dog CAN wag the tail

I must give credit to the communities in America who have overcome the barriers of local control, examples of which can be found on the 'Success Stories' portion of the Start School Later website. One of the more notable is the Fairfax Public School District in Virginia. Fairfax runs the largest bus fleet in the nation and the school board recently voted to start school later in the coming 2015/2016 school year – proving that the dog can 'wag the tail' and adults can prioritize student health and learning over the daunting task of revising bus schedules. Fairfax contracted with Children's National Medical Center to study the issue, and the consultants created a Blueprint for Change which has generously been made publicly available.

Hundreds of schools in nearly every state in the nation have adopted later start times, but those are merely drops in the bucket. Out of the over 600 public school districts in Ohio, the following schools have adjusted starting times for adolescents due on the research, or will do so in the coming school year: Hudson, Kenston, Dublin, Northridge, Perrysburg, Westlake, and Hamilton City. We can do better.

Zzz's to A's Act: Calling for a federal study

At the national level US Congresswoman Zoe Lofgren has introduced the Zzz's to A's Act that would require the US Secretary of Education to conduct a study of the issue. However just the idea of a federal study has some members of Congress declining to support the bill, citing concerns about infringing on local control. I commend Representative Lofgren and the bill's co-sponsors (including Ohio Representatives Tim Ryan and Joyce Beatty) for prioritizing child health. Unfortunately the Zzz's to A's Act is currently stagnant, with little expectation for success. Its opponents often point out that American education is in the hands of the states – to which health experts reply: "Then our states must do the right thing."

A Call to State Legislators: Be the hero

In September of 2014 the Aurora Sentinal in Colorado penned an editorial 'The school bell should toll later for better test scores', with the first sentence acknowledging the core issue: "The importance of local control of schools is one of the most critical components of a successful public school system, but there are times when only the state can fix a pervasive problem."

The editorial staff outlined the research and the need for state-level action, and ended the piece with this compelling plea: "All the state needs is a few state legislators ready to step up and be the hero. We're ready to take names."

I and my colleagues in the US and around the world echo that plea: Lawmakers – stand up for child health, safety, and learning. Stand up and introduce and support legislation requiring developmentally-appropriate school start times. Stand up and be the hero. Then sit back and watch our children excel.

References:

Creel, J. (2010) *Get up! Sleepy teens roam school halls while debate goes on about changing start times*. Buffalo News; 8 April 2010 [Accessed 11 May 2015] Available at: http://www.buffalonews.com/article/20100408/LIFE04/304089899

Davis L, Avis K, Schwebel DC. (2013) *The Effects of Acute Sleep Restriction on Adolescents' Pedestrian Safety in a Virtual Environment*. Society for Adolescent Health and Medicine Vol 53, Issue 6, pp 785-790. http://dx.doi.org/10.1016/j.jadohealth.2013.07.008

Kelley, P and Lee, C. (2014) *Later Education Start Times in Adolescence: Time for Change.* Policy Brief by the Education Commission of the States. Available at: http://www.ecs.org/clearinghouse/01/12/19/11219.pdf

Maxwell, S (2015*) 5 a.m. bus rides, 6:30 walks to school? All too early*. Orlando Sentinal; 18 April 2015. [Accessed 11 May 2015] Available at: http://www.orlandosentinel.com/opinion/os-school-start-times-scott-maxwell-20150418-column.html

Milewski, MD, Pace, JL, Ibrahim, DA, Greg Bishop, G, Barzdukas, A. and. Skaggs, DL. (2014) *Chronic lack of sleep is associated with increased sports injuries in adolescent athletes*. J Pediatr Orthop. March; 34(2): 129-33. doi: 10.1097/BPO.0000000000000151

Trimble, L. (2013) *Lawmaker pitches plan to start high school later in the morning.* Daytona Beach News Journal; 2 Nov 2013. [Accessed 11 May 2015] Available at: http://www.news-journalonline.com/article/20131102/NEWS/131109901

Wahlstrom, Kyla; Dretzke, Beverly; Gordon, Molly; Peterson, Kristin; Edwards, Katherine; Gdula, Julie. (2014). *Examining the Impact of Later High School Start Times on the Health and Academic Performance of High School Students: A Multi-Site Study*. [Accessed 11 May 2015] Available via the University of Minnesota Digital Conservancy: http://hdl.handle.net/11299/162769

Teen Drivers Need a Full Tank of Z-Z-Z-Z-Zs

Teen drivers have the highest crash rates in the country. They also are likely to have the least sleep. GEICO (geico.com) agrees with a growing number of sources that teen crash rates could be reduced by a good night's sleep.

The Insurance Institute for Highway Safety (IIHS) tracks vehicle fatalities and found that more than 3,500 teens ages 13-19 died in motor vehicle crashes in 2009. More detailed research also indicates that "drowsy driving" is a significant problem that increases the risk of a crash or near-crash, and young drivers are particularly vulnerable since they operate most of the time on much less sleep than they need.

A nation of sleepy teenagers

Two critical factors* collide when teens are in their early driving years:

- they need nearly 9.5 hours of sleep every night to accommodate an upswing in growth and hormone development, and
- they get far less sleep than they need – an average of 7.4 hours a night and considerably less for many.

Making the problem worse, teens' biological clocks are set so that they tend to fall asleep later at night and wake up later in the morning, a schedule which is impossible to follow due to early morning school starts for most teens. Parents with teen drivers should observe their teen's sleep habits and work on getting their teens more sleep.

Teens must have more sleep to:

- stay alert
- make sound judgments
- maintain clear thinking and quick reflexes while driving

It's important for both parents and teens to recognize the signs of fatigue and rework daily schedules to allow for healthier sleep cycles. It won't be easy. Teens have a lot to keep them up on school nights: studies, anxiety over grades, after-school sports and social activities that delay study time, relationship issues, over-stimulation from media sources such as Facebook, computer games and an overload of cell phone use and text messaging. These factors could lead to *sleep deprivation*.

Your teen may be sleep deprived if he or she:

- can't wake up in the morning
- is irritable late in the day
- falls asleep spontaneously throughout the day
- sleeps for long periods of time on weekends

From the **Office of Disease Prevention and Health Promotion (June 2016)**

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Expand All Objectives

SH-1 Increase the proportion of persons with symptoms of obstructive sleep apnea who seek medical evaluation

SH-2 Reduce the rate of vehicular crashes per 100 million miles traveled that are due to drowsy driving

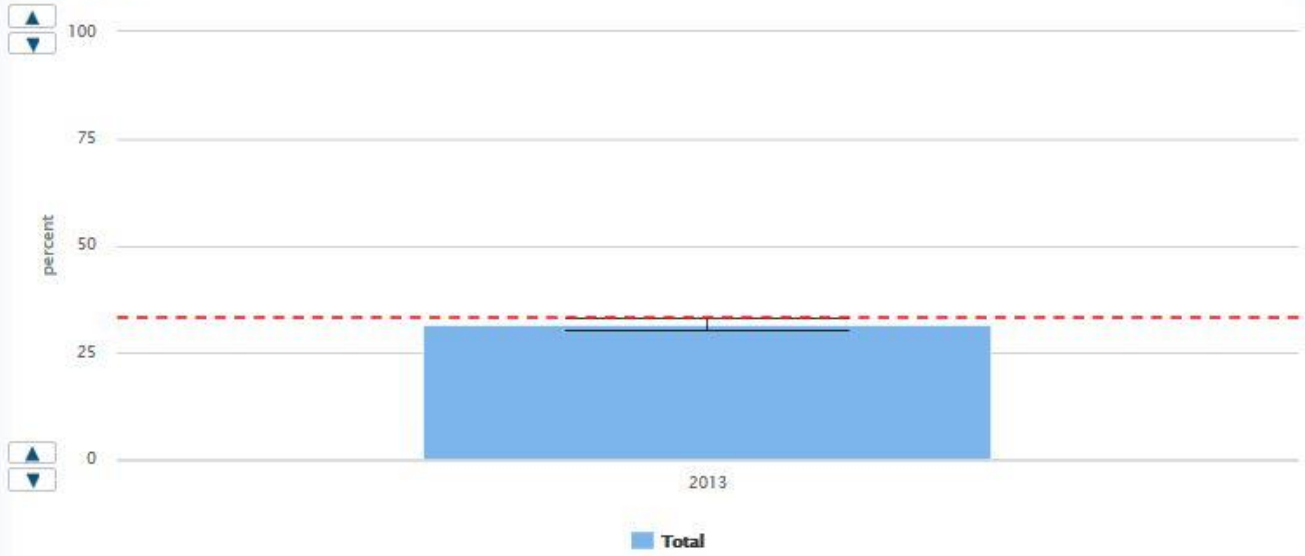
SH-3 Increase the proportion of students in grades 9 through 12 who get sufficient sleep Revised

Baseline:	30.9 percent of students in grades 9 through 12 got sufficient sleep (defined as 8 or more hours of sleep on an average school night) in 2009
Target:	33.1 percent
Target-Setting Method:	Minimal statistical significance
Data Sources:	Youth Risk Behavior Surveillance System (YRBSS), CDC/NCHHSTP
Data:	HP2020 data for this objective Spotlight on Disparities: • Disparities by race and ethnicity Details about the methodology and measurement of this HP2020 objective
Revision History:	This objective was revised. Read more about the revision history.
More Information:	Related research articles on PubMed

Students getting sufficient sleep on school nights (percent, grades 9–12)
By Total

2020 Baseline (year): 30.9 (2009) **2020 Target:** 33.1 **Desired Direction:** ↑ Increase desired

Auto Scale



---- 2020 Target: 33.1
Data Source: Youth Risk Behavior Surveillance System (YRBSS); Centers for Disease Control and Prevention, National Center for HIV/AIDS, Viral Hepatitis, STD, and TB Prevention (CDC/NCHHSTP)
Error Bar (I) represents the 95% confidence interval
Additional footnotes may apply to these data. Please refer to footnotes below the data table for further information.

SH-3 Increase the proportion of students in grades 9 through 12 who get sufficient sleep Revised

Students getting sufficient sleep on school nights (percent, grades 9–12)

Lack of Sleep Costing U.S. Economy Up to $411 Billion a Year

FOR RELEASE
Tuesday
November 29, 2016

- Lower productivity levels and the higher risk of mortality resulting from sleep deprivation have a significant effect on a nation's economy.
- Sleep deprivation increases the risk of mortality by 13 percent and leads to the U.S. losing around 1.2 million working days a year.
- Increasing nightly sleep from under six hours to between six and seven hours could add $226.4 billion to the U.S. economy.

A lack of sleep among the U.S. working population is costing the economy up to $411 billion a year, which is 2.28 percent of the country's GDP, a new report finds.

According to researchers at the not-for-profit research organisation RAND Europe, part of the RAND Corporation, sleep deprivation leads to a higher mortality risk and lower productivity levels among the workforce, putting a significant damper on a nation's economy.

A person who sleeps on average less than six hours a night has a 13 percent higher mortality risk than someone sleeping between seven and nine hours, researchers found, while those sleeping between six and seven hours a day have a 7 percent higher mortality risk. Sleeping between seven and nine hours per night is described as the "healthy daily sleep range".

In total, the U.S. loses just over 1.2 million working days a year due to sleep deprivation among its working population. Productivity losses at work occur through a combination of absenteeism, employees not being at work, and presenteeism, where employees are at work but working at a sub-optimal level.

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Researcher Spotlight

Marco Hafner
Research Leader

Marco Hafner is a research leader at RAND Europe working on employment, education and social policy research. He completed his doctoral studies in economics and applied econometrics and holds a master's degree in economics from the University of Zurich.

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The study, *Why Sleep Matters – The Economic Costs of Insufficient Sleep*, is the first of its kind to quantify the economic losses due to lack of sleep among workers in five different countries—the U.S., UK, Canada, Germany, and Japan. The study uses a large employer-employee dataset and data on sleep duration from the five countries to quantify the predicted economic effects from a lack of sleep among its workforce.

Marco Hafner, a research leader at RAND Europe and the report's main author, says: "Our study shows that the effects from a lack of sleep are massive. Sleep deprivation not only influences an individual's health and wellbeing but has a significant impact on a nation's economy, with lower productivity levels and a higher mortality risk among workers."

He continues: "Improving individual sleep habits and duration has huge implications, with our research showing that simple changes can make a big difference. For example, if those who sleep under six hours a night increase their sleep to between six and seven hours a night, this could add $226.4 billion to the U.S. economy."

The U.S. has the biggest financial losses (up to $411 billion, which is 2.28 percent of its GDP) and most working days lost (1.2 million) due to sleep deprivation among its workforce. This was closely followed by Japan (up to $138 billion, which is 2.92 percent of its GDP, and around 600,000 working days lost).

Germany (up to $60 billion, which is 1.56 percent of its GDP, and just over 200,000 working days lost) and the U.K (up to $50 billion, which is 1.86 percent of its GDP, and just over 200,000 working days lost) have similar losses. Canada was the nation with the best sleep outcomes, but still has significant financial and productivity losses (up to $21.4 billion, which is around 1.35 percent of its GDP, and just under 80,000 working days lost).

To improve sleep outcomes, the report outlines a number of recommendations for individuals, employers and public authorities:

Individuals – Set consistent wake-up times; limit the use of electronic items before bedtime; and physical exercise during the day.

Employers – Recognise the importance of sleep and the employer's role in its promotion; design and build brighter workspaces with facilities for daytime naps; combat workplace psychosocial risks; and discourage the extended use of electronic devices after working hours.

Public authorities – Support health professionals in providing sleep-related help; encourage employers to pay attention to sleep issues; and introduce later school starting times.

- ENDS -

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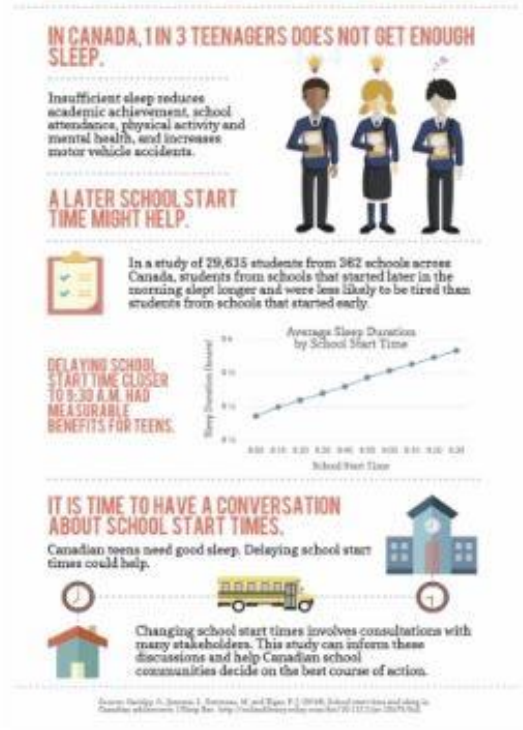
We need to talk about school start times

News

Later start times could help Canadian teens' grades and health, research indicates

PUBLISHED: 23 JAN 2017



Delaying school start times could help Canadian teenagers sleep better – giving them a better chance for success, according to McGill University researchers.

In a study published in the Journal of Sleep Research, the researchers found that students from schools that started earlier slept less, were less likely to meet the national sleep recommendations for their age, and were more often tired in the morning. The findings help explain why, according to recent data, one in three Canadian teenagers don't get enough sleep.

"It is time that we have a conversation about school start time in Canada," says lead author Geneviève Gariépy, a post-doctoral student in McGill's Institute of Health and Social Policy.

Fighting biology

"The problem is that early school start times conflict with the natural circadian clock of teenagers," Gariépy says. "As teenagers go through puberty, their circadian clock gets delayed by two to three hours. By the time they reach junior high, falling asleep before 11 p.m. becomes biologically difficult, and waking up before 8 a.m. is a struggle. Adolescents are fighting biology to get to school on time."

Previous research internationally has shown that teenagers who are sleep-deprived do worse at school, have more health problems, and are more vulnerable to depression, anxiety and behavioural problems.

The McGill researchers used Canadian data covering 30,000 students from 362 schools across Canada, from a cross-national survey conducted every four years in more than 40 countries in collaboration with the World Health Organization.

Later start times, better sleep

Start times in the Canadian schools ranged from around 8:00 to 9:30. "We found a strong association between later school start times and better sleep for teens," says Prof. Frank Elgar, co-author of the study.

"Changing school start times involves consultations among various stakeholders, and logistical issues such as bus schedules," Gariépy notes. "But these challenges can be overcome. A later school start-time policy has the potential to benefit a lot of students."

Gariépy, G., Janssen, I., Sentenac, M., & Elgar, F. J. (2016). School start time and sleep in Canadian adolescents. Journal of Sleep Research. DOI: 10.1111/jsr.12475

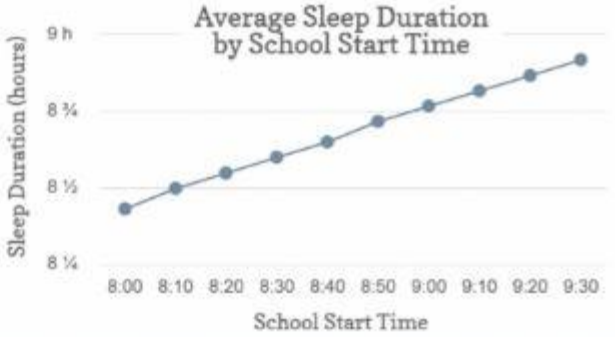
IN CANADA, 1 IN 3 TEENAGERS DOES NOT GET ENOUGH SLEEP.

Insufficient sleep reduces academic achievement, school attendance, physical activity and mental health, and increases motor vehicle accidents.

A LATER SCHOOL START TIME MIGHT HELP.

In a study of 29,635 students from 362 schools across Canada, students from schools that started later in the morning slept longer and were less likely to be tired than students from schools that started early.

DELAYING SCHOOL START TIME CLOSER TO 9:30 A.M. HAD MEASURABLE BENEFITS FOR TEENS.



IT IS TIME TO HAVE A CONVERSATION ABOUT SCHOOL START TIMES.

Canadian teens need good sleep. Delaying school start times could help.

Changing school start times involves consultations with many stakeholders. This study can inform these discussions and help Canadian school communities decide on the best course of action.

Source: Gariépy, G., Janssen, I., Sentenac, M. and Elgar, F. J. (2016), School start time and sleep in Canadian adolescents. J Sleep Res. http://onlinelibrary.wiley.com/doi/10.1111/jsr.12475/full

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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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2352-7218/

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

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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 nonnormality in the continuous variables. Statistically significant

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%	

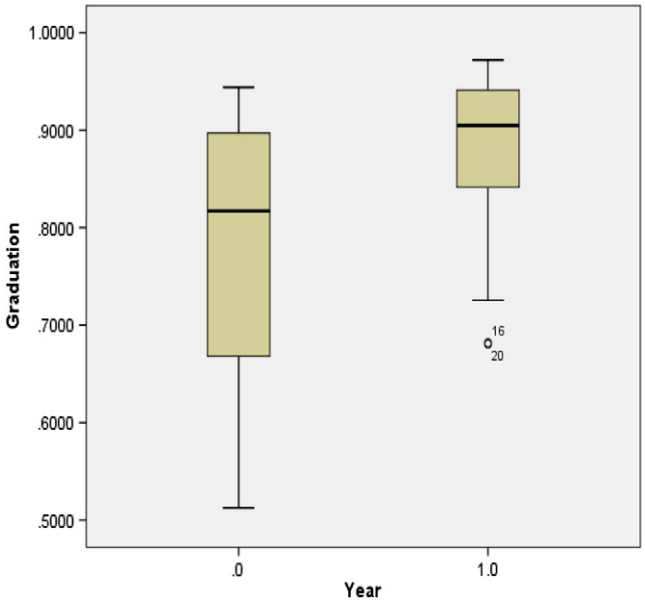

Fig. 1. Boxplot of predelay and postdelay graduation rates.

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

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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

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.

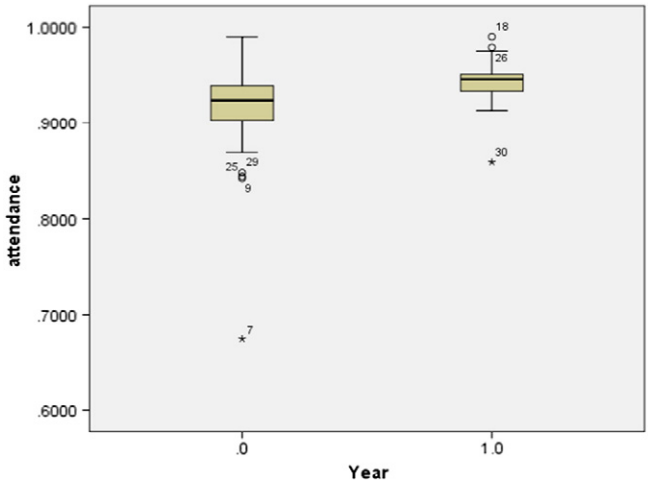

Fig. 2. Boxplot of attendance by time.

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 implementation of a delayed school start time. The study adds to the existing literature and addresses the benefits of later high school

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.

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.

References

1. Carskadon MA. When worlds collide: adolescent need for sleep versus societal demands. *Phi Delta Kappan*. 1999;80.
2. Crowley SJ, Acebo C, Carskadon MA. Sleep, circadian rhythms, and delayed sleep phase in adolescence. *Sleep Med*. 2007;8:602–612.
3. Carskadon MA, Acebo C, Jenni OG. Regulation of adolescent sleep: implications for behavior. *Ann N Y Acad Sci*. 2004;1021:276–291.
4. Eaton DK, McKnight-Eily LR, Lowry R, Perry GS, Presley-Cantrell L, Croft JB. Prevalence of insufficient, borderline, and optimal hours of sleep among high school students. *J Adolesc Health*. 2010;46:399–401.
5. Hansen M, Janssen I, Schiff PC, Dubovich ML. The impact of school daily schedule on adolescent sleep. *Pediatrics*. 2005;115:1551–1561.
6. Carskadon MA. Sleep in adolescents: the perfect storm. *Pediatr Clin N Am*. 2011;58:637–647.
7. National Sleep Foundation. Sleep in America Poll. Washington, DC: National Sleep Foundation; 2011.
8. Dawson P. More proof sleepy teens learn less. *Educ Digest*. 2005;70:43–48.
9. Lufi D, Tzischinsky O, Hadar S. Delaying school starting time by one hour: some effects on attention levels in adolescents. *J Clin Sleep Med*. 2011;7:37–143.
10. O'Malley E, O'Malley M. School start time and its impact on learning and behavior. In: Ivanenko A, editor. Sleep and Psychiatric Disorders in Children and Adolescents. New York: Informa Healthcare; 2008. p. 79–94.
11. Wahlstrom K. Changing times: findings from the first longitudinal study of later start times. *NASSP Bull*. 2002;86:633.
12. Wolfson AR, Carskadon MA. A survey of factors influencing high school start times. *NASSP Bull*. 2005;89:47–66.
13. Knutson KL, Lauderdale DS. Sociodemographic and behavioral predictors of bed time and wake time among U.S. adolescents aged 15-17 years. *J Pediatr*. 2009;154:426–430.
14. Wolfson A, Carksdon MA. Sleep schedules and daytime functioning in adolescents. *Child Dev*. 1998;69:875–887.
15. American Academy Sleep Medicine. High School Students with a Delayed School Start Time Sleep longer, Report less Daytime Sleepiness. Science Daily; 2008.
16. Centers for Disease Control and Prevention. Mortality and Morbidity Weekly Report; 2015.
17. U.S. Department of Education, National Center for Education Statistics. Schools and Staffing Survey. public school data file, 2011–12; August, 2015.
18. American Academy of Pediatrics. School start times for adolescents. *Pediatrics*. 2014;134:642–649.
19. "LIS > Bill Tracking > HB34> 2014 session". Leg1. Opening of the school day. Public high schools. United States House of Representatives; 2013.
20. Wahlstrom KL. The prickly politics of school starting times. *Phi Delta Kappan*. 1999;5:344–347.
21. Taylor D, Jenni O, Acebo C, Carskadon M. Sleep tendency during extended wakefulness: insights into adolescent sleep regulation and behavior. *J Sleep Res*. 2005;14:239–244.
22. Winsler A, Deutsch A, Vorona RD, Payne PA, Szklo-Coxe M. Sleepless in Fairfax: the difference one more hour of sleep can make for teen hopelessness, suicidal ideation, and substance use. *J Youth Adolesc*. 2014;44:362–378.
23. Roberts RE, Duong HT. Obese youths are not more likely to become depressed, but depressed youths are more likely to become obese. *Psychol Med*. 2013;43:2143–2151.
24. Goldstein TR, Bridge JA, Brent DA. Sleep disturbance preceding completed suicide in adolescents. *J Consult Clin Psychol*. 2008;76:84–91.
25. Danner F, Phillips B. Adolescent sleep, school start times, and teen motor vehicle crashes. *J Clin Sleep Med*. 2008;4:533–535.
26. Vorona RD, Szklo-Coxe M, Wu A, Dubik M, Zhao Y, Ware JC. Dissimilar teen crash rates in two neighboring southeastern Virginia cities with different high school start times. *Am Acad Sleep Med*. 2011;7:145–151.
27. McKnight-Eily LR, Eaton DK, Lowry R, Croft JB, Presley-Cantrell L, Perry GS. Relationships between hours of sleep and health-risk behaviors in US adolescent students. *Prev Med*. 2011;53:271–273.
28. Dahl RE. The consequences of insufficient sleep for adolescents: links between sleep and emotional regulation. *Phi Delta Kappan*. 1999;5:354–359.
29. O'Brien EM, Mindell JA. Sleep and risk-taking behavior in adolescents. *Behav Sleep Med*. 2005;3:113–133.
30. Dahl RE, Lewin DS. Pathways to adolescent health: sleep regulation and behavior. *J Adolesc Health*. 2002;31:175–184.
31. Drake C, Nickel C, Burduvali E, Roth T, Jefferson C, Pietro B. The Pediatric Daytime Sleepiness Scale (PDSS): sleep habits and school outcomes in middle-school children. *Sleep*. 2003;26:455–458.
32. Wahlstrom K, Wrobel G, Kubow P, Center for Applied Research and Educational Improvement. Minneapolis Public Schools Start Time Study Executive Summary 1998. University of Minnesota, Center for Applied Research and Educational Improvement; 1998. Retrieved from the University of Minnesota Digital Conservancy, http://hdl.handle.net/11299/3902.

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33. Wolfson AR, Spaulding NL, Dandrow C, Baroni EM. Middle school start times: the importance of a good night's sleep for young adolescents. *Behav Sleep Med*. 2007;5:194–209.
34. Edwards F. Early to rise? The daily effect of daily start times on academic performance. *Econ Educ Rev*. 2012;31:970–983.
35. Wahlstrom KB, Dretzke B, Gordon K, Peterson K, Edwards K, Gdula J. Examining the Impact of later School Start Times on the Health and Academic Performance of High School Students: A Multi-Site Study. University of Minnesota, Center for Applied Research and Educational Improvement; 2014[DOI: http://conservancy.umn.edu/handle/11299/162769].
36. Owens J, Drobnich D, Baylor A, Lewin D. School start time change: an in-depth examination of school districts in the United States. *Mind Brain Educ*. 2014;8:182–213.
37. Hedberg EC, Ayers S. The power of a paired t-test with a covariate. *Soc Sci Res*. 2014;50:277–291.

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It's time (in fact, it's *past time*) for safe and healthy school hours

The following organizations and experts agree

The American Academy of Pediatrics "[R]esearch 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.... middle and high schools should aim for a starting time of no earlier than 8:30 AM. However, individual school districts also need to take average commuting times and other exigencies into account in setting a start time that allows for adequate sleep opportunity for students." [1]

U.S. Centers for Disease Control and Prevention "Among adolescents, insufficient sleep has been associated with adverse risk behaviors, poor health outcomes, and poor academic performance. In view of these negative outcomes, the high prevalence of insufficient sleep among high school students is of substantial public health concern.... In puberty, biological rhythms commonly shift so that adolescents become sleepy later at night and need to sleep later in the morning.... During the school week, the chief determinant of wake times is school start time. The combination of delayed bedtimes and early school start times results in inadequate sleep for a large portion of the adolescent population... Among the possible public health interventions for increasing sufficient sleep among adolescents, delaying school start times has the potential for the greatest population impact..." [2]

National Sleep Foundation "Young people who do not get enough sleep night after night carry a significant risk for drowsy driving; emotional and behavioral problems such as irritability, depression, poor impulse control and violence; health complaints; tobacco and alcohol use; impaired cognitive function and decision-making; and lower overall performance in everything from academics to athletics." [3]

American Sleep Association "Circadian rhythm studies have demonstrated that teenagers generally go to bed later and wake up later than adults. This is not a result of societal pressures, but rather an intrinsic part of their DNA and internal biologic time clocks. Teens also require more total sleep time than adults... Early school start times and sleep deprivation are associated with weight gain, depression, mood problems, higher blood glucose levels and increased motor vehicle accidents. Later school start time[s] are associated with higher attendance rates, lower depression scores, and more even temperament at home. The American Sleep Association position on school start times is that middle school and high school should not start before 08:00. A time closer to 09:00 or later would be preferable." [4]

Scientific American "Don't blame video games or TV. Even if you take all of these away ... the poor teen will toss and turn and not fall asleep until midnight or later, thus getting only about 4 to 6 hours of sleep until it is time to get up and go to school again.... Instead of forcing teenagers to wake up at their biological midnight (circa 6 AM) to go to school, where invariably they sleep through the first two morning classes, more and more schools are adopting the reverse busing schedule: elementary schools first (around 7:50 AM), middle schools next (around 8:20 AM) and high schools last (around 8:50 AM)." [5]

Society of Pediatric Nurses and the National Association of School Nurses "Adolescence is a time when sleep patterns change and biological clocks alter, often leading to poor quality and insufficient sleep. Their ability to concentrate, problem-solve and assimilate new information is impaired. SPN and NASN encourage all parties involved to consider implementing later school start times for teens." [6]

Education Commission of the States "Sleep loss associated with early school start times can damage adolescents' learning and health. Later starting times, by contrast, are associated with longer sleep, better learning and reduced health risks. Research from the past 20 years has consistently supported these findings ... education start times requiring waking at 7 AM or earlier — which is like adults waking at 4 AM every day — cause chronic sleep loss. Losing sleep through the week on this scale leads to poorer academic achievement and increased health risks...." [7]

Education Next "Delaying school start times by one hour, from roughly 7:30 to 8:30, increases standardized test scores by at least 2 percentile points and 1 percentile point in reading. The effect is largest for students with below-average test scores, suggesting that later start times would narrow gaps in student achievement." [8]

National Education Association "The [NEA] believes that overall health and performance are best achieved with adequate rest on a regular basis. The Association supports school schedules that follow research-based recommendations regarding the sleep patterns of age groups." [9]

Maryland Department of Health and Mental Hygiene "[The] normal changes of puberty, factors intrinsic to the child and his or her developmental stage, provide a biological foundation for insufficient sleep and daytime sleepiness in adolescents particularly when an early wake time is imposed.... In preserving the status quo ... the state risks letting local resistance trump a strong body of scientific evidence that sleep is critical to health and academic achievement." [10]

1. aappublications.org/content/early/2014/08/19/peds.2014-1697 | 2. cdc.gov/features/school-start-times | 3. sleepfoundation.org/sleep-news/backgrounder-later-school-start-times | 4. https://www.sleepassociation.org/blog-post/healthy-school-start-times/ | 5. blogs.scientificamerican.com/a-blog-around-the-clock/when-should-schools-start-in-the-morning/ | 6. nasn.org/Portals/0/statements/consensus_early_school_start_times.pdf 7. | ecs.org/clearinghouse/01/12/19/11219.pdf | 8. educationnext.org/do-schools-begin-too-early/ | 9. nea.org/home/19322.htm | 10. startschoollater.net/uploads/9/7/9/6/9796500/maryland_dhmh_school_start_time_report_123114.pdf

Fact sheet by **Start School Later, Inc.** www.startschoollater.net (2016-02-07)

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http://www.aeaweb.org/articles.php?doi=10.1257/pol.3.3.62

A's from Zzzz's? The Causal Effect of School Start Time on the Academic Achievement of Adolescents†

By Scott E. Carrell, Teny Maghakian, and James E. West*

Recent sleep research finds that many adolescents are sleep-deprived because of both early school start times and changing sleep patterns during the teen years. This study identifies the causal effect of school start time on academic achievement by using two policy changes in the daily schedule at the US Air Force Academy along with the randomized placement of freshman students to courses and instructors. Results show that starting the school day 50 *minutes later has a significant positive effect on student achievement*, *which is roughly equivalent to raising teacher quality by one standard deviation.* (*JEL* I23, J13)

Each weekday morning, most high school students are sitting in their first period class by 7:30 am.While some students may be raring to go, many are struggling to stay awake and alert. In fact, survey evidence shows that over a quarter of high school students report falling asleep in class at least once per week (National Sleep Foundation 2006). As parents and administrators look for ways to improve student academic achievement, some question whether early start times are hindering the learning process for teenagers. Sleep research supports this notion, finding that many adolescents are sleep-deprived because of both early school start times and changing sleep patterns during the teen years. Consequently, policy initiatives to delay high school start times have gained momentum across the country. At the national level, House Concurrent Resolution 176, introduced to Congress in 2007 as the "Zzz's to A's Resolution," calls for secondary schools to begin after 9:00 am. State legislatures and local school districts have also introduced similar proposals. Although some districts have adopted later start times, most were forced to maintain the status quo as a result of conflicting bussing schedules or vehement opposition from coaches and skeptical parents.

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† To comment on this article in the online discussion forum, or to view additional materials, visit the article page at http://www.aeaweb.org/articles.php?doi=10.1257/pol.3.3.62.

One of the primary arguments against changing school start times is a lack of causal evidence on how start time affects student achievement, as most existing studies are correlational in nature. For instance, research has shown that early start times in high school lead to sleep deprivation among students (Amy R. Wolfson and Mary A. Carskadon 2003; Martha Hansen et al. 2005; Donn Dexter et al. 2003). Additionally, the number of hours of sleep is positively correlated with measures of academic achievement (Wolfson and Carskadon 1998; James F. Pagel, Natalie Forister, and Carol Kwiatkowki 2007; Howard Taras and William Potts-Datema 2005; Katia Fredriksen et al. 2004; Giuseppe Curcio, Michele Ferrara, and Luigi De Gennaro 2006; Arne Eliasson et al. 2002). However, in these studies, grades are not a consistent measure of student academic achievement due to heterogeneity of assignments and exams, as well as the subjectivity of assigning grades to assessments across instructors. Additionally, existing studies have been unable to take into account confounding factors, which likely bias the results. For instance, self-selection of coursework, schedules, and instructors, make it difficult to distinguish the effect of school start time from peer and teacher effects.

This paper identifies the causal effect of school start time on the academic achievement of adolescents. To do so, we use data from the United States Air Force Academy (USAFA) to take advantage of the randomized assignment of students to courses and instructors, as well as two policy changes in the school start time over a three-year period. Random assignment, mandatory attendance, along with extensive background data on students, allow us to examine how school start time affects student achievement without worrying about confounding factors or self-selection issues that bias existing estimates. USAFA's grading structure for core courses allows for a consistent measure of student achievement; faculty members teaching the same course in each semester use an identical syllabus, give the same exams during a common testing period, and assign course grades jointly with other instructors, allowing for standardized grades within a course-semester.

Despite our use of university-level data, we believe our findings are applicable to the high school student population more generally because we consider only freshmen students in their first semester at USAFA. Like high school seniors, first semester college freshman are still adolescents and have the same biological sleep patterns and preferences as those in their earlier teens. However, we recognize that USAFA students are not the average teen; they were high-achievers in high school and chose to attend a military service academy. Although we do not know for certain if school start times affect high-achievers or military-types differently than teenagers in the general population, we have no reason to believe that the students in our sample would be *more* adversely affected by early start times. Because the students in our study self-selected into a regimented lifestyle, if anything, we believe our estimates may be a lower-bound of the effect for the *average* adolescent.

Our results show that starting the school day later in the morning has a significant positive effect on student academic achievement. We find that when a student is randomly assigned to a first period course starting prior to 8 AM, they perform significantly worse in all their courses taken on that day compared to students who are not assigned to a first period course. Importantly, we find that this negative effect diminishes the later the school day begins. We verify that the negative start time

effect is not solely driven by worse performance in the first period class. Hence, our results show that student achievement suffers from earlier start times in not only courses taken during the early morning hours, but also throughout the entire day.

With schools aiming to improve student achievement while simultaneously facing large budget cuts, determining the impact of school start time has important implications for education policy. Our findings suggest that pushing back the time at which the school day starts would likely result in significant achievement gains for adolescents.

I. Background

Although school start time has not been widely studied in the economics literature, the subject of adolescent sleep behavior and its effect on academic performance has been explored extensively in the medical, education, psychology, and child development literatures. These studies focus on understanding how adolescent sleep preferences shift as a result of changing biological rhythms, how sleep deprivation from early start times affects the learning process, and how later school start times affect sleep patterns.

A. *The Circadian Rhythm*

To fully understand how school start time can influence academic achievement, it is important to first have a basic understanding of the biology of sleep and wakefulness. The biological rhythm that governs our sleep-wake cycles is called the circadian rhythm, a hard-wired "clock" in the brain that controls the production of the sleep-inducing hormone melatonin. During adolescence, there are major changes in one's circadian rhythm. More adult-like patterns of REM sleep develop, there are increases in daytime sleepiness, and there is a shift in the circadian pattern toward a more owl-like tendency for later bed and wake-up times (Daniel P. Cardinali 2008; Stephanie J. Crowley, Christine Acebo, and Carskadon 2007; Carskadon, Cecilia Vieira, and Acebo 1993; Wolfson and Carskadon 1998). The adolescent body does not begin producing melatonin until around 11 PM and continues in peak production until about 7 AM, then stops at about 8 AM. In contrast, adult melatonin levels peak at 4 AM. Therefore, waking up a teenager at 7 AM is equivalent to waking up an adult at 4 AM.

School schedules affect adolescent sleep patterns by imposing earlier rise times that are asynchronous with the circadian rhythm. That is, adolescents are forced to wake up and be alert and focused at a time at which their body wants to be asleep. Although adolescents know they have to wake up early, they are unable to adjust their bedtime accordingly because they naturally become more alert during the night hours. Physically, they won't become sleepy until melatonin production begins later in the night. Because the circadian system can't adapt easily to advances in the sleep-wake schedule (i.e., it is easier to stay awake when one is tired than it is to go to sleep when one is not tired), students cannot force themselves to fall asleep at a time early enough to get an adequate night's rest. Although there are many factors that contribute to later bedtimes, sleep researchers have found that adolescents stay awake later largely for biological, not social, reasons

(Crowley, Acebo, and Carskadon 2007; Carskadon, Vieira, and Acebo 1993). The amount of sleep deprivation for teens during the school year is sizable. Compared to the summer months (when adolescents presumably obtain their optimal amount of sleep), Hansen et al. (2005) find that students lose as much as 120 minutes of sleep per school night.

In addition to the amount of sleep students obtain, research indicates academic achievement may also be affected by the asynchrony between the preferred time of day and the time at which courses are taught. That is, the cognitive functioning of adolescents is likely to be at its peak more toward the afternoon than in the morning. Using college-level data from Clemson University, Angela K. Dills and Rey Hernandez-Julian (2008) find that even when controlling for student and course characteristics, students perform better in classes that meet later in the day. David Goldstein et al. (2007) find that scores on intelligence tests are significantly lower during the early morning hours.

B. *The Link Between Sleep and Academic Achievement*

Recent scientific research has strengthened the notion that sleep may play an important role in learning and memory, with several studies finding an inverse relationship between sleep and academic performance at both the secondary and postsecondary level (Curcio, Ferrara, and Gennaro 2006; Wolfson and Carskadon 1998; Mickey T. Trockel, Michael D. Barnes, and Dennis L. Egget 2000). Correlational studies comparing sleep-wake patterns and academic performance for early versus late starting schools find that students attending later starting schools self-report more hours slept, less daytime fatigue, and less depressive feelings (Wolfson and Carskadon 2003; R. Epstein, N. Chillag, and P. Lavie 1998; Kyla Wahistrom 2002). Interestingly, daytime fatigue and difficulty staying awake in class were not associated with the total hours of sleep, implying that these are consequences of earlier wake times that disrupt natural adolescent circadian rhythms. A recent study at an American high school found that a 30-minute delay in start time led to significant decreases in daytime sleepiness, fatigue, and depressed mood (Judith A. Owens, Katherine Belon, and Patricia Moss 2010). However, there are several acknowledged methodological weaknesses in this literature. Although studies find a correlation between sleep and grades, they cannot establish a causal relationship. Additionally, much of the existing literature relies on surveys and self-reports, which are both retrospective and subjective. Differences in academic achievement measures across studies make cross-study comparisons difficult and many suffer from small sample size.

Only a handful of studies have investigated how the school schedule affects academic achievement, and all of these studies face identification challenges stemming from students' ability to choose their courses and schedule. Minneapolis Public School District was one of the first school districts to change the start times of their high schools. In 1997, start times changed from 7:15 AM to 8:40 AM. Wahistrom (2002) examines this policy change and finds that the later start time had a positive effect on attendance and an insignificant improvement on grades. However, because of record-keeping issues, subjectivity of grading, and differences in courses

across teachers and schools, Wahistrom (2002) questioned the strength of her own findings. Peter Hinrichs (2011) also studies the effect of start time using data from Minneapolis Public School District. While high schools in Minneapolis moved back their start time, schools in St. Paul (Minneapolis' twin city) did not. He uses ACT test score data on all individuals from public high schools in the Twin Cities metropolitan area who took the ACT between 1993 and 2002 to estimate the effects of school starting times on ACT scores. Hinrichs (2011) broadens his analysis by estimating the effects of start time on achievement using statewide standardized test scores from Kansas and Virginia. His results suggest no effect of school start time on academic achievement.

II. Data

Data for this study come from the United States Air Force Academy (USAFA). USAFA is a fully-accredited post-secondary institution with annual enrollment of approximately 4,500 students, offering 32 majors within the humanities, social sciences, basic sciences, and engineering. Students are required to graduate within four years and typically serve a minimum five-year commitment as a commissioned officer in the United States Air Force following graduation. Despite its military setting, USAFA is comparable to other selective colleges and universities in the United States. Like other selective post-secondary schools, USAFA faculty hold graduate degrees from high quality programs in their fields. Approximately 40 percent of classroom instructors have terminal degrees, similar to large universities where introductory courses are taught by graduate students. However, class size at USAFA is rarely larger than 25 students, and students are encouraged to interact with faculty members in and outside of the classroom. Therefore, the learning environment at USAFA is similar to that of small liberal arts colleges. Students at USAFA are high achievers, with average math and verbal SAT scores at the 88th and 85th percentiles of the nationwide SAT distribution, respectively. Only 14 percent of applicants were admitted to USAFA in 2007. Students are drawn from each Congressional district in the US by a highly competitive admission process that ensures geographic diversity.

The school day at USAFA is highly structured, which is atypical of most universities, but very similar to a high school setting. There are four 53-minute class periods each morning and three each afternoon. All students are required to attend mandatory breakfast 25 minutes before first period.[1] In this study, we exploit five important features of the school day structure at USAFA. First, 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. Second, students are randomly assigned to course sections and cannot choose which periods they take their classes.[2] Third, not every student is assigned to a first period course. Fourth, we exploit the fact that USAFA runs

[1] Even students without a first period class must attend the breakfast. However, many students take naps after breakfast if they do not have a first period class.

[2] The USAFA Registrar employs a stratified random assignment algorithm to place students into sections within each course and semester. The algorithm first assigns all female students evenly throughout all offered sections, then places male recruited athletes, and then assigns all remaining students. Within each group (female, male athlete, and male non-athlete), assignments are random.

Table 1—Class Schedule at the US Air Force Academy

Period	AY1996–AY2005	AY2006	AY2007–AY2009
1	7:30	7:00	7:50
2	8:30	8:05	8:50
3	9:30	9:10	9:50
4	10:30	10:15	10:50
5	13:00	13:00	13:30
6	14:00	14:05	14:30
7	15:00	15:10	15:30

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. Finally, we 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. Table 1 shows the academic day schedule across the years of our sample. These unique features of our dataset enable us to cleanly identify the causal average treatment effect of school start time using both within-student and across-student/cohort variation. Importantly, we are able to identify both the effect of being assigned to a first period course (e.g., a wake-up effect), but also how this effect changes as the time in which the school day begins.

The Dataset.—Our dataset consists of 6,165 first-year students from the entering classes of 2004 to 2008. For each student we have pre-treatment demographic data and measures of their academic, athletic, and leadership aptitude. Academic aptitude is measured through SAT verbal and math scores and an academic composite computed by the USAFA admissions office, which is a weighted average of an individual's high school GPA, class rank, and the quality of the high school they attended. The measure of pre-treatment athletic aptitude is a score on a fitness test required by all applicants prior to entrance. The measure of pre-treatment leadership aptitude is a leadership composite computed by the USAFA admissions office, which is a weighted average of high school and community activities. Other individual-level controls include indicators for students who are black, Hispanic, Asian, female, recruited athlete, attended a military preparatory school, and the number of courses students have on that schedule day.

Table 2 shows summary statistics for our entire sample and separately for students enrolled in first period, second through seventh periods, athletes, and non-athletes. Each observation is a student-class. Approximately 17 percent of the students in our entire sample are female, four percent are black, seven percent are Hispanic, and eight percent are Asian. Twenty-two percent of students are recruited as athletes and seventeen percent attended a military preparatory school. To uphold the validity of our results, we want to ensure that students who are enrolled in a first period course are similar to those enrolled in the other periods. These students appear to be very similar in all background characteristics except for recruited athlete. This anomaly

Table 2—Summary Statistics

	Full sample mean	First period mean	Periods 2–7 mean	Non-athletes mean	Athletes mean
Normalized grade	0.00	−0.12	0.02	0.06	−0.25
	[1.00]	[1.00]	[0.99]	[0.99]	[0.97]
Credit hours	8.20	8.04	8.24	8.31	7.79
	[2.23]	[2.28]	[2.22]	[2.27]	[2.02]
SAT math	6.63	6.56	6.64	6.70	6.38
	[0.63]	[0.65]	[0.63]	[0.61]	[0.64]
SAT verbal	6.36	6.28	6.38	6.45	6.02
	[0.66]	[0.66]	[0.65]	[0.63]	[0.63]
Academic composite	13.04	12.93	13.06	13.20	12.47
	[2.04]	[2.10]	[2.03]	[1.97]	[2.20]
Fitness score	4.14	4.20	4.13	4.08	4.40
	[0.94]	[0.96]	[0.93]	[0.91]	[1.00]
Leadership composite	17.35	17.34	17.36	17.37	17.27
	[1.76]	[1.78]	[1.80]	[1.80]	[1.79]
Black	0.04	0.05	0.04	0.03	0.08
	[0.20]	[0.23]	[0.20]	[0.18]	[0.27]
Hispanic	0.07	0.06	0.07	0.08	0.04
	[0.26]	[0.25]	[0.26]	[0.27]	[0.20]
Asian	0.08	0.07	0.09	0.10	0.04
	[0.28]	[0.26]	[0.28]	[0.29]	[0.20]
Female	0.19	0.21	0.19	0.19	0.21
	[0.39]	[0.40]	[0.39]	[0.39]	[.40]
Recruited athlete	0.22	0.35	0.19	0.00	1.00
	[0.41]	[0.48]	[0.39]	[0.00]	[0.00]
Military preparatory school	0.17	0.18	0.17	0.16	0.19
	[0.37]	[0.38]	[0.37]	[0.37]	[0.39]

Notes: Standard deviation in brackets. The full sample included 20,680 observations, of which 3,977 are during first period and 16,703 are during periods 2–7. Of the observations, 4,512 are for recruited athletes and 16,168 are for non-athletes. SAT math, SAT verbal, academic composite, fitness score, and leadership composite were divided by 100. Credit hours is the total number of credit hours enrolled in by schedule day.

is explained by the fact that athletes at USAFA are not assigned to afternoon classes, since they have athletic practices at that time. Thus, they are more likely to be randomly assigned a first period class.[3] Athletes and non-athletes also differ slightly in their pre-treatment characteristics. Athletes, on average, have lower SAT math and verbal scores as well as a lower academic composite score. They are more likely to be black, and less likely to be Hispanic or Asian. To account for differences in peer quality across course sections, we control for the average classroom-level peer characteristics in all of our specifications.

Figure 1 plots the distributions of pre-treatment academic variables by start-time cohorts. We refer to the students who started before AY 2006 as the middle cohort, as their first period began at 7:30 AM. The cohort starting first period at 7:00 AM in AY 2004 and 2005 is referred to as the early cohort, and the late cohort started first period at 7:50 in AY 2007 and 2008. The distributions of SAT math scores are fairly even across cohorts as are SAT verbal scores for the early and late cohorts.

[3] We exclude athletes in our main specifications, but we show in our robustness checks that our results are not sensitive to this restriction.

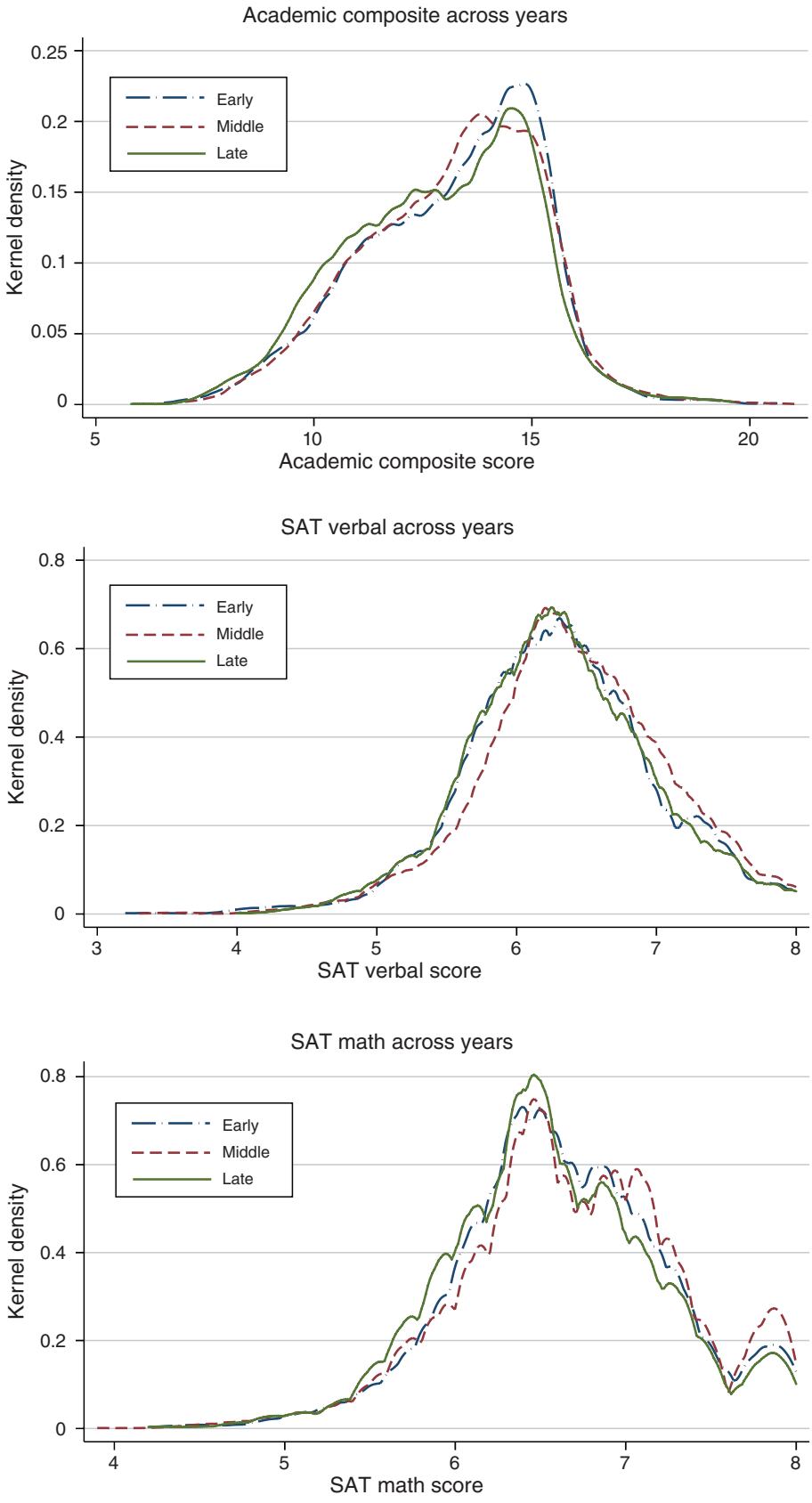

FIGURE 1. DISTRIBUTION OF STUDENT PRE-TREATMENT CHARACTERISTICS BY START TIME COHORT

Note: Recruited athletes are excluded in all figures.

Students from the middle cohort appear to have slightly higher SAT verbal scores. The distributions of high school academic composite scores show some differences across cohorts. The late cohort has slightly lower academic composite scores and the Early cohort has slightly higher scores. Even if small differences between cohorts exist, we do not expect them to affect our results as we make within course by year comparisons and control for all observable background characteristics as well as classroom peer characteristics.

We measure academic performance using students' final percentage score earned in a course. To account for differences in course difficulty or grading across years, we normalize all scores to a mean of zero and a variance of one within a course-semester.[4] We refer to this measure as the student's normalized grade. Students at USAFA are required to take a core set of approximately 30 courses in mathematics, basic sciences, social sciences, humanities, and engineering. In this study, we focus primarily on the mandatory introductory courses in mathematics, chemistry, engineering, and computer science taken during the fall semester of the freshman year. Because grades in humanities courses (English and history) are mostly determined by papers and assignments done outside the classroom, we believe that achievement measures in math and science courses, wherein grades are based on performance on common exams, better capture the level of learning that occurred during the class. However, our results are robust to the inclusion of humanities courses.

Prior to the start of the freshman year, students take placement exams in mathematics, chemistry, and select foreign languages. Scores on these exams are used to place students into the appropriate starting courses (e.g., remedial math, Calculus I, Calculus II, etc.). Conditional on course placement, athlete status, and gender, the USAFA registrar randomly assigns students to core course sections. Thus, students have no ability to choose the class period or their professors in the required core courses. Professors teaching the same course in each semester use an identical syllabus and give the same exams during a common testing period. These unique institutional characteristics assure there is no self-selection of students into (or out of) courses, towards particular class periods, or toward certain professors. Additionally, since the start time changes were not announced long before their implementation, incoming students could not have foreseen the time changes to select into or out of USAFA based on their time preferences.

We formally test whether first period assignment is random with respect to student characteristics by regressing first period enrollment on student characteristics for each course. Table 3 shows the results from these regressions. Only two of the 80 coefficients are significant at the one percent level, and three are significant at the five percent level. The coefficients are only jointly significant for one of the courses, Chemistry 141.[5] Because of this, we exclude Chem 141 in one of our robustness specifications. We also control for classroom-level peer characteristics to address differences in peers across classes. Carrell and West (2010) show that student

[4] We find qualitatively similar results when using raw scores.

[5] Chem 141 is a lab course that spans two periods; thus, it is only offered first, third, and fifth periods. Because athletes are not assigned afternoon courses, they are far more likely to be assigned a first period Chem 141 class. Additionally, in 2004–2006 the 92 lowest ability students were grouped into four Chem 141 sections—pairing the worst students with the best professors.

Table 3— Randomization Checks

Course	Math 141 (1)	Math 152 (2)	Chem 100 (3)	Chem 141 (4)	Engr 100 (5)	ComSci 110 (6)	English 111 (7)	History 101 (8)
Attended preparatory school	−0.005	0.023	−0.016	−0.008	−0.011	0.026	−0.010	0.020
	(0.017)	(0.022)	(0.055)	(0.028)	(0.034)	(0.022)	(0.023)	(0.020)
Black	0.031	−0.001	0.144*	−0.040	0.026	0.087*	0.015	−0.028
	(0.038)	(0.047)	(0.080)	(0.040)	(0.036)	(0.050)	(0.036)	(0.023)
Asian	0.022	−0.004	0.010	−0.034	−0.060**	−0.012	0.010	−0.028
	(0.017)	(0.023)	(0.058)	(0.028)	(0.028)	(0.024)	(0.019)	(0.021)
Hispanic	−0.016	−0.013	−0.067	0.021	0.002	−0.015	−0.018	−0.023
	(0.013)	(0.032)	(0.053)	(0.037)	(0.021)	(0.024)	(0.023)	(0.019)
Academic composite	0.002	−0.005	0.007	−0.013*	0.002	−0.004	−0.001	0.001
	(0.003)	(0.006)	(0.012)	(0.007)	(0.004)	(0.004)	(0.003)	(0.003)
Leadership score	0.002	0.009	−0.004	0.000	−0.009*	0.000	−0.001	−0.002
	(0.003)	(0.006)	(0.010)	(0.005)	(0.005)	(0.004)	(0.004)	(0.003)
SAT verbal	−0.023*	−0.041**	0.025	0.023	−0.01	−0.004	−0.016	0.000
	(0.012)	(0.017)	(0.024)	(0.015)	(0.014)	(0.012)	(0.012)	(0.009)
SAT math	−0.002	0.011	0.022	−0.081***	−0.009	0.021	−0.015	−0.004
	(0.011)	(0.015)	(0.025)	(0.022)	(0.015)	(0.016)	(0.016)	(0.011)
Fitness score	0.004	−0.009	0.015	0.018**	0.000	0.008	0.007	−0.001
	(0.007)	(0.010)	(0.020)	(0.008)	(0.012)	(0.009)	(0.009)	(0.006)
Female	−0.003	0.005	−0.034	0.067***	0.037	0.034*	−0.013	−0.012
	(0.012)	(0.023)	(0.026)	(0.019)	(0.025)	(0.020)	(0.016)	(0.011)
Observations	3,690	1,493	1,132	3,377	2,531	2,851	2,712	2,801
p-value: joint significance of all individual covariates	0.041	0.037	0.023	0.090	0.032	0.020	0.037	0.062

Notes: Each specification represents results for a regression where the dependent variable is an indicator for first period. The SAT verbal, SAT math, and academic composite, fitness score, and leadership composite variables were divided by 100 prior to running the regressions. All specifications include year indicators and an idicator for recruited athlete. Robust standard errors are clustered at the section by year level.

assignment to core courses at USAFA is random with respect to peer characteristics and professor experience, academic rank, and terminal degree status. Carrell, Marianne E. Page, and West (2010) find no correlation between student characteristics and professor gender.

To visualize how academic achievement changed across start time cohorts, we look at the distribution of achievement measures across cohorts in Figure 2. The distribution of scores in all class periods and first period courses shifts to the right with later start times. To assure us that the difference in scores across start time cohorts is not a result of differences in course difficulty across years, we look at the distribution of normalized grades as well. The same pattern holds for the normalized grade, wherein the later-start cohorts have a higher distribution of grades in all class periods and an even higher distribution of grades in first period courses compared to the earlier-start cohorts.

III. Methods and Results

The unique institutional characteristics of USAFA and the two policy changes in start time allow us to cleanly identify the causal effect of start time on academic

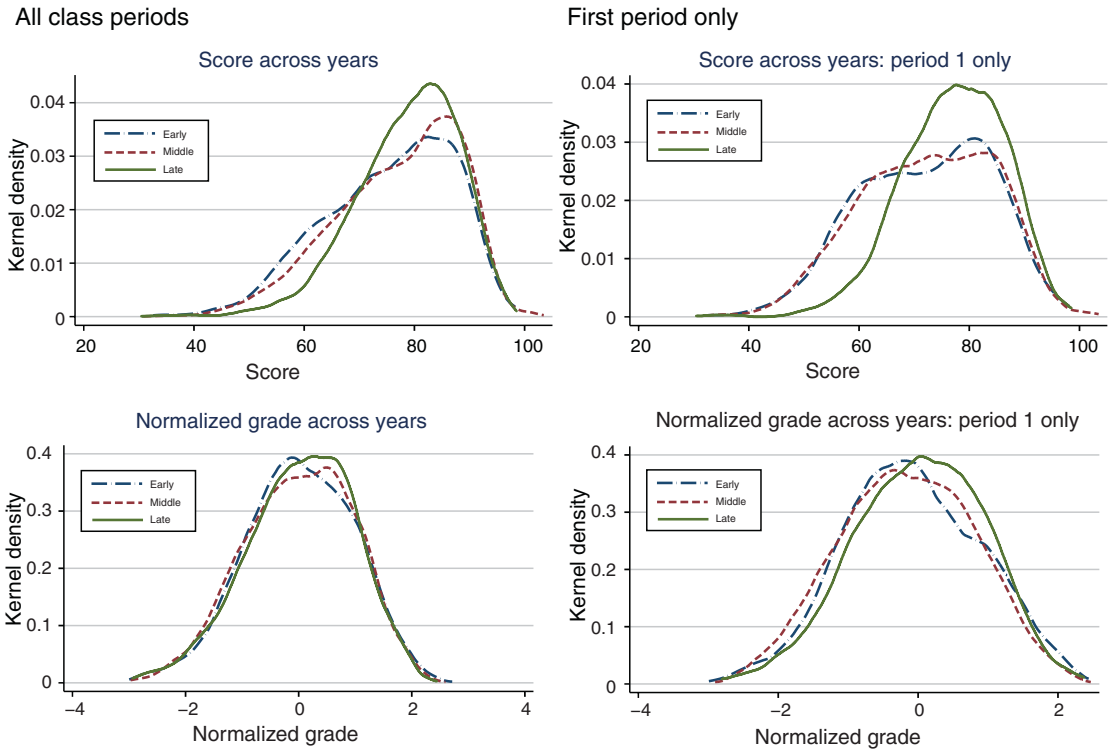

FIGURE 2. DISTRIBUTION OF ACADEMIC OUTCOMES BY START-TIME COHORT

achievement. Importantly, the opposite direction of changes in the start of the academic day at USAFA over consecutive years helps assure that we are identifying the effects of start time versus trends in grading or course difficulty. We begin by examining whether being randomly assigned to a first period course affects overall academic achievement for students throughout the entire day. This analysis measures differences in achievement in all courses taken on the same schedule day as a first period class compared to achievement in courses taken on a schedule day without a first period class. We examine how this effect differs across the various start times in our sample (7:00, 7:30, and 7:50 AM). Since not all students are randomly assigned to a first period course on a given schedule day, we are able to identify these effects using variation both across and within individuals. When including individual fixed effects, we take advantage of the fact that with randomization some students are assigned a first period on one schedule day, but not the other. Finally, we extend this model to determine if the effects we find are driven by early morning courses or performance throughout the entire day.

A. *Methods*

To measure the causal effect of early start times on academic achievement, we estimate the following equation:

$$(1)\quad Y_{icjts} = \alpha + \beta F^{1}_{icts} + \delta_1 X_{ict} + \delta_2 \frac{\sum_{k \neq i} X_{kcqt}}{n_{cqt} - 1} + \phi_{cts} + \gamma_{jts} + \mu_i + \epsilon_{icjts},$$

where Y_{icjts} is the normalized grade for student i in course c with professor j in year t on schedule day s. F^1_{icts} is an indicator variable equal to one if student i has a first period course on the same schedule day s as course c in year t. β is our coefficient of interest and measures the average effect of being assigned a first period class on all course grades throughout that academic day. The vector X_{ict} includes the following student characteristics: SAT math and SAT verbal test scores, academic and leadership composites, fitness score, race, gender, the number of credit hours the student has on that schedule day[6], whether the student was recruited as an athlete[7], and whether he/she attended a military preparatory school. To control for classroom peer effects, we include $\sum_{k \neq i} X_{kcqt}/(n_{cqt} - 1)$, the average pre-treatment characteristics of all other peers in section q of course c except individual i. ϕ_{cts} are course by year by M/T day fixed effects and are included in all specifications to control for unobserved mean differences in academic achievement or grading standards across courses, years, and schedule days. In robustness specifications we add professor by year by M/T day fixed effects, γ_{jts}, to control for fixed differences in instructor quality within a given year. Importantly, these fixed effects help control for potentially tired professors in years they may have been assigned to teach an early morning course. We also include individual student fixed effects, μ_i, to exploit the within-student variation in daily schedules across M/T days. Standard errors are clustered by student.

Next, we alter equation (1) slightly to examine how the effects from being assigned to a first period course changed as USAFA altered the start time of the academic day:

$$(2) \qquad Y_{icjts} = \alpha + \beta_1 F^{1,E}_{icts} + \beta_2 F^{1,M}_{icts} + \beta_3 F^{1,L}_{icts} + \delta_1 X_{ict} + \delta_2 \frac{\sum_{k \neq i} X_{kcqt}}{n_{cqt} - 1} + \phi_{cts} + \gamma_{jts} + \mu_i + \epsilon_{icjts}.$$

$F^{1,E}_{icts}$ is an indicator variable equal to one if student i was enrolled in a first period class that started at 7:00 a.m on the same schedule day s as course c in year t. $F^{1,M}_{icts}$ indicates classes starting at 7:30 AM and $F^{1,L}_{icts}$ indicates classes starting at 7:50 AM. Our coefficients of interest are β_1, β_2, and β_3, which show the effects of having a first period class on the same schedule day as course c for the different start times.

B. *Results*

We begin by graphically noting differences in academic achievement for students who were and were not randomly assigned a first period class. Figure 3 shows that the distribution of normalized grades of students with a first period class is lower than that of students who did not have a first period class on a given schedule day.

[6] On average, students assigned to a first period class take one more credit hour (equivalent to one-third of a course) on that schedule day compared to students not assigned a first period class.

[7] In our main specifications we exclude recruited athletes from the sample; however, results in column 1 of Table 6 show our results are not sensitive to this restriction.

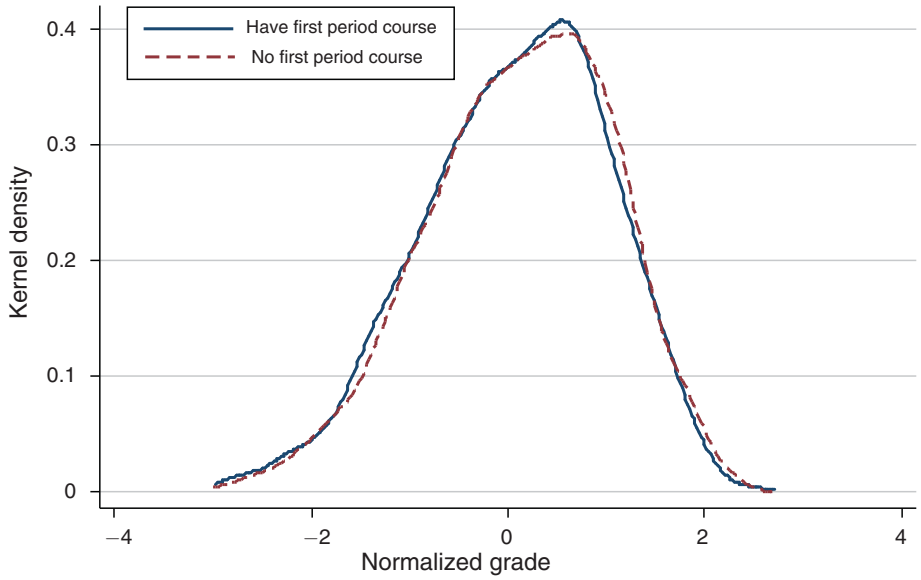

FIGURE 3. DISTRIBUTION OF NORMALIZED GRADES FOR ALL COURSES BY FIRST PERIOD ENROLLMENT

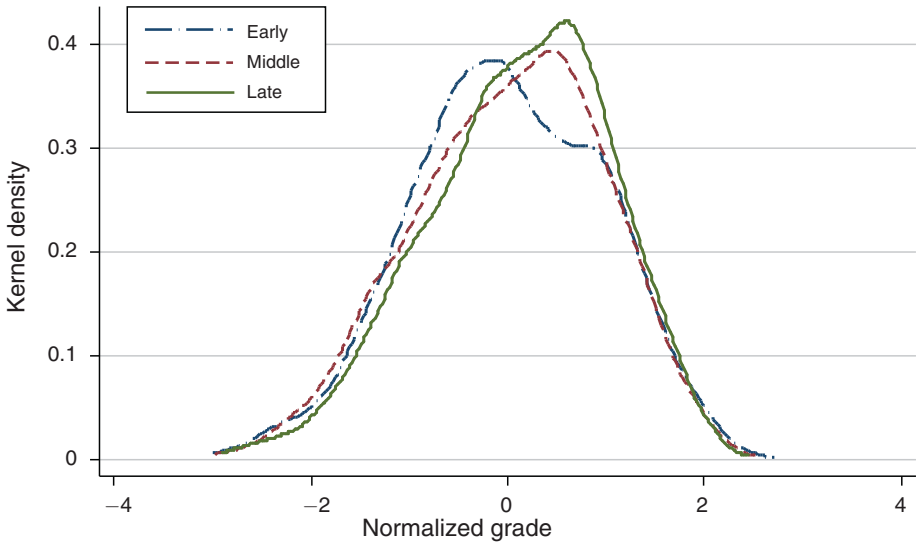

FIGURE 4. DISTRIBUTION OF NORMALIZED GRADES FOR ALL COURSES BY FIRST PERIOD ENROLLMENT BY COHORT

Figure 4 shows the distribution of grades of students with a first period class for the different start time cohorts. These figures suggest that the later first period begins, the higher the distribution of student grades.

Table 4 presents our estimates from equations (1) and (2). Columns 1–3 show the average effects from equation (1), while columns 4–6 show the effects by start time (equation (2)). Columns 2 and 5 include professor by year by M/T day fixed effects while columns 3 and 6 additionally control for student fixed effects. When including student fixed effects, the coefficients on $F^{1,\cdot}$ represent the within-student difference between average daily performance on days with a first period course, and average daily performance on days without a first period course. As noted earlier, this

Table 4—Effect of School Start Time on Academic Achievement Throughout the Day

	(1)	(2)	(3)	(4)	(5)	(6)
First period	−0.076***	−0.058**	−0.031			
	(0.021)	(0.022)	(0.027)			
7:00 AM first period				−0.139***	−0.140***	−0.116**
				(0.043)	(0.045)	(0.054)
7:30 AM first period				−0.084***	−0.052	−0.010
				(0.032)	(0.034)	(0.040)
7:50 AM first period				−0.023	−0.014	0.000
				(0.035)	(0.036)	(0.045)
Observations	11,851	11,851	11,851	11,851	11,851	11,851
R^2	0.228	0.280	0.816	0.228	0.280	0.817
Professor × year fixed effects	No	Yes	Yes	No	Yes	Yes
Student fixed effects	No	No	Yes	No	No	Yes

Notes: The dependent variable in each specification is the normalized grade in the course. First period is an indicator for whether the student had a first period class on the M/T day in which the course was taken. Robust standard errors in parentheses are clustered at the individual level. All specifications include course by year by M/T day fixed effects, peer effects controls, and individual controls. Individual-level controls include SAT verbal and math scores, academic composite, leadership composite, fitness score, the number of credit hours a student has on that M/T day, and indicators for students who are black, Hispanic, Asian, female, and attended a preparatory school. Athletes are excluded.

*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

analysis is made possible by the M/T Day schedules at USAFA in which a student may have a first period on one schedule day, but not have a first period on the other schedule day within the same semester.

Our estimates of β in columns 1–3 indicate that students who are randomly assigned to a first period course earn lower average grades in courses taken that day. The estimated average effect from being assigned a first period course is between $-.031$ and $-.076$ standard deviations. Results in columns 4–6 show that this negative effect is largest in absolute value the earlier first period begins. For example, estimates in column 5, when including professor fixed effects, show that students who are assigned to a first period course perform a statistically significant 0.140 standard deviations lower on average for the 7:00 AM start time, but only a statistically insignificant 0.014 standard deviations lower for the 7:50 AM start time. These effects are robust to the inclusion of individual student fixed effects in column 6.

These results reveal two important findings. First, they suggest that being assigned to a first period course has a negative and statistically significant effect on student achievement. Second, this negative effect diminishes and becomes statistically insignificant as the start time moves from 7:00 AM to 7:50 AM. These findings are consistent with the sleep literature that shows adolescent levels of melatonin production peak at 7 AM and stop at about 8 AM.

One important policy question is whether the effects we find are solely driven by poor performance in the first period course or performance throughout the entire day. The former could simply be a "wake-up" effect for students or from tired professors. Knowing this distinction is also important for determining optimal policy

Table 5— First Period versus Later Period Effects

	(1)	(2)	(3)	(4)	(5)	(6)
First period class	−0.092***	−0.071**	−0.100***			
	(0.026)	(0.034)	(0.038)			
First period × non-first period class	−0.067***	−0.054**	−0.01			
	(0.024)	(0.023)	(0.029)			
7 AM first period class				−0.150***	−0.124**	−0.159**
				(0.049)	(0.063)	(0.074)
7 AM first period × non-first period class				−0.131***	−0.147***	−0.099*
				(0.049)	(0.048)	(0.057)
7:30 AM first period class				−0.117***	−0.079	−0.128**
				(0.038)	(0.056)	(0.058)
7:30 AM first period × non-first period class				−0.063*	−0.046	0.021
				(0.035)	(0.035)	(0.042)
7:50 AM first period class				−0.012	−0.029	−0.030
				(0.043)	(0.055)	(0.064)
7:50 AM first period × non-first period class				−0.031	−0.010	0.010
				(0.038)	(0.038)	(0.047)
Observations	11,851	11,851	11,851	11,851	11,851	11,851
R^2	0.228	0.280	0.817	0.228	0.280	0.817
Professor × year fixed effects	No	Yes	Yes	No	Yes	Yes
Student fixed effects	No	No	Yes	No	No	Yes

Notes: The dependent variable in each specification is the normalized grade in the course. First period class is an indicator for whether the course was during first period. First period × non-first period class is an indicator for whether the student had a first period class on the M/T day in which that course was taken. Robust standard errors in parentheses are clustered at the individual student level. All specifications include course by year by M/T day fixed effects, peer effects controls, and individual controls. Individual-level controls include SAT verbal and math scores, academic composite, leadership composite, fitness score, the number of credit hours a student has on that M/T day, and indicators for students who are black, Hispanic, Asian, female, and attended a preparatory school. Athletes are excluded.

*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

responses. That is, whether schools should alter the start time of the academic day or simply offer more non-academic courses such as physical education during the early morning hours.

To help answer this question we estimate equations (1) and (2) while interacting the treatment variable (enrollment in a first period course on that schedule day) with whether or not the course was during first period or one of the other periods in that same day. Results are shown in Table 5. Across all specifications, the results suggest that the negative effects of early start times are driven by lower academic performance throughout the entire day. Students perform significantly worse in first period courses as well as non-first period courses and these effects are statistically indistinguishable in all specifications. Importantly, the evidence suggests that our results are not likely driven by tired professors who are assigned to teach during the early morning hours. That is, it seems implausible that a tired professor teaching first period in one course could negatively affect a students' later-period course performance in an unrelated subject.

TABLE 6—ROBUSTNESS CHECKS

	Including athletes (1)	Females excluded (2)	Chem 141 excluded (3)	Afternoon excluded (4)	History and English included (5)	2004–2006 only (6)	2005–2007 only (7)	2006–2008 only (8)
7:00 AM first period	−0.109***	−0.127**	−0.187***	−0.173***	−0.122***	−0.139***	−0.126***	−0.140***
	(0.039)	(0.051)	(0.051)	(0.047)	(0.04)	(0.045)	(0.05)	(0.05)
7:30 AM first period	−0.049*	−0.071*	−0.057	−0.057	−0.037	−0.051	−0.026	—
	(0.029)	(0.038)	(0.037)	(0.036)	−0.03	(0.034)	(0.04)	—
7:50 AM first period	−0.018	−0.016	−0.042	−0.021	−0.038	—	−0.043	−0.014
	(0.031)	(0.041)	(0.039)	(0.039)	(0.03)	—	(0.05)	(0.04)
Observations	15,074	9,605	8,306	9,857	16,119	7,927	7,426	6,530
R^2	0.285	0.278	0.266	0.288	0.249	0.291	0.272	0.275
Professor × year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Student fixed effects	No	No	No	No	No	No	No	No

Notes: The dependent variable in each specification is the normalized grade in the course. First period is an indicator for whether the student had a first period class on the M/T day in which the course was taken. Robust standard errors in parentheses are clustered at the individual level. All specifications include course by year by M/T day fixed effects, peer effects controls, and individual controls. Athletes are excluded, except in column 1. Individual-level controls include SAT verbal and math scores, academic composite, leadership composite, fitness score, the number of credit hours a student has on that M/T day, and indicators for students who are black, Hispanic, Asian, female, and attended a preparatory school.

*** Significant at the 1 percent level.

** Significant at the 5 percent level.

* Significant at the 10 percent level.

C. *Robustness Checks*

We verify the robustness of our estimates to several changes in model specification with results shown in Table 6. All specifications include a full set of individual controls and professor by year by M/T day fixed effects. Column 1 shows our models with the inclusion of recruited athletes, while columns 2 and 3 sequentially exclude females and observations from Chemistry 141. Column 4 shows results when excluding afternoon courses to address concerns that the make-up of students in morning courses may be different than those in afternoon courses as a result of the stratified randomization. In column 5, our model includes the humanities courses we excluded from our main specifications because of the concern that grades in these classes are mostly determined by papers and assignments done outside the classroom. Lastly, we narrow the years that we consider. We have three specifications with narrowed years: 2004–2006, 2005–2007, and 2006–2008. Restricting our sample to 2004–2006 (column 6) shows just the effect of the first start time change from 7:30 AM to 7:00 AM 2005–2007 (column 7), restricts the sample to the years immediately surrounding the two policy changes, and 2006–2008 (column 8) isolates the second start time change from 7:00 to 7:50 AM. The estimates from our robustness specifications are qualitatively similar to those from our main specification, and provide strong evidence that our results are not driven by anomalies in the data.

IV. Discussion

While we have found a positive causal relationship between start time and academic performance for the students at USAFA, it's also important to understand why such a relationship would exist. For this, we look to evidence from sleep experts. There are two main sleep factors that affect mental performance. The first is the duration (number of hours) of sleep, known as process S. The second is the time of day one is expected to function, known as process C. Process C is related to the circadian timing; regardless of the duration of sleep, there are times of the day when a person is more and less alert. For adolescents, alertness begins in the late morning, drops off mid-afternoon, and peaks again in the early evening.

It's clear to see the role process C plays in poor academic performance in early classes. However, understanding the role process S plays in our study is more difficult, as USAFA does not collect data on students' hours of sleep. Thus, we have no statistical evidence of sleep time differences between students with and without first period classes. Instead, we draw from related studies and anecdotal evidence to understand what differences might exist. Sleep research has been done at the US Military Academy in West Point, NY, where the daily schedule is very similar to that of USAFA during the 7:30 AM start time regime. These studies find that first year students sleep an average of 5.5 hours per night, far less than the 8.5–9.5 hours of sleep most adolescents need (Nita Lewis Miller et al. 2008, Aileen Kenney and Daniel Thomas Neverosky 2004). This was also three hours less than the average amount of sleep the students reported getting before the start of cadet basic training, which implies that the students were sleep deprived. We anticipate that sleep patterns are similar at USAFA, but that there may be differences in hours of sleep for students with and without a first period class.

All students at USAFA are required to attend breakfast 25 minutes before first period begins, thus we speculate that all students wake up at approximately the same time. After breakfast, some students go straight to class while those who start classes later in the day spend their time studying or napping, even though napping is prohibited at USAFA. The fact that some students nap is important for two reasons. First, the extra sleep will make the students better rested, which may benefit them throughout the day. Second, the desire and ability to nap (even when it's against the rules) reflects the students' need for sleep and likely sleep deprivation. Although we do not know what time students go to sleep, it is possible that students with a first period may be staying up later to complete assignments due during first period, whereas, students without first period wait and complete these assignments in the morning. This evidence implies that there may also be a difference in the total hours of sleep that students with and without a first period course obtain. However, this fact is unverifiable in our data.

Academic performance for all students is affected by both processes S (duration of sleep) and C (timing of activities). Students with a first period class are disadvantaged for two reasons. First, they are in class at a time that their body wants to be asleep, which both makes it difficult to learn and fatigues the brain. Second, they may be getting less sleep than their peers who napped during first period. Thus, the positive effect of later start times we find is reflective of the synchronization of

learning to optimal times of day and possibly also increased amounts of sleep. An important aspect of this study is that grades at USAFA are standardized within a course-semester. That is, a student's grade in a course is determined by the scores of everyone taking the course, regardless of which period they are taking it. Our measures of the effect of start time are determined by how students who start the day at first period perform in their courses relative to those who start later and have improved timing of learning and potentially more sleep. Because not all students at USAFA begin class at the same time, we cannot determine the effect of all students having an earlier or later start time. In contrast, Wahistrom's (2002) analysis of the Minneapolis start time change examines the effect of all students beginning school later in the morning. To do so, she compares the letter grades earned by a student before and after the start time change. Changes in student performance across start time regimes in that study would be a result of improvements in sleep amounts and timing of learning (process S and C). However, because all students face the same improvements, relative performance across all students may not change. The students who earn Bs may still earn Bs even through they've learned more, because their peers have also improved.[8] Thus, it would appear as if start time had little or no effect on achievement.

V. Conclusion

Across the country, debates about school start time are surfacing. While sleep researchers find that later start times are beneficial for adolescent learning, many argue there is not enough evidence on the benefits of later start time to warrant making such a change. Researchers have attempted to answer the question of how start time affects student achievement; however, to this point determining the causal effects of start time on student achievement has been difficult due to issues related to self-selection and measurement error.

This study identifies the causal effect of school start time on student academic achievement using data from the USAFA to take advantage of the randomized assignment of students to courses and instructors as well as two policy changes in the school start time over a three-year period. Random assignment, mandatory attendance, along with extensive background data on students, allows us to examine how school start time affects student achievement without worrying about confounding factors or self-selection issues that bias existing estimates. USAFA's grading structure for core courses allows for a consistent measure of student achievement; faculty members teaching the same course in each semester use an identical syllabus and give the same exams during a common testing period, allowing for standardized grades within a course-semester.

We find that early school start times negatively affect student achievement—students randomly assigned to a first period course earn lower overall grades in their classes on the same schedule day compared to students who are not assigned a first period class on that day. We verify that this negative effect is not solely a result of

[8] We mention other issues with grading methods in these studies earlier in the paper.

poor performance during first period courses. Although students perform worse in first period classes compared to other periods, those with first period classes also perform worse in their subsequent classes on that schedule day. These estimates are robust to professor by year by M/T day fixed effects and individual student fixed effects.

Our findings have important implications for education policy; administrators aiming to improve student achievement should consider the potential benefits of delaying school start time. A later start time of 50 minutes in our sample has the equivalent benefit as raising teacher quality by roughly one standard deviation. Hence, later start times may be a cost-effective way to improve student outcomes for adolescents.

REFERENCES

Cardinali, Daniel P. 2008. "Chronoeducation: How the Biological Clock Influences the Learning Process." In *The Educated Brain: Essays in Neuroeducation*, ed. Antonio M. Battro, Kurt W. Fischer, and Pierre J. Léna, 110–26. Cambridge, UK: Cambridge University Press.

Carrell, Scott E., and James E. West. 2010. "Does Professor Quality Matter? Evidence from Random Assignment of Students to Professors." *Journal of Political Economy*, 118(3): 409–32.

Carrell, Scott E., Teny Maghakian, and James E. West. 2011. "A's from Zzzz's? The Causal Effect of School Start Time on the Academic Achievement of Adolescents: Dataset." *American Economic Journal: Economic Policy*. http://www.aeaweb.org/articles.php?doi=10.1257/pol.3.3.62.

Carrell, Scott E., Marianne E. Page, and James E. West. 2010. "Sex and Science: How Professor Gender Perpetuates the Gender Gap." *Quarterly Journal of Economics*, 125(3): 1101–44.

Carskadon, Mary A., Cecilia Vieira, and Christine Acebo. 1993. "Association between Puberty and Delayed Phase Preference." *Sleep*, 16(3): 258–62.

Crowley, Stephanie J., Christine Acebo, and Mary A. Carskadon. 2007. "Sleep, Circadian Rhythms, and Delayed Phase in Adolescents." *Sleep Medicine*, 8(6): 602–12.

Curcio, Giuseppe, Michele Ferrara, and Luigi De Gennaro. 2006. "Sleep Loss, Learning Capacity, and Academic Performance." *Sleep Medicine Reviews*, 10(5): 323–37.

Dexter, Donn, Jagdeep Bijwadia, Dana Schilling, and Gwendolyn Applebaugh. 2003. "Sleep, Sleepiness and School Start Times: A Preliminary Study." *Wisconsin Medical Journal*, 102(1): 44–46.

Dills, Angela K., and Rey Hernandez-Julian. 2008. "Course Scheduling and Academic Performance." *Economics of Education Review*, 27(6): 646–54.

Eliasson, Arne, Anders Eliasson, Joseph King, Ben Gould, and Arn Eliasson. 2002. "Association of Sleep and Academic Performance." *Sleep and Breathing*, 6(1): 45–48.

Epstein, R., N. Chillag, and P. Lavie. 1998. "Starting Times of School: Effects on Daytime Functioning of Fifth-Grade Children in Israel." *Sleep*, 21(3): 250–56.

Fredriksen, Katia, Jean Rhodes, Ranjini Reddy, and Niobe Way. 2004. "Sleepless in Chicago: Tracking the Effects of Adolescent Sleep Loss During the Middle School Years." *Child Development*, 75(1): 84–95.

Goldstein, David, Constanze S. Hahn, Lynn Hasher, Ursula J. Wiprzycka, and Philip David Zelazo. 2007. "Time of Day, Intellectual Performance, and Behavioral Problems in Morning versus Evening Type Adolescents: Is there a Synchrony Effect?" *Personality and Individual Differences*, 42(3): 431–40.

Hansen, Martha, Imke Janssen, Adam Schiff, Phyllis C. Zee, and Margarita L. Dubocovich. 2005. "The Impact of School Daily Schedule on Adolescent Sleep." *Pediatrics*, 115(6): 1555–61.

Hinrichs, Peter. 2011. "When the Bell Tolls: The Effect of School Starting Times on Academic Achievement." Forthcoming. *Education Finance and Policy*.

Kenney, Aileen, and Daniel Thomas Neverosky. 2004. "Quantifying Sleep and Performance of West Point Cadets: A Baseline Study." Master's thesis. Naval Postgraduate School.

Miller, Nita Lewis, Lawrence G. Shattuck, Panagiotis Matsangas, and Jeff Dyche. 2008. "Sleep and Academic Performance in US Military Training and Education Programs." *Mind, Brain, and Education*, 2(1): 29–33.

National Sleep Foundation. 2006. *Sleep in America Poll: Highlights and Key Findings*. National Sleep Foundation. Arlington, VA.

Owens, **Judith A.**, **Katherine Belon**, **and Patricia Moss.** 2010. "Impact of Delaying School Start Time on Adolescent Sleep, Mood, and Behavior." *Archives of Pediatrics and Adolescent Medicine*, 164(7): 608–14.

Pagel, **James F.**, **Natalie Forister**, **and Carol Kwiatkowki.** 2007. "Adolescent Sleep Disturbance and School Performance: The Confounding Variable of Socioeconomics." *Journal of Clinical Sleep Medicine*, 3(1): 19–23.

Taras, **Howard**, **and William Potts-Datema.** 2005. "Sleep and Student Performance at School." *Journal of School Health*, 75(7): 248–54.

Trockel, **Mickey T.**, **Michael D. Barnes**, **and Dennis L. Egget.** 2000. "Health-Related Variables and Academic Performance Among First-Year College Students: Implications for Sleep and Other Behaviors." *Journal of American College Health*, 49(3): 125–31.

Wahistrom, **Kyla.** 2002. "Changing Times: Findings From the First Longitudinal Study of Later High School Start Times." *NASSP Bulletin*, 86(633): 3–21.

Wolfson, **Amy R.**, **and Mary A. Carskadon.** 1998. "Sleep Schedules and Daytime Functioning in Adolescents." *Child Development*, 69(4): 875–87.

Wolfson, **Amy R.**, **and Mary A. Carskadon.** 2003. "Understanding Adolescent's Sleep Patterns and School Performance: A Critical Appraisal." *Sleep Medicine Reviews*, 7(6): 491–506.

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Delayed High School Start Times later than 8:30 a.m. 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 a.m. The second aim of the study was to analyze the association between a delayed high school start time later than 8:30 a.m. and attendance rates.

Design: In the current study, a pre-post design using a repeated measures Analysis of Variance (ANOVA) was used to examine changes in attendance and graduation rates two years after a delayed start was implemented.

Setting: Public high schools from eight school districts *(n* = 29 high schools) located throughout seven different states. Schools were identified using previous research from the Children's National Medical Center's (CNMC) Division of Sleep Medicine Research Team.

Participants and Measurements: A total membership of over 30,000 high school students enrolled in the 29 schools identified by the CNMC 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 a.m. to improved attendance rates and graduation rates.

Conclusions: Attendance rates and graduation rates significantly improved in schools with delayed start times of 8:30 a.m. 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.

Keywords: Delayed school start times; high school bell times; attendance rates; graduation rates; graduation completion; inadequate sleep; insufficient sleep; adolescent sleep; student social-emotional health

Introduction

Sleep experts agree that school start times are not in synchronization with adolescent sleep cycles, affecting learning and overall wellbeing 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 nine hours or more a night to function at peak performance [4, 6, 7] making 8:30 a.m. or later an ideal start time for adolescent sleep/wake cycles [8, 9, 10, 11, 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 aged 15-17 years old. Findings from this comparative study indicated that over the span of time socio-economic 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 p.m. because the adolescent body begins to produce melatonin at 11:00 p.m. and stops at about 8:00 a.m. [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 (CDC) 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 a.m. or later [16]. More specifically, 42 states reported that 75%-100% of public schools start before 8:30 a.m. [16]. Survey findings raise awareness about the reluctance by school officials to adjust bell schedules to match adolescent sleep patterns [17]. Further, 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, 19, 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 are 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 wellbeing. Winsler and colleagues[22] surveyed adolescents (n=27,939) and conclude that a shortened duration of sleep by one hour increased feelings of hopelessness, doom, suicidal ideations, attempted suicides and substance abuse. Further, insomnia and major depression were two 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 a.m. 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]. Further, 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 study[12], 18,000 Minneapolis high school students (9^{th}-11^{th} grade) showed an improvement in grades and attendance rates when bell times changed from 7:15 a.m. to 8:40 a.m.[12]. In this study there was a significant improvement in attendance rates for 9^{th} -11^{th} grade students not continuously enrolled in the same high school, with speculation offered that continuously enrolled students already had high attendance rates pre-delay 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 to peers attending schools with earlier start times [32]. Research that compared the academic outcomes of two different middle schools in New England showed that students at the earlier starting school were tardy four times more frequently [33]. Edwards [34] also finds later start times related to decreased absences. Recently, in a three-year study with 9,000 students in eight public high schools over three states, Wahlstrom and colleagues [35] found significant increases in attendance and reduced tardiness with a start time of 8:35 a.m. or later.

Importance of stakeholder consideration to adjust bell times

The decision to continue to set high school start times earlier than 8:30 a.m. 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 one school district three years after the implementation of a delayed start time of 8:30 a.m. 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 pre-delay (8:30 a.m. or earlier) graduation completion rates with post-delay (later than 8:30 a.m.) graduation rates in the same eight school districts two years following 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 a.m. 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 is 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 pre-delay and post-delay 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 utilizing the data from the state repositories of 29 schools in seven states and eight school districts (of 38 districts in the original study) specifically collecting attendance and graduation rates at two time periods (pre and post delay). 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(ANOVA), reduces measurement error (any school to school variability) to a greater extent than a difference score analysis, and has 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 Children's National Medical Center's (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 eight school districts of the 38 districts in the original CNMC study *(n* = 29 high schools) are located in seven different states. To ensure a comprehensive treatment effect, only districts with post-start delay of over 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 pre to post delay 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 a.m. or earlier and post start times later than 8:30 a.m. two years after the time change [36].

Table 1

List of schools and time changes.

Location		Pre-delay time		Delay start Time	Increase in time Change (min.)
Bedford County Public Schools, Virginia	Before 2013:	8:30-3:00	After 2013:	8:55-3:35	(25 min.)
Jefferson Forest HS					
Liberty HS					
Stauton River HS					
Brevard PS, FL:	Before 2000:	7:30-2:15	After 2000:	8:45-3:30	(75 min.)
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 min)
Ithaca Senior HS					
Moore County, N.C.:	Before 2012:	8:00-3:00	After 2012:	9:00-4:00	(60 min.)
North Moore HS					
Pinecrest HS					
Union Pine					
North Clackamas SD, OR:	Before 1999:	7:30-2:20	After 1999:	8:45-3:20	(75 min.)
Clackamas HS					
Pulaski County Special, SD, Arkansas	Before 2012:	7:30-2:40	After 2012:	8:35-3:45	(65 min.)
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 min.)
Gulf Breeze					
Milton HS					
Navarre HS					
Pace HS					
South Washington, MN:	Before 2009:	7:35-2:05	After 2009:	8:35-3:05	(60 min.)
Park High School					
Woodbury HS					

Variables

Attendance rates and graduation rates are measured under two conditions (pre-delay time and post-delay time). School attendance is reported as percentages and could range from zero to 100. School start times are coded as a bivariate categorical variable coded as a zero (early start times) and one (later start times). School graduation completion percentages are measured by graduation rates collected from school districts ranging from zero to 100.

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

Table 2

Dependent variables and descriptive statistics.

Variables		Descriptive Statistics			
Dependent Variables:		Mean	Minimum	Maximum	*SD*
School Attendance	(pre-delay)	90%	68%	99%	6%
School Attendance	(post-delay)	94%	86%	99%	2%
		Mean	Minimum	Maximum	*SD*
School Graduation	(pre-delay)	79%	51%	94%	13%
School Graduation	(post-delay)	88%	68%	97%	9%

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 non-normality in the continuous variables. Statistically significant relationships were determined based on an alpha level of .025 or less to protect against the inflation of Type I error.

ANOVA 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 one year before implementation of delayed start versus two years after the implementation of delayed start times?

Descriptive Statistics

As mentioned, average overall graduation rate (before transformation) was 83% across both the pre and post measures. Schools ranged from a minimum of 51% to a maximum of 97%. The standard deviation of 11% indicates 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 pre-delay and post-delay graduation rates. The mean at the pre-delay, earlier start times, is 79%, and the mean at the post-delay is 88%. The upward trend in the rates suggests graduation rates may be improving with changes in school start times. For both time periods, the median is slightly higher than the mean, indicating both time periods may also be left skewed, similar to the aggregate data.

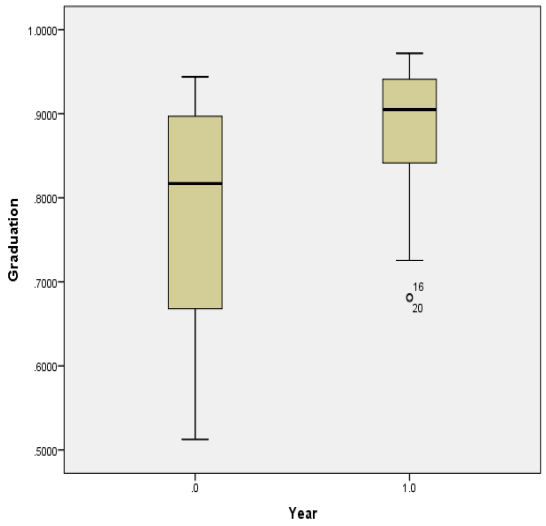

Figure 1. Boxplot of pre and post delay graduation rates.

The boxplot in Figure 1 provides a graphical illustration of the graduation rates at both bell times. In this figure, the median for post-delay time appears higher than for the pre-delay.

Inferential Statistics

Repeated Measures ANOVA

The final model for research question number one 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 a.m. was implemented. The equation for the model is:

Graduation rate = year + error.

The null hypothesis for the model is that no difference exists in graduation rates between pre and post delay years (Ho: μ1=μ2). The alternative hypothesis is that there is a significant difference between pre and post delay years (Ho: $\mu 1 \neq \mu 2$).

Given that the assumptions are met , the model for determining if significant differences exist between pre and post delay graduation rates can be interpreted. Table 3

includes the result of the repeated measure ANOVA. This table indicates 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 0.025. Hence significant increases occurred in graduation rates comparing pre and post delay times. These results mirror those in the bivariate descriptive statistics. In Figure 1, the boxplot illustrates this trend, with the median for the post-graduation rates appearing to be greater than the median for pre graduation.

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

The conclusion of the analysis suggests 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.

Question Two

What are pre to post start time delay differences in the same schools one year before implementation of delayed start versus two years after the implementation of delayed start times in attendance rates?

Descriptive Statistics

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

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

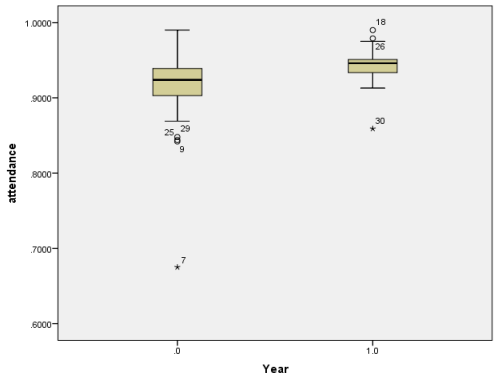

Figure 2. Boxplot of attendance by time.

Inferential Statistics

The model for research question number two 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 a.m. was implemented. The equation for the model is:

Attendance rate = year + error

Again, the null hypothesis is that there are no differences between pre and post year (Ho= μ 1= μ 2) and the alternate hypothesis is that there are significant differences between pre and post delay attendance rates (Ho: μ 1 $\neq$ μ 2).

The ANOVA model for attendance rate is significant between the pre-delay year and post-delay 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 time is an important and significant predictor for improved attendance rates.

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

The conclusion of the analysis suggests there is a significant difference in attendance rates when school start times are delayed. The transformed data meets 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 a.m. or earlier to later than 8:30 a.m., 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 a.m. 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 One: What are pre to post start time delay differences in graduation rates in the same schools one year before implementation of delayed start versus two years after the implementation of delayed start times?

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

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

A one-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] utilized a longitudinal study, and the current pre and post two-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 a.m. 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.

While 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, while 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 psycho-social 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 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 a.m. suggests 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 a.m. 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 wellbeing 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.

Reference List

1. Carskadon MA. When worlds collide: Adolescent need for sleep versus societal demands. *The Phi Delta Kappan.* 1999; *80*:384-353.
2. Crowley SJ, Acebo C, Carskadon MA. Sleep, circadian rhythms, and delayed sleep phase in adolescence. *Sleep Medicine*. 2007; *8*:602-612.
3. Carskadon MA, Acebo C, Jenni OG. Regulation of adolescent sleep: Implications for behavior. *Annals of the New York Academy of Sciences*. 2004; *1021*:276–291.
4. Eaton DK, McKnight-Eily LR, Lowry R, Perry GS, Presley-Cantrell L, Croft JB. Prevalence of insufficient, borderline, and optimal hours of sleep among high school students. *Journal of Adolescent Health*. 2010; *46*:399–401.
5. Hansen M, Janssen I, Schiff PC, Dubovich ML. The impact of school daily schedule on adolescent sleep. *Pediatrics. 2005; 115*:1551-1561.
6. Carskadon MA. Sleep in adolescents: The perfect storm. *Pediatric Clinics North America. 2011; 58*:637-647.
7. National Sleep Foundation. *Sleep in America poll*. 2011. Washington, DC: National Sleep Foundation.
8. Dawson P. More proof sleepy teens learn less. *The Education Digest. 2005; 70*: 43-48.
9. Lufi D, Tzischinsky O, Hadar S. Delaying school starting time by one hour: Some effects on attention levels in adolescents. *Journal of Clinical Sleep Medicine. 2011;* 7:37-143.
10. O'Malley E, O'Malley M. (2008). School start time and its impact on learning and behavior, published in, *Sleep and Psychiatric Disorders in Children and Adolescents*, ed. A. Ivanenko. New York: Informa Healthcare 79-94.
11. Wahlstrom, K. Changing times: Findings from the first longitudinal study of later start times. *NASSP Bulletin*. 2002; *86*: 633.
12. Wolfson AR, Carskadon MA. A survey of factors influencing high school start times. *NASSP Bulletin. 2005*: *89*:47-66.
13. Knutson KL, Lauderdale DS. Sociodemographic and behavioral predictors of bed time and wake time among U.S. adolescents aged 15–17 years. *The Journal of Pediatrics*. 2009; *154*:426–430.
14. Wolfson A, Carksdon MA. Sleep schedules and daytime functioning in adolescents. *Child Development*. 1998; *69*:875-887.
15. American Academy Sleep Medicine. High school students with a delayed school start time sleep longer, report less daytime sleepiness. *Science Daily*. June 2008.
16. Centers for Disease Control and Prevention. *Mortality and Morbidity Weekly Report*. 2015.

17. School and Staffing Survey, Public School Start Time 2011-2012. *National Center for Education Statistics*.
18. American Academy of Pediatrics. School start times for adolescents. *Pediatrics*. 2014; *134*:642-649.
19. "LIS > Bill Tracking > HB34 > 2014 session". Leg1. Opening of the school day; Public high schools. United States House of Representatives.
20. Wahlstrom KL. The prickly politics of school starting times. *Phi Delta Kappan*.1999; *5*:344-347.
21. Taylor D, Jenni O, Acebo C, Carskadon M. Sleep tendency during extended wakefulness: Insights into adolescent sleep regulation and behavior. *Journal of Sleep Research. 2005; 14*:239-244.
22. Winsler A, Deutsch A, Vorona RD, Payne PA, Szklo-Coxe M. Sleepless in Fairfax: The difference one more hour of sleep can make for teen hopelessness, suicidal ideation, and substance use. *Journal of Youth and Adolescence. 2014; 44:* 362-378.
23. Roberts RE, Duong HT. Obese youths are not more likely to become depressed, but depressed youths are more likely to become obese. *Psychological Medicine. 2013; 43*;2143–2151.
24. Goldstein TR, Bridge JA, Brent DA. Sleep disturbance preceding completed suicide in adolescents. *Journal of Consulting and Clinical Psychology*. 2008; *76*:84-91.
25. Danner F, Phillips B. Adolescent sleep, school start times, and teen motor vehicle crashes. *Journal of Clinical Sleep Medicine*. 2008; *4*:533–535.
26. Vorona RD, Szklo-Coxe M, Wu A, Dubik, M, Zhao,Y, Ware JC. Dissimilar teen crash rates in two neighboring southeastern Virginia cities with different high school start times. *American Academy of Sleep Medicine. 2011; 7:*145-151.
27. McKnight-Eily LR, Eaton D K, Lowry R, Croft JB, Presley-Cantrell L, Perry G S. Relationships between hours of sleep and health-risk behaviors in US adolescent students. *Preventive Medicine. 2011; 53:*271-273.
28. Dahl RE. The consequences of insufficient sleep for adolescents: Links between sleep and emotional regulation. *Phi Delta Kappan. 1999; 5*:354-359.
29. O'Brien EM, Mindell JA. Sleep and risk-taking behavior in adolescents. *Behavioral Sleep Medicine. 2005; 3:*113-133.
30. Dahl RE, Lewin DS. Pathways to adolescent health: Sleep regulation and behavior. *Journal of Adolescent Health*. 2002; *31*:175-184.
31. Drake C, Nickel C, Burduvali E, Roth,T, Jefferson C, Pietro B. The pediatric daytime sleepiness scale (PDSS): Sleep habits and school outcomes in middle-school children. *Sleep*. 2003; *26*:455–458.
32. Wahlstrom K, Wrobel G, Kubow P. *School Start Time Executive Summary-November 1998*. Report.

33. Wolfson AR, Spaulding NL, Dandrow C, Baroni EM. Middle school start times: The importance of a good night's sleep for young adolescents. *Behavioral Sleep Medicine*. 2007; *5*:194-209.
34. Edwards F. Early to rise? The daily effect of daily start times on academic performance. *Economics of Education Review. 2012; 31*:970-983.
35. Wahlstrom KB, Dretzke B, Gordon K, Peterson K, Edwards K, Gdula J. Examining the impact of later school start times on the health and academic performance of high school students: A multi-site study. University of Minnesota, Center for Applied Research and Educational Improvement. 2014. DOI: http://conservancy.umn.edu/handle/11299/162769
36. Owens J, Drobnich D, Baylor A, Lewin D. School start time change: An in-depth examination of school districts in the United States. *Mind, Brain, and Education*. 2014; *8*:182–213.
37. Hedberg EC, Ayers S. The power of a paired t-test with a covariate. *Social Science Research. 2014; 50*:277-291.

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I Z A
World of Labor
Evidence-based policy making

The educational effects of school start times

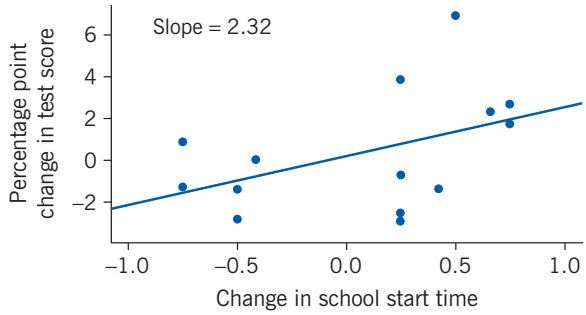
Delaying secondary school start times can be a cost-effective policy to improve students' grades and test scores

Keywords: start times, biorhythms, sleep, secondary education, education production function

ELEVATOR PITCH

The combination of changing sleep patterns in adolescence and early school start times leaves secondary school classrooms filled with sleep-deprived students. Evidence is growing that having adolescents start school later in the morning improves grades and emotional well-being, and even reduces car accidents. Opponents cite costly adjustments to bussing schedules and decreased time after school for jobs, sports, or other activities as reasons to retain the status quo. While changing school start times is not a costless policy, it is one of the easiest to implement and least expensive ways of improving academic achievement.

A one-hour delay in school start times is associated with a 2.32 percentage point increase in test scores



Source: [1].

I Z A World of Labor

KEY FINDINGS

Pros

- Hours of sleep are positively correlated with academic achievement, yet traditional secondary school schedules lead to sleep deprivation among adolescent students.
- Starting classes later in the morning improves grades in classes throughout the day and boosts standardized test scores.
- Even small adjustments in start time can have beneficial effects.
- Lower-ability students gain the most from delayed start times.
- Delaying start times can be a very cost-effective measure for raising student achievement.

Cons

- An optimal start time for secondary schools has not been determined.
- Starting school later will require ending school later, reducing the amount of time available for homework, jobs, and extracurricular activities.
- School districts that rely on one set of buses to serve all different levels of schools—e.g. elementary, middle, and high schools—may need to purchase additional buses or change the start time for the other school levels.
- Reduced time for extracurricular activities may require scheduling adjustments or additional expenses.

AUTHOR'S MAIN MESSAGE

Because adolescents have different internal clocks than younger children and adults, and later natural sleep and waking times, early secondary school start times are not conducive to learning. Empirical studies find sizable gains in test scores and grades from later start times for adolescents. A one-hour delay has the same effect as being in a class with a third fewer students or with a teacher whose performance is one standard deviation higher. Later start times are also shown to improve non-academic outcomes, such as mood and attendance, and reduce the frequency of automobile accidents. While changing start times is not costless, the benefits are likely to outweigh the costs.

MOTIVATION

Sleep–wake cycles are governed by the circadian rhythm, a hard-wired "clock" in the brain that controls the production of the sleep-inducing hormone melatonin. In the early 1990s, researchers discovered that adolescents experience major changes in their circadian rhythm, with an approximately three-hour shift toward later bed and wake-up times, making 7.30 a.m. for an adolescent equivalent to 4.30 a.m. for an adult [2]. Ideally, students whose school starts early would go to bed early to ensure a full night's sleep. However, because of this delay in circadian rhythm, adolescents are unable to fall asleep early enough to get eight or nine hours of sleep before they need to wake up for school, leading to an increase in daytime sleepiness. In much the same way, a typical adult would struggle to fall asleep at 8.00 p.m. in order to wake up at, say, 4.00 a.m. the next morning.

Thus, traditional school schedules affect adolescent sleep patterns by forcing adolescents to wake up and learn at a time when their bodies want to be asleep. A systematic review of adolescent sleep patterns across the world shows a linear trend toward later school-night bedtimes from age 11 to age 18 [3]. The majority of the students examined were deemed to be sleep-deprived after age 13.

Schools have spent a lot of money on improving student outcomes. They have hired better teachers, reduced class size, increased their use of technology, and changed class content and pedagogy, among other measures. Delaying school start times to better align with adolescents' sleep–wake cycles offers sizable benefits to students' academic and emotional outcomes at a relatively low cost.

DISCUSSION OF PROS AND CONS

Adolescents all around the world start their school day early in the morning, at a time when their bodies prefer to be asleep. For example, in the US, most adolescents begin their school day around 7.30 a.m., several hours before their bodies are ready to wake up and begin the day's activities. Studies from multiple disciplines and from many countries have indicated that early school start times lead to sleep deprivation among students and that hours of sleep are positively correlated with academic achievement [4]. While both correlational and anecdotal evidence point toward the benefits of later school start times, the causal relationship between start times and academic achievement has only recently been studied.

Empirical studies on sleep time and school start time

A few studies have looked at how time of day affects student performance. Scores on intelligence tests are significantly lower in the early morning hours for adolescents, which suggest that adolescents' circadian rhythms affect their ability to learn and perform [5]. This hypothesis is supported by research that finds that college students perform better in classes that meet later in the day [6]. Similarly, in Chicago public high schools, both attendance and achievement are significantly lower in first-period classes than in other periods; this effect is particularly strong for mathematics classes [7]. While these studies begin to shed light on the relationship between time of day and learning, the estimated effects are likely biased due to students' ability to select their classes. Students may choose to take a class with a friend or a class that is taught by an instructor they particularly like,

or they may decide to schedule most of their classes during their preferred times of day for learning. Thus, these studies cannot tell us about the causal relationship between school start times and student academic achievement.

There are just a handful of empirical studies that have specifically assessed the academic effects of school start times. Despite the fact that these studies are based in the US, correlational research on start times and global sleep patterns give us no reason to believe that these findings are unique to US students. Most of these studies take advantage of natural experiments based on exogenous changes in school start times. Two studies use the start time change in Minneapolis public high schools from 7.15 a.m. to 8.40 a.m., which was introduced in the 1997/1998 school year. The first study examined course grades earned by students attending Minneapolis high schools in the three years before and the three years after the start time change and found a small, but statistically non-significant, improvement [8].

Grading often has a subjective component, and therefore grades are not easily comparable across instructors or time, the study admits the challenge that arises in measuring academic success with this metric. The second study examining the change in start times in Minneapolis looked at students' ACT (American College Test) exam scores instead. The study compared the ACT scores of students in Minneapolis to those of students in St. Paul, Minneapolis's "twin city," where start times had not changed, and found that the later start times had no effect [9]. Although the ACT is scored more objectively than class assignments and tests, the exam correlates quite highly with general cognitive ability [10]. Since later school start times cannot change students' innate ability, a delayed start time would not be expected to show any effect on ACT scores.

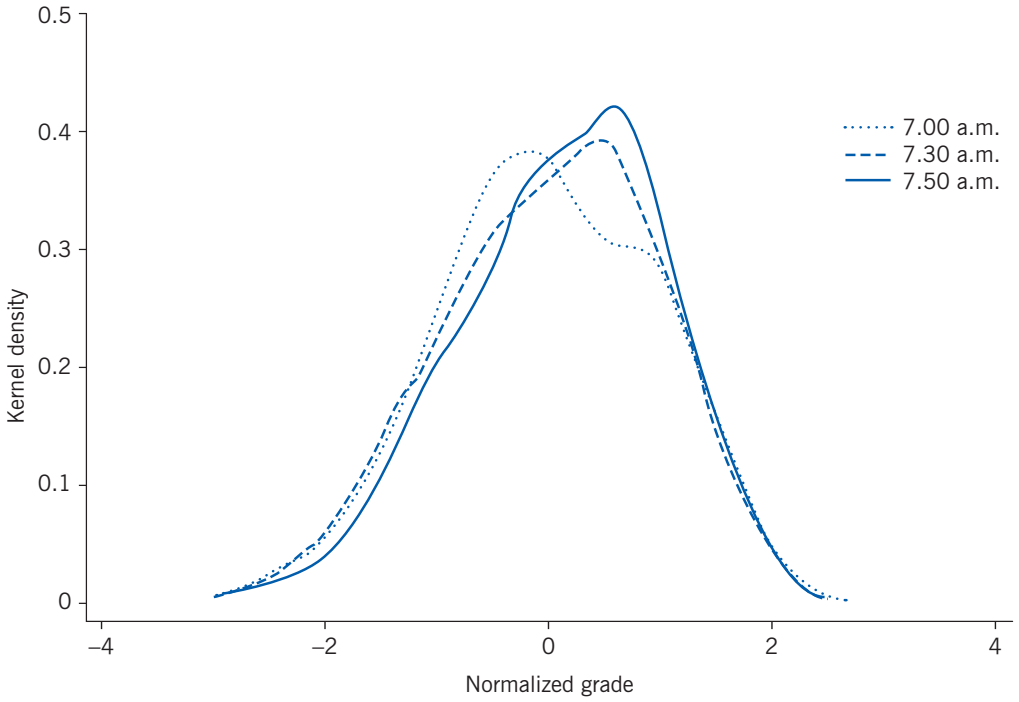
Another study aimed to answer this question by looking at end of the year standardized mathematics and reading test scores in middle schools in Wake County, North Carolina. School start times varied from 7.30 a.m. to 8.45 a.m. as a result of idiosyncrasies in school boundary changes and bus scheduling [1]. These differences enabled the study to explore the effect of later start times by comparing outcomes across schools with different start times and within schools that experienced a change in start time (some were assigned earlier start times while others were assigned later ones). The study finds that an increase in start times by one hour leads to a three percentile point gain in both mathematics and reading test scores for the average student.

A study analyzing course grade data for first-year students at the US Air Force Academy found similar results [11]. Several characteristics of the academic setting there allow for a compelling study of the effects of start time. First, the Air Force Academy had two changes in start times. Classes initially started at 7.30 a.m. They were then moved to 7.00 a.m. and later to 7.50 a.m. Second, students at the Air Force Academy are randomly assigned to their classes and professors during their first year, which eliminates the issue of students selecting into certain classes or class times. Additionally, all students take standardized exams for their core classes, and grading is standardized across all instructors teaching the same course in a given semester. Finally, attendance is mandatory for all classes.

Figure 1, which presents the distribution of students' grades across the three different start times, shows that the later the start time, the higher the distribution of grades. The statistical analysis shows that a 50-minute delay in start times leads to a 0.15 standard deviation increase in course grades across the day. This effect comes not only from improved performance in a student's earliest class, but also from improved performance

in classes throughout the day. Despite the fact that students at the Air Force Academy are not average adolescents (they were high achievers in high school and self-selected into a military academy), there is no reason to believe that this group of students would be more adversely affected by early start times than the average adolescent.

Figure 1. The distribution of grades across school start times shows that the later the start time, the higher the distribution



Note: Grades are "normalized" when certain procedures transform raw grades into standardized ones with an average at 0 and a standard deviation of 1. This kernel density plot shows the smoothed distribution of normalized course grades across start times at the US Air Force Academy.

Source: Carrell, S. E., T. Maghakian, and J. E. West. "A's from zzzz's? The causal effect of school start time on the academic achievement of adolescents." *American Economic Journal: Economic Policy* 3:3 (2011): 62–81 [11].

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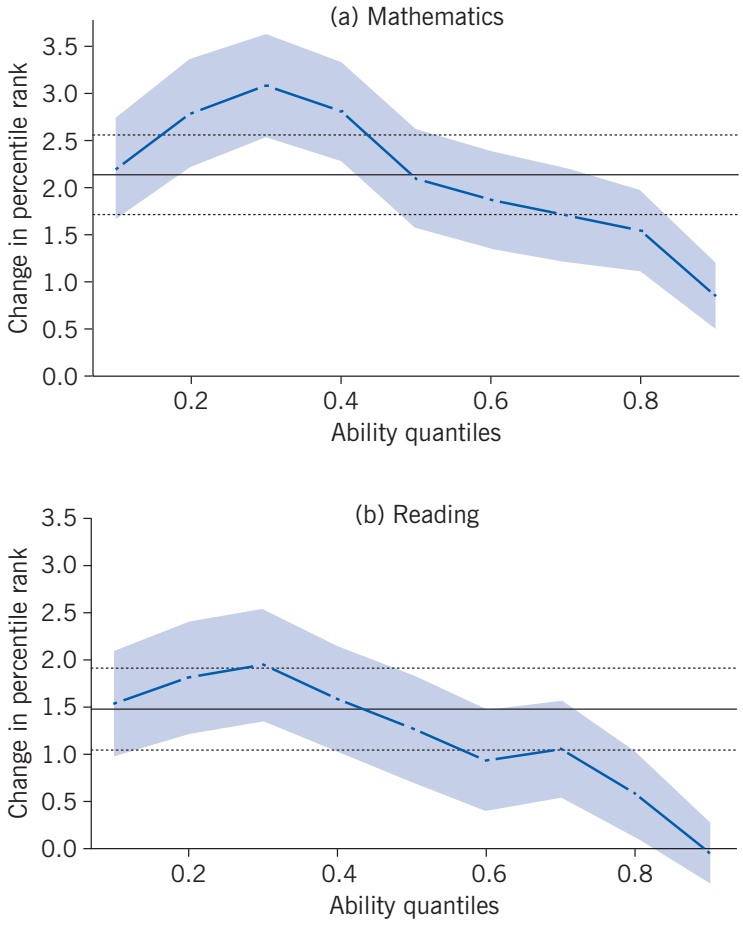
Who benefits the most from start time changes?

Students across the entire ability distribution experience the benefits of later school start times, including the high-achieving students at the US Air Force Academy. Thus, delaying start times has the potential to make all students better off. However, certain students benefit more than others. Both the North Carolina and Air Force Academy studies find that the benefits of later start times are largest for students at the bottom of the grade distribution [1], [11]. Figure 2 shows how the effect of a one-hour delay in start times differs across the grade distribution at middle schools in Wake County, North Carolina. For instance, students in the 30th percentile of the ability distribution end up performing about three percentile points higher on the mathematics exam as a result of a one-hour delay in start time, while students at the 90th percentile perform around one percentile point higher. The fact that benefits differ across ability groups allows for opportunities to alter class schedules for some students if delaying the overall start time is not feasible.

Figure 2. Students at the lower end of the performance distribution benefit more than others from a one-hour delay in school start times



Note: Each point in the figure represents the effect of a one-hour later start time in Wake Country, North Carolina, middle schools for students in different quantiles of the ability distribution on their percentile rank on end of grade exams. The shaded areas represent 95% confidence intervals. The solid horizontal line is the average effect for all students, and the dotted horizontal lines bound a 95% confidence interval around the estimated average.

Source: Edwards, F. "Early to rise? The effect of daily start times on academic performance." *Economics of Education Review* 31:6 (2012): 970–983 [1].

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For example, for schools that have free periods as part of the daily schedule, the lower ability students could be given the first period off, allowing them to start their day later than their peers. Alternatively, their schedules could be set up so that they take their less rigorous classes early in the morning.

How large are the benefits?

The benefits of later school start times are quite large, especially when compared with other—more costly—educational interventions. A one-hour delay in a school's start time has the same effect as being in a class with one-third fewer students or replacing an average teacher with one in the 84th percentile of effectiveness.

Delaying start times by one hour for students in secondary school would increase overall student achievement by roughly 0.10 standard deviation, on average. As in previous studies, this gain can be quantified as a dollar value in order to compare the benefits of this policy change with its potential costs [12]. A one standard deviation rise in test scores is estimated to increase future earnings by 8%. Assuming a 1% growth rate for real wages and productivity and a 4% discount rate, this translates to an approximately $10,000 increase in future earnings per student, on average, in present value terms. The benefit is even larger for students at the bottom of the grade distribution.

Channels of impact and optimal start times

There are at least two channels linking later school start times to improved academic outcomes. The first has to do with sleep and time of day. Early start times lead to increased sleep deprivation, which affects students throughout the day. Because adolescents do not become tired until around 11.00 p.m. or midnight, they are unable to fall asleep early enough to get the recommended amount of sleep. In addition, regardless of the duration of sleep, there are times of day when individuals are more alert and capable of learning. Later start times not only increase the duration of sleep, but they also align more of a student's classes with the hours in the day when students are best able to learn.

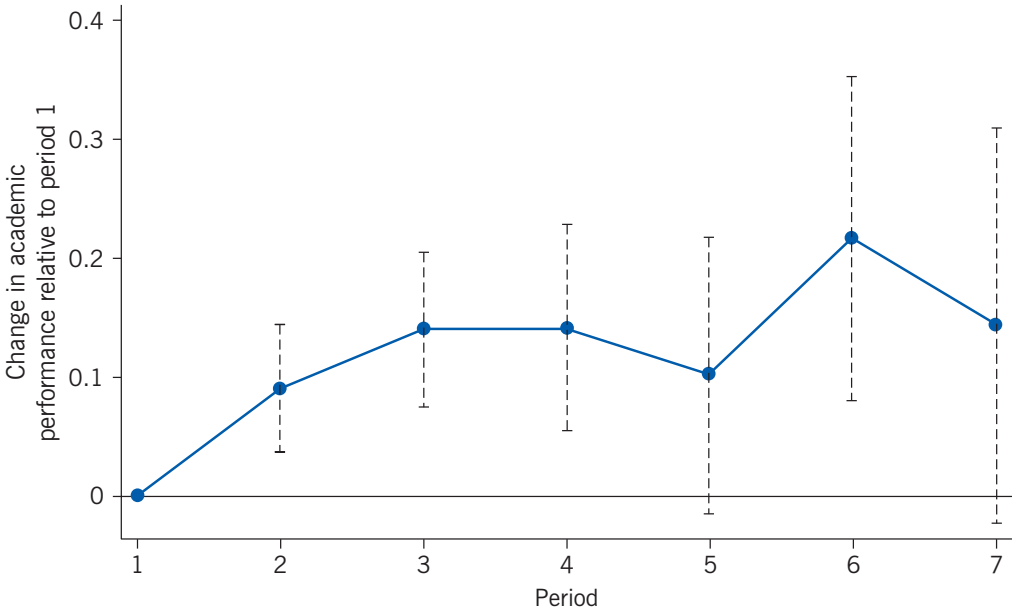
A second channel through which later start times can boost academic outcomes is through improved attendance in the first classes of the day. At many schools, attendance is lower in early classes, and the later the start time, the higher the attendance in first-period classes [7]. However, class attendance is mandatory at the US Air Force Academy, which implies that the negative effects of early school start times are not driven solely by absences or tardiness.

While research has established that later start times can improve academic outcomes, no study has determined the optimal school start time. Studies show that between 7.00 a.m. and 8.45 a.m., later is better. However, whether students would benefit more from having school start even later, 9.30 a.m. for instance, has not been studied. The randomized scheduling at the US Air Force Academy provides the best opportunity to shed some light on this problem. The Air Force Academy study assessed how student performance differs across class periods relative to first period, holding all else constant [11]. As shown in Figure 3, the biggest gains would come from delaying start times to what is traditionally second or third period in many secondary schools (approximately 8.30–9.30 a.m.). In the US, most secondary schools start between 7.00 a.m. and 8.30 a.m., with a majority starting at 7.30 a.m. While there are clear gains to delaying start time to 8.00 a.m. or later, even small delays in the hour between 7.00 a.m. and 8.00 a.m. have been shown to increase achievement.

The costs of delaying school start times

Delaying start times, while far more cost-effective than many other education policies aimed at improving student achievement, is not costless. The two most costly changes, for instance in the US, that may be needed to accommodate delayed school start times would be a larger bus fleet and costs associated with moving after-school activities to later in the day: for example, outdoor lighting for athletic fields. While not insubstantial,

Figure 3. Changes in grades across the school day suggest that later start times would boost achievement for secondary school students



Note: The figure shows the standard deviation change in academic performance in each period relative to the first period, controlling for the characteristics of the class, students, and their daily schedule. The bars represent the 90% confidence intervals of the estimate.

Source: Calculations based on US Air Force Academy data.

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the investment seems worthwhile given the large benefits for students of later start times. For schools without bussing systems and those able to accommodate extracurricular activities in other ways, the cost of this policy change can be even smaller.

To put the estimated costs discussed below in context, recall that delaying start times by one hour would result in an estimated 0.10 standard deviation increase in overall student achievement and an approximately $10,000 average increase in future earnings per student, in present value terms. In the US, the largest cost of delaying start times comes from altering bussing schedules for schools or districts that operate buses. Many districts stagger the start times of their three levels of schools—elementary, middle, and high—to use one set of buses for all schools. Generally, the high schools start first because of safety concerns arising from having younger children waiting outside for buses or walking to school very early in the morning, when it is still dark during much of the school year. Schools that currently provide bussing for their students and that want to change their high school start times will have to accommodate the change by having the other school levels start earlier (at no additional operating cost) or by operating more buses, at additional cost, so that all schools can start later in the morning. Having districts alter their bussing system so that all students start school at the same time would cost approximately $150 per student per year—or $1,950 over a student's school career [10].

Another cost of later start times is the reduction in time available for after-school activities, such as athletic team practice. The average length of the US school day is 6.6 hours, so a 9.00 a.m. start time, for example, would coincide with a dismissal time of about 3.30 p.m.

Many athletic coaches in US schools oppose later school start times because it would limit the number of daylight hours available for team practices and matches. This is less of a problem for indoor sports and other activities.

Schools have several options to offset this concern. One option is to install lights on athletic fields so that students can practice later in the day. The estimated cost of adding lights to athletic fields would be a one-time expense of approximately $110,000 and an annual operating cost of $2,500 [12]. The second option is to alter students' schedules so that the last period of the day is made available for practice if they are on a sports team that practices outdoors. Finally, practices and extracurricular activities can be moved to the morning. While this would not allow students to get more sleep, it would better align class times with the times of day that students learn best.

LIMITATIONS AND GAPS

One limitation of the literature on later school start times is that it has been unable to distinguish how much of the benefits of later school start times arise from absolute learning (how much someone has learned) and how much from relative learning (how much someone has learned compared to their peers). For example, the measured effects of start time on course grades in the US Air Force Academy study are determined by the performance of students who have early start times relative to students taking the same course who start later and have a start time that is more conducive to learning and potentially allows them to get more sleep [11]. Because not all students at the Air Force Academy begin class at the same time, the study could not determine the effect of all students having an earlier or later start time. The effect the study measures is relative learning. Similarly, the North Carolina study looked at percentile scores on standardized tests as an outcome, which, by construction, are relative to peers' test scores in the same year. In that setting, students' percentile scores may increase as a result of later start times not only because of more sleep and increased learning in the classroom, but also because the test is taken at a time when students perform better.

SUMMARY AND POLICY ADVICE

Secondary school students have been subject to school start times and schedules developed around the convenience of others, extracurricular activities, and the status quo, and not around their own best interests. Because adolescents have different internal clocks and sleep patterns than younger children and adults, early school start times are not conducive to their learning. Empirical studies of the impact of later start times on adolescents find sizable gains in grades and test scores. A one-hour delay in school start times leads to a 0.10 standard deviation increase in achievement (the same as improving from a grade of B to a B+ on an A to F scale) in classes throughout the entire day. Scholars across disciplines agree that adolescents would benefit from later school start times. A growing body of research outside of economics has found that delaying school start times has positive effects on a number of non-academic outcomes as well, including hours of sleep, attendance rates, mental health, and frequency of automobile accidents [13].

While research on sleep patterns across the world shows a linear trend toward later school-night bedtimes from age 11 to age 18 [3], sleep research also shows that the biological shift toward later time preference during adolescence usually shifts back in

one's early 20s. This pattern was also detected empirically in the study of Wake County middle schools, which finds that the benefits of later school start times increase with students' age [1]. Thus, the policy discussion about later start times should focus first on high schools and then on middle schools, but does not apply to elementary schools.

These findings suggest that schools and districts have an opportunity to improve student learning and achievement by delaying middle and high school start times. Every school and district will face its own set of challenges associated with changing start times. Schools that do not provide bussing, have a dedicated set of buses for high school students, or already have lighted athletic fields will face the lowest associated costs. A pilot study can be a useful tool for schools and districts to assess the impact of the schedule change on their students. Districts with multiple high schools may choose to have one of the schools start later, while districts with one high school can institute a split schedule in which one set of students starts (and ends) the school day later.

For schools that are unable to delay start times, changing the configuration of the school schedule may also improve student outcomes. Research suggests that the benefits from later start times come not only from allowing students to get more sleep, but also from having classes that are better aligned with the time of day when students are best able to learn. Better alignment can also be achieved by scheduling extra-curricular activities, electives, and non-academic classes (such as physical education) at the start of the school day.

One of the biggest challenges to changing start times is measuring the impact of the change. Course grades at most schools are subjective, curved (assigned to yield a pre-determined distribution of grades), and not comparable across years or instructors. Standardized tests do not necessarily measure what students have learned, most obviously for subjects not tested and especially for students at the top of the grade distribution. Because of these issues, school districts need to be thorough in their assessment of the effects of later start times. Both quantitative measures of achievement (uncurved course grades, standardized test scores) and qualitative measures (feedback from students and teachers) should be assessed to get a complete picture of the impacts.

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Competing interests

The IZA World of Labor project is committed to the *IZA Guiding Principles of Research Integrity*. The author declares to have observed these principles.

REFERENCES

Further reading

Cardinali, D. P. "Chronoeducation: How the biological clock influences the learning process." In: Battro, A. M., K. W. Fischer, and P. J. Léna (eds). *The Educated Brain: Essays in Neuroeducation*. Cambridge, UK: Cambridge University Press, 2008; pp. 110–126.

National Sleep Foundation. *Sleep in America Poll, Teens and Sleep: Highlights and Key Findings*. Arlington, VA: National Sleep Foundation, 2006.

Key references

[1] Edwards, F. "Early to rise? The effect of daily start times on academic performance." *Economics of Education Review* 31:6 (2012): 970–983.

[2] Crowley, S. J., C. Acebo, and M. A. Carskadon. "Sleep, circadian rhythms, and delayed phase in adolescents." *Sleep Medicine* 8:6 (2007): 602–612.

[3] Gradisar, M., G. Gardner, and H. Dohnt. "Recent worldwide sleep patterns and problems during adolescence: A review and meta-analysis of age, region, and sleep." *Sleep medicine* 12:2 (2011): 110–118.

[4] Wolfson, A. R., and M. A. Carskadon. "Understanding adolescent's sleep patterns and school performance: A critical appraisal." *Sleep Medicine Reviews* 7:6 (2003): 491–506.

[5] Goldstein, D., C. Hahn, L. Hasher, U. Wiprzycka, and P. D. Zelazo. "Time of day, intellectual performance, and behavioral problems in morning versus evening type adolescents: Is there a synchrony effect?" *Personality and Individual Differences* 42:3 (2007): 431–440.

[6] Dills, A. K., and R. Hernandez-Julian. "Course scheduling and academic performance." *Economics of Education Review* 27:6 (2008): 646–654.

[7] Cortes, K. E., J. Bricker, and C. Rohlfs. "The role of specific subjects in education production functions: Evidence from morning classes in Chicago public high schools." *The BE Journal of Economic Analysis & Policy* 12:1 (2010).

[8] Wahlstrom, K. "Changing times: Findings from the first longitudinal study of later high school start times." *NASSP Bulletin* 86:633 (2002): 3–21.

[9] Hinrichs, P. "When the bell tolls: The effect of school starting times on academic achievement." *Education Finance and Policy* 6:4 (2011): 486–507.

[10] Koenig, K. A., M. C. Frey, and D. K. Detterman. "ACT and general cognitive ability." *Intelligence* 36:2 (2008): 153–160.

[11] Carrell, S. E., T. Maghakian, and J. E. West. "A's from zzzz's? The causal effect of school start time on the academic achievement of adolescents." *American Economic Journal: Economic Policy* 3:3 (2011): 62–81.

[12] Jacob, B. A., and J. E. Rockoff. *Organizing Schools to Improve Student Achievement: Start Times, Grade Configurations, and Teacher Assignments*. Washington, DC: Brookings Institution Hamilton Project, 2011.

[13] Wahlstrom, K., B. Dretzke, M. Gordon, K. Peterson, K. Edwards, and J. Gdula. *Examining the Impact of Later School Start Times on the Health and Academic Performance of High School Students: A Multi-site Study*. St. Paul, MN: University of Minnesota Center for Applied Research and Educational Improvement, 2014.

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Academic Achievement Across the Day: Evidence from Randomized Class Schedules

Teny Maghakian Shapiro * Kevin M. Williams†

April 5, 2016

Abstract

Students' biological rhythms influence their ability to focus and learn. This paper examines how the daily structure of classes could be reorganized to improve student achievement, all within the confines of a traditional school day schedule. Specifically, we identify the effects of course timing, student fatigue, and teacher schedules. Data consists of five cohorts of college freshman who face randomized scheduling. We find students perform 0.2 standard deviations better in the afternoon than in the morning, but fatigue from prior courses dampens net gains. Heterogeneous effects suggest that redistributing schedules could aid low-achievers, equivalent to improving teacher quality by 0.4 standard deviations.

JEL: I20, J24
Keywords: human capital, class schedules, learning, school start time, adolescents

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1. Introduction

Nearly sixty percent of high school students report feeling tired during class, making it hard for them to focus or stay awake (National Sleep Foundation (2006)). While some inattention during the school day is inevitable, it may also be preventable. A growing body of evidence from economics and other social sciences has shown students' alertness and academic achievement is strongly affected by their biological rhythms. Student's focus will be naturally different based on the time of day a class takes place and what they have done earlier that day. Thus far, the strongest evidence of the impact that class times have on achievement comes from showing that delaying school start times has a positive effect on teens (Carrell et al. (2011), Edwards (2012)). While the evidence on delaying start times has led to passionate discussions in a number of schools and districts across the United States, relatively few school have actually changed their start times, with opponents arguing that the challenges of delaying start times are too large to overcome.

In this paper, we extend upon the link between students' academic achievement and their biological rhythms and determine precisely how the organization of courses throughout the school day impacts performance. Specifically, we explore the independent roles of three aspects of the school day schedule: the time a class is held, student fatigue due to preceding courses, and the instructors' schedule. We also determine heterogeneity of these effects across course and student type and determine whether the order of classes and breaks can affect achievement. Finally, we show through simulations that improvements in average student achievement are possible by rescheduling students within the confines of existing scheduling constraints. By understanding precisely how these features affect academic achievement, school administrators and students may be able to improve outcomes without needing to alter the overall timing and structure of school schedules.

This is the first paper to separately identify the effects of the time a class is held, student fatigue, and the instructors' schedule. This would be difficult, if not impossible, to do in most school settings due to selection into courses/instructors and the subjectivity of grading. Further, in schools where students and teachers are assigned a class during each period, the effect of time

of day can not be separately identified from the effect of fatigue. We are able to overcome these issues by utilizing data from the United States Air Force Academy (USAFA). The school day at USAFA is split into seven class periods, four before lunch and three after, a daily structure very similar to that of the average U.S. middle or high school. But there are a number of other institutional characteristics at USAFA that make it an ideal setting to assess the role of schedules on academic achievement. Schedule assignment is random, grading and instruction are standardized across all sections of a course, exams are taken during a common testing session and teachers regularly teach multiple sections of the same course. Students also alternate daily between two class schedules within the same semester. While total academic course load is similar across students, the alternating schedule creates variation in how much time students spend in class on a given schedule-day. It also allows us to assess how a student performs with one schedule relative to *themselves* with a different schedule.

We focus our analyses on fall-semester freshmen, as they are still in their teens and much of the focus of changes in school start times and schedules is on teens because of their distinct time preferences and its misalignment with traditional school schedules Crowley et al. (2007). We recognize that USAFA students are not the average student; they were high-achievers in high school and chose to attend a military service academy. Although we do not know for certain if school schedules affect high-achievers or military-types differently than the average student, we have no reason to believe that the students in our sample would be *more* adversely affected by components of their daily schedule than the average teen.

We find that, all else equal, the afternoon is the best time of day for student learning, but gains from having a class during the afternoon relative to the morning are mostly offset by fatigue. Specifically, if a student were taking their first class of the day at 2:00 p.m. rather than 7:30 a.m., they would perform about a fifth of a standard deviation better. However, fatigue is such that a student in a 2:00 class which follows a full schedule of classes is predicted to perform 0.13 standard deviations *worse* than in the 7:30 class. Even two students in the same class at the same

time of day may have differences in expected grade as large as 0.1 standard deviations simply due to variation in fatigue from their prior schedules.

Subgroup analysis reveals that the negative effects of fatigue are more extreme for students in the bottom tercile of predicted aptitude. In fact, students in the top tercile are impacted by neither the time of day a course takes place nor schedule fatigue. This suggests that schools can raise mean performance by assigning struggling students to the schedules that are best matched with biological rhythms. Our simulations, which reassign the worst students to the best schedules, find that we can obtain gains for bottom tercile students that are equivalent to increasing teacher quality by 0.4 standard deviations in all courses.[1] We conclude with a discussion of policies, obstacles, costs, and benefits facing the implementation of a rescheduled school day and argue that, compared to many of the inputs commonly studied in the education production function, such as teacher quality and class-size, rescheduling classes to better align with students' optimal learning times is a cost-effective intervention that may be easier for schools to implement than a later start time.

2. Background

To fully understand how the organization of the school day schedule can influence academic achievement, it is important to have a basic understanding of the biology of sleep, wakefulness, and daily fluctuations in cognitive function. The biological rhythm that governs our sleep-wake cycle is called the circadian rhythm, a hard-wired "clock" in the brain that controls the production of the sleep-inducing hormone melatonin. During adolescence, there are major changes in one's circadian rhythm. More adult-like sleep patterns develop, there are increases in daytime sleepiness, and there is a shift in the circadian rhythm towards later bed and wake-up times (Crowley et al. (2007); Carskadon et al. (1993); Wolfson and Carskadon (1998)). There are also times of the day

[1]This is scaled relative to work from Chetty et al. (2014), Kane and Staiger (2008) and Carrell and West (2010) who find a one standard-deviation increase in teacher quality benefits students anywhere from .1-.2 of a standard deviation. We conservatively use a .1 standard deviation improvement for relating our predicted schedule impacts an increase in teacher quality.

when a person is more alert, independent of sleep, which is related to their circadian timing (Blake, 1967). For adolescents, alertness begins in the late morning, drops off mid-afternoon, and peaks again in the early evening (Cardinali, 2008). Research from various scientific fields, including neurobiology and cognitive science, finds that an individual's ability to learn fluctuates throughout the day based on both their biological rhythm (Schmidt et al., 2007) and the total amount of mental activity they have already engaged in (Persson et al., 2007). Goldstein et al. (2007) find that teens perform six points higher on IQ tests if tested during their preferred time of day. Standard academic schedules are quite "out of sync" with teens' circadian rhythms and require students to wake up earlier than their ideal wake time and have many of their classes at a time that is asynchronous with their optimal cognitive function.[2]

Our understanding of sleep, wakefulness, and cognitive function suggests that a student's daily schedule can affect their grades in two separate ways. The first is through the timing of the class; students may not perform as well if classes are scheduled when they're naturally less alert. We refer to this as the time-of-day effect. The second is through the cognitive load a student has experienced prior to the start of a class. We refer to this as the student fatigue effect. While we expect student fatigue to unambiguously hinder academic performance, the time-of-day effect may vary throughout the day. Because academic achievement is an interaction of both learning and teaching, we also estimate the effect of instructor fatigue. However, the expected effect of instructor fatigue is ambiguous. Unlike students, teachers are frequently assigned to teach the same class multiple times per day. Tiredness and mental fatigue could mean teachers are less effective as the day goes on, but learning-by-doing could lead to improvements later in the day. Separately identifying these three components of the daily school schedule allows us to suggest a number of strategies for improving student achievement.

[2]This is not to understate the importance of sleep, which itself is an important to cognitive function. Several studies find an inverse relationship between sleep and academic performance at both the secondary and post-secondary level (Curcio et al., 2006; Wolfson and Carskadon, 1998; Trocket et al., 2000).

A few of strands of literature have assessed the role of time and scheduling on academic and workplace outcomes. The impact of school start times on student achievement has been studied using natural variation across schools or cohorts for identification. The findings have been mixed. Edwards (2012) find positive effects from start time delays on standardized test scores and Carrell et al. (2011), who use the same data as this study, find that grades throughout the entire day benefit from later start times. Meanwhile, Wahlstrom (2002) and Hinrichs (2011) find no effect from the start time change within the Minneapolis Public School district.

Relatively few studies have looked at differential achievement across morning and afternoon classes. Pope (2015) concludes that learning actually decreases throughout the school day by comparing standardized test scores of students who had classes in the morning versus afternoon. Cortes et al. (2012) and Dills and Hernandez-Julian (2008) find the opposite – students perform better in classes that meet later in the day. In each of these studies, the time-of-day effect can not be separately identified from the effect of fatigue.

3. Data

Data for this study come from the United States Air Force Academy (USAFA). USAFA is a fully accredited post-secondary institution with annual enrollment of approximately 4,500 students, offering 32 majors within the humanities, social sciences, basic sciences, and engineering. Despite its military setting, USAFA is comparable to other selective colleges and universities in the United States. Like other selective post-secondary schools, USAFA faculty hold graduate degrees from high quality programs in their fields. Approximately 40 percent of classroom instructors have terminal degrees, similar to large universities where graduate students teach introductory courses. However, class size at USAFA is rarely larger than 25 students, and students are encouraged to interact with faculty members in and out of the classroom. Therefore, the learning environment at USAFA is similar to that of small liberal arts colleges. Students at USAFA are high achievers, with average math and verbal SAT scores at the 88^{th} and 85^{th} percentiles of the nationwide SAT distri-

bution, respectively. Only 14 percent of applicants where admitted to USAFA in 2007. Students are drawn from each Congressional district in the US by a highly competitive admission process that ensures geographic diversity.

A number of USAFA's institutional characteristics make it ideal for addressing this research question. First, the school day at USAFA is very structured, which is atypical of most universities, but similar to a high school setting. Table 1 shows the class schedules for our sample period. There are four 53-minute class periods each morning and three each afternoon after an 85-minute lunch break.[3] All students are required to attend a mandatory breakfast 25 minutes before first period, thus, they must all wake up at around the same time regardless of the time of their first class. Second, students are randomly assigned to all of their courses and instructors. Prior to the start of freshman year, students take placement exams in mathematics, chemistry, and select foreign languages. Scores on these exams are used to place students into the appropriate starting courses (e.g., remedial math, Calculus I, Calculus II, etc.). Conditional on course placement, athlete status, and gender, the USAFA registrar randomly assigns students to required course sections. Students have no ability to choose the class period or their professors in the required core courses. Third, attendance in all classes is mandatory. Fourth, USAFA's grading structure for core courses allows for a consistent measure of student achievement; faculty members teaching the same course in each semester use an identical syllabus, give the same exams during a common testing period, and assign course grades jointly with other instructors, allowing for standardized grades within a course-semester. Finally, 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 schedules alternate days of the week. Thus, the same student has two different class schedules within the same semester.[4] These

[3]The class schedule changed twice during this time period. In our robustness analyses, we show that this does not affect our findings.

[4]Language courses are an exception and meet every schedule-day during the same period. Students are coded as in class for both M and T day of their language course, but only the grade and preceding courses from the M day are included in analysis.

institutional characteristics provide us with random variation in class schedules both across and within students, which, along with extensive background data on students, allow us to examine how course scheduling affects student achievement without worrying about confounding factors or self-selection issues. Athletes are dropped from primary analysis due to their course schedules being influenced by practice times.

Our dataset consists of 4,816 first-year students from the entering classes of 2004 to 2008 who collectively took 22,600 core courses. For each student we have pre-treatment demographic data and measures of their academic, athletic, and leadership aptitude. Academic aptitude is measured through SAT verbal and math scores and an academic composite computed by the USAFA admissions office, which is a weighted average of an individual's high school GPA, class rank, and the quality of the high school they attended. The measure of pre-treatment athletic aptitude is a score on a fitness test required by all applicants prior to entrance. The measure of pre-treatment leadership aptitude is a leadership composite also computed by the USAFA admissions office, which is a weighted average of high school and community activities. Other individual-level controls include indicators for whether a student is Black, Hispanic, Asian, female, a recruited athlete, whether they attended a military preparatory school, and the number of class credits students have on that schedule-day.

We measure academic performance using students' final percentage score earned in a course. To account for differences in course difficulty or grading across years, we normalize all scores to a mean of zero and a variance of one within a course-semester. We refer to this measure as the student's normalized grade. We also consider whether a student received an A or F in the course as an outcome to see the impacts on the extremes of the grade distribution. Students at USAFA are required to take a set of approximately 30 core courses in mathematics, basic sciences, social sciences, humanities, and engineering. In this study, we focus primarily on the mandatory introductory courses in mathematics, chemistry, engineering, computer sciences, English, foreign languages and history. We refer to these as the required freshman courses. Grades in the humanities

courses (English and history) are mostly determined by papers and assignments done outside the classroom, whereas grades in STEM (science, technology, engineering, and math) courses are based on performance on common exams. Accordingly, we examine the effects of STEM and non-STEM course timing separately to see if the effects differ across course type.

Tables 2 and 3 show summary statistics for our sample. The data are at the student-course level. Column (1) of Table 2 shows the summary statistics at this level. Column (2) shows summary statistics at the student-level. Nineteen percent of the students are female, approximately four, eight, and nine percent are black, Hispanic, and Asian, respectively. The mean SAT math score was 669. Column (3) of Table 2 shows statistics for the freshman core courses that we focus our analysis on, while Column (4) shows the STEM core classes specifically. Students enrolled in STEM classes are very similar to those in all required courses. This makes us confident that there is no selection into STEM courses by higher achieving students. The final columns show the characteristics of the students by their tercile of academic composite scores; the "high" tercile are the highest achievers.

Table 3 shows summary statistics by class period. There are some differences across class periods. First, the number of observations for each class period differs, with the most for fifth period (4,600) and the fewest for seventh period (1,738). Student characteristics also vary, as do grades. The goal of this analysis is to determine how much of the variation in grades across the class periods is due to time of day and course schedules, abstracting from differences in student, instructor, and course characteristics.

4. Methodology and Results

Primary Analysis

We begin our analysis by verifying that assignment to different class periods is random with respect to student ability. To do so, we regress student background characteristics on periods of the day dummy variables and course-semester fixed effects to capture within-course deviations in

characteristics. Figure 1 shows the results for the distribution of females, minorities, academic composite, SAT math and verbal and peer academic composite. The 90% confidence intervals are shown. All individual characteristics are clearly uncorrelated with class period. Peer academic composite is the one variable showing differences, with peer "quality" being lower in the morning and higher in the afternoon. This is due to the inclusion of athletes whose courses are disproportionately in the morning. Athletes are included when calculating other students' peer variables, but excluded from the sample we analyze. Carrell et al. (2010) further show that student assignment to required courses at USAFA is random with respect to peer characteristics and professor experience, academic rank, and terminal degree status. They also find no correlation between student characteristics and professor gender. Nonetheless, we are also careful to control for classroom-level peer characteristics to address differences in peers across classes and control for professor characteristics by including instructor-semester and course-by-day fixed effects.

To get a general sense of how grades fluctuate throughout the day, we regress the normalized grade on period dummy variables and course-semester fixed effects. The estimates for all students in our sample are shown in the top panel of Figure 2. The second panel shows grades for STEM and non-STEM courses separately. The third panel shows grades by the three terciles of academic aptitude. A few patterns emerge. First, grades rise and fall over the course of the day–grades dip during 1^{st}, 4^{th} and 7^{th} periods and a peak during 2^{nd} and 6^{th} periods. Second, performance in STEM courses is generally higher than in non-STEM classes, but they follow a very similar pattern across class periods. Finally, the general pattern is similar across ability groups, but appears to be more pronounced for the lower tercile students. Within these patterns are some interesting puzzles. Mean performance in 2^{nd} period is quite strong even though it is at a time asynchronous with adolescents' optimal learning times. Alternatively, 4^{th} period is at a time that is synchronous with adolescents' optimal learning times for learning; however, mean grades in those periods are quite low. While looking at means gives us some insight into patterns that may exist, especially at USAFA where courses and professors are randomly assigned, they also reflect differences in

courses offered during different class periods and differences in professor quality. Using a regression framework, we are able to disentangle the effect of different components of the daily class schedule on student achievement from all other attributes of the student and their schedule. To do so, we estimate the following equation:

$$\begin{aligned} Grade_{icjtsp} =& \alpha + \psi_p + \beta Fatigue + \mu InstructorSchedule + \delta_1 X_{ict} + \delta_2 Peers_{cjtsp} \\ &+ \phi_{cts} + \gamma_{jt} + \rho_i + \epsilon_{icjtsp} \end{aligned} \tag{1}$$

where $Grade_{icjtsp}$ is the normalized grade for student i in course c with instructor j on schedule-day s in period p in year t. ψ_p are period-of-day dummies with 1^{st} period omitted, which measure the time-of-day effect. $Fatigue$ is a vector of the student fatigue characteristics, which we discuss in detail below and $InstructorSchedule$ is a vector of instructor schedule characteristics, also described below. The vector X_{ist} includes the following student characteristics: SAT math and SAT verbal test scores, academic and leadership composites, fitness score, race, gender, whether s/he attended a military preparatory school, and how many credit hours the student had on that schedule-day. To control for classroom peer effects, we include $Peers_{icjtsp}$, the average pre-treatment characteristics of all students in the class except for individual i.[5] ϕ_{cst} are course by year by schedule-day fixed effects, which control for unobserved mean differences in academic achievement or grading standards across courses, years, and schedule-days. Professor by year fixed effects, γ_{jt}, control for fixed differences in instructors within a given year. We also show specifications that include individual student fixed effects, ρ_i, to exploit the within-student variation in schedules across the M/T schedule-days. Standard errors are clustered by student.

[5]Formally, the $Peers$ variables are defined as follows: $\frac{\sum_{k \neq i} X_{kcjtsp}}{n_{cjtsp}-1}$, where X represents the various observable student characteristics.

To assess the effect of student fatigue, we exploit the random variation in both the number of classes a student has had before a given class without a break (consecutive classes) and the number of total classes a student has had before a given class (cumulative classes). The number of consecutive and cumulative classes can vary both *across* students and *within* students because of the M/T schedule-days. For example, Student A may have classes during 2^{nd}, 4^{th}, and 6^{th} periods on one schedule-day, while Student B has classes during 1^{st}, 2^{nd}, 5^{th}, and 6^{th} periods. By 6^{th} period, Student A has had two cumulative classes, but zero consecutive classes (since he had 5^{th} period off), while Student B has had three cumulative classes and one consecutive class. If academic achievement is affected by having had to focus and learn earlier in the day, Student A and B's performance in 6^{th} period will be affected by the time the class is held *and* the number of classes they have had that day, both consecutive and cumulative.[6] Accordingly, we include the following variables in the $Fatigue$ vector: the number of consecutive and cumulative classes a student had before a class and the squares of these variables to account for non-linear fatigue effects.[7]

We include analogous variables in the $InstructorSchedule$ vector: the number of consecutive and cumulative classes an instructor has taught before a given class and the squares of these terms. As with students at USAFA, there is random variation both in the number of consecutive and cumulative classes a professor has taught before a given class. It is unclear, a priori, exactly how instructor schedules should affect student achievement. Teaching may not be cognitively-taxing as learning, but certainly leads to more physical fatigue. While instructors may grow tired as they teach more classes (reflected by a negative effect on student grades), they may also become better at teaching that specific content (reflected by a positive effect on student grades).

[6]We count lunch as a break, so 5^{th} period classes are always given a consecutive value of zero. We have explored alternate definitions of the variable where we do not consider lunch a break and results are quantitatively similar.

[7]We acknowledge that there are a number of ways to define student fatigue, and have explored a variety of alternate definitions. Results are qualitatively very similar and are available upon request.

Classmate Comparison

Our first analysis identifies the time-of-day and fatigue effects on learning by leveraging variation in the times a given course is offered. Our second approach considers only within-class differences in performance. Here, rather than comparing two students taking the same course at different times of the day, we are comparing students in the same class (classmates) who had different schedules earlier in the day. This is achieved by including section specific, rather than course specific, fixed effects. For a given section of a class, students have been randomly assigned to the section at hand and also their preceding schedules. In essence, a student's schedule immediately beforehand can be thought of as a "treatment" on their ability to learn at that time. By comparing students in the same section, we are holding teacher quality and time of day constant.

We refer to the student's schedule preceding a class as their $LeadUp$ scenario and estimate the following equation:

$$Grade_{icjtsp} = \alpha + \beta LeadUp_{icjtsp} * \psi_p + \delta_1 X_{ict} + \delta_2 Peers + \phi_{ctspj} + \gamma_{jt} + \rho_i + \epsilon_{icjtsp} \qquad (2)$$

The primary difference between Equation 1 and this one is the inclusion of the $LeadUp_{icjtsp}$ variables, of which there are four possibilities: Free Period, P.E., STEM Class, Non-STEM Class. Interacting the $LeadUp$ variables with period dummies, ψ_p allows for the effect of a student's prior classes to vary over the day. The section fixed effects, ϕ_{ctspj}, replace the course fixed effects from Equation 1.[8]

Results

The results from the primary analysis are shown in Table 4. The first two columns show the coefficients when excluding the fatigue measures from Equation 1. All columns include individual controls, peer controls and teacher fixed effects. Even-numbered columns also include individual

[8]As before, only core freshman courses are considered. 1^{st} period observations are dropped due to lack of variation.

fixed effects. The third and fourth column add measurements of student fatigue and the fifth and sixth add the instructor fatigue variables. The estimates show that the time of day a class is taken can have a large effect on achievement. For example, all else equal, a student taking their first class of the day at third period performs approximately 0.14 standard deviations better in a class than if they had taken the same class during first period. Interestingly, the period coefficients follow a similar pattern to adolescent sleep-wake cycles, where alertness increases throughout the morning, dips in the early afternoon and then rises again. For easier interpretation, we plot the period coefficients from Column (5), our preferred specification, and their 90% confidence intervals in the first panel of Figure 3.

The student fatigue estimates show consistently negative effects of consecutive classes– each consecutive class decreases performance in a course by about 0.06 standard deviations. The number of cumulative classes a student had before a given class also has negative effects on achievement, but the statistical significance of these estimates are sensitive to the econometric specification. These results suggest that achievement is certainly affected by the fatigue that students experience throughout the school day. However, student achievement is not affected by instructor fatigue. That is, an instructor's prior experience during the school day has no effect on a student's performance in a class. Aggregated coefficients that correspond to a regular daily class schedule are shown in Table 7. The first column assumes student has a full schedule with no breaks besides lunch. The second column shows predictions for a student who has one free period, which is assumed to be in the prior period for each estimate (i.e. number of consecutive classes is always assumed to be 0). Fatigue hinders students' performance as the school day progresses, offsetting the benefits of the later time. For example, a student taking a class during 3^{rd} period is estimated to perform 0.024 standard deviations *worse* than if they had taken the same class during 1^{st} period if the 3^{rd} period class is following two consecutive classes. However, they are estimated to do 0.106 standard deviations *better* if they have 2^{nd} period off. Pope (2015)'s conclusion that students

perform better in the morning than in the afternoon is likely a result of accumulated fatigue in the afternoons, not because students learn better in the morning.

We next assess the heterogeneity of these effects across subsamples of the data. Doing so can help us understand how to optimize class schedules so that the classes and/or students that benefit the most from being during "prime" times are the ones given those times. We use our preferred specification, which includes all fatigue variables and instructor fixed effects, for these analyses.[9] Estimates are shown in Table 5. Column (1) shows estimates with our full sample for easy comparison. Columns (2) - (4) show estimates for students based on their predicted academic tercile upon entering USAFA. It is important to note that since USAFA is a highly selective institution, even the bottom tercile students are among the top 15 percent of students nationally.

We see no statistically significant effects for the top tercile students. Middle tercile students are negatively impacted by having consecutive classes, but their performance does not vary with the time of day. The bottom tercile students, on the other hand, are quite affected by both the time of day and fatigue. The time-of-day effect is striking for this group. The bottom tercile students perform a quarter of a standard deviation better in a 4^{th} period class than during 1^{st} period, with the effects of the afternoon classes being even larger.

These differences by subgroup have meaningful implications for how schools could use scheduling to improve mean achievement. Top students seem robust to their schedules. A likely explanation is that top students are both generally more focused throughout the day and also better able to learn material on their own outside of class. Lower ability students are more dependent on absorbing knowledge during lectures and thus are more adversely affected when unable to focus in class. Given that USAFA students are high achievers to begin with, the cognitive penalties could be even larger for other student populations. Some ill-timed classes are inevitable, but a school could target better schedules at struggling students.

[9] We do not show the estimates from the instructor fatigue variables in the table since they continue to be statistically insignificant; however, these variables are included in the regressions.

Columns (5) and (6) of Table 5 show estimates for STEM and non-STEM classes, respectively. Estimates for STEM classes are very similar to those from our full sample. While non-STEM courses hold a similar pattern, most of the estimates are not statistically different from zero. It's important to note that there are more observations of STEM classes, since a larger share of USAFA's core classes are STEM. Columns (7) and (8) include the full sample of students, but considers different outcomes to better understand the margins at which student achievement is affected. Ace considers whether a student earned an A or A- in the course and fail considers whether the student earned a D or F in the course. Time of day affects students at both these margins, but more significantly in the morning class periods.

Results from the classmate comparison are shown in Figure 4. This specification includes section fixed effects and variation comes from comparing differences in prior schedules among students in the same section. Each bar in the figure represents a single coefficient, β, from Equation 2 sorted by period of the day and color-coded by $LeadUp$ scenario. Having had a non-STEM course prior is the reference group. The second graph includes individual student fixed effects.[10] For two students in the same 3^{rd} period section, one who had a free period during 2^{nd} period and one who had a non-stem course, the student with the free period has an expected normalized grade of 0.15 standard deviations higher. P.E. is similarly beneficial in the morning, but it doesn't seem as though the physicality of P.E. causes it to have differential effects from a free period. A free period beforehand is a strong predictor of success in 2^{nd}, 3^{rd}, 4^{th} and 6^{th} periods; 7^{th} period is an interesting exception. Here, both P.E. and a free period beforehand lead to an expected decrease in performance. One explanation is that these students are mentally "checked out." Lunch, combined with either P.E. or no class means that students have had a nearly three and a half hour break from the classroom. After being in academic mode for some portion of the morning, it may be difficult for students to take an extended break and then re-focus for a single afternoon class. Students who

[10]P.E. is a two-period class, but only meets starting in periods 1, 3 ,and 5 so there are no estimates for a P.E. $LeadUp$ effect in periods 2 or 4.

have two or more classes in the afternoon (thus likely having had breaks in the morning) appear to be better able to perk-up for their classes after lunch.

Robustness Checks

We verify the robustness of our estimates to several changes in model specification with results shown in Table 6. Columns (1) excludes foreign language courses from the analysis. Since students select into their foreign language and classes meet on both schedule-days, these are the least subjective of all the core courses. Column (2) excludes chemistry courses from the analysis since it is a two-period long class. Next, we verify that the results are not purely driven by one of the start-time regimes. Column (3) shows the model restricted to academic year 2007, when first period started at 7:00 a.m. Column (4) is limited to academic years 2005 and 2006, when first period started at 7:30, and Column (5) is for academic years 2008 and 2009, with a 7:50 a.m. start time. The point estimates in the 7:00 start time are much larger than the other years; however, the time of day patterns are similar, as are the fatigue effects. Column (6) shows estimates with the inclusion of recruited athletes, a group whose class assignment may not be as random since they are generally not assigned afternoon courses. The estimates from our robustness specifications are qualitatively similar to those from our main specification, and provide strong evidence that our results are not driven by anomalies in the data.

Simulations

Our main results focus on the impact that time of day, student fatigue and instructor schedules have on grades in individual classes, but we are also interested schedules' aggregate impacts. To examine the overall impact course rescheduling could have on student achievement, we perform two simulations where we assess how achievement would differ if students were assigned schedules based on their academic aptitude. The simulations aim to estimate the extent to which course schedules could be used to equalize student outcomes while raising mean achievement.

We first calculate a predicted own-GPA score for each student, determined using only their background characteristics (e.g. gender, SAT scores). This is used to rank students by predicted ability. Then, every observation (i.e. a student-course) is assigned a schedule-GPA using the time of day and fatigue coefficients.[11] The schedule-GPA value is independent of the characteristics of the student and represents the average impact of each course in a student's schedule. We calculate the average of the schedule-GPA scores by student, yielding each schedule's average impact. In total, there are 4,536 student-schedules, representing over 1,900 different combinations of schedules.

We then re-assign schedules, controlling for the number of courses students take, such that students with low predicted GPAs are given the best-performing schedules and the high-ability students are given the worst ones. We limit ourselves to the set of existing schedules in our data to ensure that results would be feasible within USAFA's current scheduling constraints, such as faculty size and classroom availability, which most schools also face.

The first simulation assumes that the time-of-day and fatigue effects are homogenous across students. Results are shown in Table 8. Results show a narrowing of the overall grade distribution with no change in average performance across students. Specifically, the standard deviation of grades decreases from 0.415 to 0.397, an overall decrease in variance of around 8%. Bottom tercile students experience a 2% of a standard deviation increase in overall performance, but a similar loss is predicted for the top tercile.

The second simulation allows for heterogeneous effects of schedules based on students' predicted ability. The simulation is done in a similar fashion, but we use coefficients from Columns (2) - (4) of Table 5 to estimate the schedule-GPA of each course. Once again, students are assigned schedules in an inverse relationship to their predicted ability– the worst student (based on predicted

[11] Both own-GPA and schedule-GPA use coefficients taken from Column (5) of Table 4.

ability) is assigned the best schedule, while the best student is assigned the worst schedule.[12] By assuming that top, middle, and bottom tercile students experience differing effects of fatigue, there is an opportunity to both narrow the overall GPA distribution and also raise mean performance.

Results from the second simulation are shown in Table 9 and show that re-assigning schedules raises expected performance by 1.2% of a standard deviation for all students. Variance in student achievement is again reduced by 8%. These gains are concentrated in the bottom tercile of student ability – this group experiences an average GPA increase of 3.3% of a standard deviation. This gain is equivalent to increasing teacher quality in all their courses by 0.4 standard deviations. Middle- and top-tercile students experience very slight gains and losses, respectively. Since these students are less affected by course schedule than lower-ability students, being assigned sub-optimal course schedules does not greatly affect their predicted achievement.

5. Discussion and Conclusions

The goal of this study was to determine how the organization of classes throughout the school day affects academic achievement for adolescents. To do this, we consider the effects of three distinct components of course schedules: time of day, student fatigue, and teacher fatigue. We find clear results that both the time of day a class is held and the level of cognitive fatigue a student faces impacts their academic achievement in the class. Two similar students taking the same classes with the same teachers, but with different schedules could be expected to get grades as different as two-tenths of a standard deviation (approximately a grade difference of a B- to a B+). These findings support the notion that the way in which school schedules are currently organized hinders student performance. Adolescents learn better in the late morning and afternoon– times that are better aligned with their circadian rhythms. These results are consistent with Goldstein et al. (2007) who find, that for adolescents, scores on intelligence tests are significantly lower

[12]For each student's schedule, three scores are calculated: one each for the schedule's predicted impact on top, middle and bottom tercile students. A schedule's predicted impact is, again, independent of student characteristics and is only based on the time of day the course takes place and timing of courses a student took earlier on that day.

during the early morning hours. The course and grading structure at USAFA is ideal for this study. Assignment to classes and professors is random, attendance in all classes is mandatory, and all students enrolled in a course in a given semester take the exams during a common testing period and are graded on a collective curve. Because of these features we can be certain that the effects we find reflect differences in learning/understanding of class material and not differences in grading standards. Lower ability students at USAFA, the population in our sample most likely to be similar to the average student nationwide, are most affected by class timing. This research extends our understanding of what outside factors affect academic achievement and provides an opportunity to increase achievement, and, presumably human capital, by rescheduling the times that classes are held.

There are several recommended policies, or rules-of-thumbs, administrators or students could follow, based on our results.[13] First, our findings consistently and strongly support start times in the 9 a.m.-10 a.m. range. However, shifting a school's entire schedule may be expensive to implement or an unpopular policy among parents, teachers, and coaches.[14] Morning P.E. classes, however, can be an effective way to mitigate some of the negative effects of early start times. We also show a clear penalty of consecutive classes, especially for the lowest-performing students. Thus, scheduling free periods and P.E. so they provide breaks throughout the day is beneficial to students.[15]

Subgroup results show that average ability students and STEM classes are most susceptible to the effects of timing and fatigue. The STEM effect could be due to the nature of STEM classes

[13]We recognize that schedules are often difficult to create, because of the multitude of constraints facing specific schools and districts. These include factors such as busing and transportation schedules, after-school programs, classroom availability, athletic schedules, field availability, and teacher loads, among others.

[14]See Jacob and Rockoff (2011) for a full discussion. The authors find that moving back school start time may cost anywhere from $0-$1,900 per student.

[15]We show that an hour-long lunch is akin to a free period. Thus, a break immediately before or after lunch does not provide as much benefit. Free periods during the last period of the day are also wasteful– teens learn well in the afternoon and breaks are best used to offset accumulating fatigue. Sports commonly dictate that students have their last period free because of scheduling conflicts, but our evidence suggests that giving students their last period free should be avoided whenever possible.

(often more lecture based versus discussion based non-STEM courses), but also may simply be due to the limited non-STEM courses in our data. These results suggest that a student's weakest classes should be scheduled at the best times of day, either in the afternoon or following a break. In general, targeting one or two classes per student for optimal timing may be more feasible than restructuring their entire schedule. Unfortunately, our data do not allow us to determine *why* differences across ability groups exist. There are a number of hypotheses as to what explains this difference (high achieving students may be better able to learn when tired, teach themselves material they missed in class, or are more likely to be morning-oriented individuals), and would be an interesting area for further research within the social or biological sciences.

References

Blake, M. (1967), 'Time of day effects on performance in a range of tasks', *Psychonomic science* **9**(6), 349–350.

Cardinali, D. (2008), Chronoeducation: How the biological clock influences the learning process, *in* A. Battro, K. Fischer and P. Lena, eds, 'The Educated Brain', Cambridge University Press.

Carrell, S. E., Maghakian, T. and West, J. E. (2011), 'A's from zzzz's? the causal effect of school start time on the academic achievement of adolescents', *American Economic Journal: Economic Policy* **3**(3), 62–81.

Carrell, S. E., Page, M. E. and West, J. E. (2010), 'Sex and science: How professor gender perpetuates the gender gap', *The Quarterly Journal of Economics* **125**(3), 1101–1144.

Carrell, S. E. and West, J. E. (2010), 'Does professor quality matter? evidence from random assignment of students to professors', *Journal of Political Economy* **118**(1).

Carskadon, M., Vieira, C. and Acebo, C. (1993), 'Association between puberty and delayed phase preference', *Sleep* **16**(3).

Chetty, R., Friedman, J. N. and Rockoff, J. E. (2014), 'Measuring the impacts of teachers i: Evaluating bias in teacher value-added estimates', *American Economic Review* **104**(9), 2593–2632.

Cortes, K., Bricker, J. and Rohlfs, C. (2012), 'The role of specific subjects in education production functions: Evidence from morning classes in chicago public high schools', *The B.E. Journal of Economic Analysis & Policy* **12**.

Crowley, S., Acebo, C. and Carskadon, M. (2007), 'Sleep, circadian rhythms, and delayed phase in adolescents', *Sleep Medicine* **8**.

Curcio, G., Ferrara, M. and Gennaro, L. D. (2006), 'Sleep loss, learning capacity, and academic performance', *Sleep Medicine Reviews* **10**, 323–337.

Dills, A. and Hernandez-Julian, R. (2008), 'Course scheduling and academic performance', *Economics of Education Review* **27**, 646–654.

Edwards, F. (2012), 'Early to rise? the effect of daily start times on academic performance', *Economics of Education Review* **31**(6), 970–983.

Goldstein, D., Hahn, C., Hasher, L., Wiprzycka, U. and Zelazo, P. D. (2007), 'Time of day, intellectual performance, and behavioral problems in morning versus evening type adolescents: Is there a synchrony effect?', *Personality and Individual Differences* **42**(3).

Hinrichs, P. (2011), 'When the bell tolls: The effects of school starting times on academic achievement', *Education Finance and Policy* **6**(4), 486–507.

Jacob, B. A. and Rockoff, J. E. (2011), *Organizing schools to improve student achievement: start times, grade configurations, and teacher assignments*, Brookings Institution, Hamilton Project.

Kane, T. J. and Staiger, D. O. (2008), Estimating teacher impacts on student achievement: An experimental evaluation, Working Paper 14607, National Bureau of Economic Research.

National Sleep Foundation (2006), Sleep in america poll: Highlights and key findings, Technical report, National Sleep Foundation.

Persson, J., Welsh, K. M., Jonides, J. and Reuter-Lorenz, P. A. (2007), 'Cognitive fatigue of executive processes: Interaction between interference resolution tasks', *Neuropsychologia* **45**(7), 1571–1579.

Pope, N. (2015), 'How time of day affects productivity: Evidence from school schedules', *The Review of Economics and Statistics* **98**(1).

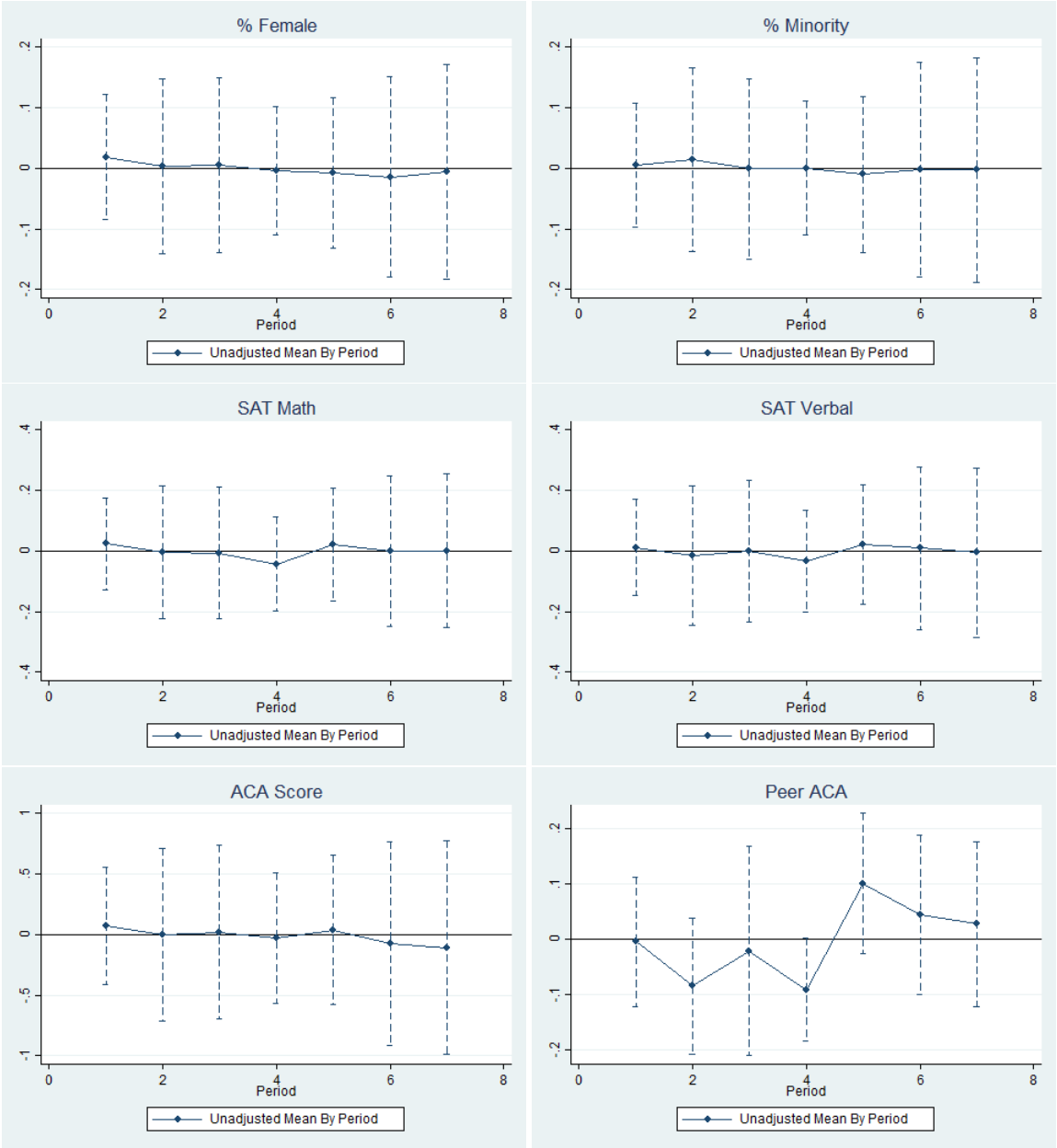
Schmidt, C., Collette, F., Cajochen, C. and Peigneux, P. (2007), 'A time to think: circadian rhythms in human cognition', *Cognitive Neuropsychology* **24**(7), 755–789.

Trocket, M., Barnes, M. and Egget, D. (2000), 'Health-related varibales and academic performance among first-year college students: Implications for sleep and other behaviors', *Journal of American College Health* **49**.

Wahlstrom, K. (2002), 'Changing times: Findings from the first longitudinal study of later high school start times', *NASSP Bulletin* **86**(633).

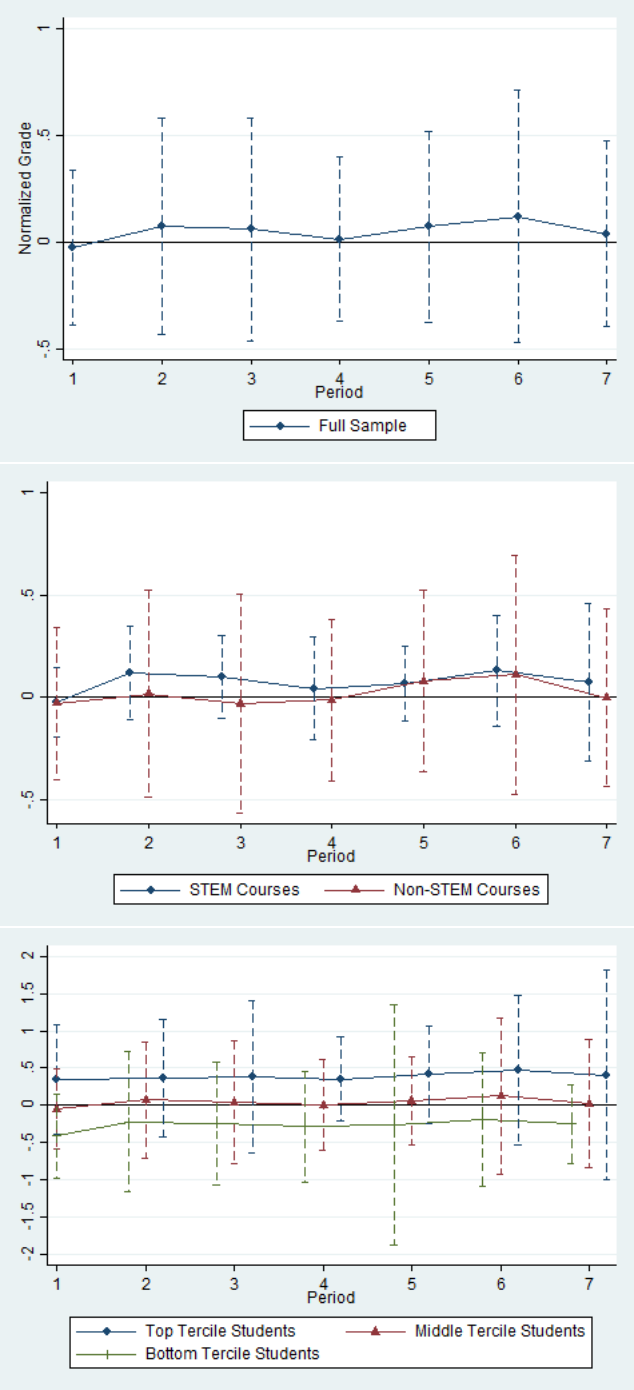
Wolfson, A. and Carskadon, M. (1998), 'Sleep schedules and daily functioning in adolescents', *Child Development* **69**(4).

Figure 1: Randomness Checks



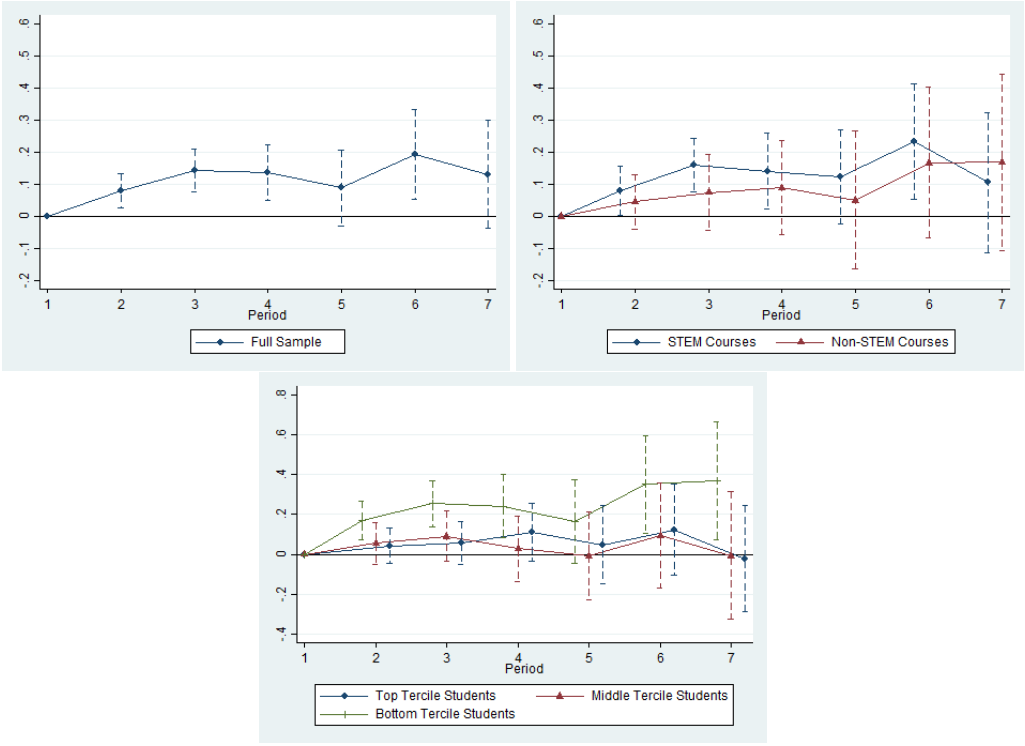
Note:The figures above show the regression coefficients on the class period dummy variables when regressing each of the above background characteristics on class period dummy variables and course-semester fixed effects. The 90% confidence intervals are shown.

Figure 2: Mean Normalized Grades Across Class Periods



Note:The figures above show the regression coefficients on the class period dummy variables when regressing each of the above background characteristics on class period dummy variables and course-semester fixed effects. The 90% confidence intervals are shown.

Figure 3: Plotted Regression Coefficients
Outcome: Normalized Grade



Note:The figures above show the regression coefficients on the class period dummy variables from Equation 1. These estimates are also shown in Table 4. The 90% confidence intervals are shown.

Figure 4: Effects of Preceding Class

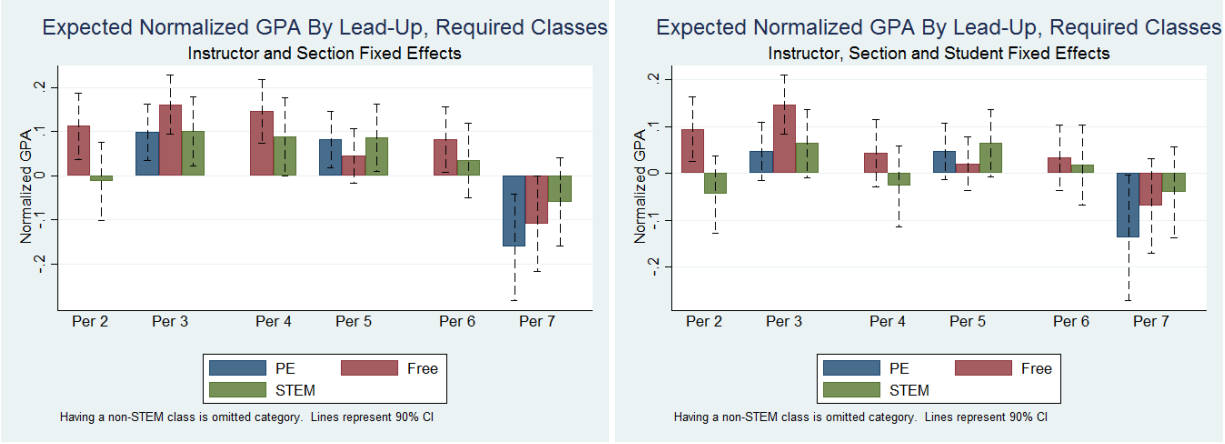


Figure 5: GPA distribution before and after homogenous simulation

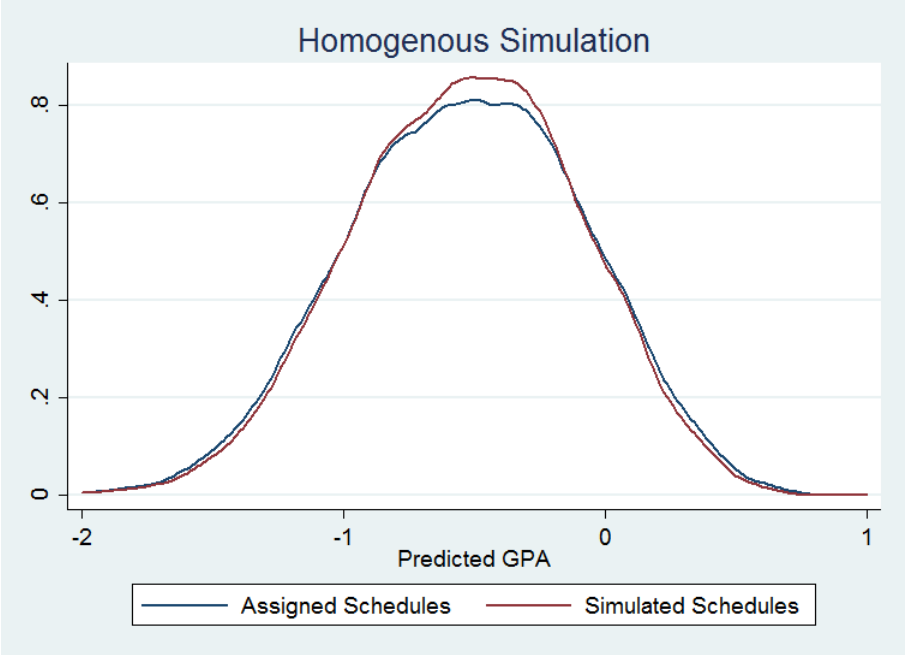


Table 1: **Daily Class Schedule at the U.S. Air Force Academy**

Period	AY1996 - AY2005	AY2006	AY2007 - AY2009
1	7:30	7:00	7:50
2	8:30	8:05	8:50
3	9:30	9:10	9:50
4	10:30	10:15	10:50
5	13:00	13:00	13:30
6	14:00	14:05	14:30
7	15:00	15:10	15:30

Table 2: Student Summary Statistics by Subgroup

	Student-Course		Student		Core		STEM		High		Middle		Low	
	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
Black	0.0363	(0.187)	0.0372	(0.189)	0.0374	(0.190)	0.0340	(0.181)	0.0318	(0.176)	0.0407	(0.198)	0.0394	(0.195)
Hispanic	0.0816	(0.274)	0.0822	(0.275)	0.0816	(0.274)	0.0778	(0.268)	0.0829	(0.276)	0.0722	(0.259)	0.0897	(0.286)
Asian	0.0939	(0.292)	0.0939	(0.292)	0.0941	(0.292)	0.0958	(0.294)	0.0958	(0.294)	0.0888	(0.284)	0.0977	(0.297)
Female	0.190	(0.393)	0.192	(0.394)	0.193	(0.394)	0.189	(0.391)	0.196	(0.397)	0.217	(0.413)	0.165	(0.371)
Prep School	0.167	(0.373)	0.171	(0.376)	0.171	(0.376)	0.164	(0.370)	0.190	(0.393)	0.140	(0.347)	0.183	(0.386)
Fitness Level	4.040	(0.902)	4.045	(0.905)	4.040	(0.901)	4.076	(0.910)	4.073	(0.876)	4.012	(0.890)	4.036	(0.936)
Academic Comp.	13.18	(2.013)	13.16	(2.031)	13.16	(2.007)	13.25	(1.974)	15.28	(0.861)	13.41	(0.585)	10.87	(1.105)
Leadership Score	17.34	(1.796)	17.33	(1.797)	17.35	(1.793)	17.38	(1.798)	17.51	(1.763)	17.34	(1.819)	17.19	(1.783)
Sat Verbal	6.460	(0.650)	6.450	(0.656)	6.450	(0.647)	6.478	(0.643)	6.494	(0.710)	6.460	(0.633)	6.397	(0.589)
Sat Math	6.695	(0.633)	6.689	(0.639)	6.676	(0.627)	6.722	(0.624)	6.778	(0.688)	6.660	(0.608)	6.594	(0.569)
Credits/Day	8.602	(2.292)	8.498	(1.129)	8.854	(2.203)	8.782	(2.233)	8.883	(2.147)	8.896	(2.191)	8.786	(2.267)
Consecutive Classes	0.586	(0.880)	0.574	(0.344)	0.631	(0.902)	0.586	(0.870)	0.650	(0.922)	0.633	(0.899)	0.610	(0.884)
Cumulative Classes	1.524	(1.337)	1.499	(0.321)	1.663	(1.338)	1.508	(1.311)	1.684	(1.348)	1.674	(1.340)	1.633	(1.325)
Cumulative Taught	0.735	(0.888)	0.737	(0.406)	0.760	(0.897)	0.668	(0.869)	0.702	(0.859)	0.758	(0.892)	0.817	(0.932)
Consecutive Taught	0.326	(0.584)	0.325	(0.239)	0.368	(0.599)	0.289	(0.546)	0.346	(0.584)	0.359	(0.587)	0.398	(0.623)
Grade	0.0399	(0.993)	0.0292	(0.696)	0.0515	(0.996)	0.0683	(0.994)	0.390	(0.895)	0.0410	(0.971)	-0.263	(1.008)
Ace	0.216	(0.412)	0.213	(0.260)	0.228	(0.419)	0.253	(0.435)	0.360	(0.480)	0.209	(0.407)	0.119	(0.324)
Failed	0.0626	(0.242)	0.0644	(0.142)	0.0745	(0.263)	0.0947	(0.293)	0.0277	(0.164)	0.0686	(0.253)	0.125	(0.331)
Observations	29736		4816		24264		13210		7891		8175		8198	

Note: The mean and standard deviation of each variable are shown in the table above. The observations are at the student-course level, as shown in the first column. The third column shows the statistics when aggregating the data to the student level. The subsequent columns show summary statistics by course and student characteristics.

Table 3: Student Summary Statistics by Class Period

	Period 1		Period 2		Period 3		Period 4		Period 5		Period 6		Period 7	
	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
Black	0.0412	(0.199)	0.0473	(0.212)	0.0397	(0.195)	0.0401	(0.196)	0.0311	(0.174)	0.0340	(0.181)	0.0236	(0.152)
Hispanic	0.0787	(0.269)	0.0818	(0.274)	0.0837	(0.277)	0.0905	(0.287)	0.0770	(0.267)	0.0814	(0.274)	0.0771	(0.267)
Asian	0.0982	(0.298)	0.0979	(0.297)	0.0890	(0.285)	0.0826	(0.275)	0.0948	(0.293)	0.0953	(0.294)	0.109	(0.312)
Female	0.212	(0.408)	0.196	(0.397)	0.198	(0.399)	0.189	(0.391)	0.185	(0.389)	0.178	(0.383)	0.187	(0.390)
Prep School	0.170	(0.376)	0.180	(0.384)	0.177	(0.381)	0.190	(0.392)	0.157	(0.364)	0.160	(0.367)	0.159	(0.366)
Fitness Level	4.035	(0.888)	4.044	(0.879)	4.074	(0.916)	4.061	(0.902)	4.034	(0.904)	3.998	(0.898)	4.011	(0.924)
Academic Comp.	13.23	(1.996)	13.16	(2.032)	13.18	(2.026)	13.13	(2.031)	13.20	(1.971)	13.09	(1.994)	13.05	(1.997)
Leadership Score	17.38	(1.798)	17.28	(1.774)	17.38	(1.815)	17.36	(1.831)	17.32	(1.802)	17.35	(1.758)	17.34	(1.729)
Sat Verbal	6.461	(0.645)	6.436	(0.660)	6.448	(0.658)	6.416	(0.659)	6.470	(0.629)	6.459	(0.637)	6.445	(0.636)
Sat Math	6.701	(0.645)	6.672	(0.649)	6.669	(0.641)	6.633	(0.622)	6.698	(0.609)	6.676	(0.611)	6.676	(0.599)
Credits/Day	9.050	(2.176)	9.109	(2.129)	8.853	(2.165)	8.906	(2.171)	8.613	(2.305)	8.684	(2.203)	8.864	(2.185)
Consecutive Classes	0	(0)	0.467	(0.499)	1.352	(0.849)	1.275	(1.361)	0	(0)	0.437	(0.496)	1.199	(0.771)
Cumulative Classes	0	(0)	0.467	(0.499)	1.415	(0.782)	1.890	(1.020)	2.473	(1.056)	2.766	(1.007)	3.223	(0.952)
Cumulative Taught	0	(0)	0.510	(0.500)	0.581	(0.680)	0.799	(0.756)	0.954	(0.951)	1.312	(1.010)	1.605	(1.144)
Consecutive Taught	0	(0)	0.516	(0.500)	0.406	(0.686)	0.670	(0.734)	0	(0)	0.464	(0.499)	1.002	(0.752)
Grade	-0.0259	(1.011)	0.0738	(0.981)	0.0586	(1.009)	0.0146	(1.006)	0.0722	(0.987)	0.120	(0.986)	0.0375	(0.974)
Ace	0.216	(0.412)	0.238	(0.426)	0.233	(0.422)	0.221	(0.415)	0.223	(0.417)	0.243	(0.429)	0.219	(0.414)
Failed	0.110	(0.313)	0.0551	(0.228)	0.0855	(0.280)	0.0646	(0.246)	0.0834	(0.277)	0.0503	(0.219)	0.0475	(0.213)
STEM_course	0.669	(0.471)	0.500	(0.500)	0.627	(0.484)	0.440	(0.496)	0.588	(0.492)	0.405	(0.491)	0.503	(0.500)
Observations	3645		3105		4529		3269		4600		3378		1738	

Note: The table above shows the mean and standard deviation of each variable for each class period. The observations are at the student-course level.

Table 4: Primary Analysis

	(1)	(2)	(3)	(4)	(5)	(6)
Period 2	0.0552**	0.0806***	0.0906***	0.123***	0.0797**	0.105***
	(0.0262)	(0.0253)	(0.0284)	(0.0270)	(0.0329)	(0.0308)
Period 3	0.0680***	0.0958***	0.147***	0.181***	0.143***	0.144***
	(0.0246)	(0.0233)	(0.0319)	(0.0299)	(0.0400)	(0.0378)
Period 4	0.0880***	0.117***	0.151***	0.193***	0.136**	0.133***
	(0.0314)	(0.0292)	(0.0393)	(0.0370)	(0.0532)	(0.0503)
Period 5	0.0586	0.0792**	0.100*	0.140***	0.0881	0.0403
	(0.0374)	(0.0352)	(0.0514)	(0.0487)	(0.0720)	(0.0674)
Period 6	0.164***	0.165***	0.228***	0.249***	0.194**	0.125
	(0.0439)	(0.0420)	(0.0562)	(0.0537)	(0.0843)	(0.0793)
Period 7	0.0933*	0.117**	0.180***	0.219***	0.131	0.0704
	(0.0499)	(0.0478)	(0.0623)	(0.0600)	(0.101)	(0.0945)
Consecutive Classes			-0.0655**	-0.0530*	-0.0675**	-0.0553**
			(0.0280)	(0.0271)	(0.0281)	(0.0274)
Cumulative Classes			-0.0326	-0.0469**	-0.0338	-0.0463**
			(0.0236)	(0.0224)	(0.0237)	(0.0225)
Consecutive Squared			0.0154	0.0127	0.0168	0.0143
			(0.0104)	(0.0103)	(0.0105)	(0.0104)
Cumulative Squared			0.00607	0.00944**	0.00612	0.00888**
			(0.00463)	(0.00437)	(0.00464)	(0.00437)
Cumulative Taught					-0.0140	0.0468
					(0.0370)	(0.0346)
Consecutive Taught					0.0618	-0.00242
					(0.0441)	(0.0421)
Teach Cumul Squared					0.0104	0.00199
					(0.00958)	(0.00897)
Teach Consec Squared					-0.0346	-0.0145
					(0.0222)	(0.0213)
Teacher FEs	Y	Y	Y	Y	Y	Y
Individual FEs	N	Y	N	Y	N	Y
N	22600	22600	22600	22600	22445	22445
R2	0.253	0.680	0.254	0.681	0.255	0.682

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < .01$

Note: The table above shows the estimates from Equation 1 when including the variables listed above. All regressions include controls for student characteristics and classroom peer effects as well as course by year by schedule-day fixed effects. Standard errors are clustered by student.

Table 5: Subgroup Analysis

	(1) All	(2) Top Tercile	(3) Mid Tercile	(4) Low Tercile	(5) STEM	(6) Non-STEM	(7) Ace	(8) Fail
Period 2	0.0797**	0.0425	0.0555	0.168***	0.0801*	0.0456	0.0193	-0.0344***
	(0.0329)	(0.0532)	(0.0634)	(0.0585)	(0.0463)	(0.0519)	(0.0142)	(0.00992)
Period 3	0.143***	0.0561	0.0908	0.254***	0.159***	0.0745	0.0404**	-0.0502***
	(0.0400)	(0.0650)	(0.0769)	(0.0699)	(0.0497)	(0.0723)	(0.0171)	(0.0131)
Period 4	0.136**	0.111	0.0280	0.243**	0.140**	0.0889	0.0598***	-0.0413**
	(0.0532)	(0.0893)	(0.0994)	(0.0944)	(0.0713)	(0.0889)	(0.0227)	(0.0166)
Period 5	0.0881	0.0472	-0.00713	0.164	0.122	0.0502	0.0397	-0.0306
	(0.0720)	(0.119)	(0.134)	(0.128)	(0.0884)	(0.130)	(0.0314)	(0.0236)
Period 6	0.194**	0.123	0.0930	0.351**	0.233**	0.167	0.0693*	-0.0410
	(0.0843)	(0.138)	(0.159)	(0.148)	(0.109)	(0.143)	(0.0365)	(0.0266)
Period 7	0.131	-0.0220	-0.00584	0.368**	0.105	0.168	0.0400	-0.0441
	(0.101)	(0.161)	(0.193)	(0.180)	(0.132)	(0.167)	(0.0430)	(0.0310)
Consecutive Classes	-0.0675**	0.0163	-0.0982*	-0.110**	-0.0541	-0.0751*	0.00476	0.0147*
	(0.0281)	(0.0477)	(0.0517)	(0.0525)	(0.0392)	(0.0411)	(0.0122)	(0.00752)
Cumulative Classes	-0.0338	-0.0590	0.00942	-0.0493	-0.0525*	0.0110	-0.0168*	0.00391
	(0.0237)	(0.0402)	(0.0417)	(0.0430)	(0.0299)	(0.0347)	(0.00987)	(0.00619)
Consecutive Squared	0.0168	-0.00277	0.0183	0.0355*	0.0106	0.0216	-0.00384	-0.00284
	(0.0105)	(0.0169)	(0.0198)	(0.0202)	(0.0149)	(0.0154)	(0.00446)	(0.00284)
Cumulative Squared	0.00612	0.00939	-0.00147	0.0129	0.00947	-0.00270	0.00396**	-0.000913
	(0.00464)	(0.00772)	(0.00817)	(0.00851)	(0.00597)	(0.00685)	(0.00196)	(0.00116)
Teacher FEs	Y	Y	Y	Y	Y	Y	Y	Y
Teacher Fatigue	Y	Y	Y	Y	Y	Y	Y	Y
Individual FEs	N	N	N	N	N	N	N	N
N	22445	7291	7550	7604	13080	9365	22445	22445
R2	0.255	0.324	0.242	0.238	0.282	0.267	0.220	0.148

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < .01$

Note: The table above shows the estimates from Equation 1 when including the variables listed above. The outcomes for the regressions shown in columns (1) - (6) is the normalized grade in the course. The outcome for Column (7) is whether the student earned an A or A- in the course while the outcome for Column (8) is whether the student earned a D or F in the course. All regressions include controls for student characteristics and classroom peer effects as well as course by year by schedule-day fixed effects. A full set of teacher schedule variables are included in all regressions, but not shown because they remain statistically insignificant. Standard errors are clustered by student.

Table 6: Robustness Checks

	(1) No Languages	(2) No Chem	(3) 7:00am	(4) 7:30am	(5) 7:50am	(6) Athletes
Period 2	0.0904***	0.0791**	0.119	0.0235	0.109**	0.0589**
	(0.0349)	(0.0371)	(0.0756)	(0.0585)	(0.0513)	(0.0276)
Period 3	0.158***	0.140***	0.291***	0.124**	0.107	0.117***
	(0.0409)	(0.0525)	(0.105)	(0.0587)	(0.0717)	(0.0344)
Period 4	0.150***	0.135**	0.357**	0.124	0.0630	0.127***
	(0.0549)	(0.0666)	(0.151)	(0.0754)	(0.0961)	(0.0460)
Period 5	0.122*	0.0878	0.363	0.109	-0.0184	0.0764
	(0.0735)	(0.0964)	(0.239)	(0.0981)	(0.131)	(0.0643)
Period 6	0.250***	0.193*	0.560**	0.190*	0.106	0.175**
	(0.0870)	(0.107)	(0.277)	(0.114)	(0.155)	(0.0741)
Period 7	0.186*	0.124	0.460	0.155	0.0228	0.116
	(0.104)	(0.124)	(0.320)	(0.137)	(0.186)	(0.0887)
Consecutive Classes	-0.0655**	-0.0684**	-0.108*	0.00663	-0.124***	-0.0851***
	(0.0293)	(0.0292)	(0.0626)	(0.0457)	(0.0434)	(0.0242)
Cumulative Classes	-0.0409*	-0.0500*	-0.0798	-0.0608	0.0123	-0.0364*
	(0.0242)	(0.0260)	(0.0502)	(0.0377)	(0.0384)	(0.0220)
Consecutive Squared	0.0164	0.0185*	0.0324	-0.00454	0.0324**	0.0228***
	(0.0111)	(0.0108)	(0.0236)	(0.0171)	(0.0162)	(0.00884)
Cumulative Squared	0.00765	0.00815	0.0141	0.00872	-0.000950	0.00621
	(0.00479)	(0.00500)	(0.0102)	(0.00746)	(0.00734)	(0.00437)
Teacher FEs	Y	Y	Y	Y	Y	Y
Teacher Fatigue	Y	Y	Y	Y	Y	Y
Individual FEs	N	N	N	N	N	N
N	20655	18643	4503	8963	8979	28825
R2	0.256	0.250	0.273	0.253	0.256	0.256

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < .01$

Note: The table above shows the estimates from Equation 1 when including the variables listed above. All regressions include controls for student characteristics and classroom peer effects as well as course by year by schedule-day fixed effects. Columns (1) and (2) exclude foreign language courses. Columns (3) and (4) exclude student athletes. Columns (5) - (7) limit the sample to each of the start time regimes. Standard errors are clustered by student.

Table 7: Aggregated Coefficients

	Full Schedule	One Break
Period		
1	0	0
2	0.012	0.104
3	-0.024	0.106
4	-0.092	0.075
5	-0.043	-0.058
6	-0.065	-0.043
7	-0.069	-0.009

Estimates are taken from Column (6) of Table 4 and represent predicted impacts of course time and schedule fatigue on student GPA. The earliest class is normalized to 0*. The first column assumes student has a full schedule with no breaks. The second column shows predictions for a student who has one free period, which is assumed to be in the prior period for each estimate (i.e. number of consecutive classes is always assumed to be 0)*

Table 8: Simulation Results: Homogenous Schedules

	All			Bottom Tercile		
	Mean	SD	N	Mean	SD	N
$ActualGPA$	0.0	0.451	4,536	-0.585	0.226	1525
$SimulatedGPA^{homo}$	0.0	0.435	4,536	-0.566	0.219	1525
Difference	**0.0**			**0.019**		

Note: The table above shows the estimates from simulations where students were inversely re-assigned schedules based on predicted own-GPA and predicted overall schedule impact. Schedules were assumed to have homogenous impacts across all students using results from Column (5) of Table 4.

Table 9: Simulation Results: Heterogenous Schedules

	All			Bottom		Middle		Top	
	Mean	SD	N	Mean	SD	Mean	SD	Mean	SD
$ActualGPA$	0.0	0.415	4,536	-0.429	0.245	-0.013	0.121	0.467	0.207
$SimulatedGPA^{het}$	0.013	0.397	4,536	-0.396	0.226	-0.007	0.113	0.464	0.199
Difference	**0.013**			**0.033**		**0.006**		**-0.003**	

Note: The table above shows the estimates from simulations where students were inversely re-assigned schedules based on predicted own-GPA and predicted overall schedule impact. Schedule impacts were predicted separately by ability tercile using results from Columns (2)-(4) of Table 5 .

Press/Articles

STATE CAPITOL
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California State Senate

SENATOR
ANTHONY J. PORTANTINO
TWENTY-FIFTH SENATE DISTRICT

For Immediate Release

Sen. Anthony Portantino Introduces Bill to Start the School Day Later

New Start Time Embraces Overwhelming Research for Student Success and Well-Being

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February 13, 2017

Sacramento, CA – Today, Senator Anthony Portantino introduced SB 328 which will require California school districts to start their middle and high school days no earlier than 8:30 am.

"Every year we discuss as parents, educators, and legislators, best practices and interests of the children and education? Well data is clear; starting the school day later improves the quality of education, health and welfare of our children. So let's do it" said Sen. Portantino.

In 2014, the American Academy of Pediatrics (AAP) issued a policy statement advising school districts to change the school day start time to no earlier than 8:30 am, specifically for middle schools and high schools. Studies have confirmed that insufficient sleep in teenage adolescents poses a public health risk and has an adverse effect on academic success.

According to the APA, reports on school districts who have adopted this policy have found increased attendance rates, grade point averages, state assessment scores, college admission test scores, student attention, and student and family interaction. Additionally, studies also found decreases in student involved car accidents, disciplinary actions, and decrease in student sleeping during lectures.

Currently, California has over 3 million public middle and high school students. The average school day start time for these students is 8:07 am according to the Center for Disease and Control. California school districts would benefit with later school day start times as funding is tied to attendance. The Los Angeles Unified School District estimated by improving the current

attendance rate by just 1%, the district would gain an additional $40 million per year which could be re-invested in California student's educational growth.

#####

Sen. Portantino represents nearly 930,000 people in the 25th Senate District, which includes Altadena, Atwater Village, Bradbury, Burbank, Claremont, Duarte, Glendale, Glendora, La Cañada Flintridge, La Crescenta, La Verne, Monrovia, Montrose, Pasadena, San Dimas, San Marino, Shadow Hills, Sierra Madre, South Pasadena, Sunland-Tujunga, and Upland.

DAILY DEMOCRAT

State senator wants school to start an hour later

By Beau Yarbrough, Los Angeles News Group

POSTED: 02/20/17, 10:18 AM PST | UPDATED: 16 HRS AGO
0 COMMENTS

Anyone who has a teenager, or been one, knows the difficult of getting them out of bed in the morning and off to school.

Scientists have said for years there's a scientific basis for teens' inability to get up bright and early. Now one state legislator wants public schools to bow to scientific consensus and push back the start of the school day.

Senate Bill 328, introduced by State Sen. Anthony Portantino, D-La Cañada, would "require the school day for middle schools and high schools to begin no earlier than 8:30 a.m."

"In education reform, there's arguments raging on all sides, except for this one," Portantino said. "8:30 is the earliest a high schooler or middle schooler should start school."

Portantino, whose district stretches from Burbank in the west to Upland in the east, cites the American Academy of Pediatrics, which in 2014 said that teens who don't get enough sleep "often suffer physical and mental health problems, an increased risk of automobile accidents and a decline in academic performance."

"Adolescents who get enough sleep have a reduced risk of being overweight or suffering depression, are less likely to be involved in automobile accidents, and have better grades, higher standardized test scores and an overall better quality of life," the academy's statement reads in part. "Studies have shown that delaying early school start times is one key factor that can help adolescents get the sleep they need to grow and learn."

It's not just a matter of teens staying up late online, according to Irina Keller, adjunct professor of Child and Adolescent Development at San Jose State University, and a state leader for Start School Later, a "coalition of health professionals, sleep scientists, educators, parents, students and other concerned citizens" seeking to push back school start times.

"It's not because of bad habits, and it's not because of discipline," she said. "There is also a physiological shift in their biological clock."

The influx of hormones and other changes during puberty change teens' circadian, or internal body, clock, she said.

“Unless you can completely isolate from the real natural light and provide artificial lighting, you cannot change their circadian clocks to earlier,” Keller said. “They have to wake up later and go to sleep later.”

Currently, students are essentially walking around jet-lagged, getting up earlier than their brains want to and not getting as much sleep as they need.

“You can forcefully wake them up, but you cannot forcefully make them fall asleep,” Keller said. “Even though they’re tired, and need their sleep, they have trouble falling asleep because their biological clock is not there yet.”

And that means the earliest classes of the day might as well not happen.

“The first hours in school, they cannot learn,” Keller said. “It’s a waste of everybody’s time, energy, money.”

There are other potential benefits as well: Later school start times have been linked to higher attendance rates, according to Portantino. Because schools are paid based on the number of students who show up each day, higher attendance is directly linked to finances. For example, Los Angeles Unified would receive an additional $40 million in annual funding if attendance went up by 1 percent.

Portantino believes the change needs to be adopted statewide. School district schedules are more or less synchronized across the state because of after-school sports schedules and similar activities.

“I’m normally a local control guy,” he said. “But in this incidence, because of all the extracurricular activities are linked to this, you have to do this on a state level.”

But while the science may be clear, changing school start times also means changing the schedules for many of the parents of the more than 6 million California public school students.

“The controversy is not between science and science but between science and a resistance to change,” Keller said.

Portantino acknowledges that challenge but believes it can be overcome.

“There will be an inconvenience to the family routine as we’ve known it for the past 50 years,” Portantino said. “The implementation needs to have deference and respect to that problem.”

Portantino, who served six years in the state Assembly before being elected to the Senate this past November, is optimistic about SB 328’s chances.

“I think if the people look at the science and the data, most parents want what’s in the best interests of their kids,” he said. “The fact that we’re going to make the benefit to the kids front and center, and have the data to back it up, I think the odds of getting it to the governor’s desk are good.”

Keller believes it’s a matter of when, not if, school start times will change

“I do believe at some point, people will look back and say, ‘Gosh, what did we do to our teenagers, waking them up so early?’” she said. “There’s always a gap between science and policy.”

THE BLOG HUFFINGTON POST

02/15/2017 09:19 am ET

Want to Start School Later? You May Want to Move to California

By Terra Ziporyn Snider, PhD

If Senator Anthony Portantino gets his way, California will be the first state in the nation to ensure that teenagers can go to school without sacrificing a good night's sleep. This week he introduced SB328, a bill that would require California school districts to start middle and high school classes no earlier than 8:30 a.m.

"Every year we discuss as parents, educators, and legislators, best practices and interests of the children and education," says Portantino. "Well, data is clear: starting the school day later improves the quality of education, health, and welfare of our children. So let's do it."

The average school day for middle and high school students in California starts at 8:07 a.m., with commute times considerably earlier. These very-early hours were established largely to save money on bus costs before schools understood teen sleep needs and patterns. According to the Centers for Disease Control, more than 4 in 5 American secondary schools start the day before 8:30 a.m., with nearly 10% of high schools requiring attendance before 7:30 a.m.

The result is a public health and equity issue right up there with child labor , smoking, and seatbelts. According to the nonprofit advocacy organization Start School Later (which, full disclosure, I co-founded and now direct) restoring more traditional school start times — as recommended by the American Academy of Pediatrics (AAP), the American Medical Association (AMA), the U.S. Centers for Disease Control (CDC) and other medical and education experts — is a practical and necessary solution with broad and immediate benefits for children of all ages.

Start School Later has nearly 90 chapters across the U.S.A., including a statewide California chapter led by Irena Keller, PhD, adjunct professor of child and adolescent development at San Jose State University, and local chapters in Chico, Los Angeles, Redlands, and San Diego.

LEGISLATION TO HELP LOCAL DISTRICTS

If passed, Portafino's bill will ensure that the more than 3 million public middle and high students in California can go to school at times that allow them to get a healthy night's sleep, have time for breakfast, commute to school after sunrise, and arrive at school ready to learn. It would also be a model for many other states and municipalities around the country that have been unable to restore developmentally appropriate school hours on their own.

Local school districts must, of course, set their specific schedules. However, in many districts local resistance prevents school leaders from acting on the strong body of scientific evidence showing that sleep, and school hours that allow for healthy sleep, are critical to health, safety, and academic achievement. (Those who want help might also benefit from an upcoming national conference on teen sleep and school start times, which includes leaders from districts that have navigated this change successfully.)

Parameters for developmentally appropriate school hours would be consistent with the many other state regulations for local districts, including requirements about the number of days and hours students must be in class. To date, however, no state has provided clear guidelines for safe, healthy school hours, although Maryland and New Jersey recently passed legislation to study or incentivize later school start times.

Last year, Maryland passed the "Orange Ribbon for Healthy Schools" bill to create a no-cost incentive program to recognize districts moving to later bell times. At the federal level, California Congresswoman Zoe Lofgren has also repeatedly introduced versions of a "ZZZ's to A's" Bill and Resolution to the U.S. Congress — all unsuccessful to date — proposing limits on the hours at which American high schools can begin required instruction.

MORE SLEEP = MORE SUCCESS

A large, broad, and consistent body of evidence shows that moving middle and high school bell times later gives more students more (and better) sleep and reduces rates of sleeping in class, mood swings, depression, stimulant and illegal drug use, and car crashes, as well as suspensions, tardies, absences, and drop-outs.

Just this month a new study of 30,000 teenagers across 29 schools in 7 states showed that two years after moving bell times to 8:30 or later, the average graduation rate moved from 79% to 88%. According to study author Pamela McKeever, EdD, the study's findings linking later bell times to improved attendance and graduation rates raise questions for school officials about "whether later start times are a mechanism for closing the achievement gap."

In California, as in many states, improved attendance would also benefit districts financially because school funding is tied to attendance. By improving current attendance by just 1%, The Los Angeles Unified School District would gain an estimated $40 million per year, funds that could be re-invested in schools to benefit students.

INLAND VALLEY BULLETIN

Start high school and middle school one hour later, state senator says

This Sept. 4, 2013 staff file photo shows students at the new Ernest McBride High School heading to class on the first day of school in Long Beach.

This Sept. 4, 2013 staff file photo shows students at the new Ernest McBride High School heading to class on the first day of school in Long Beach. Photo by Stephen Carr, Long Beach Press-Telegram/SCNG/File

By Beau Yarbrough, Inland Valley Daily Bulletin

This April 18, 2016 staff file photo shows Anthony J. Portantino, who represents the 25th State Senate District.

This April 18, 2016 staff file photo shows Anthony J. Portantino, who represents the 25th State Senate District. Photo by Leo Jarzomb, San Gabriel Valley Tribune/SCNG/File

Anyone who has a teenager, or been one, knows the difficult of getting them out of bed in the morning and off to school.

Scientists have said for years there's a scientific basis for teens' inability to get up bright and early. Now one state legislator wants public schools to bow to scientific consensus and push back the start of the school day.

Senate Bill 328, introduced Monday by State Sen. Anthony Portantino, D-La Cañada, would "require the school day for middle schools and high schools to begin no earlier than 8:30 a.m.

"In education reform, there's arguments raging on all sides, except for this one," Portantino said. "8:30 is the earliest a high schooler or middle schooler should start school."

Portantino, whose district stretches from Burbank in the west to Upland in the east, cites the American Academy of Pediatrics, which in 2014 said that teens who don't get enough sleep "often suffer physical and mental health problems, an increased risk of automobile accidents and a decline in academic performance."

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There are other potential benefits as well: Later school start times have been linked to higher attendance rates, according to Portantino. Because schools are paid based on the number of students who show up each day, higher attendance is directly linked to finances. For example, Los Angeles Unified would receive an additional $40 million in annual funding if attendance went up by 1 percent.

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Portantino, who served six years in the state Assembly before being elected to the Senate this past November, is optimistic about SB 328’s chances.

“I think if the people look at the science and the data, most parents want what’s in the best interests of their kids,” he said. “The fact that we’re going to make the benefit to the kids front and center, and have the data to back it up, I think the odds of getting it to the governor’s desk are good.”

Keller believes it’s a matter of when, not if, school start times will change

“I do believe at some point, people will look back and say, ‘Gosh, what did we do to our teenagers, waking them up so early?’” she said. “There’s always a gap between science and policy.”

California State Senator Introduces Bill to Start School Day Later

Posted 3:17 PM, February 13, 2017, by Tracy Bloom, Updated at 03:20PM, February 13, 2017

A California state senator on Monday introduced legislation that would likely result in many schools beginning classes at a later start time.

File photo of a high school classroom. (Credit: KTLA)

Under Senate Bill 328, school districts would be required to implement a start time of no earlier than 8:30 a.m. at middle and high schools, according to a news release from State Sen. Anthony Portantino, who proposed the legislation.

“Data is clear; starting the school day later improves the quality of education, health and welfare of our children. So let’s do it,” said Portantino, who represents the state’s 25th district, which includes Pasadena, Glendale, Glendora, La Cañada Flintridge, Claremont and Upland.

Portantino cited an American Academy of Pediatrics policy statement from 2014, which advised school districts to have a start time of at least 8:30 a.m. for secondary schools, according to the release.

“Studies have confirmed that insufficient sleep in teenage adolescents poses a public health risk and has an adverse effect on academic success,” the release stated.

School districts who have adopted such a policy have found increases in attendance rates, grade point average, college admission test scores, and student and family interaction, among other benefits, the APA reported.

The studies also found a decline in disciplinary action and students sleeping during lectures, as well as a decrease in student-involved car crashes, according to the release.

More than 3 million students attend middle and high schools in California. On average, classes start for these students at 8:07 a.m., according to the Center for Disease and Control.

Noting that funding is tied to attendance, Portantino said California school districts would also benefit with the later start time.

“The Los Angeles Unified School District estimated by improving the current attendance rate by just 1 percent, the district would gain an additional $40 million per year which could be re-invested in California student’s educational growth,” the release stated.

NEWS 7 San Diego

Middle School, High School Students Could Start Day Later Under Bill Introduced by Calif. Senator

By Jessica Rice

Some California middle school and high school students may get a little more sleep under a bill introduced by California Senator Anthony Portantino, D-La Cañada Flintridge.

Portantino introduced SB 328 on Monday, which would require middle schools and high schools in California school districts to start school days no earlier than 8:30 a.m.

"Every year we discuss as parents, educators, and legislators, best practices and interests of the children and education? Well data is clear; starting the school day later improves the quality of education, health and welfare of our children. So let's do it," Portantino said in a statement.

In a statement Monday, Portantino referenced a policy statement from the American Academy of Pediatrics from 2014, in which the organization advised school districts to change start times to 8:30 in the morning or later.

The lead author of the statement, pediatrician Judith Owens, said students who get enough sleep are less likely to be overweight, suffer from depression, become involved in car accidents, and are also more likely to experience positive effects including better grades and standardized test scores.

During multiple studies at schools that delayed start times, at least nine benefits were observed, according to the American Psychological Association. Portantino said his favorite benefit was "increase in quality of student-family interaction.

Another one of the benefits observed was increased attendance at schools that made the shift.

Stemming from that observation, Portantino believes later start times will improve attendance at schools, and thus funding for those schools. If the current attendance rate were improved by one percent, the district would gain an added $40 million a year, Portantino said, citing the Los Angeles Unified School District.

It is unclear how the bill could affect zero period classes, classes that meet before a school's typical start time. Portantino said they have not come to a conclusion about zero period, and said it was left out of

the bill on purpose because they would like to hear from educators and school districts in the state before a decision is made.

Published at 7:49 PM PST on Feb 14, 2017

Source: http://www.nbclosangeles.com/news/local/California-Senator-Introduces-Bill-for-Later-Start-to-School-Day-413745223.html#ixzz4YmyG1AXe

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Sen. Anthony Portantino Introduces Bill to Start the School Day Later

New Start Time Embraces Overwhelming Research for Student Success and Well-Being

Published : Monday, February 13, 2017 | 2:37 PM

Share32

Today, Senator Anthony Portantino introduced SB 328 which will require California school districts to start their middle and high school days no earlier than 8:30 am.

“Every year we discuss as parents, educators, and legislators, best practices and interests of the children and education? Well data is clear; starting the school day later improves the quality of education, health and welfare of our children. So let’s do it” said Sen. Portantino.”

In 2014, the American Academy of Pediatrics (APA) issued a policy statement advising school districts to change the school day start time to no earlier than 8:30 am, specifically for middle schools and high schools. Studies have confirmed that insufficient sleep in teenage adolescents poses a public health risk and has an adverse effect on academic success.

According to the APA, reports on school districts who have adopted this policy have found increased attendance rates, grade point averages, state assessment scores, college admission test scores, student attention, and student and family interaction. Additionally, studies also found decreases in student involved car accidents, disciplinary actions, and decrease in student sleeping during lectures.

Currently, California has over 3 million public middle and high school students. The average school day start time for these students is 8:07 am according to the Center for Disease and Control. California school districts would benefit with later school day start times as funding is tied to attendance. The Los Angeles Unified School District estimated by improving the current attendance rate by just 1%, the district would gain an additional $40 million per year which could be re-invested in California student's educational growth.

FEBRUARY 13, 2017 5:23 PM

California senator wants to push back school start times

Capitol Alert

The go-to source for news on California policy and politics

A teacher goes over first-day-of-class information for students at El Camino High School in 2012. A state Senate bill introduced Monday, Feb. 13, 2017 would prohibit middle and high schools from starting before 8:30 a.m. Randy Pench rpench@sacbee.com

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tluna@sacbee.com

New California legislation may be a boon to tardy teens.

State Sen. Anthony Portantino, D-La Cañada Flintridge, introduced a bill Monday that would prohibit middle and high schools from starting classes before 8:30 a.m. Citing a recommendation from the American Academy of Pediatrics, Portantino says school districts that push back the school day start see an increase in attendance rates, grade point averages and test scores, among other benefits.

“Education reform is a buzz word these days,” Portantino said. “To me this is education reform where there’s no debate about the benefits. The science and research are clear: Our kids will do better if we start the school day later.”

While pediatricians approve, Portantino said his own wife was a little more hesitant to sign on.

She pointed out that an earlier start time may create problems for parents who drop their kids off before heading to work in the morning, he said. The average start time for middle and high school students in California during the 2011 to 2012 school year was 8:07 a.m., according to the Centers for Disease Control and Prevention.

Portantino said he drafted the bill without an implementation date to gather feedback from stakeholders and give parents time to adjust. He believes the benefits for children will outweigh a schedule disruption to parents.

“Most working parents wants what’s in the best interest of their children, as well,” Portantino said.

Beyond health effects, Portantino argues that Senate Bill 328 will increase funding for schools, which is often tied to attendance. The Los Angeles Unified School District, for example, estimates that a 1 percent bump in attendance could bring an additional $40 million in funding to the district.

Taryn Luna: 916-326-5545, @TarynLuna

Read more here: http://www.sacbee.com/news/politics-government/capitol-alert/article132538534.html#storylink=cpy

Beyond time for later school day start for our students

A tired student yawns during history class last year at Belmont High School in Los Angeles. (Los Angeles Times)

The San Diego Union-Tribune Editorial Board

It takes a lot to change a status quo that's been accepted with few questions for generations, especially one that affects tens of thousands of California teachers, millions of public school students and so many parents.

But it's time to revisit the tradition of starting school days as early as Americans do — often before 8 a.m. Evidence is piling up that the sleep deprivation resulting from adolescents' early start times takes a mental, physical and emotional toll, and a new bill by state Sen. Anthony Portantino, D-La Cañada Flintridge, amounts to a wake-up call about wake-up calls.

Portantino's SB 328 would ban public middle and high schools in California from starting class before 8:30 a.m. Introducing it, he cited a 2014 American Academy of Pediatrics study that reported that on school nights, 87 percent of high school students and 59 percent of middle school students slept less than the 8.5 to 9.5 hours recommended by health experts, with the primary reason early school starts that conflict with the students' circadian rhythms — their bodies' 24-hour physiological cycle.

"The research is clear that adolescents who get enough sleep have a reduced risk of being overweight or suffering depression, are less likely to be involved in automobile accidents, and have better grades, higher standardized test scores and an overall better quality of life," academy member Judith Owens wrote. "Studies have shown that delaying early school start times is one key factor that can help adolescents get the sleep they need to grow and learn."

Research by Santa Clara University economist Teny Maghakian Shapiro found that a one-hour delay in school starts produces gains equivalent to those seen when replacing an average teacher with one in the 84th percentile of effectiveness. Specific examples of how students are helped by later school starts are easy to find. At Nauset Regional High School in Eastham, Massachusetts, for instance, D and F grades plunged by half after the start of school was changed from 7:35 a.m. to 8:35 a.m.

Rep. Zoe Lofgren, D-San Jose, has sought to draw attention to sleep deprivation among students since 1998. The National Sleep Foundation supported Lofgren's initial legislation, the Zzz's to A's Act, by citing the findings of Dr. William C. Dement, who founded the first U.S. sleep clinic at Stanford University in 1972: "Students in our nation's schools are walking zombies trying to cope with the stresses of school, work and social activities that may literally be putting their lives in peril."

Now the seriousness of this problem may finally be sinking in. About 1,000 schools in 70 districts have switched to later starts in recent years, with public high schools in Seattle the highest-profile example. This trend must continue.

Yes, later start times may inconvenience parents, frustrate employers and cause headaches for scheduling of school buses and before- and after-school activities. But moving all public school start times at once would make it easier to schedule interscholastic sporting contests. Resulting reductions in absenteeism could mean more school revenue because state funding for schools is tied to attendance. And these days, technology gives workers greater

flexibility than ever, so any adjustments outside campus would be easier. It's clear delaying the start of the school day would help adolescents lead healthier, more productive lives in class and beyond. The facts are plain. It's time to act.

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The Patch

California State Senator Wants Schools to Start Later For Teens

The American Academy of Pediatrics recommends the later start time to align school schedules to the biological sleep rhythms of adolescents.

By Alexander Nguyen (Patch Staff) - February 17, 2017 4:21 pm ET •

California State Senator Wants Schools to Start Later For Teens

LA CANADA FLINTRIDGE, CA — Any parents with teenagers know just how hard it is to wake them up for school in the morning. That is a why a Southern California lawmaker introduced a bill this week to start middle and high school classes later.

The bill by state Sen. Anthony Portantino, a Democrat from La Canada Flintridge, would require school districts in the state start their middle and high school days no earlier than 8:30 a.m. in accordance with a recommendation from the American Academy of Pediatrics.

The APA issued a policy statement in 2014 recommending the later start time to align school schedules to the biological sleep rhythms of adolescents. Teenagers' sleep-wake cycles begin to shift up to two hours later at the start of puberty, according to Dr. Judith Owens, lead author of the policy statement.

"The research is clear that adolescents who get enough sleep have a reduced risk of being overweight or suffering depression, are less likely to be involved in automobile accidents, and have better grades, higher standardized test scores and an overall better quality of life," Owens said. "Studies have shown that delaying early school start times is one key factor that can help adolescents get the sleep they need to grow and learn."

The average school day start time for California's 3 million public middle and high school students is 8:07 a.m., according to Portantino, citing data from the U.S. Centers for Disease Control and Prevention.

California school districts would benefit with later school day start times as funding is tied to attendance, according to Portantino. The Los Angeles Unified School District estimated by improving the current attendance rate by 1 percent, the district would gain an additional $40 million per year, he said.

"Every year we discuss as parents, educators, and legislators, best practices and interests of the children and education," Portantino said. "Well data is clear — starting the school day later improves the quality of education, health and welfare of our children."

LOS ANGELES TIMES

What time should school start? Sen. Portantino introduces bill calling for 8:30 a.m. start time

State Sen. Anthony Portantino (D-La Cañada Flintridge) has introduced a bill that would require middle and high schools across California to start the school day no earlier than 8:30 a.m.

(Tim Berger / Burbank Leader)

Kelly CorriganContact Reporter

Local teens may catch a few more Zs during the school week under a bill that state Sen. Anthony Portantino (D-La Cañada Flintridge) introduced Monday.

Senate Bill 328 would require middle and high schools across California to start the school day no earlier than 8:30 a.m.

In his bill introduction, Portantino cited the American Academy of Pediatrics' policy statement released in 2014 advising school districts to start the day no earlier than 8:30 a.m.

Districts that have adopted the policy have reported improved attendance rates, state exam and college admission scores, and grade-point averages, according to the academy.

Research has also shown that students who start classes later are involved in fewer disciplinary measures and car accidents.

"I wanted to put an evidence-based, sound public policy discussion on the table," Portantino said, when reached by phone on Monday. "The educators I've talked to have all been supportive."

Since school districts coordinate with each other to schedule extracurricular activities and sports games, one district can't set classes back without others doing the same, which gave Portantino another reason to introduce the bill.

"I think it's important to have a statewide conversation on the issue," he said.

In Glendale and Burbank, most middle and high school students begin the school day at 8 a.m., but some students enrolled in a zero-period schedule, where there is an additional period at the beginning of the day, can start as early as 6:55 or 7 a.m.

Each year, a few Glendale parents call school officials or speak at a school board meeting to inquire about starting the school day later, said Kristine Nam, communications director for Glendale Unified, but most complaints are tied to the start time of a zero-period schedule.

Locally, the challenge in coordinating after-school activities and sports games at a later time has halted any serious change.

Shortly after the American Academy of Pediatrics endorsed a later start time, Burbank parent Melinda Froelich requested in 2014 that the school board look into making a change in Burbank's secondary schools.

School board members were not opposed to the idea at the time, but start times remained the same, spurring Froelich to return to the school board in 2015 to again ask about starting later, said Burbank Unified Supt. Matt Hill.

In response, school officials surveyed parents, employees and community members, but the results were mixed.

"We didn't have a consensus of people saying they wanted to move forward," Hill said.

Some respondents were concerned about pushing sports games and after-school activities back, while some working parents said they preferred dropping off their children at school under the current schedule.

In years past, Burbank school officials asked secondary teachers if they've wanted to teach periods two through seven instead of one through six, which would give some students the option to start the school day later.

While no teachers stepped up in years past, Hill said school officials have started asking teachers about their preference again.

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Kelly Corrigan, kelly.corrigan@latimes.com

Twitter: @kellymcorrigan

Stress is making our children ill; here is what we can do about it

By Ro Khanna, Vicki Abeles and Tarun Galagali | January 2, 2017 | Updated: January 2, 2017 12:43pm

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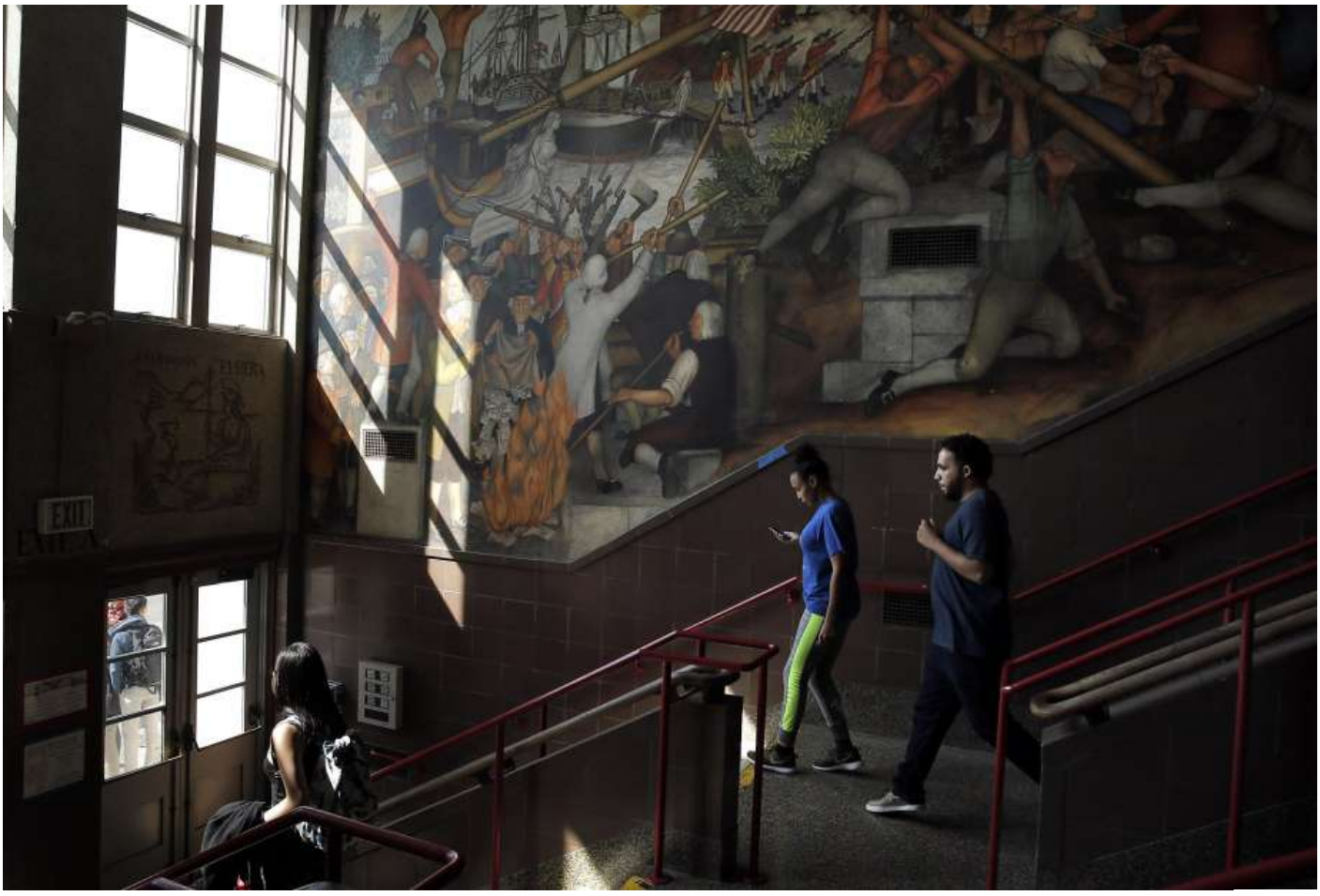

Photo: Carlos Avila Gonzalez, The Chronicle

High school students have-ever increasing demands to perform academically, athletically and socially and less and less time to relax. Many don't get enough sleep. The result: harmful stress.

I will take my oath of office today and have the honor of representing Silicon Valley in the U.S. House of Representatives. My political campaign succeeded because of the help of hundreds of

students. Their ambition and drive will allow them to flourish, but I am concerned about their well-being.

These students were volunteering because of a genuine passion for giving back to the community. But a few also told me that the campaign work was a release, or as one student put it “a respite from our reality.” And while these young adults may not have used terms like anxiety and depression, I gradually got the sense that their “reality” was sometimes darker than their smiles would suggest.

In the most recent California Healthy Kids Survey, 1 in 3 high school juniors reported feeling chronically sad. An astonishing 1 in 5 freshmen and juniors reported contemplating suicide. The causes of student distress vary, but 1 in 3 teens told the American Psychological Association that stress was a primary driver, and the single biggest cause teens named was school.

A large study commissioned by the Centers for Disease Control and Prevention and Kaiser Permanente confirms that children who experience more serious and lasting stress in their youth are more likely to suffer not only anxiety and depression, but also lung, liver and heart disease as adults. While that research examined severe traumas such as abuse or neglect, psychologists and pediatricians increasingly suspect that chronic, lower-intensity stress, like that caused by constant performance pressure, could cause similar biological strain.

It has become clear that we need to do something. Vicki Abeles and Tarun Galagali have helped me put together a five-point plan:

Collect data annually on student wellness: We need to know precisely what we're dealing with at each school. Stuart Slavin, a St. Louis University pediatrics professor, pioneered such a survey at Fremont's Irvington High School, asking students research-backed questions on sleep, stress, anxiety and depression. The results helped guide Irvington administrators in crafting wellness programs. Data makes inaction a costly political decision for officials responsible to constituents.

Create wellness centers: Every school should have a wellness center on site, providing counseling and other services that will help equip students with tools to cultivate good mental health, such as mindfulness. Southern California's Burbank High School is a guiding example.

Shift school start times to 8:30 a.m.: Sleep matters, especially for children and teens. Yet more than two-thirds of our country's students get fewer hours than they need. Sleep deprivation is linked with a weaker immune system and higher levels of depression and suicide (not to mention poorer academic performance). Pushing school start times from 7:30 to 8:30 a.m., as the American Academy of Pediatrics recommends, might be logistically challenging but sensible.

Remake expectations about homework: Homework seems like a given — a central and unquestioned part of a rigorous education. But in truth it is a reflex, borne out of tradition rather than research. Studies suggest that, if homework helps at all, it does so only when assigned in moderation. Today's runaway homework demands are doing more harm than good. Schools should cap the amount of time students can be required to work after the last bell, granting them the chance for rest and exercise, and returning to families the evening hours that are rightfully theirs.

Defuse the college admissions arms race: There's little that drives students to experience more stress than the ever-escalating contest to cram their college applications full of more advanced classes and activities than the next applicant. Yet it's a contest that has little to do with real individual potential or learning. Schools at all levels have a responsibility to intervene. We call on public colleges and universities to cap the number of Advanced Placement classes and activities they will consider on applications.

With the same fervor that we demand our candidates value Medicare and Social Security, we need to ask our public officials to tackle the mental health epidemic afflicting our nation's children. It is an urgent task.

Ro Khanna is the U.S. representative-elect of California's 17th Congressional District. He wrote this commentary with Vicki Abeles, the producer/director of the film "Race to Nowhere" and author of "Beyond Measure: Rescuing an Overscheuled, Overtested, Underestimated Generation" (Simon & Schuster, 2015), and Tarun Galagali, an alumnus of Monta Vista High School in Cupertino.

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Stacy Simera

Still Sleepless in America: The paradox of local control in education

Adolescent sleep loss is a growing concern around the world, and one of the more complicated barriers to addressing this public health issue in America is the paradox of local control.

Experts across the US, most notably the American Academy of Pediatrics, have called for middle and high school start times after 8:30am. Other US groups to support later start times include the American Academy of Child and Adolescent Psychiatry, the National Association of School Nurses, the Society of Pediatric Nurses, and the National Education Association as well as myriad state and local organizations.

There is a body of evidence linking early school start times with chronic adolescent sleep deprivation. Chronic sleep loss is linked with a host of concerns including diabetes, heart disease, more aggressive forms of cancer, car crashes, depression, suicide, substance abuse, aggression, poorer academic functioning, and more.

In regards to academic success, the non-partisan Education Commission of the States released a policy brief last year titled 'Later Education Start Times in Adolescence: Time for Change' that concluded: "Few, if any, educational interventions are so strongly supported by research evidence from so many different disciplines and experts in the field." (Kelley and Lee, 2014, pg 3)

Why, then, do schools in the US continue to run at unhealthy hours when the support is so strong and the science is so overwhelming?

Education and Health ran an editorial in 2012 titled "Sleepless in America: School Start Times" that featured examples of two Americans who were using the evidence to promote healthy school start times: California attorney Dennis Nolan who created the website SchoolStartTime.org, and me. I have been working to raise awareness in Ohio since 2009, and now serve as chair of the Sleep Committee for the Ohio Adolescent Health Partnership and serve on the Executive Board of the national non-profit Start School Later.

Editor David McGeorge contacted me and asked if I could write this follow-up to the 2012 editorial, updating the rest of the world about the progress in Ohio and the US in protecting adolescent sleep. My initial response was that the news is not entirely positive. Awareness is raised, and some communities have acted, but unfortunately the great majority of schools in America have failed to respond to the science. Some schools, in fact, have chosen to shift to even earlier start times - primarily to accommodate bus scheduling.

This article is meant to shed light on the limitations of local control in a key public health issue that exists not only in the United States, but in other countries around the world. A documentary crew from EBS TV in Korea came to visit me last year to talk about the topic, and I heard the same stories of Korean teen sleep and stress that I hear in my own Ohio counselling practice.

Transportation: The tail that wags the dog

Transportation is an oft-cited barrier to adopting school schedules that are healthiest for the students. Former school superintendent, and now professor at Fredonia State College, Dr. Charles Stoddard famously stated: "The tail of transportation wags the dog of the educational system" (Creel, 2010).

Health professionals are very concerned about this trend. Research consistently shows that adolescents experience a later shift in sleep cycle and need adequate sleep for health, yet we have consistently inched school start times earlier and earlier to accommodate bus schedules. Florida, for example, boasts some of the earliest bus runs in the country - including 5:05am bus pick-ups in Orange County (Maxwell, 2015).

Florida state representative Matt Gaetz proposed a state-wide bill in 2013 prohibiting high school start times before 8am, saying: "If local school districts are so caught up in the bus schedule they cannot see the forest for the trees, I think the state has the responsibility to set guidelines. At what point does the bus ride become more important than what happens at the school?" (Trimble, 2013) The bill failed, with some people arguing that the state should not impose upon 'local control'.

In America we often value local control to the point where public health is compromised and where 'control', paradoxically, is limited or lost. My state of Ohio is an example of good intentions gone bad.

Ohio: A case study of the paradox of local control

Ohio, with a population of about 11.5 million, is considered a microcosm of the United States – representing nearly all types of US industry, religions, ethnicities, political views, and geography. Ohio is also the epitome of 'local control' in education – with over 600 sovereign public school districts with its own superintendent and school board. Such localized control could lead one to assume that change is therefore easier, however it is often the opposite – and primarily due to transportation issues.

If an Ohio student chooses to attend a private or STEM school instead of his/her local public school, the public school must, in most instances, provide the student with transportation to the school of choice. Public schools also often band together to create vocational schools or 'compacts' in which 5 to 15 local schools send select students to a different facility to learn a trade while completing high school. In addition, the scheduling of athletic events or other extra-curricular activities requires a level of cooperation between schools in the same athletic conference.

Thus if a public school wishes to adopt later start times without cooperation from nearby schools, the resulting upheaval in transportation schedules can be daunting and possibly create an economic burden if the school must create separate bus runs for literally one or two STEM or charter school students. Because of localized control, neighbouring schools are not answerable to each other, and regional attempts at change can be thwarted by one stubborn school board. Local control has become, in this instance, the reason that local school boards have limited control over their ability to act on the recommendations of the nation's pediatricians. Local control becomes 'local lack of control'.

This paradox, and of course the overwhelming scientific evidence, is why many experts are calling for the states to step in to set healthy boundaries for school start times.

Legislation: Protecting children by setting healthy parameters

State and federal regulations to protect children are common - such as seat belt usage, graduated driver's licenses, school lunch requirements, and child labor laws. The lack of state and federal intervention on school start times, therefore, baffles most experts.

In America we pride ourselves on our child labour laws, yet look the other way when children rise in the 4 or 5 o'clock hour and walk to school or the bus stop in the dark. Given the approximately 90-minute later shift in sleep cycle experienced during puberty, and given that adolescents require approximately 90 minutes more sleep than adults – a compulsory wake time of 5am for teens is biochemically similar to a compulsory wake time of 2am for all adults – something few Americans would tolerate. In recent decades, for example, changes to the regulations surrounding the work schedules of air traffic controllers, pilots, train conductors, truck drivers, and naval submarine crews have been made to further protect the sleep of working adults.

Many people have stated that early school start times 'prepare kids for the real world' – however when it comes to sleep, American adults appear to have better protection than children.

Children will also be better prepared for the 'real world' if they can make it through puberty intact. Davis et al (2013) found that 14 and 15

year olds who were sleep-restricted experienced 50% more 'hits' and 'close calls' in virtual cross-walk situations. Milewski et al (2013) found that teens who obtained less than 8 hours of sleep per night experienced 68% more sports injuries than their peers who slept more. And Walhstrom et al (2014) found that teen drivers in school districts that adopted later school start times experienced 65% and 70% fewer car crashes. Space limits me from citing the research on the links between chronic sleep disruption and diabetes, multiple sclerosis, depression, and other conditions that limit our American goals of life, liberty, and the pursuit of happiness. To sum: later school start times can literally save lives.

Local Success: The dog CAN wag the tail

I must give credit to the communities in America who have overcome the barriers of local control, examples of which can be found on the 'Success Stories' portion of the Start School Later website. One of the more notable is the Fairfax Public School District in Virginia. Fairfax runs the largest bus fleet in the nation and the school board recently voted to start school later in the coming 2015/2016 school year – proving that the dog can 'wag the tail' and adults can prioritize student health and learning over the daunting task of revising bus schedules. Fairfax contracted with Children's National Medical Center to study the issue, and the consultants created a Blueprint for Change which has generously been made publicly available.

Hundreds of schools in nearly every state in the nation have adopted later start times, but those are merely drops in the bucket. Out of the over 600 public school districts in Ohio, the following schools have adjusted starting times for adolescents due on the research, or will do so in the coming school year: Hudson, Kenston, Dublin, Northridge, Perrysburg, Westlake, and Hamilton City. We can do better.

Zzz's to A's Act: Calling for a federal study

At the national level US Congresswoman Zoe Lofgren has introduced the Zzz's to A's Act that would require the US Secretary of Education to conduct a study of the issue. However just the idea of a federal study has some members of Congress declining to support the bill, citing concerns about infringing on local control. I commend Representative Lofgren and the bill's co-sponsors (including Ohio Representatives Tim Ryan and Joyce Beatty) for prioritizing child health. Unfortunately the Zzz's to A's Act is currently stagnant, with little expectation for success. Its opponents often point out that American education is in the hands of the states – to which health experts reply: "Then our states must do the right thing."

A Call to State Legislators: Be the hero

In September of 2014 the Aurora Sentinal in Colorado penned an editorial 'The school bell should toll later for better test scores', with the first sentence acknowledging the core issue: "The importance of local control of schools is one of the most critical components of a successful public school system, but there are times when only the state can fix a pervasive problem."

The editorial staff outlined the research and the need for state-level action, and ended the piece with this compelling plea: "All the state needs is a few state legislators ready to step up and be the hero. We're ready to take names."

I and my colleagues in the US and around the world echo that plea: Lawmakers – stand up for child health, safety, and learning. Stand up and introduce and support legislation requiring developmentally-appropriate school start times. Stand up and be the hero. Then sit back and watch our children excel.

References:

Creel, J. (2010) *Get up! Sleepy teens roam school halls while debate goes on about changing start times*. Buffalo News; 8 April 2010 [Accessed 11 May 2015] Available at: http://www.buffalonews.com/article/20100408/LIFE04/304089899

Davis L, Avis K, Schwebel DC. (2013) *The Effects of Acute Sleep Restriction on Adolescents' Pedestrian Safety in a Virtual Environment*. Society for Adolescent Health and Medicine Vol 53, Issue 6, pp 785-790. http://dx.doi.org/10.1016/j.jadohealth.2013.07.008

Kelley, P and Lee, C. (2014) *Later Education Start Times in Adolescence: Time for Change.* Policy Brief by the Education Commission of the States. Available at: http://www.ecs.org/clearinghouse/01/12/19/11219.pdf

Maxwell, S (2015*) 5 a.m. bus rides, 6:30 walks to school? All too early*. Orlando Sentinal; 18 April 2015. [Accessed 11 May 2015] Available at: http://www.orlandosentinel.com/opinion/os-school-start-times-scott-maxwell-20150418-column.html

Milewski, MD, Pace, JL, Ibrahim, DA, Greg Bishop, G, Barzdukas, A. and. Skaggs, DL. (2014) *Chronic lack of sleep is associated with increased sports injuries in adolescent athletes*. J Pediatr Orthop. March; 34(2): 129-33. doi: 10.1097/BPO.0000000000000151

Trimble, L. (2013) *Lawmaker pitches plan to start high school later in the morning.* Daytona Beach News Journal; 2 Nov 2013. [Accessed 11 May 2015] Available at: http://www.news-journalonline.com/article/20131102/NEWS/131109901

Wahlstrom, Kyla; Dretzke, Beverly; Gordon, Molly; Peterson, Kristin; Edwards, Katherine; Gdula, Julie. (2014). *Examining the Impact of Later High School Start Times on the Health and Academic Performance of High School Students: A Multi-Site Study*. [Accessed 11 May 2015] Available via the University of Minnesota Digital Conservancy: http://hdl.handle.net/11299/162769

NEWS

Teens' Self-Regulation Associated with Circadian Rhythms & Daytime Sleepiness

A study in the December 2016 *Pediatrics* indicated that, among adolescents, daytime sleepiness and a circadian-based eveningness chronotype (the tendency to be a "night owl (/English/healthy-living/sleep/Pages/Staying-Out-Late-and-Curfews.aspx)" who falls asleep later and wakes up later) are stronger predictors of poor self-regulation than a short amount of nighttime sleep (/English/healthy-living/sleep/Pages/Healthy-Sleep-Habits-How-Many-Hours-Does-Your-Child-Need.aspx).

The study, "Self-Regulation and Sleep Duration, Sleepiness, and Chronotype in Adolescents (http://pediatrics.aappublications.org/cgi/doi/10.1542/peds.2016-1406)," (to be published online Nov. 1), surveyed 2,017 students between 7th and 12th grades in Fairfax County, Va., schools.

Self-regulation is defined in the study as "the act of managing cognition and emotion" in a way that that helps to organize behavior, control impulses and solve problems constructively. Self-regulation is governed by a number of brain regions that undergo profound developmental changes during adolescence. Impaired self-regulation is associated with adverse effects on health and functioning, with long-term implications.

The authors suggest that early school start times may interfere with teens' self-regulation because during puberty (/English/ages-stages/gradeschool/puberty/Pages/Physical-Development-of-School-Age-Children.aspx) most children naturally shift to a "night owl" tendency, making teens sleepy early in the day when greater self-regulation is required to meet academic and social demands.

Published 11/1/2016 12:00 AM

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Sleep Tips for Children's Mental Health

Sleep has become a casualty of modern life. The 2003 National Survey of Children's Health showed that 15 million US children and teens get inadequate sleep. Teenagers aren't' the only ones accumulating sleep deficits. Read More
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AAP Policy

School Start Times for Adolescents (AAP Policy Statement)

The American Academy of Pediatrics recognizes insufficient sleep in adolescents as an important public health issue that significantly affects the health and safety, as well as the academic success, of our nation's middle and high school students. Read More
(http://pediatrics.aappublications.org/content/early/2014/08/19/peds.2014-1697)

Op-Ed Why school should start later in the day

Students head to Thomas Starr King Middle School in East Hollywood on a December morning last year. (Los Angeles Times)

By **Lisa L. Lewis**

SEPTEMBER 18, 2016, 5:00 AM

Each fall, groggy teenagers resign themselves to another year of fighting their body clocks so they can get to class on time. It's well known that teens who don't get at least eight hours of sleep a night face a slew of problems. That's why both the American Academy of Pediatrics and the Centers for Disease Control recommend shifting middle- and high-school start times to 8:30 a.m. or later. Yet during the 2011-12 school year — the most recent statistics available — only 17.7 % of the nation's public middle, high and combined schools met the 8:30 a.m. guideline, and nearly 40% started before 8 a.m. In California, the average start time was 8:07 a.m.

Many districts are reluctant to change their schedules because they see the shift as too expensive and disruptive. But that's short-sighted. In the long run, a later start could actually save schools money — and benefit society at large.

Later start times can mean less missed school — absences dropped 15% in Bonneville County, Idaho, after it instituted such a change, according to a 2014 Children's National Medical Center report. In states such as California where state funding for schools is tied to attendance, it follows that later start times could translate

into extra dollars. Megan Reilly, chief financial officer for the Los Angeles Unified School District, has estimated that boosting attendance by just 1% districtwide would bring in an additional $40 million per year.

Repeated studies also show that when the school day starts later and teens get more sleep, both grades and standardized test scores go up. A Colby College economist, Finley Edwards, found that a one-hour delay in start time increased math test and reading test scores by three percentile points. Even more striking, the lowest-scoring students showed the biggest jumps.

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Compared to other strategies for boosting performance, delaying the start of the school day is easy and efficient.

Compared to other strategies for boosting performance, delaying the start of the school day is easy and efficient. Teny M. Shapiro, an economist at Santa Clara University, estimates that a one-hour change produces the same benefit as shrinking class size by one-third or replacing a teacher in the 50th percentile of effectiveness with one in the 84th percentile.

Another potential problem schools commonly raise is that later start times would lead to kids missing classes at the end of the day in order to attend sporting events, or that athletic participation rates would decline. There may be something to these concerns; but on the other hand, there’s reason to believe more sleep would result in fewer student injuries — and, in turn, fewer missed hours in class and on the field.

Student athletes who get enough sleep are far less likely to get injured. In a 2012 study of Los Angeles middle- and high-school athletes, researchers found that getting less than eight hours of sleep was the strongest predictor of injury. Two-thirds of the athletes who didn’t meet this threshold got injured.

Another study, in North Carolina, showed that more than a quarter of injured high-school athletes missed at least one week of playing time. While less than 20% of the injuries required emergency room treatment, according to the North Carolina study, the costs were still significant: the researchers found that even the minor injuries added up to nearly $1 million a year in medical costs.

But sleepy teens aren’t just a problem in school. When they get behind the wheel, they contribute to what the National Highway Traffic Safety Administration calls the “extreme danger” of drowsy driving, which has an estimated annual societal cost of $109 billion. “Teens and young adults are involved in more than half of all drowsy driving crashes annually,” notes Jonathan Adkins, executive director of the Governors Highway Safety Assn. Beyond the obvious safety concerns, there’s a corresponding hike in car insurance premiums, with a 2013 study by InsuranceQuotes.com finding that Californians’ rates jump an average of 62% after just one claim.

Again, later school start times have been shown to improve the situation. In Lexington, Ky., teen car crashes for 17- and 18-year-olds dropped 16.5% in the two years following a start-time shift; during the same period, the

accident rate for this age group increased 7.8% elsewhere in the state.

As if all of this weren't enough, teens who don't get enough sleep are more at risk for drug and alcohol use, depression and suicide. The title of a 2014 report in the Journal of Youth and Adolescence says it all: "Sleepless in Fairfax: The Difference One More Hour of Sleep Can Make for Teen Hopelessness, Suicidal Ideation, and Substance Use."

In the first half of the 20th century, school started later. Districts implemented early starts for efficiency and cost-cutting reasons; tiered bus systems, for instance, led to staggered start times for elementary, middle and high schools — with high schools starting first. At the time, the risks of teen sleep deprivation were not widely known. Schools don't have that excuse anymore.

If schools go ahead and shift their start times, they may have to change bus schedules or alter team practice schedules. But that's nothing in comparison to what they'd gain.

Lisa L. Lewis lives in Redlands, where high school starts at 7:30 a.m. Her last piece for the Los Angeles Times was on school lockdowns.

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EDUCATION GETTING SCHOOLED.

APRIL 20 2016 3:35 PM

The U.S.'s Best High School Starts at 9:15 a.m.

Why aren't more schools following its lead?

By Lisa L. Lewis

Science says he ought to be tired.

Purestock/Thinkstock

On Tuesday, *U.S. News and World Report* **released its annual public high-school rankings**, with the School for the Talented and Gifted in Dallas earning the top spot for the fifth year in a row. The rankings are based on a wealth of data, including graduation rates and student performance on state proficiency tests and advanced exams, as well as other relevant factors—like the percentage of economically disadvantaged students the schools serve. But there's one key metric that isn't tracked despite having a **proven impact** on academic performance: school start times.

First-period classes at the School for the Talented and Gifted start at 9:15 a.m. That's unusually late compared to other schools but is in keeping with the best practices now recommended by public health experts.

Teens require more sleep than adults and are hardwired to want to sleep in. Eight hours a night may be the goal for adults, but teens need between 8.5–9.5 hours, according to the **American Academy of Pediatrics**. Unfortunately, few teens meet that minimum: Studies show that two out of three high school students get less than eight hours of sleep, with high school seniors averaging less than seven hours.

Sure, kids could go to bed earlier. But their bodies are set against them: Puberty makes it hard for them to fall asleep before 11 p.m. When combined with too-early start times, the result is sleep deprivation.

While body clocks may be hardwired, school start times are not. In the last two years, both the AAP and the Centers for Disease Control and Prevention have grown so alarmed about teen sleep deficits that they are **urging** middle schools and high schools to shift start times to **8:30 a.m. or later**.

The side effects are severe: Sleep-starved teens are **more likely to** misbehave, be tardy for class, and underperform academically. They're also more likely to be overweight, suffer from depression, drink alcohol and use drugs, and get in more car accidents. Moreover, their sleep habits now raise their risk later in life for diabetes, cardiovascular disease, and even Alzheimer's.

Unfortunately, the CDC's most recent report showed that nationally, less than 20 percent of middle and high schools had start times of 8:30 a.m. or later. The average? 8:03 a.m.

This average masks some of the pain. In my district, the middle schools begin at 8:45 a.m. but the high schools, including the one where my son is a student, start at 7:30 a.m.

It's true that altering middle-school and high-school start times often presents a few major hurdles for school districts: Bus schedules and athletic programs must be retooled, and resistance to change from parents, coaches and others must be overcome. And yet districts from **Seattle** to **Cape Cod, Massachusetts**, are doing it. In fact, Seattle will be the largest district to date to make the shift, which will take effect this fall.

More important, the potential longterm gains—students who are well-rested and better performing—far outweigh the short-term logistical headaches. Even school athletics stand to benefit, given that sleep deprivation drags down peak physical performance.

Until schools make these shifts, kids will be forced to do what they can to feel less drowsy, like sleeping in on weekends to try to make up for sleep lost during the week. Unfortunately, a teen sleep **study** published last month showed that this strategy doesn't work. Instead, the researchers found even two nights of recovery sleep do not undo some of the many cognitive impairments caused by just one week of partial sleep deprivation.

Other teens load up on caffeine before class. Earlier this spring, a new Starbucks opened a block from my son's high school. On school days, there's a pre–7:30 morning rush. It's mostly teens.

There are doubtless many reasons why the School for the Talented and Gifted landed in the top spot—for the fifth straight year—in the *U.S. News and World Report* rankings. That its start time allows students to get a good night's sleep is likely just a part of the equation—but it's one that we can easily implement elsewhere. Our students deserve it.

BUSINESS INSIDER

A study of 30,000 high-school students found kids do better when classes start after 8:30 a.m.

CAROLYN CRIST, REUTERS
FEB. 10, 2017, 5:46 PM

When high schools start at 8:30 a.m. or later, attendance rates and graduation rates improve, according to a new study.

YouTube

The study backs previous research that says additional sleep boosts psychological, behavioral and academic benefits for teens.

"So much research explains the impact of insufficient sleep on suicide, substance abuse, depression, auto accidents and more," said lead study author Pamela McKeever of Central Connecticut State University in New Britain.

"This connects the dots between the world of science and education," she told Reuters Health. "Through this, educators and parents can see how lack of sleep impacts the school indicators that we use to measure student success."

McKeever and colleague Linda Clark looked at school start times, graduation rates and attendance rates for 30,000 students in 29 high schools across seven states. They found that two years after a delayed start was implemented at these high schools, average attendance rates and graduation rates had increased several percentage points.

For example, the average graduation completion rate was 79 percent before the delayed start was implemented, and it was 88 percent afterward.

"This doesn't only impact our high school students. This impacts all of society," McKeever said. "As graduation rates improve, young adults experience less hardship after graduation, a lower chance of incarceration and a higher chance of career success."

Delayed bell times could close the achievement gap as well, McKeever and Clark wrote in Sleep Health, the journal of the National Sleep Foundation. When schools start later, students in lower socioeconomic categories are more likely to get to the bus on time. When they arrive at school on time, they're more likely to stay in class and graduate.

"When kids miss a bus early in the morning and that's their only form of transportation, they miss class and then soon the credits," said Kyla Wahlstrom of the University of Minnesota in Minneapolis, who wasn't involved with this study. "People don't understand the link between early wake-up times and graduation rates, but it's that direct."

Since the late 1990s, Wahlstrom and other researchers have suggested that delayed high school start times may help students. In 2014, she and her colleagues reported that in a three-year study with 9,000 students in eight public high schools across three states, attendance rates increased with a start time of 8:35 a.m. or later.

In December, the American Academy of Sleep Medicine advised that later school start times could improve sleep, reduce car accidents and reduce sleepiness. The American Academy of Pediatrics also recommends 8:30 a.m. as the earliest time to begin school.

But school policies have yet to change nationwide. The U.S. Centers for Disease Control and Prevention (CDC) reports that in 42 states, 75-100 percent of public schools start before 8:30 a.m.

Teens are "driven by biology to go to sleep later, and there's not much we can do about that, but school start times are the main reason they get up when they do," said Anne Wheaton, an epidemiologist at the CDC in Atlanta, in email to Reuters Health. Wheaton wasn't involved with this study.

A limitation of the study is that many variables affect attendance and graduation rates. Changes at the school level, such as different teachers, policies and the surrounding community itself, could affect students and their ability to complete class credits, extracurricular activities and after-school jobs. Also, the data didn't measure sleep time or indicate whether students slept more due to delayed start times.

"The debate about school start time and adolescent sleep patterns has been going on for a number of years," said Mary Carskadon of the Sleep for Science Research Lab at Brown University in Providence, Rhode Island, who wasn't involved with this study.

"Efforts to delay the school bell are more likely to succeed best when parents and the teens themselves use better choices," she told Reuters Health by email. "This includes having a set bedtime and limiting arousing activities in the evening."

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