

Effects of Sleep Deprivation and Early School Start Times on Adolescent Health

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ABSTRACT

As sleep deprivation is a general public health issue reported by the Center for Disease Control, it becomes an even more detrimental problem in adolescent years with potential consequences of physical, mental, and academic impairments leading to chronic health issues such as obesity, metabolic dysfunction, and increased cardiovascular morbidity into adulthood. The reasons behind the epidemic of insufficient sleep during adolescence are complex and multifactorial which include the biological and central changes in sleep regulation in teenage years as well as early high school start times (SST) determined by state legislation and local school districts. This important public health issue of sleep loss in adolescents has led increased research and policy changes about the ideal SST. Studies have shown that later SSTs are associated with positive student outcomes, including improved academic performance, mental health, and physical health, along with increased public safety and long-term economic gains. In light of this scientific evidence, the average teenager is best suited to wake at 8:00 AM or later. In this review article, we aim to summarize the literature and raise awareness on long-term effects of insufficient sleep-in teenagers, school start times (and its potential delay), as well as general health recommendations.

Introduction

Insufficient sleep is a well-established problem which has been accepted by the Center for Disease Control as a public health epidemic in teenagers and older populations ("CDC data "). A common misconception about adolescence is that sleep needs decline from preadolescent levels. Although teenagers need 8 to 10 hours of sleep per night, more than two-thirds of U.S. high school students report getting less than 8 hours of sleep on school nights (Wheaton, Ferro, & Croft, 2015). Sleep duration (the amount of sleep one receives) is an important indicator of health and well-being in children and adolescents, and it influences physical and emotional well-being (e.g., brain maturation, biological and psychosocial changes in puberty) (Chen, Wang, & Jeng, 2006). The reasons behind the epidemic of insufficient sleep during adolescence are complex and multifactorial. There are two main biological changes in sleep regulation are thought to be responsible (Adolescent Sleep Working, Committee on, & Council on School, 2014). One of these factors is delayed timing of nocturnal melatonin secretion across adolescence years which results in difficulty falling asleep at an earlier bedtime. The second biological factor is an altered "sleep drive" across adolescence in which the pressure to fall asleep accumulates more slowly because of the adolescent brain's response to sleep loss. Busy with schoolwork, social lives, family, sports and other extracurriculars, adolescents in high school are often exposed to many new and old responsibilities while being expected to perform their best as they enter their first years of autonomy. However, this only makes the lives of adolescents more stressful as, for many youths, this is the first time they experience such hardship and responsibility. Among adolescents, these developmental changes in circadian and sleep characteristics are associated with increased daytime sleepiness, reduced alertness, impairments in cognitive functioning and poorer academic performance (Stone et al., 2022). For instance, adolescents who are chronically sleep-deprived perform academically poorer in morning classes and in overall performance, have increased absenteeism and

tardiness, and decreased ability to learn and retain material, actively participate in class, and perform decision-making tasks. In addition to this, from a mental health standpoint, they are more likely to be depressed, anxious, irritable, defiant, apathetic, and impulsive than adolescents who get optimal sleep (Minges & Redeker, 2016). Research shows that a majority of adolescents do not receive adequate sleep, and this lack of sleep negatively affects them whether it be from a physical or mental health standpoint.

This important public health issue of sleep loss in adolescence as a long-term health consequence into adult years has led to increased research and policy changes about the ideal school start time (SST) in light of scientific evidence that supports that the average teenager is best suited to wake at 8:00 a.m. or later. A National Sleep Foundation poll found that 59% of 6th to 8th graders and 87% of high school students in the U.S. were getting less than the recommended 8.5- 9.5 hours of sleep on school nights (Adolescent Sleep Working et al., 2014; Foundation, 2006). In the same survey, however, 71% of parents believed that their adolescent was obtaining sufficient sleep. This significant mismatch indicates a lack of awareness among adults regarding the extent of adolescent sleep loss (Adolescent Sleep Working et al., 2014; Foundation, 2006). With insufficient community awareness and limited solutions, many teenagers are predisposed to potential consequences of physical, mental, and academic impairments related to deficient sleep. A correlation between insufficient sleep and lower academic achievement as well as higher rates of absenteeism and tardiness to classes have been also demonstrated in other studies, further emphasizing the consequences of sleep loss for adolescents (Adolescent Sleep Working et al., 2014). This literature review aims to summarize the health implications of sleep, explore school start times (and its potential delay), and provide a general health recommendation.

Physical and Mental Health Implications of Poor Sleep on Adolescents

Although it is recommended that 8 hours of sleep is optimal, it is estimated that 50 to 70 million Americans chronically suffer from a lack of sleep. Adolescents who do not get enough sleep are more likely to be overweight, not engage in daily physical activity, suffer from mental health disorders, engage in unhealthy risk behaviors such as drinking, smoking tobacco, using illicit drugs, and perform poorly in school. Overall, research points to a host of drawbacks results from a lack of sleep (Adolescent Sleep Working et al., 2014; Wheaton et al., 2015) (Table 1). This table highlights key consequences that result from a lack of sleep in 4 major domains: physical health and safety, mental health, cognitive capacity, and academic performance.

Insufficient sleep has further been linked with lower levels of physical activity, increased food intake and obesity, which can set the stage for chronic health conditions in adulthood such as obesity, metabolic dysfunction, and increased cardiovascular morbidity (Adolescent Sleep Working et al., 2014; Hart et al., 2013; Lowry et al., 2012). A significant negative association was found between low sleep (4 or less hours) and the following health-related behaviors in adolescents: (1) life appreciation; (2) taking responsibility for health; (3) adopting a healthy diet; (4) effective stress management; (5) regular exercise (Chen et al., 2006).

An increased prevalence of anxiety and mood disorders has also been linked to poor and insufficient sleep in adolescents. Another health-related correlate of sleep loss include increased use of stimulants (e.g., caffeine, prescription medications) to counter the effects of chronic sleepiness on academic performance. These stimulants further put adolescents at greater risk of drowsy driving and related crashes as a result (Adolescent Sleep Working et al., 2014).

In addition to these physical and long-term outcomes, it has been shown that insufficient sleep can cause unhealthy risk behaviors such as alcohol, drug, and illicit drug use. More than two-thirds of US high school students report insufficient sleep, making unhealthy risk behaviors more common in adolescents (McKnight-Eily et al., 2011; O'Brien & Mindell, 2005). Further, insufficient sleep among teens has been linked with an increased risk of engaging in property and violent crime (Umlauf, Bolland, & Lian, 2011). As a result, a lack of sleep is seen to be correlated with risk behaviors.

Table 1. The effects of sleep deprivation on physical and mental health, behavior, safety, and academic performance

Physical Health and Safety	
	Obesity
	Lower physical activity
	Metabolic dysfunction (e.g., type 2 diabetes, high cholesterol)
	Cardiovascular morbidity (hypertension, stroke)
	Higher caffeine consumption
	Increased risk of stimulant medication use and associated side effects
	Increased rate of motor vehicle accident
Mental Health	
	Anxiety
	Depression
	Emotional dysregulation; decreased positive affect
	Suicidal ideation
Cognitive Capacity	
	Poor impulse control and self-regulation
	Increased risk-taking behaviors
	Increased risk of alcohol, drug and illicit drug use
Academic performance	
	Poor school attendance
	Impairments in attention and memory
	Cognitive deficits
	Lower academic achievement

Intervention Efforts: Findings & Implications

To counter the lack of sleep in adolescents, there have been studies that explored solutions such as delaying school start times. In the light of the importance of adequate and good quality sleep that is consistent with the adolescent circadian rhythm, which is important for healthy growth and development during childhood and adolescence, there have been different levels of efforts to delay school start times. Minges et al. (Minges & Redeker, 2016) have reviewed multiple studies to compare the outcomes of delayed school times on different aspects including total sleep time, bedtime, health care utilization, mental health problems, academic achievement, and school attendance to find a potential solution.

Total sleep time was the main result that was reported in the studies in which there was a significant positive increase in the total minutes of sleep which ranged from an additional 25 minutes to 77 minutes of sleep per weeknight (Minges & Redeker, 2016). In randomized designed studies, there was no significant difference in bedtime between the control and intervention groups after delayed start time, suggesting that students went to bed at the same time regardless of the school start time. Relative to pre-intervention, wake times were delayed between 21 minutes to 66 minutes (Minges & Redeker, 2016). With the delay of school start time, significant improvements in measures of daytime sleepiness were observed. In one study, investigators compared just over 800 Israeli fifth graders and separated them based on SSTs that ranged from 7:10 to 8:30 a.m.. The mean total sleep times of the students attending schools with earlier start times were significantly shorter than those at later starting schools. In addition, the former

group expressed more complaints of daytime sleepiness and tendency of sleeping in class (Wolfson & Carskadon, 2003).

Another study looking into the physical aspect of outcomes between intervention groups found a decrease in BMI for the intervention groups and an increase in the control group. Here, socio-demographic characteristics were examined at the baseline in 2007 and the follow-up in 2009 in the intervention trial where they introduced a change in sleep duration. Although, this finding was not statistically significant (Li et al., 2013).

In a study that evaluated the effects of delayed school start times and academic achievement, no significant difference in self-reported grades from pre-intervention was found (Wolfson & Carskadon, 2003). However, there was a significant decline in tardiness and falling asleep during class due to oversleeping. One other study found significant improvement in attention levels in class following delayed SST (Lufi, Tzischinsky, & Hadar, 2011).

Sleep influences school performance based the duration and quality on the sleep the adolescent receives. Given that normal sleep patterns and duration play an important role in learning and memory consolidation, it should also result in better academic performance (Rasch & Born, 2013). The Seattle (WA) School District had delayed the SST from 7:50 to 8:45 a.m. starting for the 2016–2017 academic year which allowed a pre-/post-study (Dunster et al., 2018). They demonstrated that a later SST was associated with a better alignment of sleep timing with the circadian system, reduced sleepiness, and increased academic performance, along with 4.5% higher grades on increased sleep hours. Later SST also led to an increase in punctuality and attendance which was significant only in the economically disadvantaged school. This might also suggest that delaying high school start times could decrease the learning gap between low and high socioeconomic groups (Dunster et al., 2018). It is important to note that the delay of SST for adolescents can not only benefit wellbeing but also decrease the learning gap between different socioeconomic groups and improve school academic performance.

Economic impacts of later school start times

In addition to improving the wellbeing of adolescents, later school start times also have projected economic benefits. Initial evidence shows that later SST can improve adolescent sleep patterns and help students get more sleep. With later starts, adolescent's bedtimes remain fairly constant, but their wake-up times are extended, resulting in more weekday sleep (Wolfson & Carskadon, 2003). In addition, numerous studies have shown that later SSTs are associated with positive student outcomes, including improvements in academic performance, mental and physical health, and public safety (Lufi et al., 2011). Despite these positive mental and physical impacts on teenagers, there is still opposition against delaying SST. A major argument against later SST is the claim that delaying SST will result in significant additional costs for schools including school bus schedules. Since many school districts might already face significant shortages and economic challenges, concerns about added costs could become a deterrent to this policy change for delayed start times.

A study performed by the Brookings Institution (Jacob, 2011) examined the cost and benefits of delaying SST and found a benefit–cost ratio of 9:1 for a one hour later start time among middle and upper grade students. In other words, for every \$1 spent, the return was \$9. Cumulatively, the study estimated an average \$17,500 gain per student in terms of lifetime earnings compared to \$1,950 cost per student over the school career.

A study by RAND Corporation investigated in detail the economic implications of creating a hypothetical policy experiment involving a universal and statewide shift in SSTs of at least 30 minutes (Hafner M, 2017). The potential costs that had been taken into account included changes in school bus schedules, rescheduling for after school activities such as sports team practices, later school dismissals and diminishing outdoor light costs of making additions to school infrastructure like additional lighting equipment, additional childcare expense, and further cost scenarios (Hafner M, 2017). The study revealed a link between a delay in SSTs and profound economic gains across 47 U.S. states, showing that a state-wide universal move to at least 8:30 a.m. could contribute \$83 billion to the U.S. economy within a decade and roughly \$140 billion in about 15 years. The authors of this study stressed that they were applying parameters in the model for which robust empirical evidence was available in the literature concerning the impact of

sleep loss on affects adolescents' health, academic performance, and car crash mortality. However, other potential impacts of insufficient sleep, such as the effects on mental health, other negative effects related to obesity, or other morbidities have not been taken into account. They explain that the reported benefits in this study were likely an underestimation of the full benefits related to delaying SST. In the short and long term, later school start times will be beneficial for the economy along with improving adolescent wellbeing.

School start times across different states in the United States

Although later SSTs are beneficial to adolescent wellbeing, not every state in the US has idealistic start times. To assess state-specific distributions of public middle, 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) (Wheaton et al., 2015). 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%) (Wheaton et al., 2015). Schools started earliest in Louisiana, where the average start time was 7:40 a.m., and latest in Alaska, where the average start time was 8:33 a.m. Only about one in five middle school students, and one in seven high school students started the school day at the recommended time of 8:30 a.m. or later.

In 2019, California's Legislature and Governor placed restrictions on what time schools may start ("Senate Bill ", 2019). This bill, Senate Bill 328, does not allow middle schools to start before 8 a.m. and does not allow high schools to start before 8:30 a.m.. This legislation in California now has gone into effect in July 2022. Other states including New York and New Jersey, are now considering similar legislation and allowing for delayed start times than before. As states are beginning to implement later SST for adolescent wellbeing, there is light shed on issue of chronic sleep deprivation in adolescents and are efforts to prevent this going forward.

Conclusion and Future Directions

In general, SST policies are established at the district and individual school levels. California so far is the only state that placed restrictions on what time schools may start at the state level according to California's Legislature. Educating parents and school system decision-makers about the impact of sleep deprivation on adolescent health will likely lead to adoption of later school start times despite financial concerns from school districts or parental concerns. In turn, delaying school start times will improve long term implications from a physical and mental health standpoint, as well as improve academic performance and provide long term economic gains on the US economy. As sleep deprivation in adolescents is an issue, it is becoming more popular of a topic at the state and even national level. The spread of awareness combined with further research going forward will dawn light onto the importance of sleep for adolescents. As for future directions for policy makers and researchers, a much larger and more generalizable study would be effective for decision making. In conclusion, as many adolescents are subject to chronic sleep deprivation, the delay of SST will improve adolescent wellbeing.

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