

THE IMPACT OF SLEEP ON TEENS - BIOLOGY AND BEHAVIOR

**Teton County School District #1,
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“Sleep is not optional; it is biologically necessary.”

-Mary A. Carskadon, Ph.D., Director of Chronobiology [study of biological rhythms] and Sleep Research at Bradley Hospital & Professor of Psychiatry & Human Behavior at Brown University School of Medicine

“Scientific studies have shown that sleep contributes significantly to several important cognitive, emotional and performance-related functions.”

-Nonprofit, private group, National Sleep Foundation in conjunction with NIH, “Adolescent Sleep Needs and Patterns: Research Report and Resource Guide,” 2000.

“The National Institutes of Health (NIH) have identified adolescents and young adults (ages 12 to 25 years) as a population at high risk for problem sleepiness...”

-NIH’s National Center on Sleep Disorders Research and the Office of Prevention, Education, and Control, 1997.

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Report Summary

The purpose of this report is threefold:

- First, to present the results of scientific research on the impact of sleepiness on adolescents' bodies and minds and to explore the dynamic biological changes taking place in the brains of 12 to 25 year olds.
- Second, to highlight the findings of schools that have chosen to increase the sleep time of their high school students by pushing back school start times.
- Third, to state the challenges for the Jackson Hole community in considering a change to start times for Jackson Hole (JHHS) and Summit High Schools (SHS) and Jackson Hole Middle School (JHMS).

This report presents the impact that sleep has on adolescents' behaviors and biological functions. It focuses on key scientific sleep research; specifically the seminal report developed by the National Sleep Foundation, "Adolescent Sleep Needs and Patterns: Research Report and Resource Guide." Since its publication in 2000, there have been numerous studies in the U.S. that targeted how the lack of sufficient sleep impacts the cognitive, behavioral, performance-related, and psychological behaviors of teens and young adults. This document also includes findings from research conducted in Canada, Israel, Japan, Switzerland, the United Kingdom, Connecticut, Minnesota, Rhode Island, Kentucky, and Virginia.

Pivotal sleep research has concluded that:

- Adolescents require at least as much sleep as they did as pre-adolescents, in general **8.5 to 9.25 hours each night**.
- Adolescent sleep patterns undergo a phase delay; that is, a tendency toward later times for both sleeping and waking. **Studies show that the typical high school student's natural time to fall asleep is 11:00 p.m. or later.** (So, biologically their bodies want to sleep-in later in the mornings.)
- Many adolescents are chronically sleep-deprived due to social, work, recreational, and academic pressures.
- Insufficient sleep accumulates into a sleep debt that can ultimately be relieved only through additional sleep.
- Adolescents in the U.S. have irregular sleep patterns (weekdays vs. weekends) and many of them do not get enough sleep.

With this incontrovertible foundation of sleep studies, researchers have further delved into studying how sleep impacts at-risk behaviors in youth. While more longitudinal studies are needed, there is evidence that insufficient sleep and at-risk behaviors are bi-directional (impacting each other in both directions). "Excessive sleepiness is also associated with reduced short-term memory and learning ability, negative mood, inconsistent performance, poor productivity and loss of some forms of behavioral control." (NIH, 1997)

Other at-risk behaviors that appeared to be amplified by excessive sleepiness included "physical fights, current cigarette, alcohol, or marijuana use, current sexual activity, feelings of sadness or hopelessness, lack of physical activity, contemplation of suicide, drinking soda, and more than 3 hours per day of computer use." (*Relationships between hours of sleep and health-risk behaviors*

in US adolescent students,” McKnight-Eily, Eaton, Lowry, Croft, Presley-Cantrell, and Perry, Preventive Medicine, August 2011, and further disseminated by the National Institutes of Health.)

As we conducted research for this report, it became quickly evident that a discussion of teen brain development was critical for understanding teen behavior and biology. For example, The National Institutes of Health (NIH) studied over 100 young people during the 1990s using brain-imaging technology. Those researchers learned that our brains take much longer to develop than we had thought and undergo a huge reorganization well into our 25th year. “The brain undergoes extensive remodeling, resembling a network and wiring upgrade.” (*National Geographic, October 2011*)

Next, this report explores the impact that our sleep cycles have on memory. Steve Joordens, Ph.D., Professor of Psychology, University of Toronto Scarborough, states that sleep is critical for our survival and essential for memory. He explains that, “Sleep seems to play a role in consolidating the memories we encode during the day, and different stages of sleep consolidate different kinds of memory.” (*Memory and the Human Lifespan, The Great Courses, The Teaching Company, 2011, in Lecture 11 Sleep and the Consolidation of Memories.*)

With this extensive research on the importance of sleep for adolescents, many school districts have changed their high school (and some middle school) start times – pushing them back between 40 to 60 minutes. Accomplishing this change met with resistance throughout their communities.

In fact, The National Sleep Foundation states on its website www.sleepfoundation.org that there are eight major obstacles to delaying school start times. That is, after school activities, transportation, other students and programs, reduced time to access community resources, teachers/coaches, stress for families, a community not educated about teens and sleep, as well as the resistance of students. For the Jackson Hole community, a shift in students’ schedules impacts students, parents/guardians, teachers, coaches, employers, day-care, after school activities, transportation and food service employees, police, and community organizations.

This report includes case studies from Minneapolis, Wilton, Connecticut, Rhode Island, Virginia, and Kentucky that show how these communities addressed the above obstacles to implementing a later start time for their high school (and middle school) students. The success of these communities and the positive results for their teens merits consideration for a similar change for JHHS, SHS, and JHMS.

A four-year, longitudinal study of students in seven high schools in Minneapolis and Edina showed: improved attendance, an increase in continuous enrollment, less tardiness, and fewer trips to the school nurses. Also, students seemed more alert in class. Five of eight principals reported a calmer atmosphere in the halls and cafeteria, and they received fewer disciplinary referrals. Students self-reported in surveys an upward trend in their grades, but the results were not statistically relevant as there were over one million data points for analysis.

In Wilton, Connecticut, the start-times for both the middle and high school were pushed back 40 minutes. The results reported by the Wilton League of Women Voters were “a resounding success. Teachers recognized a change in student behavior: they were more awake, had better

attitudes and were overall more pleasant. Parents also reported changes in their kids' attitudes...and high school athletic programs saw a continued rise in participation." Similar positive results were found in a private school in Rhode Island.

More difficult to quantify, but interesting to note were reports from schools in Virginia and Kentucky that showed a decrease in student car crashes after the later school start times. The Virginia Department of Motor Vehicles collected data on crash numbers and the number of drivers between 16 and 18 years in two counties: Virginia Beach and Chesapeake. Virginia Beach, with its earlier start time of 7:20 a.m., had a 40% higher crash rate than Chesapeake with its 8:40 am start time.

Also a 2008 study in the *Journal of Clinical Sleep Medicine* found that "...when high schools in Fayette County, Kentucky, changed their start times from 7:30 a.m. to 8:30 a.m., teen car crash rates dropped by more than 16%."

In summary, this report brings forth enough evidence to consider the idea of pushing back the school start times for JHHS, SHS, and JHMS. The scientific evidence shows that teens need between 8 ½ to 9 ¼ hours of sleep each night, and they are biologically prone to staying up until around 11:00 pm. If they do not get sufficient sleep, their bodies will accumulate a sleep debt that can only be relieved through additional sleep.

The remaining portions of this document describe in detail the studies cited above in this Report Summary, and describe schools and districts that have successfully implemented changes to their high school and/or middle school start times. The final list of references includes all reports, articles, podcast, course, and scientific studies used to develop this report.

The Developing Brains of Adolescents and Young Adults

For the past 20 years, there has been an explosion of scientific research on how our brains develop during adolescence. Using the first full series of teen brain scans, the National Institutes of Health (NIH), learned that it takes much longer for our brains to develop. In fact, "...our brains undergo a massive reorganization between our 12th and 25th years." So, a process that was once believed to be complete in elementary school has now been shown to continue throughout adolescence. An excellent summary of our developing brains is found in the October, 2011, issue of *National Geographic*, "The New Science of the Teenage Brain, Beautiful Brains" and in studies conducted by Duke University Medical Center, Department of Psychiatry, April 2009.

The National Institutes of Health (NIH) studied over 100 young people during the 1990s using brain-imaging technology. Those researchers learned that our brains take much longer to develop than we had thought and undergo a huge reorganization well into our 25th year. The *National Geographic* article further states that "...as we move through adolescence; the brain undergoes extensive remodeling, resembling a network and wiring upgrade." Moreover, the "...brain's cortex – the outer layer of gray matter where we do much of our conscious and complicated thinking...becomes more efficient."

Subsequent studies showed that "...these physical changes move in a slow wave from the brain's rear to its front, from areas close to the brain stem that look after older and more behaviorally basic functions, such as vision, movement, and fundamental processing, to the evolutionarily newer and more complicated thinking areas up front."

"Taken together, these changes make the entire brain a much faster and more sophisticated organ." One of the researchers quoted in the article, B.J. Casey, a neuroscientist at Weill Cornell Medical College, sees this phase in adolescent brain development as a "highly functional, even adaptive period" when teens are exploring and seeking new and exciting things.

In short, neuroscientists have demonstrated that the brains of teens and young adults are undergoing massive remodeling and "synaptic pruning." Concurrently, teens are lacking in life's experiences in general, and "they are still learning to use their brain's new networks. **Stress, fatigue or challenges can cause a misfire.**" Abigail Baird, a Vassar psychologist who studies teens, calls this "neural gawkiness – an equivalent to the physical awkwardness teens sometimes display while mastering their growing bodies."

This remodeling and reorganization of adolescent and young adult brains adds ballast to the critical issue of teen sleepiness. That is, while our teens are navigating the biological changes taking place in their brains – they must also ensure that they are getting sufficient sleep. This next section focuses on sleep research and its impact on the biological, psychological, and social aspects of adolescents' lives. It demonstrates that U.S. teens are sleep deprived which impacts their performance in school, extracurricular activities, and cognitive abilities.

Findings from NIH and National Sleep Foundation Report

“Adolescent Sleep Needs and Patterns: Research Report and Resource Guide” (Mary Carskadon, Thomas Roth, Ruth M. Benca, Ronald E. Dahl, William C. Dement, Mark Mahowald, Jodi A. Mindell, Kyla L. Wahlstrom, Amy R. Wolfson,) 2000.

While these clinical studies of adolescent and young adult brain development have evolved, there has also been significant research conducted on the impact of sleep in mental and physical health during adolescence. Moreover, research has been conducted on how we get information into memory. Since the 1990s, studies from the U.S., Japan, Israel, U.K., Switzerland, China, Canada, and Australia have concluded that teens are a population at high risk for problem sleepiness.

In 2000, the National Sleep Foundation (NSF) published its seminal work, *Adolescent Sleep Needs and Patterns: Research Report and Resource Guide*. In summary, the report stated these conclusions about sleep-related issues affecting adolescents:

- Sleep is not optional; it is biologically necessary.
- Scientific studies have shown that sleep contributes significantly to several important cognitive, emotional, and performance-related functions.
- Many adolescents are chronically sleep-deprived due to social, work, recreational, and academic pressures.
- The prevalence of problem sleepiness is high and increasing with particularly serious consequences.
- **Adolescents require at least as much sleep as they did as pre-adolescents, in general 8.5 to 9.25 hours each night.**
- Insufficient sleep accumulates into a sleep debt that can ultimately be relieved only through additional sleep.
- Adolescent sleep patterns undergo a phase delay; that is, a tendency toward later times for both sleeping and waking. **Studies show that the typical high school student’s natural time to fall asleep is 11:00 p.m. or later. (So, biologically their bodies want to sleep-in later in the mornings.)**
- Adolescents in the U.S. have irregular sleep patterns (weekdays vs. weekends) and many of them do not get enough sleep.

Mary A. Carskadon, Ph.D. (Director of Chronobiology and Sleep Research at Bradley Hospital, Professor of Psychiatry & Human Behavior, Brown University), states that “...teens need on the order of 9+ hours nightly to have optimal sleep...most teens fall short of this goal, many by a considerable amount. Although we think that the need for sleep does not really change across adolescence, the amount of sleep young people get does decrease in older teens. Thus, the sleep deficit grows right along with the youngster.”

Carskadon goes on to explain that teen sleep deprivation is a version of the *perfect storm*; that is, psychological, parental, societal, and cultural aspects of a teen’s life collide with the biological changes in their developing brains and bodies. So at a time when teens need up to 9+ hours of sleep per night – their circadian timing systems (daily biological clocks) keep them up later, school begins earlier, and there is an expansion of teens’ social, school and work activities. In short, “the sleep pressure system appears to change in a way that makes it easier to stay awake longer (with a desire to sleep later) though without changing the amount of sleep that is needed.”

In addition to the above sobering facts, the NIH and National Sleep Foundation's analysis of past sleep research focused on these risks for sleep-deprived teens:

- Sleep is, in essence, food for the brain, and *insufficient* sleep can be harmful, even life-threatening. When hungry for sleep the brain becomes relentless in its quest to satisfy its need and will cause feelings of “sleepiness,” decreased levels of alertness or concentration, and, in many cases, unanticipated sleep.
- Excessive sleepiness is also associated with reduced short-term memory and learning ability, negative mood, inconsistent performance, poor productivity and loss of some forms of behavioral control (NIH, 1997)
- **Young drivers age 25 or under cause more than one-half of fall-asleep driving crashes.** (National Highway Traffic Safety Administration, 1994). NHTSA data also show that males are five times more likely than females to be involved in drowsy-driving crashes. The reasons for this are unclear as both young men and women are likely to be chronically sleep-deprived.
- Professor Mary Carskadon notes in a 1990 study that “...boys with the greatest extracurricular time commitments were most likely to report falling asleep at the wheel. The subgroup at greatest risk comprised the brightest, most energetic, hardest-working teens.”
- Studies have found a relationship between the quantity and quality of one's sleep and many health problems. “For example, insufficient sleep affects growth hormone secretion that is linked to obesity; as the amount of hormone secretion decreases, the chance for weight gain increases. Other studies posit that insufficient sleep impairs the body's ability to use insulin and to decrease blood pressure.”

While the precise correlations between lack of sleep and specific health issues are still being examined, there is significant research that shows the importance of sleep for encoding our experiences into memory. The following section explains how we consolidate information into memory during the phases of sleep – especially during the REM (random eye movement) which is when we dream.

The Importance of Sleep for Memory and Consolidating Information

Further evidence of the critical importance of sleep on adolescent brains is found in the superb work by Steve Joordens, Ph.D., Professor of Psychology, University of Toronto Scarborough. He specializes in innovative research on human memory, consciousness, and attention. Professor Joordens states that sleep is critical for our survival and essential for memory. He explains that, “Sleep seems to play a role in consolidating the memories we encode during the day, and different stages of sleep consolidate different kinds of memory.” (*Memory and the Human Lifespan*, The Great Courses, The Teaching Company, 2011, in Lecture 11 *Sleep and the Consolidation of Memories*.)

Joordens explains that “there are five stages of sleep, each of which may be relevant to the consolidation of different sorts of memory.” For example, critical factors take place during stage 4 or REM (rapid eye movement) sleep which is when we dream. During REM sleep - we think, solve problems, and replay critical events from our recent pasts, or our *procedural memories*.”

Procedural memories include memory systems that use little or no conscious mediation; for example, any set of motor skills - learning to play an instrument, driving a car, using tools, or performing athletic plays or drills. During REM sleep, our brains consolidate these memories and allow us to recall them during our waking hours. Joordens states that “Evidence suggests dreams are replays of critical events from our recent past, making our memory of those events more stable.” So, sufficient sleep is not only important for academic excellence, but it ensures that our youth can optimize their memories for improving athletic performance, mastering an instrument, or becoming proficient at work procedures.

Joordens further explains that during the third phase of sleep – the “slow-wave sleep” - our brains receive very little external input, and one function of this phase may be the repair and maintenance of our bodies. Also research seems to show that during slow-wave sleep, we appear “to improve declarative memory consolidation. For example, humans who spent more time in slow-wave sleep were much better at memorizing lists than those spending more time in REM sleep.”

The crux of Joordens lecture on “Sleep and the Consolidation of Memories” is that humans need the full five cycles of sleep which rotate throughout our sleep time. Science continues to explore the direct impact of the five cycles to human memory, cognition, and health, and how this encoding changes throughout our lives.

Now that we have established the singular importance of sufficient sleep for adolescents (indeed all humans), and the fact that sleepiness in teens is a wide-spread problem – let us examine current research on the impact of sleep on at-risk youth.

Studies that Focus on Sleep’s Impact on At-Risk Students

From 2006 to 2011, sleep researchers, neuroscientists, and behavioral scientists have focused on the impact of sleepiness on adolescents. There is agreement that lack of sleep impacts decision-making, cognitive abilities, alertness, and can be dangerous if driving or using hazardous materials or tools at home or work.

However, the challenge for parents, educators and community members is to determine if there are direct correlations between the lack of sleep and high-risk behavior or emotional difficulties in youth. This research area of the impact of sleep on at-risk adolescents is relatively young and very complex. Researchers worldwide lack a consensus on how best to assess and define sleep disturbances.

Also, it is challenging to determine if at-risk behaviors and lack of sleep are “bidirectional,” that is moving or taking place in two directions. For example, is a tendency towards drug and alcohol abuse due to chronic sleep problems, or is a teen having sleep problems because of his/her drug and alcohol use? Or are both situations bi-directional?

Given the complexities of this segment of sleep research in relation to adolescents, the following five studies have been chosen based upon their currency, publication in respected journals, the experience of the researchers, and the acceptance of their findings by other authorities in the field. It is important to note that there are not many large-scale, longitudinal studies, but more research is conducted each year worldwide. For each study, we have listed its title, authors/researchers, publication and date – plus a summary and conclusion.

“Relationships between hours of sleep and health-risk behaviors in US adolescent students.” (McKnight-Eily, Eaton, Lowry, Croft, Presley-Cantrell, and Perry, *Preventive Medicine*, August 2011, and further disseminated by the National Institutes of Health.)

Summary: This was the first large sample, nationally representative study of adolescents “which examined associations between self-reported insufficient sleep on an average school night and selected health-risk behaviors and to examine if those associations varied by sex and race.” Specifically, the study examined the “associations between insufficient sleep (that is, less than 8 hours of sleep on average schools nights) and health-risk behaviors of adolescent students.”

Conclusion: “Two-thirds of adolescent students self-reported insufficient sleep, which was associated with many health-risk behaviors.” These health-risk behaviors included: physical fights, current cigarette, alcohol, or marijuana use, current sexual activity, feelings of sadness or hopelessness, lack of physical activity, contemplation of suicide, drinking soda, and more than 3 hours per day of computer use.

“Sleep and risk-taking behavior in adolescents.” (O’Brien, Mindell, Dept. of Clinical & Health Psychology, University of Florida, Gainesville, *Behavioral Sleep Med.*, 2005)

Summary: “The primary purpose of this study was to examine the relationship between adolescents’ sleep-wake patterns and risk-taking behavior, and to replicate the results obtained by Wolfson and Carskadon (1998) regarding adolescents’ sleep habits.”

Conclusions: “The results indicated that adolescents who reported longer weekend delay and higher levels of sleep problems also reported significantly higher levels of risk-taking behaviors, and students’ weekend delay was also related to their academic performance in this sample of 388 (217 males, 171 females). However, in the present study, only school-night sleep time and weekend delay were related to adolescents’ daytime functioning... This provides partial support for the findings of Wolfson and Carskadon. Overall, sleep-wake patterns were found to relate to risk-taking behavior during adolescence in this study.”

“Sleep, emotional and behavioral difficulties in children and adolescents.” (Gregory, Dept. of Psychology, Goldsmiths, University of London, U.K., and Sadeh, The Adler Center for Research in Child Development and Psychopathology, Dept. of Psychology, Tel Aviv University, Israel.)

Summary: “Given the known importance of sleep in youth, as well as the importance of having detailed knowledge of associations with other phenotypes [definition: the physical properties of an organism and its relation to its environment] – this review presents a selection of key empirical findings on the links between sleep and emotional and behavioral difficulties in children and adolescents.”

Conclusions: “Links between sleep and psychopathology are complex and likely bidirectional. Sleep problems and alteration of normal sleep patterns have been identified in major forms of child psychopathology including anxiety, depression, and attention disorders as well as symptoms of difficulties in the full range.” The study recommends parameters for further research and suggests an “interdisciplinary approach to further understand the links between sleep and associated difficulties.”

“Associations between sleep disturbance and mental health status: A longitudinal study of Japanese junior high school students” (Kaneita, Yokoyama, Harano, Tamaki, Suzuki, Munezawa, Jakajima, Asai, Ohida, Division of Public Health, Dept. of Social Medicine, Nihon University School of Medicine, Tokyo, Japan, *Sleep Medicine*, January, 2009.)

Summary: “A limited number of longitudinal studies have addressed the association between sleep disturbance and mental health status among adolescents. This study examined students attending three private junior high schools in Tokyo. The baseline study began in 2004 with a follow-up study in 2006 of the same 516 students. The Pittsburgh Sleep Quality Index was used to evaluate sleep disturbance and the 12-item General Health Questionnaire was used to evaluate mental health status.

Conclusion: “Sleep disturbance and poor mental health status increase each other’s onset risk... It was suggested that sleep disturbance and mental health status show a bidirectional relationship, in which either can be a cause or result of the other.” Moreover, it is important that “any measures taken are based on a full understanding of the association between sleep and mental health status” of the individual.

“Sleep and its importance in adolescence and in common adolescent somatic and psychiatric conditions.” (Brand, Kirov, Depression and Research Unit, Psychiatric Hospital of the University of Basel, Basel, Switzerland, June, 2011)

Summary: “Poor or disordered sleep is related to impairment of cognitive and psychological functioning and worsened physical health.” The review examines the complex neurobiology of sleep and its significant implications for adolescents.

Conclusion: “It is concluded that poor or altered sleep in adolescent patients may trigger and maintain many psychiatric and physical disorders or combinations of these conditions which presumably hinder recovery and may cross into later stages of life. Therefore, timely diagnosis and management of sleep problems appear critical for growth and development in adolescent patients.”

In summary, there have been numerous studies about the dire impact that sleepiness has on adolescents’ cognitive abilities, behaviors, and physical well-being. More specifically, the five reports above show how sleep deprivation can impact at-risk teens or impel them towards at-risk behaviors.

Now the question follows: What can parents, educators, and communities do to ensure our teens are getting adequate sleep? Many schools and districts have embarked on educational campaigns to inform their communities about the problems of sleep-deprived teens, and they have changed their high school start times to better coincide with the circadian sleep rhythms of their teens.

Overcoming Obstacles to Changing High School Start Times

This final section lists the main obstacles encountered by schools and districts who implemented the change of start times for their high school students. It also describes how school districts in Minnesota, North Carolina, Rhode Island, and Connecticut managed the change in high school start-times, and the results of these changes. Of particular significance, this section includes a summary of findings from a four-year study of secondary students in Minnesota - whose high schools changed their school start time from 7:15 a.m. to 8:40 a.m.

The National Sleep Foundation states on its website www.sleepfoundation.org that there are eight major obstacles to delaying school start times.

1. **Transportation** (Bus schedules and additional drivers could potentially increase district costs. However, in Las Vegas and other cities, transportation costs actually decreased.)
2. **After School Activities** (Long road trips for games and athletic practices are particular sticking points. Also, businesses might be concerned about the work schedules of their part-time student employees.)
3. **Other Students and Programs** (A change in schedule for high school and middle school students imparts a change of schedule for younger children if the start times for elementary students are switched with the start time for high school students.)
4. **Reduced Time to Access Public Resources** (That is, possibly less time to use the library, community resources, or potentially limiting the use of school facilities by other community organizations.)
5. **Teachers** (Some worry that a later start and release time will leave them with less time with their families. But in practice, teachers rarely find this to be true.)
6. **Stress for Families** (Impacts to families with younger children who rely on their teens for after-school child care; change in everyone's schedule; planning a transition period to adjust for new sleep-time schedules.)
7. **Uneducated Community** (The community must understand the biological changes that occur in teens that make them generally unable to fall asleep until 11:00 pm, and why they continue to need between 8 ½ and 9 ¼ hours of sleep each night.)
8. **Resistance of Students** (Teens, like adults, will be resistant to change and will worry about how this change will impact their after-school activities.)

The following case studies from Minneapolis, Wilton, Connecticut, Rhode Island, Virginia, and Kentucky show how these communities addressed the above obstacles to a implementing a later start time for their high school (and middle school) students. The success of these communities and the positive results for their teens merits consideration for a similar change for Jackson Hole and Summit High Schools and Jackson Hole Middle School.

“Changing Times: Findings from the First Longitudinal Study of Later High School Start Times” (Wahlstrom, College of Education and Human Development, Associate Director of the Center for Applied Research and Educational Improvement, University of Minnesota, 2002.)

This four-year study examined the changes in student behavior of seven comprehensive high schools in the Minneapolis Public School District that shifted their school start times from 7:15 a.m. to 8:40 a.m. The longitudinal (long-term) data is from a stratified random sample of 1,200 students in grades 9-12 (of a total population of 12,000).

Beginning with the 1997-1998 school year, the Minneapolis Public School District changed the seven high school times: to begin at 8:40 a.m. and to end classes at 3:20 p.m. At the same time, the Minneapolis School Board asked the Center for Applied Research and Educational Improvement (CAREI) at the University of Minnesota to examine the impact of this later start time on students, staff, families, and community members.

The researchers methodology included quantitative data of letter grades before and after the time change, attendance records, norm-referenced written questionnaires, the School Sleep Habits survey (in year 1 and year 4), and qualitative data from student focus groups and interviews with teachers, administrators, and parents. The results of the four-year study of seven high schools concluded that there were “significant benefits such as improved attendance and enrollment rates, less sleeping in class, and less student-reported depression.” Other findings of the suburban high schools included:

- Many parents and administrators feared that students would merely use the later morning start time as an excuse to stay up an hour later on school nights. The data showed that this did not happen. Students continued to go to bed at the same time.
- Survey questions that measured feelings and behaviors often associated with depression (e.g., feeling too tired to do things; feeling hopeless about the future; feeling sad, unhappy, or depressed; feeling nervous or tense) showed statistically significant less depressive feelings than the early start students.
- Attendance rates for all students in grade 9, 10, and 11 improved in the years 1995 to 2000, with the greatest rate of improvement for grade 9.
- The attendance rate for at-risk students improved significantly (particularly those who had insufficient credits for graduation). This suggests that changing start times might be a way to recapture those students.
- Coaches and activity leaders were generally supportive of the change because they saw students who were less tired and seemingly more mentally alert at the end of the day. However, a few coaches whose sports involved long practices and traveling distances were outspoken about their dislike of the time change.
- Actual participation rates in after-school activities remained at the same levels as before the late start time.
- Suburban teachers expressed a positive experience from the later start time. In interviews, they were nearly unanimous in the view that students were more alert during the day.
- 57% of both urban and suburban teachers reported a greater number of students being more alert during the first two periods of the day.
- Teachers cited more time for team planning before the start of school.
- High school principals were personally interviewed, and their most common response was the mood of students in the hallways which was now calmer. As a result, 5 of the 8 principals noted they were dealing with fewer disciplinary referrals to their offices. (Urban teachers, however, did not see any general improvement in student behavior.)
- Seventeen school counselors and 3 school nurses noted that significantly fewer students were coming to them to report peer relationship problems and/or difficulties with their parents.
- Students were eating breakfast more frequently and there was less tardiness.
- Students were able to complete more homework during school hours, because they were more alert and efficient during the day.

- An analysis of letter grades earned in classes during the 3 years prior to and the 3 years after the time change showed a slight improvement in grades overall. However, the results were not statistically significant, because of the difficulty in obtaining “clean” data. (There were more than a million data points.) Nonetheless, students in grades 9-12 self-reported on a written survey that their grades were on an upward, positive slope after the time change.

The author of this report, Kyla Wahlstrom, cautions against the sole use of letter grade improvement as a measure of the merits of a change in school start times. She states, “The use of grades as a sole determinant of a new program’s success is short-sighted. In reality, grades are often a rather subjective measure due to local factors such as curricular changes, teacher and administrator turnover, changes in assessing student work, and possibly grade inflation.” She states that a “minimum of three years’ worth of grades is needed to gauge any possible changes...and, at best, that is only one measure among many.”

There are other equally important measures of impact, such as student physical and emotional well-being, benefits of learning and memory, and improved family and peer relationships.

We have quoted extensively from the four-year CAREI study as it assessed seven high schools and included a stratified sample of over 12,000 students, 3,000 teachers, and interviews from over 750 parents. There have been smaller studies of individual high schools that pushed back their start time; these are discussed below.

“Changing School Start Times: Wilton Connecticut” (Wilton League of Women Voters [WLWV] and Wilton Public Schools)

Profile: Wilton is a small suburban community with a school district of five schools with about 4,300 students (1,000 middle school and 1,230 high school students) managed by a Superintendent and a six-member Board of Education. The effort to change the start times of Wilton’s middle and high schools was championed by the Wilton League of Women Voters. The League initiated a research and study project of their community and became the advocates for change. They provided the blueprint for raising community awareness and worked closely with the Superintendent of Public Schools and the BOE.

Summary: The Wilton School District switched the upper elementary school start time of 8:15 a.m. with the middle/high school start times of 7:35 a.m., thus gaining 40 minutes of sleep time for its adolescents. “Wilton’s start time change was a resounding success. Teachers recognized a change in student behavior; they were more awake, had better attitudes and were overall more pleasant. Parents also reported changes in their kids’ attitudes.”

“Teachers who also coached at the schools were concerned before the change that they would be unable to make it to practices, but this turned out not to be a problem. Wilton High School had one of its best athletic seasons, even earning several state championships.”

“The only problems were for students who had to be pulled out of class early for away games, and for students who participated in more than one sport, although this full schedule would be difficult with any school start time.”

“Later School Start Time Leads to Better Students” (Cynthia Graber, *Scientific American*, July 5, 2010, podcast, citing study in *Archives of Pediatrics and Adolescent Medicine*.)

Profile: Researchers evaluated 201 Rhode Island high school students whose school pushed back its start time from 8:00 to 8:30 a.m. The kids completed a sleep habits survey before and after the time change. Before the actual time change, teachers, coaches and administrators all resisted the change.

Summary: After the change in high school start time, the percentage of students who said they got at least eight hours of sleep per night jumped from about 16% to 55%. Also, class attendance improved, and there were fewer visits to the health center for fatigue-related complaints. Plus, there was a significant drop in the number of students who said they felt unhappy, depressed, annoyed, or irritated.

Other News Reports about Changes in School Start Times

Schools in Virginia and Kentucky have reported a decrease in student car accidents which they have credited to the later start of high school start times. While these studies do not prove that an earlier start time to school leads to more auto accidents, there is a link to drowsy driving and accidents for adults as well as adolescents.

“The Virginia Department of Motor Vehicles collected data on crash numbers and the number of drivers between ages 16 and 18 in two counties: Virginia Beach, where high schools start at 7:20 a.m., and Chesapeake, where high schools start at 8:40 a.m.” The data showed a clear difference between the two counties. Virginia Beach, with its start time of 7:20 a.m. had a 40% higher crash rate. (Note: there are many variables that could impact the difference between crash rates – including, student demographics, road and weather conditions, etc.)

Also a 2008 study in the *Journal of Clinical Sleep Medicine* found that “...when high schools in Fayette County, Kentucky, changed their start times from 7:30 a.m. to 8:30 a.m., teen car crash rates dropped by more than 16%.

What is clear is that driving while drowsy is as dangerous as driving under the influence of alcohol. In fact, the National Highway Traffic Safety Administration (NHTSA) states that “traffic crashes are the leading cause of death for teenagers in America. Mile for mile, teenagers are involved in three times as many fatal crashes as all other drivers.” Our teens must be educated on the dangers of driving while drowsy. The article ends with this admonition: “And if your kids got far too few hours of shut-eye, don’t let them drive to school. They may hate to take the bus, but at least they can safely nap on it.”

Conclusion

“Even without the pressure of biological changes, if we combine an early school starting time - say 7:30 am. Which, with a modest commute, makes 6:15 am a viable rising time – with our knowledge that optimal sleep need is 9 ¼ hours, we are asking 16-year olds go to bed at 9 pm. Rare is a teenager that will keep such a schedule. School work, sports practices, clubs, volunteer work, and paid employment take precedence. When biological changes are factored in, the ability even to have merely ‘adequate’ sleep is lost.”

-Mary Carskadon, PhD., Director of Sleep Research Bradley Hospital. Professor, Brown University Medical School

This report was developed to provide the Jackson Hole community with solid information about the impact of sleep on adolescents and young adults. Research was gleaned from valid scientific sleep research and brain development covering this age group. Also, it is important to understand that the biological changes impacting our teens and young adults are found in other countries around the world. Sleep deprivation in youth has become a critical problem not only in the U.S., but is a critical issue in Japan, Canada, China, Israel, the United Kingdom, Australia, Switzerland, Brazil, and other countries.

From the foregoing research studies, we know that our local teens should be getting between 8½ to 9¼ hours of sleep each night and that their biological or circadian rhythms keep them awake until around 11:00 p.m. Therefore, it is worthy of our consideration as a community to explore the idea of pushing back the start times of JHHS, SHS, and JHMS. We should discuss if our teens are chronically sleep-deprived due to social, work, recreational, and academic pressures. Then, ideally we can focus on what is best for the mental, biological, and emotional health of Jackson Hole’s teens.

Clearly, the crux of this report bolsters the importance of Jackson Hole’s teens getting sufficient sleep at this important time in their lives. Our teens can use an extra hour or more of sleep each night, which would help to ensure vibrant minds and healthy bodies. It is our conclusion that by depriving our kids of sufficient sleep, we are essentially handicapping their ability to learn.

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