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POLICY STATEMENT

School Start Times for Adolescents

abstract

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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]

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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

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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

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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

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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.

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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

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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

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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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