

The Impact of School Start Times on Adolescent Health and Academic Performance

A. Academic Performance

“SLEEP IS THE MOST EFFECTIVE COGNITIVE ENHANCER WE HAVE.” (325.5

(<http://www.ndcn.ox.ac.uk/research/sleep-circadian-neuroscience-institute/research-projects-4/teensleep>))—

Russell Foster (<http://www.bnc.ox.ac.uk/about-brasenose/news/1322-professor-russell-foster-cbe>), Ph.D., F.R.S. (<https://royalsociety.org/people/russell-foster-11452/>), C.B.E.

(<http://www.physoc.org/news/2015/professor-sir-john-bell-and-professor-russell-foster-recognised-2015-new-years-honours>), Professor of Circadian Neurosciences, Head of the Nuffield Laboratory of Ophthalmology, Director of the Sleep and Circadian Neuroscience Institute, University of Oxford.

Sleep, Cognition, & Circadian Timing

Traditionally, cognitive ability, conscientiousness, achievement motivation, and the need for cognition have been “quite effective in predicting academic performance.” (261

(<https://teensneedsleep.files.wordpress.com/2011/05/morningness-eveningness-and-educational-outcomes-the-lark-has-an-advantage-over-the-owl-at-high-school.pdf>)) Sleep, however, also plays an

important role in learning and memory, (11

(<https://teensneedsleep.files.wordpress.com/2011/08/dawson-sleep-and-adolescents.pdf>), 111

(http://www.nap.edu/openbook.php?record_id=9941&page=14), 113

(<https://teensneedsleep.files.wordpress.com/2011/03/sleep-and-memory-in-healthy-children-and-adolescents-a-critical-review.pdf>), 114 (<http://learnmem.cshlp.org/content/15/5/373.full>), 117

(http://books.nap.edu/openbook.php?record_id=11633&page=63), 117.5

(<http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0042191>)) with studies finding an inverse relationship between sleep and academic performance in children, adolescents, and young adults at every educational level. (2

(<https://teensneedsleep.files.wordpress.com/2011/04/omalley-omalley-school-start-time-and-its-impact-on-learning-and-behavior.pdf>), 21

(<https://teensneedsleep.files.wordpress.com/2011/03/millman-2005.pdf>), 24

(<https://teensneedsleep.files.wordpress.com/2011/05/carrell.pdf>), 27

(<https://teensneedsleep.files.wordpress.com/2011/04/roberts-et-al-sleepless-in-adolescence.pdf>), 29

(<https://teensneedsleep.files.wordpress.com/2011/03/willis-how-students-sleepy-brains-fail-them.pdf>), 30 (<https://teensneedsleep.files.wordpress.com/2011/03/wolfson-et-al-2007-middle-school-start-times.pdf>), 34 (<http://web.mit.edu/writing/2010/July/Wolfson&Carskadon2003.pdf>), 35 (http://sleepforscience.com/stuff/contentmgr/files/73fcbc8090d3aca81567db2c113cf0e8/pdf/wolfson_), 44 (<https://teensneedsleep.files.wordpress.com/2011/04/edwards-early-to-rise-the-effect-of-daily-start-times-on-academic-performance-published-version.pdf>), 112 (<https://teensneedsleep.files.wordpress.com/2011/03/sleep-duration-wakesleep-symptoms-and-academic-performance-in-hong-kong-secondary-school-children.pdf>), 115 (<https://teensneedsleep.files.wordpress.com/2011/03/sleep-loss-learning-capacity-and-academic-performance1.pdf>), 116 (<https://teensneedsleep.files.wordpress.com/2011/03/sleep-and-student-performance-at-school.pdf>), 181 (http://faculty.nps.edu/nlmiller/docs/Sleep_and_academic_performance.pdf))

“Two main, though not mutually exclusive, hypotheses have been predominant in interpreting sleep: (i) sleep is restorative for brain metabolism; (ii) sleep serves memory consolidation and the learning process.” (Cardinali (<http://daniel-cardinali.blogspot.com/>), Chronoeducation: How the Biological Clock Influences the Learning Process, publish. in, **The Educated Brain: Essays in Neuroeducation** (http://books.google.com/books?id=YMxtzo_JpWwC&printsec=frontcover&dq=The%20Educated%20Brain%3A%20Essays%20in%20N) (Battro, Fischer (<https://www.gse.harvard.edu/faculty/kurt-fischer>), & Léna, edit., Cambridge Univ. Press 2008) p. 113.)

Sleep loss is associated with “brief mental lapses in attention during simple tasks that can be partially offset by increased effort or motivation.” (11 (<https://teensneedsleep.files.wordpress.com/2011/08/dawson-sleep-and-adolescents.pdf>), 220 (<https://teensneedsleep.files.wordpress.com/2011/04/dahl-the-consequences-of-insufficient-sleep-for-adolescents.pdf>)) Tiredness and fatigue, however, tend to diminish motivation, particularly for tasks perceived as boring or tedious. (220 (<https://teensneedsleep.files.wordpress.com/2011/04/dahl-the-consequences-of-insufficient-sleep-for-adolescents.pdf>)) Sleep deprivation can (<https://teensneedsleep.files.wordpress.com/2011/03/confused-kid.png>) “sometimes mimic or exacerbate symptoms of ADHD (attention deficit/hyperactivity disorder), including distractibility, impulsivity, and difficulty with effortful control of attention.” (220 (<https://teensneedsleep.files.wordpress.com/2011/04/dahl-the-consequences-of-insufficient-sleep-for-adolescents.pdf>), 11 (<https://teensneedsleep.files.wordpress.com/2011/08/dawson-sleep-and-adolescents.pdf>)) There is also evidence that sleep deprivation has marked influences on the ability to perform complex tasks or tasks that require attention in two or more areas at the same time. (11 (<https://teensneedsleep.files.wordpress.com/2011/08/dawson-sleep-and-adolescents.pdf>), 21



(<https://teensneedsleep.files.wordpress.com/2011/03/millman-2005.pdf>), 220

(<https://teensneedsleep.files.wordpress.com/2011/04/dahl-the-consequences-of-insufficient-sleep-for-adolescents.pdf>))

Memory consolidation, long-term recall, and retrieval, particularly of novel material, are all affected by sleep restriction. (182 (http://faculty.nps.edu/nlmiller/docs/SLEEP_Article_2010.pdf)) “[I]nstalling new memories—i.e., learning—clearly benefits from, if not depends upon, intervals of normal sleep.” (2 (<https://teensneedsleep.files.wordpress.com/2011/04/omalley-omalley-school-start-time-and-its-impact-on-learning-and-behavior.pdf>)) “Not getting enough sleep may result in problems with attention, memory, decision-making, organization, and creativity, all of which are clearly important for success in school.” (Mindell (<http://www.chop.edu/doctors/mindell-jodi-a>) & Owens (<http://www.childrenshospital.org/doctors/judith-owens>), **Clinical Guide to Pediatric Sleep: Diagnosis and Management of Sleep Problems** (http://books.google.com/books?id=z-sOmHYJ0VYC&printsec=frontcover&dq=Clinical+Guide+to+Pediatric+Sleep:+Diagnosis+and+Manag+N3WBg&sa=X&oi=book_result&ct=result&resnum=1&ved=0CDEQ6AEwAA#v=onepage&q&f=false) (Lippincott Williams & Wilkins, 2nd ed. 2010) p. 258.)

With two notable exceptions (326 (<https://teensneedsleep.files.wordpress.com/2011/03/eliasson-et-al-association-of-sleep-and-academic-performance.pdf>), 327

(<https://teensneedsleep.files.wordpress.com/2011/05/sleep-and-student-achievement.pdf>)) (the latter

has been criticized for its conclusions re optimal sleep duration), (328

(http://www.huffingtonpost.com/mary-a-carskadon-phd/kids-sleep_b_1348872.html), 329

(http://www.huffingtonpost.com/dr-michael-j-breus/sleep_b_1362886.html)) “studies actually show that students who get better grades sleep *more*, not less.” (Mindell

(<http://www.chop.edu/doctors/mindell-jodi-a>) & Owens

(<http://www.childrenshospital.org/doctors/judith-owens>), *supra*, p. 258, original italics; see, n. 224.5

(<http://www.nrcresearchpress.com/doi/full/10.1139/apnm-2015-0627#.V4Jc7rgrLIW>.) Fundamentally, it

should be noted that the most fatigued students may be the least likely to even make it to class. (329.3

(<https://teensneedsleep.files.wordpress.com/2011/04/hysing-et-al-sleep-and-school-attendance-in-adolescence-results-from-a-large-population-based-study.pdf>), 354

(<http://educationnext.org/do-schools-begin-too-early/>))

A recent study of 8,347 Norwegian adolescents (ages 16-19) found several sleep parameters (i.e., insomnia, daytime tiredness, significant sleep deprivation, and large bedtime discrepancies in weekend versus weekdays) closely associated with increased risk of school non-

attendance. (329.3 (<https://teensneedsleep.files.wordpress.com/2011/04/hysing-et-al-sleep-and-school-attendance-in-adolescence-results-from-a-large-population-based-study.pdf>))

attendance. (329.3 (<https://teensneedsleep.files.wordpress.com/2011/04/hysing-et-al-sleep-and-school-attendance-in-adolescence-results-from-a-large-population-based-study.pdf>))

A 2014 study of 20,026 Swedish students attending grades 7, 9, and upper secondary school (2nd year), demonstrated via **multivariate binary logistic regression analysis**

(<http://galton.uchicago.edu/~pmcc/pubs/paper25.pdf>) that self-reported short sleep duration increased the risk to fail one or more subjects during the school year, with the highest odds for adolescents

sleeping less than 7–8 hours on both school and weekend nights. (329.5 ([<https://schoolstarttime.org/early-school-start-times/academic-performance/>](http://www.sleep-</p>
</div>
<div data-bbox=)

journal.com/article/S1389-9457(14)00386-4/abstract?cc=y)) Students reporting sleep disturbances had an approximately twofold higher relative risk to fail at least one subject during the school year. (329.5 ([http://www.sleep-journal.com/article/S1389-9457\(14\)00386-4/abstract?cc=y](http://www.sleep-journal.com/article/S1389-9457(14)00386-4/abstract?cc=y)))

Scientists have consistently found a constellation of sleep factors—earlier bedtimes, more total sleep, and later rise times—associated with superior academic performance and higher grades. (2

(<https://teensneedsleep.files.wordpress.com/2011/04/omalley-omalley-school-start-time-and-its-impact-on-learning-and-behavior.pdf>), 29 (<https://teensneedsleep.files.wordpress.com/2011/03/willis-how-students-sleepy-brains-fail-them.pdf>), 30

(<https://teensneedsleep.files.wordpress.com/2011/03/wolfson-et-al-2007-middle-school-start-times.pdf>), 34 (<http://web.mit.edu/writing/2010/July/Wolfson&Carskadon2003.pdf>), 145

(https://teensneedsleep.files.wordpress.com/2011/05/f_2879-ccrpm-sleep-insufficiency-sleep-health-problems-and-performance-in-high-sch_3860.pdf), 181

(http://faculty.nps.edu/nlmiller/docs/Sleep_and_academic_performance.pdf) A 2010 meta-analysis (statistical method combining different study results) of 61 studies concerning students 8-18 years of age, found sleepiness most strongly related to school performance, followed by sleep quality and sleep sufficiency. (330 (<https://teensneedsleep.files.wordpress.com/2011/03/dewald-et-al-the-influence-of-sleep-quality-sleep-duration-and-sleepiness-on-school-performance-in-children-and-adolescents-a-meta-analytic-review.pdf>), see also, discussion n (<https://schoolstarttime.org/endnotes/>). 330, *infra*.) In studies examining subject areas independently, mathematics grades appear to be more related to the amount of sleep obtained than other core courses. (112

(<https://teensneedsleep.files.wordpress.com/2011/03/sleep-duration-wakesleep-symptoms-and-academic-performance-in-hong-kong-secondary-school-children.pdf>))



(<https://teensneedsleep.files.wordpress.com/2011/03/counting-sheep-huff-post.jpg>) Increased weekend catch-up sleep has been associated with poor performance on objective attention tasks in a severely sleep deprived (mean 5 hours, 42 minutes per school night) Korean adolescent population, (331

(<http://archpedi.jamanetwork.com/article.aspx?articleid=1107586>))

whereas less sleep deprived New Jersey students partially compensating on weekends for shortened school night sleep (mean <7 hours) were less likely to have school performance deficits. (145

(https://teensneedsleep.files.wordpress.com/2011/05/f_2879-ccrpm-sleep-insufficiency-sleep-health-problems-and-performance-in-high-sch_3860.pdf)) Studying at the expense of sleep appears to be a

noble (and frequent) (100 (<https://teensneedsleep.files.wordpress.com/2011/05/noland-et-al.pdf>))

enterprise offering quickly diminishing returns. (331

(<https://teensneedsleep.files.wordpress.com/2011/04/gillen-oneel-to-study-or-to-sleep.pdf>))

“Dr. **Kyla Wahlstrom** (<http://www.cehd.umn.edu/olpd/people/faculty/Wahlstrom.asp>) of the University of Minnesota surveyed more than 7,000 high schoolers in Minnesota about their sleep habits and grades. Teens who received A’s averaged about fifteen more minutes sleep than the B students, who in turn averaged eleven more minutes than the C’s, and the C’s had ten more minutes than the D’s. **Wahlstrom** (<http://www.cehd.umn.edu/olpd/people/faculty/Wahlstrom.asp>)’s data was an almost perfect replication of results from an earlier study of more than 3,000 Rhode Island high schoolers by Brown’s **Mary Carskadon** (http://research.brown.edu/myresearch/Mary_Carskadon). [38 (<http://www.sleepforscience.org/stuff/contentmgr/files/5598e427689cd7382cdb641dbb672c2a/pdf/car> Certainly, these are averages, but the consistency of the two studies stands out. Every fifteen minutes counts.” (142 (<http://nymag.com/news/features/38951/index1.html>), n. added.)

Even with 9 hours of sleep, adolescents are not as alert as when pre-adolescents they slept for the same length of time. (**Carskadon** (http://research.brown.edu/myresearch/Mary_Carskadon), *Risks of Driving While Sleepy in Adolescents and Young Adults*, publish. in, **Adolescent Sleep Patterns: Biological, Social, and Psychological Influences** (<http://books.google.com/books?id=FydMXE2s2QwC&printsec=frontcover&dq=Adolescent+Sleep+Patterns,+Biological,+Social,+and> (**Carskadon** (http://research.brown.edu/myresearch/Mary_Carskadon), edit., Cambridge Univ. Press 2002) p. 149, citation omitted.) “Furthermore, during the course of pubertal development, the pattern of sleep propensity changes in a way that leads to a decrease of midday alertness, and this pattern appears to be maintained as humans age.” (*Ibid* (<http://books.google.com/books?id=FydMXE2s2QwC&printsec=frontcover&dq=Adolescent+Sleep+Patterns,+Biological,+Social,+and> citation omitted.) A survey of 6,632 students from 349 secondary schools across Italy found an association between increased complaints of daytime sleepiness and poor academic achievement. (Gianotti & Cortesi, *Sleep Patterns and Daytime Function in Adolescents: An Epidemiological Survey of an Italian High School Student Sample*, publish. in, **Adolescent Sleep Patterns: Biological, Social, and Psychological Influences** (<http://books.google.com/books?id=FydMXE2s2QwC&printsec=frontcover&dq=Adolescent+Sleep+Patterns,+Biological,+Social,+and> (http://research.brown.edu/myresearch/Mary_Carskadon), edit., Cambridge Univ. Press 2002) pp. 132-147.) Overall, however, adolescent students tend to perform better on cognitive tasks as the day wears on. (6 (<https://teensneedsleep.files.wordpress.com/2011/08/the-impact-of-school-daily-schedule-on-adolescent-sleep.pdf>), 267 (<https://teensneedsleep.files.wordpress.com/2011/04/matchock-and-mordkoff-chronotype-and-time-of-day-influence-on-alerting-orienting.pdf>))

A 2005 Northwestern University study, for example, found 60 high school seniors performed better in the afternoon (3:00 p.m.–4:30 p.m.), than in the morning (6:30 a.m.–8:00 a.m. and 11:30 a.m.–1:00 p.m.), on vigilance tests, symbol copying, visual search tasks, and logical reasoning. (6 (<https://teensneedsleep.files.wordpress.com/2011/08/the-impact-of-school-daily-schedule-on-adolescent-sleep.pdf>)) In 2009, Matchock and Mordkoff found that in a sample of 80 older adolescents and young adults (mean age = 21.6 years), general attentional scores for all chronotypes were significantly low at 8 a.m. and twice as high at noon, 4 p.m. and 8 p.m. (267 (<https://teensneedsleep.files.wordpress.com/2011/04/matchock-and-mordkoff-chronotype-and-time-of-day-influence-on-alerting-orienting.pdf>))

Larks v. Owls (<https://teensneedsleep.files.wordpress.com/2011/03/lark-with-worm.jpg>)

Evening types are more likely to complain of daytime sleepiness and underachieve academically than morning types, (333 (<https://teensneedsleep.files.wordpress.com/2011/03/giannotti-et-al-circadian-preference-sleep-and-daytime-behaviour-in-adolescence.pdf>)) despite evidence giving the edge in cognitive ability, on average, to owls. (334 (<https://teensneedsleep.files.wordpress.com/2011/03/kanazawa-why-night-owls-are-more-intelligent.pdf>), 335 (<https://teensneedsleep.files.wordpress.com/2011/03/roberts-et-al-morningness-eveningness-and-intelligence-early-to-bed-early-to-rise-will-likely-make-you-anything-but-wise.pdf>))



A recent study of 9th and 10th grade German children found larks outperformed owls on exams administered from 10 a.m. to noon. (261 (<https://teensneedsleep.files.wordpress.com/2011/05/morningness-eveningness-and-educational-outcomes-the-lark-has-an-advantage-over-the-owl-at-high-school.pdf>)) In 2011, scientists from Germany and the United States undertaking a 20 study meta-analysis of research pertinent to assessing the effect of chronotype upon academic achievement and intelligence made similar findings.

“Across all studies, eveningness was found to be negatively related to academic achievement, whereas morningness correlated positively with academic achievement. These relationships were found to be independent of the age of the sample. That is, morningness was adaptive and eveningness was maladaptive for academic achievement within school and university settings alike. There are several possible explanations for this series of findings. One involves a synchrony effect which states that people show better performance at times that match their individual preferences for the time of day. Synchrony effects could be found for a number of school relevant tasks such as attention and memory. However, other researchers reported that time of day did not affect cognitive performance. An alternative explanation focuses on sleep deprivation as a relevant factor for understanding the negative relation between eveningness and academic achievement. Due to an early start to the school day, eveningness-oriented persons are at risk for sleep deficits. Quality and quantity of sleep are positively related to academic achievement. Because of sleep deficit, evening-oriented students may show higher levels of day time tiredness and a higher likelihood of falling asleep (or zoning out) during lessons. Thus, sleep deprivation might lead to impaired learning and performance. In addition, some studies suggest that behavioral problems are more common in poor sleepers than in their control peers. Thus, a third possible explanation might involve a number of confounding factors, such as behavioral problems. Persons with proclivity towards eveningness appear to be more likely to show some characteristics that are negatively related to scholastic achievement such as lower levels of conscientiousness, higher levels of depression and anxiety, or a negative attitude towards school. [9] People with an evening orientation tend to be, on average, more intelligent, but they do not do as well in school as their morning-oriented counterparts. The reverse is true for individuals with a preference for morningness: they tend to do better in school, yet their cognitive ability tends to be, on average, lower. Since intelligence and academic performance are consistently found to be positively related we can surmise that chronotype may serve as a naturally occurring attenuating variable.” (336 (<https://teensneedsleep.files.wordpress.com/2011/03/preckel-et-al-chronotype-cognitive-abilities-and-academic-achievement-a-meta-analytic-investigation.pdf>))

(<http://www.uni-trier.de/index.php?id=7638>)

(<https://teensneedsleep.files.wordpress.com/2011/03/owls-at-night.jpg>) While recognizing further research in this area is needed, the scientists propose that “changes in students’ schedule may result in better achievement. Initial attempts to push start of the school day until later hours resulted in significant academic gains (Wahlstrom



(<http://www.cehd.umn.edu/olpd/people/faculty/Wahlstrom.asp>), 2002). These gains might be especially prevalent for students with a strong preference for evening activities.” (336

(<https://teensneedsleep.files.wordpress.com/2011/03/preckel-et-al-chronotype-cognitive-abilities-and-academic-achievement-a-meta-analytic-investigation.pdf>)) Adolescents unable to fall asleep before

11:30 p.m. on school nights tend to perform worse in school than their more “phase-advanced” counterparts. (146 (<https://teensneedsleep.files.wordpress.com/2011/05/asarnow-et-al-the-effects-of-bedtime-and-sleep-duration-on-academic-achievement-and-emotional-outcomes.pdf>))

Norwalk Hospital (<http://www.norwalkhospital.org/medical-services/sleep/>) sleep specialists advise, “The circadian biology of sleep would predict that among individual children, those who are predisposed to be ‘night owls’ would be even more likely to suffer the consequences of sleepiness in a school system that imposes start times before 9 a.m.” (2

(<https://teensneedsleep.files.wordpress.com/2011/04/omalley-omalley-school-start-time-and-its-impact-on-learning-and-behavior.pdf>)) Many scientists urge even later starting times, (7

(<http://www.abc.net.au/science/articles/2007/05/03/1913123.htm>)) particularly for older adolescents.

(65 (<https://teensneedsleep.files.wordpress.com/2011/04/kelley-et-al-synchronizing-education-to-adolescent-biology-let-teens-sleep-start-school-later.pdf>)) Notably, morning administration of the ACT and SAT exams tends to favor larks over owls. (261

(<https://teensneedsleep.files.wordpress.com/2011/05/morningness-eveningness-and-educational-outcomes-the-lark-has-an-advantage-over-the-owl-at-high-school.pdf>), 336

(<https://teensneedsleep.files.wordpress.com/2011/03/preckel-et-al-chronotype-cognitive-abilities-and-academic-achievement-a-meta-analytic-investigation.pdf>))

Start Times and Academic Achievement

“Since children’s time of day preference shifts towards eveningness as they get older, their cognitive functioning is likely to be at its peak more towards the afternoon than in the morning. Thus, if important basic classes such as reading and mathematics are taught in the morning, older school children will be learning this critical material at their less-preferred or non optimal time of day, resulting in poorer school performance than might be found were the courses in greater synchrony with circadian arousal rhythms.” (Cardinali (<http://www.daniel-cardinali.mymedfusion.com/index.cfm/fuseaction/site.physicians/action/dtl/phys/99847076.cfm>),

Chronoeducation: How the Biological Clock Influences the Learning Process, publish. in, **The Educated Brain: Essays in Neuroeducation** (http://books.google.com/books?id=YMxtzo_JpWwC&printsec=frontcover&dq=The%20Educated%20Brain%3A%20Essays%20in%20N

supra, p. 122, citation omitted.)

“[D]elayed sleep schedules and early school start times are associated with daytime sleepiness, dozing in class, attention difficulties, and poorer academic performance.” (12

(<https://teensneedsleep.files.wordpress.com/2011/03/wolfson-carskadon-a-survey-of-factors-of-influencing-high-school-start-times.pdf>)

A 2005 study published in *Pediatrics*, the official Journal of the American Academy of Pediatrics, concluded, “School schedules are forcing [adolescents] to lose sleep and to perform academically when they are at their worst.” (6

(<https://teensneedsleep.files.wordpress.com/2011/04/hansen-et-al-the-impact-of-daily-school-schedule-on-adolescent-sleep.pdf>)

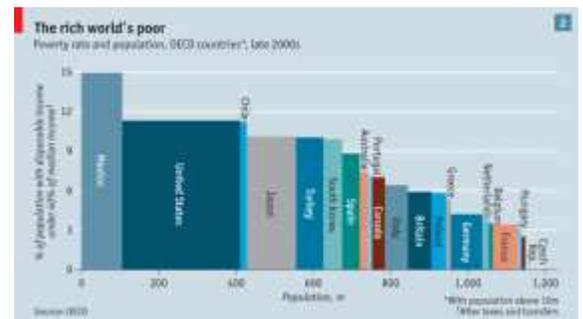
University of Oxford scientists report that the adolescent “circadian drive isn’t optimised for wakefulness and engagement until around 10:00.” (346

(<https://www.youtube.com/watch?v=2BoLqqNuqWA>) As noted briefly above (see, § III

(<https://schoolstarttime.org/early-school-start-times/>), *supra*), and discussed further, *infra*, a recent 13-year study of Chicago public high schools found students beginning morning classes at 8 a.m. show marked deficiencies in performance in first period courses throughout the term. (318

(<https://teensneedsleep.files.wordpress.com/2011/09/cortes-bricker-and-rohlf-the-role-of-specific-subjects-in-education-production-function.pdf>)

(<https://teensneedsleep.files.wordpress.com/2011/03/the-rich-worlds-poor-oecd.png>) Restricted sleep for students from lower socioeconomic backgrounds is more likely to be associated with diminished cognitive outcomes. (Wolfson



(<http://www.loyola.edu/departments/academicaffairs/about/biography>) & Richards, Young Adolescents: Struggles with Insufficient Sleep, publish. in, *Sleep and Development* (http://books.google.com/books?id=hjsqNZAtaEQC&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false) (Oxford Univ. Press, El Sheikh (<http://www.humsci.auburn.edu/~elshemm/>) edit. 2011) p. 272, citations omitted.) Writing for the Brookings Institute, economists Jonah Rockoff

(<http://cupop.columbia.edu/people/jonah-e-rockoff>) of Columbia University and Brian Jacob (http://www.fordschool.umich.edu/faculty/Brian_Jacob) of the University of Michigan calculate that “[e]arly school start times reduce performance among disadvantaged students by an amount equivalent to having a highly ineffective teacher. [¶] The earliest school start times are associated with annual reductions in student performance of roughly 0.1 standard deviations for disadvantaged students, equivalent to replacing an average teacher with a teacher at the sixteenth percentile in terms of effectiveness.” (49 (<https://teensneedsleep.files.wordpress.com/2012/02/jacob-and-rockoff-organizing-schools-to-improve-student-achievement.pdf>))

In 2009, Kyla Wahlstrom (<http://www.cehd.umn.edu/olpd/people/faculty/Wahlstrom.asp>), Director of the University of Minnesota Center for Applied Research and Educational Improvement (CAREI (<http://www.cehd.umn.edu/carei/>)), reported that in schools delaying start times, the academic trend following the change goes exclusively towards higher grades, (45 (<https://teensneedsleep.files.wordpress.com/2011/03/lamberg-jama-article.pdf>)) an assertion which appears supported by the evidence. (13 (<https://teensneedsleep.files.wordpress.com/2011/04/lufi-et-al>

delaying-school-starting-time-by-one-hour-some-effects-on-attention-levels-in-adolescents.pdf), 30 (<https://teensneedsleep.files.wordpress.com/2011/03/wolfson-et-al-2007-middle-school-start-times.pdf>), 34 (<http://web.mit.edu/writing/2010/July/Wolfson&Carskadon2003.pdf>), 35 (http://sleepforscience.com/stuff/contentmgr/files/73fcbc8090d3aca81567db2c113cf0e8/pdf/wolfson_), 41 (<http://archpedi.jamanetwork.com/article.aspx?articleid=383436>), 44 (<https://teensneedsleep.files.wordpress.com/2011/04/edwards-early-to-rise-the-effect-of-daily-start-times-on-academic-performance-published-version.pdf>), 142 (<http://nymag.com/news/features/38951/index1.html>), 316 (<http://www.progresivno.org/download/attachments/2162934/Nurture+shock.PDF?version=1&modificationDate=1297352858000>), 342 (<http://www.nytimes.com/2008/01/14/opinion/14kalish.html>), 343 (<https://teensneedsleep.files.wordpress.com/2011/04/carei-school-start-time-study-final-rep-summary-1998.pdf>) “[T]rend lines show grades rise when schools open later. We never see trend lines suggesting grades go down.” (45 (<https://teensneedsleep.files.wordpress.com/2011/03/lamberg-jama-article.pdf>)) “[C]learly ... they’re more alert and awake throughout the day[.]” (350 (http://chronicle.augusta.com/news/education/2012-04-26/glenn-hills-principal-wants-start-school-later-time?mmo_ccc=xfinity))

A 2007 study led by Holy Cross Professor of Psychology **Amy Wolfson** (<http://www.loyola.edu/department/academicaffairs/about/biography>) compared two New England middle schools with different start times (7:15 a.m. vs. 8:37 a.m.). (30 (<https://teensneedsleep.files.wordpress.com/2011/03/wolfson-et-al-2007-middle-school-start-times.pdf>))

“Previous research demonstrated that high school students benefit when school start times are delayed by over 1 hr. In particular, **Wahlstrom** (<http://www.cehd.umn.edu/olpd/people/faculty/Wahlstrom.asp>) (2002) found that attendance rates improved, continuous enrollment remained the same or increased, grades showed slight improvement, and students reported bedtimes similar to students in schools that did not change start times when obtaining 1 hr more sleep on school nights. The present study adds to the field by demonstrating that middle school students are also at an advantage when school start times are delayed. Results reveal that seventh and eighth graders attending an early starting middle school are obligated to wake up earlier in the morning to attend school and are not compensating by going to bed earlier throughout the school year. As a result, these young adolescents are getting significantly less sleep than their peers at a later starting school and report more irregular weekly sleep patterns, increased daytime sleepiness, and more sleep–wake behavior problems. The seventh and eighth graders at the early starting middle school obtained about $\frac{3}{4}$ hr less sleep each night, which amounts to about 3.5 hr less sleep over a 5-night school week. Furthermore, after students had been on their school schedules for over 6 months, those at the early starting school reported more sleep–wake behavior problems, raising questions about the longer range negative implications of early start times for young adolescents. In addition to the sleep deficit, school records indicated that students at the earlier starting school were tardy four times more frequently, and eighth graders at the earlier starting school obtained significantly

worse average grades than the eighth graders at the comparison, later starting school.” (30 (<https://teensneedsleep.files.wordpress.com/2011/03/wolfson-et-al-2007-middle-school-start-times.pdf>))



(<https://teensneedsleep.files.wordpress.com/2011/03/book-quill-pen-magnifying-glass-etc.jpg>) Following a delay in the **Arlington** (<http://www.apsva.us/domain/10>), Virginia, public school system high school start time (7:30 a.m. to 8:15 a.m.), teachers reported improvements in both student alertness and participation. (43 (http://www.nap.edu/openbook.php?record_id=11633&page=210)) A start time delay of 30 minutes to 8:30 a.m. at **St. George’s School**

(<http://www.stgeorges.edu/>), Rhode Island, resulted in

increases in student-reported levels of motivation and “significant improvements” in objective measures of adolescent alertness. (41 (<http://archpedi.jamanetwork.com/article.aspx?articleid=383436>)) Students

self-reported improved grades, but the differences were not statistically significant. (41

(<http://archpedi.jamanetwork.com/article.aspx?articleid=383436>), 351

(<http://www.browndailyherald.com/owens-80-advocates-later-start-for-more-sleep-1.2343466>))

A 2011 study of Israeli middle school students found “significant improvement” in mathematics and alphabet attention tasks when classes were delayed by one hour to 8:30 a.m. (13

(<https://teensneedsleep.files.wordpress.com/2011/05/lufi-et-al-delaying-school-starting-time-by-one-hour-some-effects-on-attention-levels-in-adolescents.pdf>), 352

(<http://www.aasmnet.org/jcsm/rss/transcripts/0702.pdf>)) The study “strongly recommends that middle schools should consider delaying the school starting time by *at least* one hour. Such a change could enhance students’ cognitive performance by improving their attention level, increasing rate of performance, as well as reducing their mistakes and impulsivity.” (13

(<https://teensneedsleep.files.wordpress.com/2011/05/lufi-et-al-delaying-school-starting-time-by-one-hour-some-effects-on-attention-levels-in-adolescents.pdf>), italics added.) Similarly, when start times

were delayed by one hour to 9:30 a.m., Norwegian 10th graders demonstrated improved performance in reaction time tests (e.g. “psychomotor vigilance” tasks), “proven as valid predictors of performance and levels of fatigue[.]” (353 (<https://teensneedsleep.files.wordpress.com/2011/05/school-start-time-sleepiness-and-functioning-in-norwegian-adolescents.pdf>))

In **Edina** (<http://www.edina.k12.mn.us/>), SAT scores improved (and students’ self-reported levels of motivation increased) following the start time change there. (62

(<https://teensneedsleep.files.wordpress.com/2011/04/bronson-nurture-shock.pdf>), 142

(<http://nymag.com/news/features/38951/index1.html>), Smolensky & Lamberg, **The Body Clock:**

Guide to Better Health

(http://books.google.com/books/about/The_Body_Clock_Guide_to_Better_Health.html?id=aW9IgEJYlt0C) (Henry Holt & Co., 2000) p. 89.) A 2014 CAREI (<http://www.cehd.umn.edu/carei/>)

study found significant increases in overall performance on national standardized achievement tests (ACT/ACT Plan) following start time delays at **Boulder High School**

(<http://bvsd.org/high/boulder/Pages/boulder.aspx>) (7:30 a.m. to 8 a.m., with one late



(<https://teensneedsleep.files.wordpress.com/2011/03/graduates.jpg>) start day, 9 a.m.) in Colorado, and Mahtomedi High School (<http://www.highschool.mahtomedi.k12.mn.us/>) (7:30 a.m. to 8 a.m.) in Minnesota. (309 (<https://teensneedsleep.files.wordpress.com/2011/03/wahlstrom-et-al-impact-of-later-start-time-final-report-feb-2014.pdf>)) A 2017 study of more than 30,000 students attending 29 U.S. high schools found delaying start times to later than 8:30 a.m. increased mean attendance rates by 4 percent and mean graduation rates by 9 percent. (48.7 (<https://teensneedsleep.files.wordpress.com/2011/05/mckeever-et-al-delayed-high-school-start-times-later-than-8-30-a-m-and-impact-on-graduation.pdf>))

Recent meta-analyses of school start time studies (CDC (<http://www.cdc.gov/>), (53.9 (<https://teensneedsleep.files.wordpress.com/2014/10/wheaton-et-al-school-start-times-sleep-behavioral-health-and-academic-outcomes.pdf>)) Yale University (<http://www.yale.edu/>) (43.5 (<https://teensneedsleep.files.wordpress.com/2011/04/minges-et-al-delayed-school-start-times-and-adolescent-sleep-a-systematic-review-of-the-experimental-evidence.pdf>)) multi-agency) (348 (<https://teensneedsleep.files.wordpress.com/2011/03/morgenthaler-et-al-high-school-start-times-and-the-impact-on-high-school-students.pdf>)) found later scheduling associated with longer sleep, improved attendance, and significant declines in tardiness. (43.5 (<https://teensneedsleep.files.wordpress.com/2011/04/minges-et-al-delayed-school-start-times-and-adolescent-sleep-a-systematic-review-of-the-experimental-evidence.pdf>), 53.9 (<https://teensneedsleep.files.wordpress.com/2014/10/wheaton-et-al-school-start-times-sleep-behavioral-health-and-academic-outcomes.pdf>)) Later start times were also associated with reductions in falling asleep in class (53.9 (<https://teensneedsleep.files.wordpress.com/2014/10/wheaton-et-al-school-start-times-sleep-behavioral-health-and-academic-outcomes.pdf>)) and presenteeism (struggling to stay awake during class). (43.5 (<https://teensneedsleep.files.wordpress.com/2011/04/minges-et-al-delayed-school-start-times-and-adolescent-sleep-a-systematic-review-of-the-experimental-evidence.pdf>))

Notably, "regular school attendance is positively associated with academic achievement" (344 (http://www.mitpressjournals.org/doi/pdf/10.1162/EDFP_a_00180)) and obviously, "everybody learns better when they're awake." (345 (<http://www.ewa.org/blog-educated-reporter/schools-slow-wake-research-sleepy-teens>))

The **Yale University** (<http://www.yale.edu/>) research team found later school scheduling associated with evidence of improved academic functioning, (43.5 (<https://teensneedsleep.files.wordpress.com/2011/04/minges-et-al-delayed-school-start-times-and-adolescent-sleep-a-systematic-review-of-the-experimental-evidence.pdf>)) while **CDC** (<http://www.cdc.gov/>) and multi-agency scientists judged the evidence relatively “weak.” (53.9 (<https://teensneedsleep.files.wordpress.com/2014/10/wheaton-et-al-school-start-times-sleep-behavioral-health-and-academic-outcomes.pdf>), 348 (<https://teensneedsleep.files.wordpress.com/2011/03/morgenthaler-et-al-high-school-start-times-and-the-impact-on-high-school-students.pdf>)) Remarkably, all three meta-analyses accorded studies relying upon limited assessment periods and self-reported grades the same value as those relying upon years of data gathered from more objective measures. (43.5 (<https://teensneedsleep.files.wordpress.com/2011/04/minges-et-al-delayed-school-start-times-and-adolescent-sleep-a-systematic-review-of-the-experimental-evidence.pdf>), 53.9 (<https://teensneedsleep.files.wordpress.com/2014/10/wheaton-et-al-school-start-times-sleep-behavioral-health-and-academic-outcomes.pdf>), 348 (<https://teensneedsleep.files.wordpress.com/2011/03/morgenthaler-et-al-high-school-start-times-and-the-impact-on-high-school-students.pdf>))

Economists, by contrast, rely primarily on decades of standardized test scores data collected by fellow economists without regard to sleep duration (i.e., **Carrell** (<http://www.econ.ucdavis.edu/faculty/scarrell/>), et al., (24 (<https://teensneedsleep.files.wordpress.com/2011/05/carrell.pdf>)) **Cortes** (http://www.iza.org/en/webcontent/personnel/photos/index_html?key=1410), et al., (318 (<https://teensneedsleep.files.wordpress.com/2011/09/cortes-bricker-and-rohlf-the-role-of-specific-subjects-in-education-production-function.pdf>)) **Edwards** (<http://www.finleyedwards.com/>), (44 (<https://teensneedsleep.files.wordpress.com/2011/04/edwards-early-to-rise-the-effect-of-daily-start-times-on-academic-performance-published-version.pdf>), 354 (<http://educationnext.org/do-schools-begin-too-early/>)) **Hinrichs** (<http://www.clevelandfed.org/research/economists/hinrichs/>), (356 (<https://teensneedsleep.files.wordpress.com/2011/03/hinrichs-when-the-bell-tolls-the-effects-of-school-starting-times-on-academic-achievement.pdf>)) in determining the fiscal and achievement impact of school scheduling. (49 (<https://teensneedsleep.files.wordpress.com/2012/02/jacob-and-rockoff-organizing-schools-to-improve-student-achievement.pdf>), 295 (http://www.brookings.edu/~media/research/files/papers/2011/9/organization-jacob-rockoff/092011_organize_jacob-rockoff_brief.pdf), 344 (<http://wol.iza.org/articles/educational-effects-of-school-start-times.pdf>)) The United States Air Force Academy study, *infra*, in particular, is believed to capture the “causal effect” of school start times on adolescent academic performance. (24 (<https://teensneedsleep.files.wordpress.com/2011/05/carrell.pdf>), 49

(<https://teensneedsleep.files.wordpress.com/2012/02/jacob-and-rockoff-organizing-schools-to-improve-student-achievement.pdf>), 295 (https://www.brookings.edu/wp-content/uploads/2016/06/092011_organize_jacob_rockoff_brief.pdf))



(https://teensneedsleep.files.wordpress.com/2011/03/bag_of_money.jpg) *Economic Assessments of School Scheduling*

Until recently, most researchers did not believe a cause and effect relationship between later start times and higher scores had been established. Even so, as **Wahlstrom** (<http://www.cehd.umn.edu/olpd/people/faculty/Wahlstrom.asp>) recognized following the start time delays in **Edina** (<http://www.edina.k12.mn.us/>) (7:20 a.m. to 8:30 a.m.) and **Minneapolis** (<http://www.mpls.k12.mn.us/>) (7:15 a.m. to 8:40 a.m.),⁽³⁾ (https://teensneedsleep.files.wordpress.com/2011/04/late-start-times-for-high-school-students_-cehd_-u-of-m.pdf), 37 (<https://teensneedsleep.files.wordpress.com/2011/04/wahlstrom-changing-times-findings-from-the-first-longitudinal-study-of-later-high-school-start-times.pdf>), 322 (<http://cehdvision2020.umn.edu/cehd-blog/later-high-school-start-times/>)) “**there is clearly a statistical relationship between these two variables** that may be explained by other variables (e.g., less depression, less struggle to stay awake in class) that change when the start time of school is changed.” (343 (<https://teensneedsleep.files.wordpress.com/2011/04/carei-school-start-time-study-final-rep-summary-1998.pdf>), emphasis in original.)

Finley Edwards (<http://www.finleyedwards.com/>), Clinical Assistant Professor of Economics at Baylor University, compiled test data covering an 8-year period for middle school students in Wake County, North Carolina, now the 16th largest school district in the country.⁽⁴⁴⁾ (<https://teensneedsleep.files.wordpress.com/2011/04/edwards-early-to-rise-the-effect-of-daily-start-times-on-academic-performance-published-version.pdf>), 354 (<http://educationnext.org/do-schools-begin-too-early/>)) Published in 2012, **Edwards** (<http://www.finleyedwards.com/>)’ study analyzes data for students beginning classes according to their bus scheduling; i.e., Tier I classes (7:30-7:45) and Tier II classes (8:00-8:45).⁽⁴⁴⁾ (<https://teensneedsleep.files.wordpress.com/2011/04/edwards-early-to-rise-the-effect-of-daily-start-times-on-academic-performance-published-version.pdf>)) (Tier III classes (9:15 a.m.) are reserved for elementary school students.)⁽⁴⁴⁾ (<https://teensneedsleep.files.wordpress.com/2011/04/edwards-early-to-rise-the-effect-of-daily-start-times-on-academic-performance-published-version.pdf>)) **Edwards** (<http://www.finleyedwards.com/>) examined standardized test data from the 14 middle schools changing start times by 30 minutes or more during the study period (1999-2006), and compared test scores for respective grade levels.⁽⁴⁴⁾

(<https://teensneedsleep.files.wordpress.com/2011/04/edwards-early-to-rise-the-effect-of-daily-start-times-on-academic-performance-published-version.pdf>) **Edwards**

(<http://www.finleyedwards.com/>) also examined individual achievement before and after the change. (44 (<https://teensneedsleep.files.wordpress.com/2011/04/edwards-early-to-rise-the-effect-of-daily-start-times-on-academic-performance-published-version.pdf>))

The data showed that starting school one hour later (i.e., at 8:30 a.m.) led to average gains of 1.5 to 3 percentile points in standardized math test scores (0.06 to 0.09 standard deviations) and standardized reading test scores (0.03 to 0.10 standard deviations). (44 (<https://teensneedsleep.files.wordpress.com/2011/04/edwards-early-to-rise-the-effect-of-daily-start-times-on-academic-performance-published-version.pdf>)) With most middle schools beginning at 8:15 a.m., (354 (<http://educationnext.org/do-schools-begin-too-early/>)) the gains in **Edwards'**

(<http://www.finleyedwards.com/>) data derive largely from the changes from 7:30 a.m. to 8:15 a.m. (44 (<https://teensneedsleep.files.wordpress.com/2011/04/edwards-early-to-rise-the-effect-of-daily-start-times-on-academic-performance-published-version.pdf>)) Unlike disadvantaged elementary school students (69 (<http://www.apa.org/pubs/journals/releases/edu-a0037195.pdf>) [among school-aged children,

(<https://teensneedsleep.files.wordpress.com/2011/03/low-income-students-in-public-schools.png>) only middle and upper class students show achievement gains as a result of later school scheduling]; see, § IV (<https://schoolstarttime.org/delaying-school-start-times/>), *infra*), disadvantaged middle school students benefited the most from delayed starting hours, with effects roughly twice as large as advantaged students. (44

(<https://teensneedsleep.files.wordpress.com/2011/04/edwards-early-to-rise-the-effect-of-daily-start-times-on-academic-performance-published-version.pdf>), 354

(<http://educationnext.org/do-schools-begin-too-early/>)) Students in the 30th percentile of the ability distribution ended up performing about three percentile points higher on the mathematics exam as a result of a one-hour delay in start time, while students at the 90th percentile performed around one percentile point higher. (44 (<https://teensneedsleep.files.wordpress.com/2011/04/edwards-early-to-rise-the-effect-of-daily-start-times-on-academic-performance-published-version.pdf>), 354

(<http://educationnext.org/do-schools-begin-too-early/>))

Edwards (<http://www.finleyedwards.com/>)' data showed the benefits of later start times increased as the students progressed through adolescence. (44

(<https://teensneedsleep.files.wordpress.com/2011/04/edwards-early-to-rise-the-effect-of-daily-start-times-on-academic-performance-published-version.pdf>), 354 (<http://educationnext.org/do-schools-begin-too-early/>)) Moreover, tests administered to high school sophomores showed "[t]he benefits of a

later start time in middle school appear to persist through at least the 10th grade." (354

(<http://educationnext.org/do-schools-begin-too-early/>)) By contrast, "the negative impact of early start times persists over time." (44 (<https://teensneedsleep.files.wordpress.com/2011/04/edwards-early-to-rise-the-effect-of-daily-start-times-on-academic-performance-published-version.pdf>), 354



rise-the-effect-of-daily-start-times-on-academic-performance-published-version.pdf)) **Edwards** (<http://www.finleyedwards.com/>) also found later start times associated with fewer absences (about 25%), less time spent watching television, and a greater amount of time spent on homework, indicating that these factors may help explain why later starting students have higher test scores. (44 (<https://teensneedsleep.files.wordpress.com/2011/04/edwards-early-to-rise-the-effect-of-daily-start-times-on-academic-performance-published-version.pdf>), 354 (<http://educationnext.org/do-schools-begin-too-early/>)) **Edwards** (<http://www.finleyedwards.com/>) finds that “an increase in start times by 1 h would lead to a 3 percentile point gain in both math and reading test scores for the average student.” (44 (<https://teensneedsleep.files.wordpress.com/2011/04/edwards-early-to-rise-the-effect-of-daily-start-times-on-academic-performance-published-version.pdf>)) Auburn University Professor of Psychology **Joseph Buckhalt** (<http://www.auburn.edu/~buckhja/>) cites **Edwards’** (<http://www.finleyedwards.com/>) study as “direct evidence” of the “measurable significant effect” of later start times on adolescent academic achievement. (355 (<http://www.psychologytoday.com/blog/child-sleep-zzzs/201209/can-later-start-times-affect-school-achievement>))



(<https://teensneedsleep.files.wordpress.com/2011/03/chicago-public-schools.jpg>) In a 2012 study not considered in the meta-analyses, Texas A&M University Associate Professor of Public Policy **Kalena Cortes** (<http://bush.tamu.edu/faculty/kcortes/>), et al., examined how high school students perform in morning versus afternoon classes in **Chicago Public Schools** (<http://cps.edu/Pages/home.aspx>), the third largest school district in the U.S., where classes typically begin at 8:00 a.m. and students are commonly tardy. (318

(<https://teensneedsleep.files.wordpress.com/2011/09/cortes-bricker-and-rohlfs-the-role-of-specific-subjects-in-education-production-function.pdf>)) Examining data obtained from the years 1993-94 to 2005-06, the authors found students were absent roughly six more days per year in first period relative to other periods. (318 (<https://teensneedsleep.files.wordpress.com/2011/09/cortes-bricker-and-rohlfs-the-role-of-specific-subjects-in-education-production-function.pdf>)) Student grades and test score performance were notably lower in first-period courses. (318 (<https://teensneedsleep.files.wordpress.com/2011/09/cortes-bricker-and-rohlfs-the-role-of-specific-subjects-in-education-production-function.pdf>)) For example, students assigned to a math class in first period perform systematically worse on the end-of-year standardized mathematics exams, whereas students assigned to English during first period perform worse on the English exams. (318 (<https://teensneedsleep.files.wordpress.com/2011/09/cortes-bricker-and-rohlfs-the-role-of-specific-subjects-in-education-production-function.pdf>)) Having math in first period reduced test scores in all subjects and reduced grades in future classes. (318 (<https://teensneedsleep.files.wordpress.com/2011/09/cortes-bricker-and-rohlfs-the-role-of-specific-subjects-in-education-production-function.pdf>))

Former Georgetown University Assistant Professor of Public Policy **Peter Hinrichs**

(<http://www.clevelandfed.org/research/economists/hinrichs/>) (now a research economist in the Research Department of the Federal Reserve Bank of Cleveland) has found later start times had no effect on ACT college entrance exam testing scores in Minnesota between 1993 and 2002. (356

(<https://teensneedsleep.files.wordpress.com/2011/03/hinrichs-when-the-bell-tolls-the-effects-of-school-starting-times-on-academic-achievement.pdf>)) As **Hinrichs**

(<http://www.clevelandfed.org/research/economists/hinrichs/>) points out, however, only 59-66% of Minnesota students sat for the ACT test. (356

(<https://teensneedsleep.files.wordpress.com/2011/03/hinrichs-when-the-bell-tolls-the-effects-of-school-starting-times-on-academic-achievement.pdf>)) **Hinrichs**

(<http://www.clevelandfed.org/research/economists/hinrichs/>) additionally observes that the ACT is generally given early on Saturday mornings at a uniform time. (356

(<https://teensneedsleep.files.wordpress.com/2011/03/hinrichs-when-the-bell-tolls-the-effects-of-school-starting-times-on-academic-achievement.pdf>))

“A problem with using ACT data is that the early testing time may not be in sync with the usual sleep-wake cycles of students who attend late-starting high schools. Thus even if later start times increase the amount that students learn, this may not necessarily translate into higher scores on exams taken in the morning.” (356 (<https://teensneedsleep.files.wordpress.com/2011/03/hinrichs-when-the-bell-tolls-the-effects-of-school-starting-times-on-academic-achievement.pdf>))

Writing for the Brookings Institute, economists from Columbia University and the University of Michigan note, “While **Hinrichs** (<http://www.clevelandfed.org/research/economists/hinrichs/>)’ analysis is well done, it is likely that the ACT does not fully capture changes in student learning. Moreover, it is not possible to disentangle completely the schedule changes from other factors that may have changed in Minneapolis (<http://www.mpls.k12.mn.us/>) over this period.” (49

(http://www.brookings.edu/~media/Files/rc/papers/2011/09_organize_jacob_rockoff/092011_organize_jacob_rockoff.pdf))

Edwards (<http://www.finleyedwards.com/>) surmises his results differ from **Hinrichs**

(<http://www.clevelandfed.org/research/economists/hinrichs/>)’ because start times have a greater impact on the bottom half of the distribution. (44

(<https://teensneedsleep.files.wordpress.com/2011/04/edwards-early-to-rise-the-effect-of-daily-start-times-on-academic-performance-published-version.pdf>)) In 2002, echoing the same point, **Wahlstrom**

(<http://www.cehd.umn.edu/olpd/people/faculty/Wahlstrom.asp>) observed, “Those students who do take these tests [SAT/ACT] typically tend to be the most academically able, attend classes regularly, and are likely have study habits that supersede any tiredness they experience. As a result, it is difficult to compare their scores with those of their suburban counterparts on nationally normed tests. ... They are likely to be academically successful no matter what the local policy is about the starting time of the school day.” (37 (<https://teensneedsleep.files.wordpress.com/2011/04/wahlstrom-changing-times-findings-from-the-first-longitudinal-study-of-later-high-school-start-times.pdf>))

(<https://teensneedsleep.files.wordpress.com/2011/03/u-s-air-force-f-16s.jpg>) It appears, however, that start times may account for significant differences in academic performance even among highly qualified, high-achieving, highly disciplined young men and women. (49



(<https://teensneedsleep.files.wordpress.com/2012/02/jacob-and-rockoff-organizing-schools-to-improve-student-achievement.pdf>) Bearing in mind that biological adolescence lasts until around 19.5 years for women and 20.9 years for men, ⁽⁷⁾

(<http://www.abc.net.au/science/articles/2007/05/03/1913123.htm>), 103

(<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2820578/>), 250.3 ([http://www.cell.com/current-biology/abstract/S0960-9822\(04\)00928-5?](http://www.cell.com/current-biology/abstract/S0960-9822(04)00928-5?_returnURL=http%3A%2F%2Flinkinghub.elsevier.com%2Fretrieve%2Fpii%2FS0960982204009285%3Fsho)

[_returnURL=http%3A%2F%2Flinkinghub.elsevier.com%2Fretrieve%2Fpii%2FS0960982204009285%3Fsho](http://www.cell.com/current-biology/abstract/S0960-9822(04)00928-5?_returnURL=http%3A%2F%2Flinkinghub.elsevier.com%2Fretrieve%2Fpii%2FS0960982204009285%3Fsho)

250.4 (<http://www.newscientist.com/article/mg21829130.100-why-teenagers-really-do-need-an-extra-hour-in-bed.html>))

a study of 6,165 first semester United States Air Force Academy freshman from the entering classes of 2004 to 2008 published in the American Economic Journal: Economic Policy found a 50 minute delay in the first class increased grades by 0.15 standard deviations. ⁽²⁴⁾

(<https://teensneedsleep.files.wordpress.com/2011/05/carrell.pdf>)

Air Force Academy students have no choice over their course schedules and, during the years studied, were assigned start times ranging from 7:00 a.m. to 8:50 a.m. ⁽²⁴⁾

(<https://teensneedsleep.files.wordpress.com/2011/05/carrell.pdf>) Unlike most high schools, all first-year students take the same classes and the same standardized course exams, providing a consistent objective outcome measure. ⁽²⁴⁾

(<https://teensneedsleep.files.wordpress.com/2011/05/carrell.pdf>) Thus, the researchers, economists from the Air Force Academy and the University of California, were able to control for potentially confounding factors — grading structure, class selection and teachers, for example — to determine the “causal effect” of start times on adolescent academic achievement. ⁽²⁴⁾

(<https://teensneedsleep.files.wordpress.com/2011/05/carrell.pdf>)

“We find that when a student is randomly assigned to a first period course starting prior to 8 a.m., they perform significantly worse in *all* their courses taken on that day compared to students who are not assigned to a first period course. Importantly, we find that this negative effect diminishes *the later the school day begins*. [¶] Our findings suggest that pushing back the time at which the school day starts would likely result in significant achievement gains for adolescents. [¶] Students with a first period class are disadvantaged for two reasons. First, they are in class at a time that their body wants to be asleep, which both makes it difficult to learn and fatigues the brain. Second, they may be getting less sleep than their peers who napped during first period. [¶] Our findings have important implications for education policy; administrators aiming to improve student achievement should consider the potential benefits of delaying school start time. [¶]

(https://teensneedsleep.files.wordpress.com/2011/03/basic_training_formation-usaf.jpg) “Despite our use of university-level data, we believe our findings are applicable to the high school student population more generally because we consider only freshmen students in their first semester at USAFA. Like high



school seniors, first semester college freshman are still adolescents and have the same biological sleep patterns and preferences as those in their earlier teens. However, we recognize that USAFA students are not the average teen; they were high-achievers in high school and chose to attend a military service academy. Although we do not know for certain if school start times affect high-achievers or military-types differently than teenagers in the general population, we have no reason to believe that the students in our sample would be *more* adversely affected by early start

times. Because the students in our study self-selected into a regimented lifestyle, if anything, we believe our estimates may be a lower-bound of the effect for the *average* adolescent.” (24

(<https://teensneedsleep.files.wordpress.com/2011/05/carrell.pdf>), italics added in 1st ¶, *supra*, original italics in 2nd ¶, *supra*.)

Class attendance is mandatory at the U.S. Air Force Academy, “which implies that the negative effects of early school start times are not driven solely by absences or tardiness.” (344

(<http://wol.iza.org/articles/educational-effects-of-school-start-times.pdf>) Brookings Institute economists believe the Air Force study may have “broader implications. [¶] College freshmen are just slightly older than high school students and share many of the biological characteristics associated with their sleep cycles. While Air Force cadets are clearly a special group, we cannot think of a good rationale why such high-achieving and highly disciplined young men and women would be more adversely affected by early start times than are typical teenagers.” (49

(<https://teensneedsleep.files.wordpress.com/2012/02/jacob-and-rockoff-organizing-schools-to-improve-student-achievement.pdf>) University of California and U.S. Air Force Academy economists offer this additional observation:

“A later start time of 50 minutes in our sample has the equivalent benefit as *raising teacher quality* by roughly one standard deviation. Hence, later start times may be a cost-effective way to improve student outcomes for adolescents.” (24 (<https://teensneedsleep.files.wordpress.com/2011/05/carrell.pdf>), italics added.)

Stanford University economist **Eric Hanushek** (<http://hanushek.stanford.edu/>) calculates that replacing one average teacher with one above average teacher (one standard deviation above the mean) for a class of 20 “will—each year—raise students’ aggregate earnings ... by more than \$400,000.” (323 (<http://educationnext.org/valuing-teachers/>))

(<https://teensneedsleep.files.wordpress.com/2011/03/cash-money-2.jpg>) Economists from Columbia University, the University of Michigan, and Santa Clara University estimate that delaying secondary school start times by one hour would increase overall annual student achievement by roughly 0.10 standard deviation, on average. (49



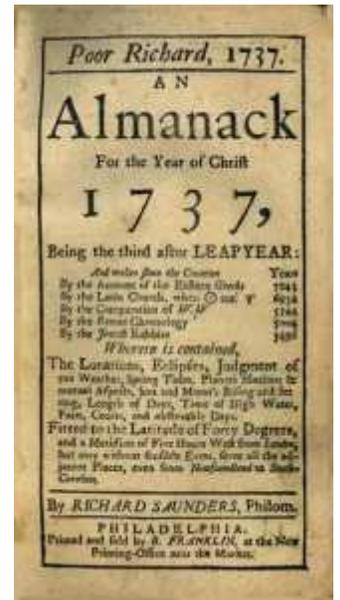
(http://www.brookings.edu/~media/research/files/papers/2011/9/organization-jacob-rockoff/092011_organize_jacob-rockoff_paper.pdf), 344 (<http://wol.iza.org/articles/educational-effects-of-school-start-times.pdf>)) This translates to an approximately \$10,000 increase in future earnings per

student, on average, in 2015 dollars. (344 (<http://wol.iza.org/articles/educational-effects-of-school-start-times.pdf>)) The benefit is even larger for students at the bottom of the grade distribution. (344 (<http://wol.iza.org/articles/educational-effects-of-school-start-times.pdf>)) The impact is equivalent to an additional two months of schooling (295 (http://www.brookings.edu/~media/research/files/papers/2011/9/organization-jacob-rockoff/092011_organize_jacob-rockoff_brief.pdf)) or being in a class with one-third fewer students. (344 (<http://wol.iza.org/articles/educational-effects-of-school-start-times.pdf>))

While students may realize these benefits each year, prior research on other educational interventions suggests that the impacts on test scores may fade out significantly over time. (49 (http://www.brookings.edu/~media/research/files/papers/2011/9/organization-jacob-rockoff/092011_organize_jacob-rockoff_paper.pdf)) For example, research on the benefits of having a highly effective teacher suggests that as much as three quarters of the initial benefits will disappear within three years. (49 (http://www.brookings.edu/~media/research/files/papers/2011/9/organization-jacob-rockoff/092011_organize_jacob-rockoff_paper.pdf)) Assuming students will retain only one quarter of the benefit they realize each year, Brookings Institute economists **Jacob** (http://www.fordschool.umich.edu/faculty/Brian_Jacob) and **Rockoff** (<http://cupop.columbia.edu/people/jonah-e-rockoff>) “conservatively” estimate an increase in academic achievement of 0.175 standard deviations on average, over the course of a student’s middle and high school career, with effects for disadvantaged students roughly twice as large as advantaged students, where middle and high school classes delay from “roughly 8 a.m. to 9 a.m.” (49 (<https://teensneedsleep.files.wordpress.com/2012/02/jacob-and-rockoff-organizing-schools-to-improve-student-achievement.pdf>)) The economists estimate a corresponding lifetime average increase of approximately \$17,500 (2011 dollars) in individual student future earnings. (49 (http://www.brookings.edu/~media/research/files/papers/2011/9/organization-jacob-rockoff/092011_organize_jacob-rockoff_paper.pdf)) **Edwards** (<http://www.finleyedwards.com>)’ study and the study of Air Force Academy cadets suggest that changing start time policies generates these effects for the entire middle or high school. (49 (http://www.brookings.edu/~media/research/files/papers/2011/9/organization-jacob-rockoff/092011_organize_jacob-rockoff_paper.pdf))

(<https://teensneedsleep.files.wordpress.com/2011/03/poor-richards-almanack.jpg>) Sleep expert and Cornell Professor of Psychology **James Maas** (<https://www.sleepassociation.org/contributors/james-maas/>) proposes we reconsider **Poor Richard** (<https://teensneedsleep.files.wordpress.com/2014/10/de-proverbio-mieder-electronic-journal-of-international-proverb-studies-proverbs-quotations-sayings-wellerisms.pdf>)’s advice:

“Sleep deficit is hampering high school achievement. Tiredness should not be confused with laziness. All teens should have the right to learn in an optimum environment. Rather than the ‘early to bed...’ adage, the new adage should be, ‘Wake up later and your grades will be greater.’ ” (4 (http://issuu.com/lungne/docs/healthy_air_matters_9-08))



Blog at WordPress.com.