Sleep in America: A Public Health Priority

Judith Owens MD MPH
Co-Director of Sleep Medicine Boston Children's Hospital
Professor of Neurology Harvard Medical School

Image by CollegeDegrees360. bit.ly/31iyVxA. CC BY-SA 2.0.

Conflict of Interest Disclosure

- I do not have any potential conflicts of interest related to content in this lecture to disclose

Learning Objectives

- Review current research evidence which links deficient sleep to adverse physical and mental health, risk behaviors, and safety outcomes
- Describe risk factors for deficient sleep in adolescents
- Discuss healthy school start times as a potential public health intervention for deficient sleep in adolescents
- Outline ways in which pediatric healthcare providers can advocate for sleep

What is "Deficient" Sleep?

- A concept that acknowledges that short sleep duration (compared to sleep needs) and circadian misalignment (a mismatch between biological circadian rhythms and environmental demands), while inter-related, may both contribute to behavioral and cognitive impairments and poor health outcomes
- In other words, it's not just **how much** you sleep, but **when** you sleep that's critical

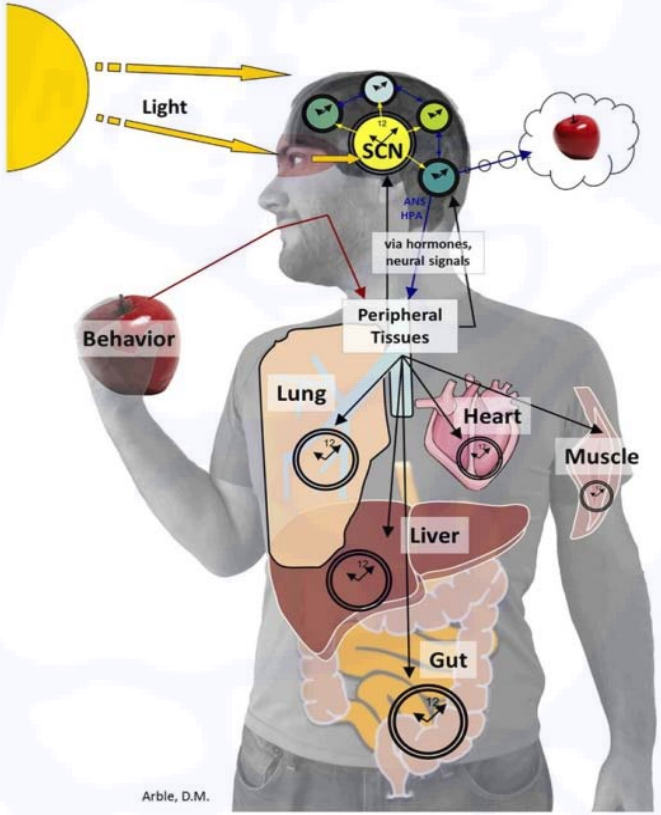
What is Sleep Health?*

- Five dimensions of sleep associated with health outcomes:
  - Satisfaction (subjective “quality”)
  - Alertness/Sleepiness
  - Timing (placement of sleep in 24 hour day)
  - Efficiency (continuity)
  - Duration (24 hour)
- Evidence-based adverse health outcomes include: mortality, coronary heart disease/hypertension, diabetes, depression, accidental injuries, neurobehavioral performance impairments
- BUT little research on *positive* health associations

** Buysse et al SLEEP 37 2014*

Both Sleep Time and Sleep Timing are "Biological Imperatives"

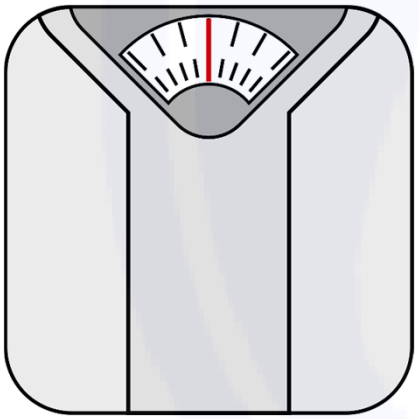
In addition to a "master clock" in the brain, each cell in the body posses a "circadian oscillator"/ "clock" which must be synchronized with one another and the environment

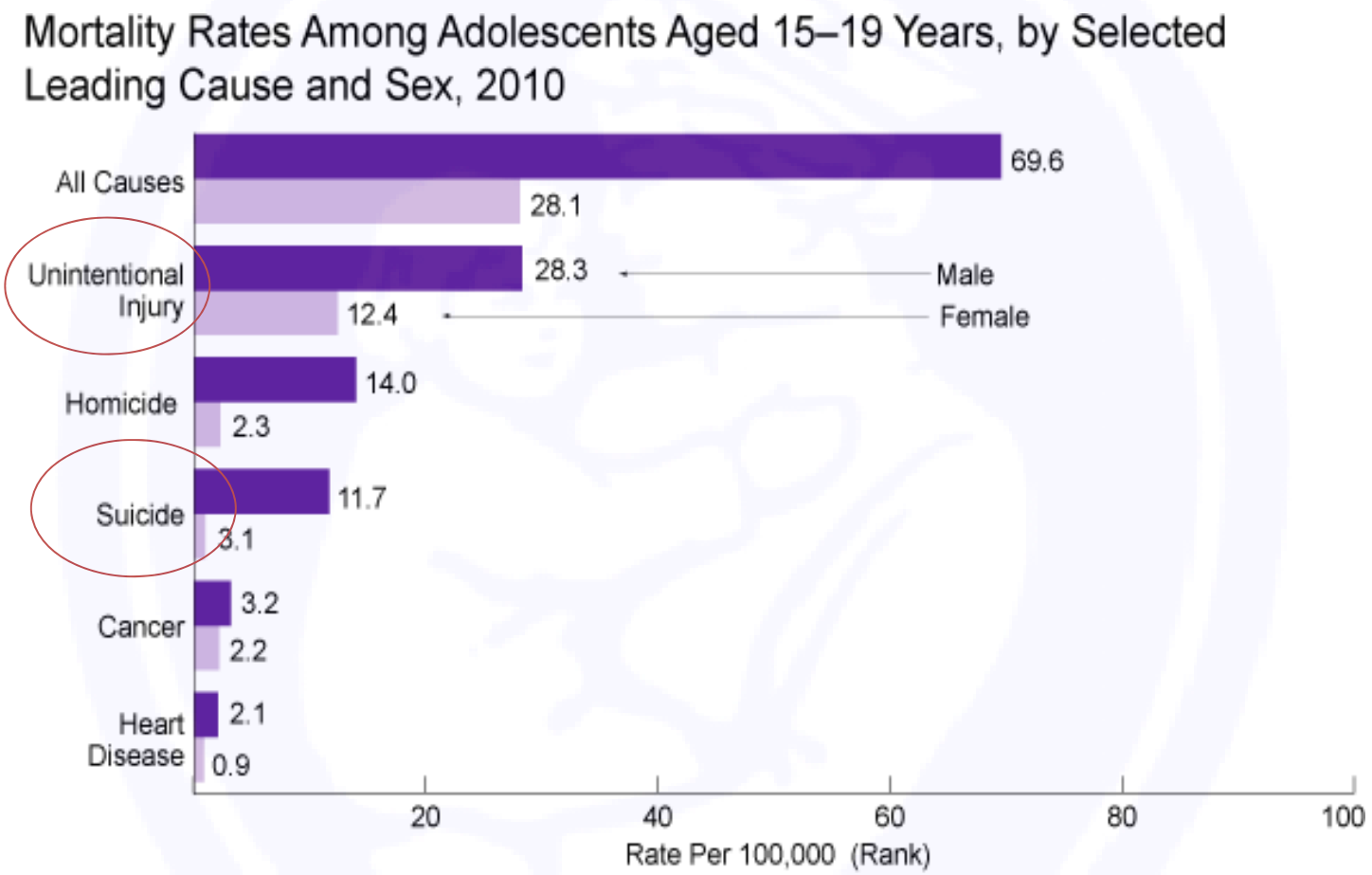


"Misalignment" between internal circadian clocks and the external light-dark cycle results in profound impairments in physiologic function and health

Frontiers in Neurocience, 2013

Effects on Performance, Health and Safety





Source: Centers for Disease Control and Prevention, National Center for Health Statistics. Compressed Mortality File 1999-2010. CDC WONDER Online Database, compiled from Compressed Mortality File 1999-2010 Series 20 No. 2O, 2012. Retrieved from: http://wonder.cdc.gov/ucd-icd10.html. Accessed: November 15, 2012.

Sleep-Starved?

- Multiple studies suggest shorter sleep amounts associated with increased risk of obesity
- Sleep duration and timing affect:
  - Hunger
  - Food intake: increased amount, more calories, more fat
  - Eating patterns (skipping breakfast, increased night eating)
  - Physical activity
  - Cardiovascular function
  - Insulin metabolism and increased diabetes risk
- Sleep apnea more common in obese children, further compromising cardiovascular and metabolic health

Depression Symptoms and Risky Behaviors

- 38% overall with insufficient sleep
  - ≤ 6 hours; 19% 8th graders/42% 10th graders/56% 12th graders
  - Non-white students more likely to have insufficient sleep
- 10% overall with optimal sleep
  - ≥9 hours; 19% 8th graders/6% 10th graders/3% 12th graders
- 40% of teens getting 6 or less hours of sleep report depression symptoms (sadness, hopelessness)
- Almost 3 times as many students getting less than 6 hours of sleep report alcohol use in the past 30 days compared to those getting 9+ hours

*YRBS 2010-2012 Fairfax County VA

Sleep and Safety: Accidental Injuries

- Drowsy driving:
  - Drivers 16-25 years are involved in more than 50% of the 100,000 police-reported fatigue-related traffic crashes each year
  - Sleep loss impairments are equal or greater than those due to alcohol intoxication (ie, 3-4 beers)[1]
- Sleep loss is associated with an increased risk of pedestrian injuries in children and adolescents[2]
- Sleep loss is associated with increased sports-related injuries in high school students[3]

1Arnedt, Owens et al, JAMA 2005; 2 Davis et al, Jl Adol Health 53 2013; 3Milewski et al, Jl Ped Orthoped 34 2014

Safety Issues: MVAs

- Two-thirds of accidental injury fatalities in adolescents are related to road crashes (CDC 2012)
- National poll: 68% of HS seniors have driven while drowsy; 15% at least 1x/wk[1]
- AAA study (2015) found that 16.3% of 16-18 year olds reported driving while "so tired you had a hard time keeping your eyes open" at least once in the past 30 days[2]
- 2015 survey of HS drivers in Fairfax County VA (SST 7:20am)[3]:
  - 48% reported drowsy driving
  - Prevalence 14% higher in students getting <7h vs ≥8
  - Compared to those with a morning chronotype, prevalence of drowsy driving was 10.5% higher among those who were intermediate chronotype and 15.2% higher among those who with an evening chronotype

1NSF 2006 ; 2Tefft 2016 3Owens 2018

Safety Issues: Risk Behaviors

- Sleep Duration and Injury-Related Risk Behaviors (2007-13)[1]
- >50,000 US high school students; 60% 9th graders, 77% 12th graders reporting < 7 hrs sleep
- Injury risk behaviors significantly more frequent in students sleeping < 7 vs 9hrs
  - Infrequent bicycle helmet use
  - Infrequent seatbelt use
  - Texting while driving
  - Rode with drinking driver
  - Drinking and driving (increased 8 vs 9 hrs)

[1]CDC MMWR 4/8/16

Adolescent Sleep: The "Perfect Storm"?

*Includes middle and high school students

Sleep in Adolescents: Later Bedtimes

- All adolescents experience a normal shift in circadian rhythms with age and in association with the onset of puberty
- This results in a biologically-based shift (delay) of up to several hours in both the natural fall sleep and morning wake times
- On a practical level, due to the “forbidden zone” this means that it’s almost impossible for the average adolescent to fall asleep much before 11pm on a regular basis
- Teens cannot “make” themselves fall asleep earlier

Sleep in Adolescents: Later Bedtimes

- Environmental factors
  - Competing priorities for sleep: homework, activities, after-school employment, “screen time”, social networking
  - Circadian phase delay may be further exacerbated by evening light exposure
    - Suppresses brain release of melatonin

Adolescents: Later Wake Times

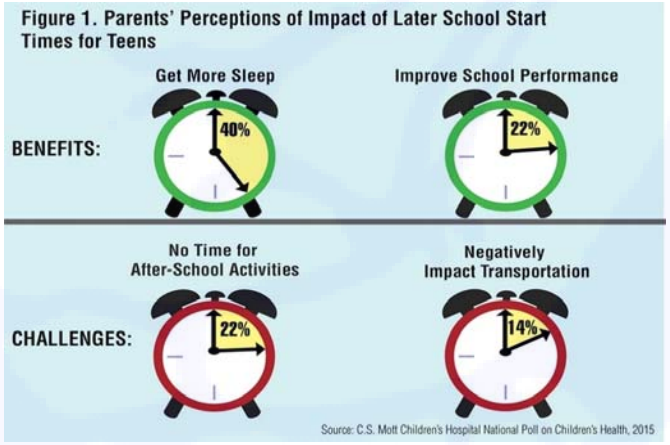
- These biological changes are in direct conflict with earlier high school start times (before 8:30am) because adolescents are biologically programmed to wake at 8am or later
- As a result, students are required to wake for the day and function during the “circadian nadir” (the lowest level of alertness during the 24 hour day)
- Early wake times also selectively rob teens of REM (rapid eye movement) sleep, which is critical for learning *(of new information in particular)* and memory

"Weekend Oversleep"

Image by Tumisu from Pixabay

- Leads to "circadian misalignment"
  - Exacerbation circadian phase delay
  - Shift melatonin onset
- Prevents sufficient build-up of sleep drive
  - Difficulty falling asleep Sunday night
- Result: permanent state of "social jet lag"
  - Adjustment takes 1 day/time zone crossed
  - Effects persist up to 3 days
  - Associated daytime sleepiness, poor academic performance, depressed mood

What is the Role of School Start Times?



Longitudinal Analyses of Student Self-Reported Data in US Schools That Changed to Later School Start Times[1]

- Significant changes ($p<0.05$):
  - Stable bed times
  - Later rise time
  - Longer sleep durations
  - Less weekend catch-up sleep
  - Decline in Epworth scores and less daytime sleepiness
  - Greater sleep satisfaction
  - Less depressed mood
  - More time doing homework

[1]Wheaton A et al, 2016

Longitudinal Analyses of Administrative Data in US Schools That Changed to Later Start Times[1]

- School administration pre- and post-change records show significant changes ($p<0.05$):
  - Increase in % continuously enrolled students
  - Increase in attendance rates
  - Decline in absenteeism rates
  - Decline in tardiness rates
  - 1st period grades improved
  - Higher standardized test scores
  - Increase in GPA

[1]*Wheaton A*. et al, 2016

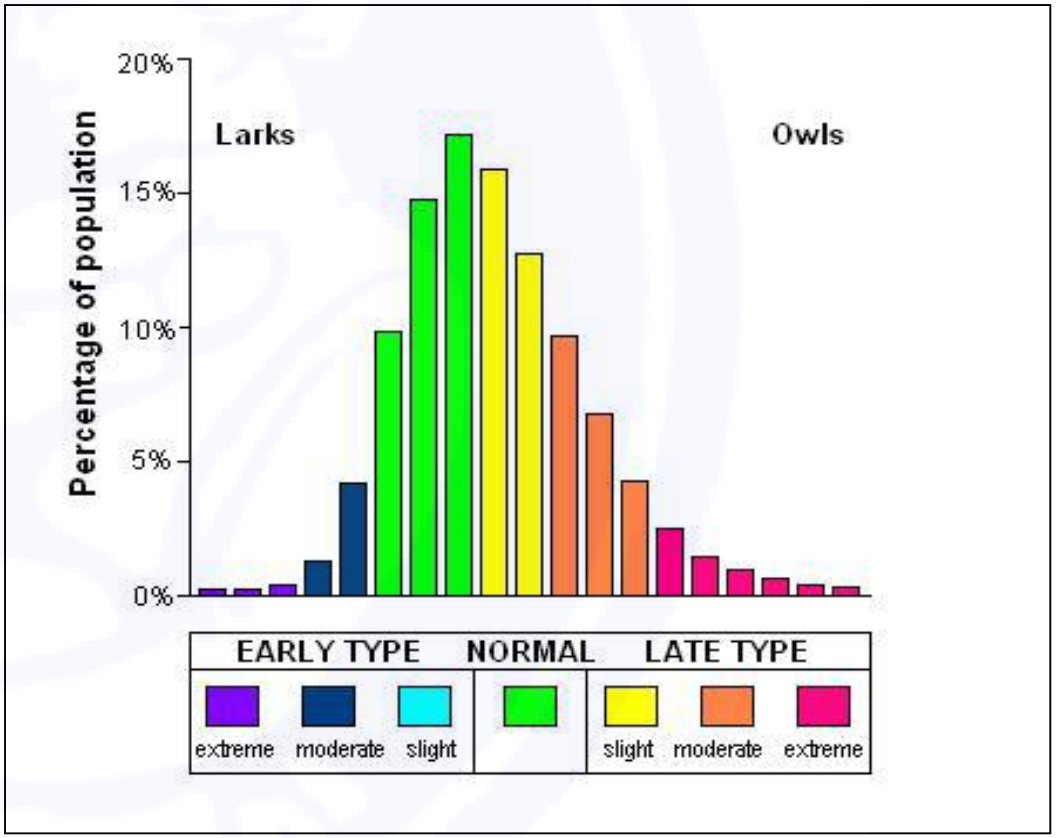
Outcomes: Health & Safety

- Delayed SST are associated with improvements in safety:
  - Kentucky: 7:30 to 8:40a start time; teens involved in car crashes down by 16% (vs 9% increase in the rest of the state)[1]
  - Virginia: Adolescent crash rates VA Beach (7:20a) vs Chesapeake (8:40a) 40% higher and peak 1 hour earlier; similar results follow up study[2,3]
  - CDC study (2014): Reduction crash rates in 16-18yo by as much as 65-70% (Minnesota, Colorado, Wyoming) [4]
  - FCPS (2013-16): Significant decrease in crash rates in FC and a slight increase in the rest of VA; amounting to approximately 126 fewer crashes[5]

Danner and Phillips 2008; 2Vorona et al 2011; 3Vorona et al 2014; 4Wahlstrom 2014; 5Bin-Hasan and Owens, 2020 in press

What is the Role of Chronotype?

- Phase preference—propensity of the individual to sleep or feel most awake at a particular time during a 24-hour period
- Evening chronotype associated with increased risky behaviors, depression, academic failure, obesity, metabolic dysfunction



The Bottom Line: Economic Benefits?[1]

- Recent study (macroeconomic modeling of US state-wide change from current SST to 8:30am vs status quo in 47 states) suggested that benefits of later start times far out-weigh immediate costs ($150 per student/yr ± $110,000 for infrastructure); includes grades 6-12
  - Based on projected student lifetime earnings: increase HS graduation rates by 13.3%; university attendance by 9.6% PLUS reduction in adolescent car crashes
  - After just two years, the study projects an economic gain of $8.6 billion to the U.S. economy
  - After a decade, the study showed that delaying schools start times would contribute $83 billion to the U.S. economy, increasing to $140 billion after 15 years. During the 15 year period examined by the study, the average annual gain to the U.S. economy would about $9.3 billion/yr*
  - Some states (including Massachusetts) would "break even" after just 2 years
- This study suggests that delaying school start times to 8:30am is a cost-effective, population-level strategy which could have a significant impact on public health and the U.S. economy

[1]*Hafner, M,Stepanek M and Troxel W. Later school start times in the U.S.: An economic analysis. Santa Monica, CA: RAND Corporation, 2017. https://www.rand.org/pubs/research_reports/RR2109.html.*

What Can Health Professionals Do?

- Screen
  - Systematically assess sleep patterns, sleep duration, daytime sleepiness at every well child encounter
  - Ask about drowsy driving, electronic media use, caffeine consumption
  - Consider deficient sleep as a factor in patients presenting with academic failure, depression, risk behaviors, obesity
- Educate
  - Inform caregivers and patients about the warning signs and potential impact of insufficient sleep as part of anticipatory guidance
  - Discourage nighttime use of electronic media
- Advocate
  - Delay start times middle/high school until 8:30a or later
  - Include and prioritize sleep as pillar of health

Acknowledgements

- Funding:
  - Robert Wood Johnson Foundation
- Collaborators:
  - Robert Whitaker MD MPH, Tracy Dearth-Wesley PhD MPH and Allison Herman Med MPH, Temple University
  - Michael Oakes PhD, University of Minn
  - Saadoun Bin-Hasan MBBCh, University of Toronto
  - Kshitiz Rakesh MSc and Kush Kapur PhD, Boston Children's Hospital

Boston Children's Hospital
Until every child is well™