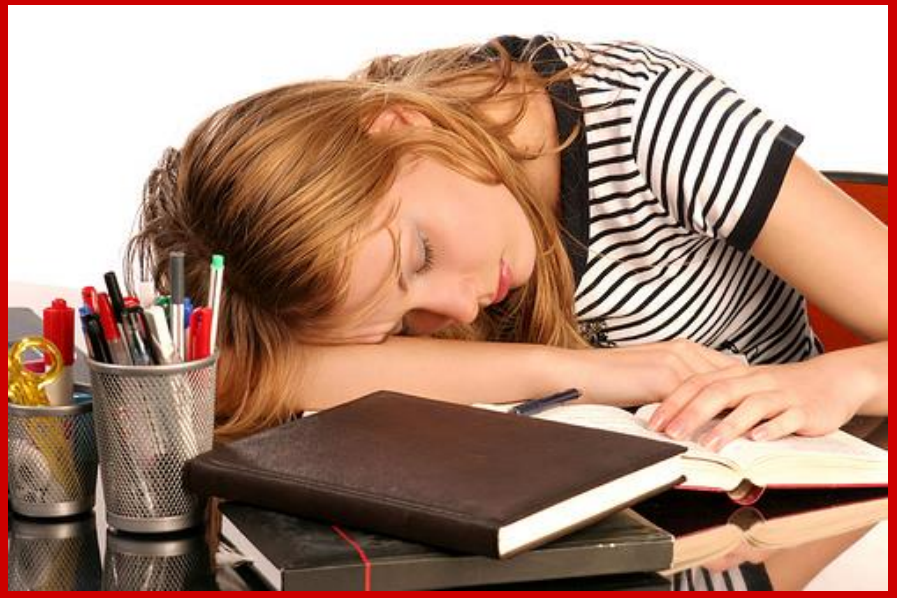

The Science of Sleep and School Start Times

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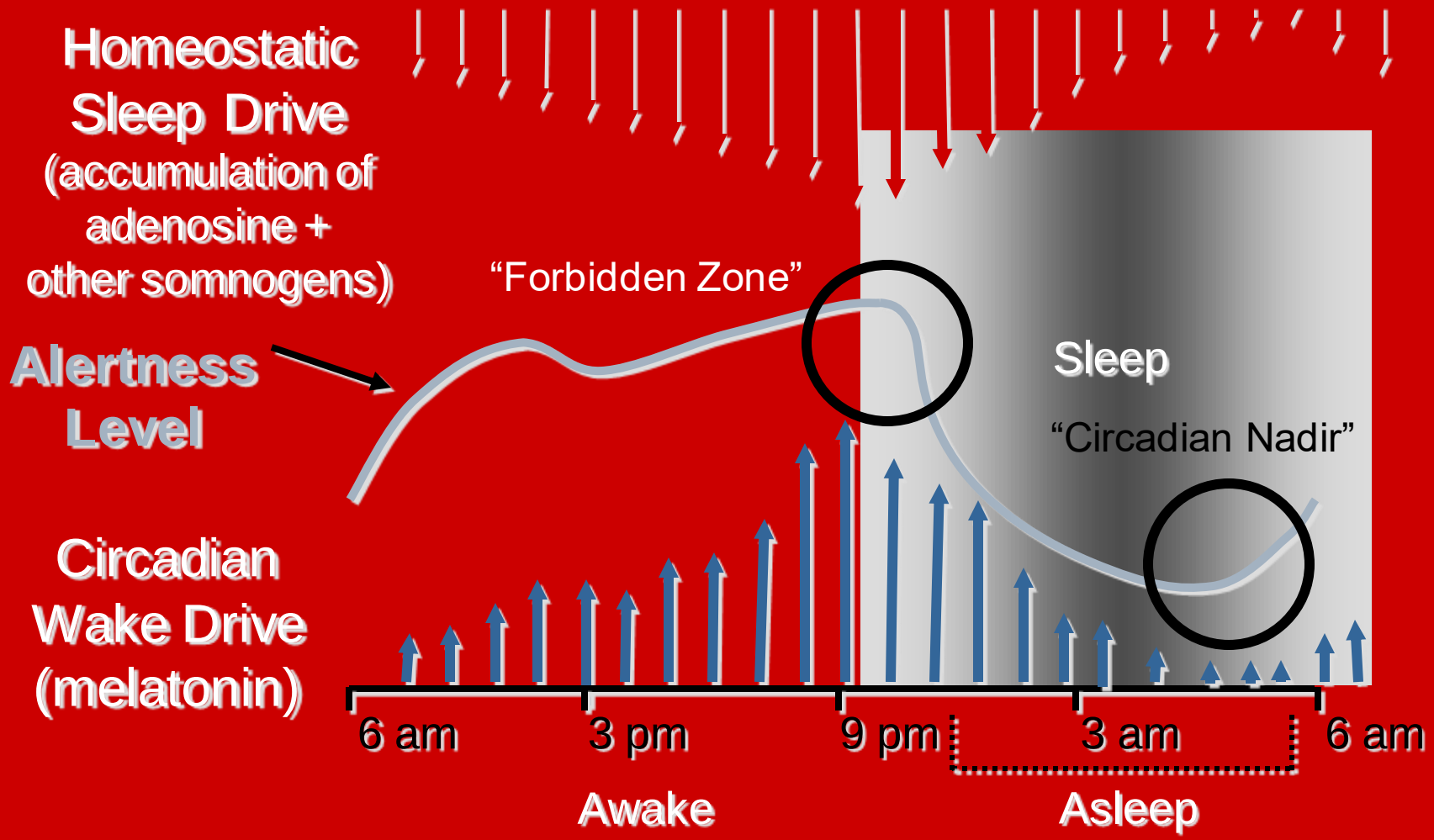
Myths and Misconceptions

- Teens would go to sleep earlier if their parents just made them do it
- Some teens might need 9 hours of sleep, but mine does just fine with 6 (and so do I!)
- Take the cell phones (TV, laptops, tablets) away and kids will fall asleep
- If school starts later, they'll just stay up later
  - And if school lets out later, they'll have to cram in the same amount of stuff in even less time
- Teens can just make up lost sleep by sleeping late on weekends or going to school later one day/wk
- Kids need to learn to get up early; that's real life
- They'll survive

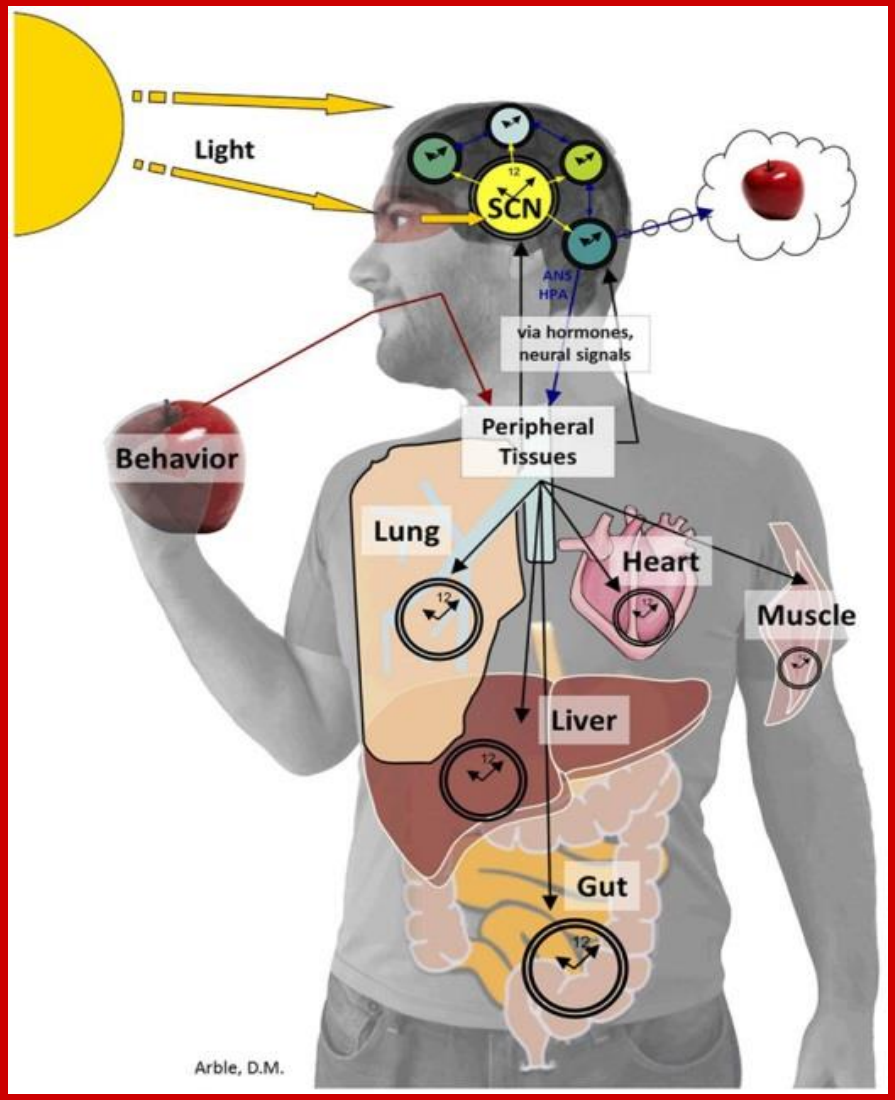
“Two Process” Model of Sleep Regulation



Now, imagine all of this shifting later by 2 hours…

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

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

Adolescents: “Make-Up” Sleep

- Increasing discrepancy between bed and wake times weekday/end
- Adequate compensation for sleep loss?
  - Does not address compromised alertness on school days
  - Does not reverse performance impairments

“Weekend Oversleep”

- 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

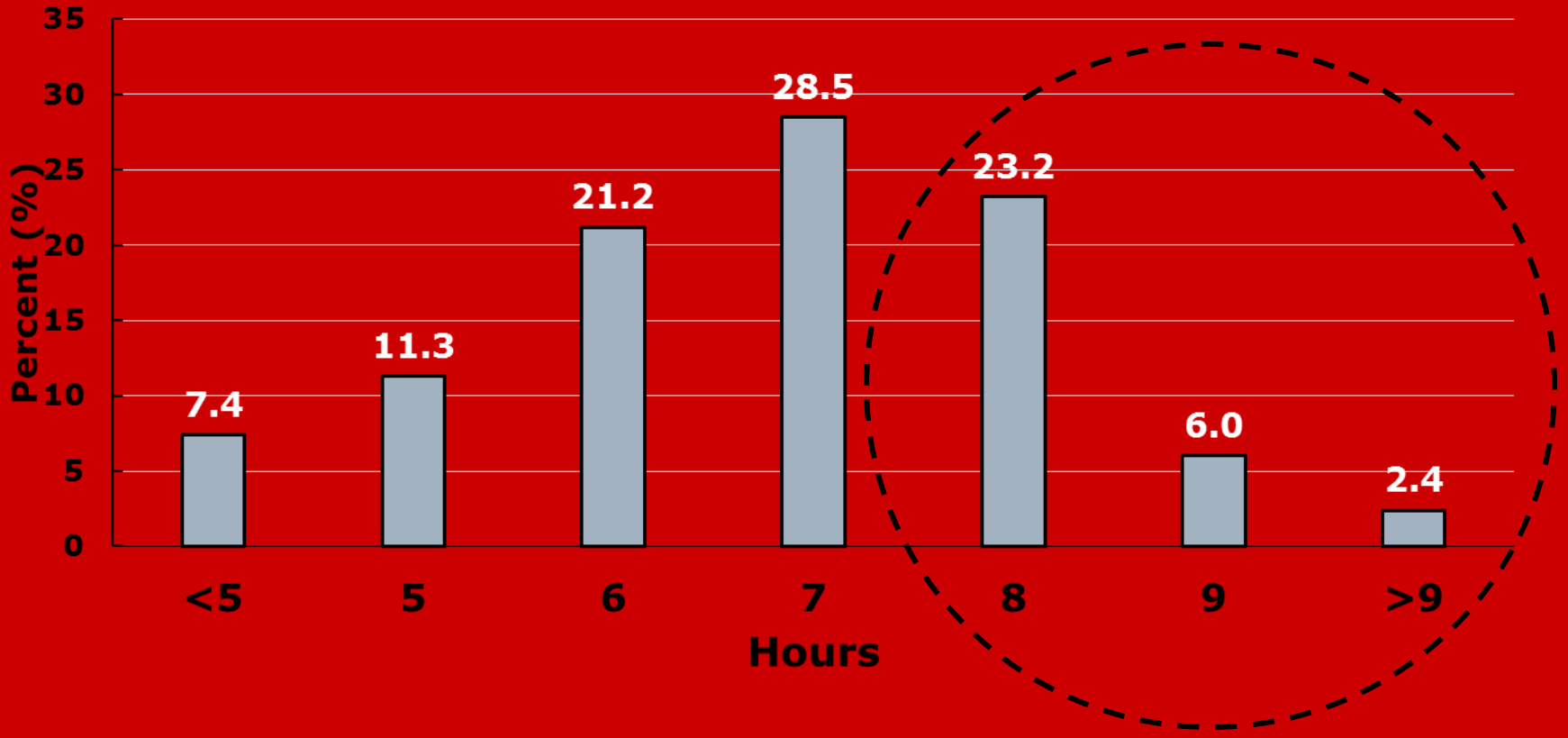
Adolescent Sleep: The Bottom Line

- For optimal health, safety and achievement the average middle and high school student needs:

8-10 hours of sleep*

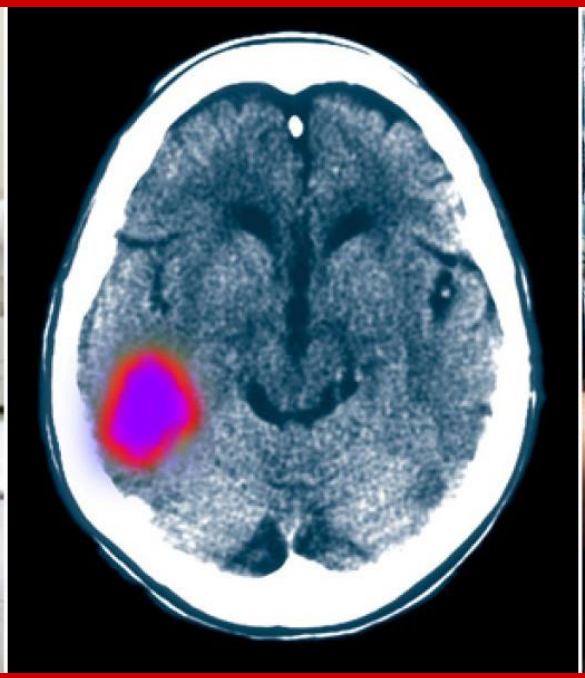
**2016 AASM recommendations based on 10 month review by 13 sleep experts of published scientific evidence addressing the relationship between sleep duration and health (total of 864 scientific articles)*

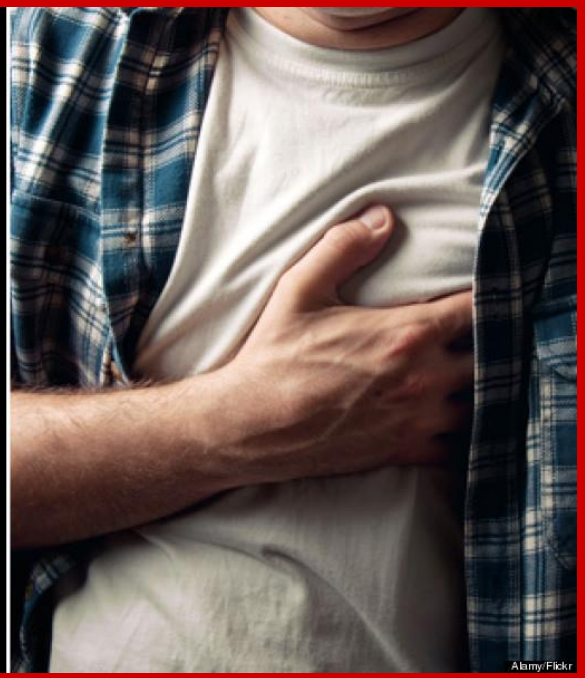
Distribution of Sleep Durations among 12,050 High School Students: US, 2013



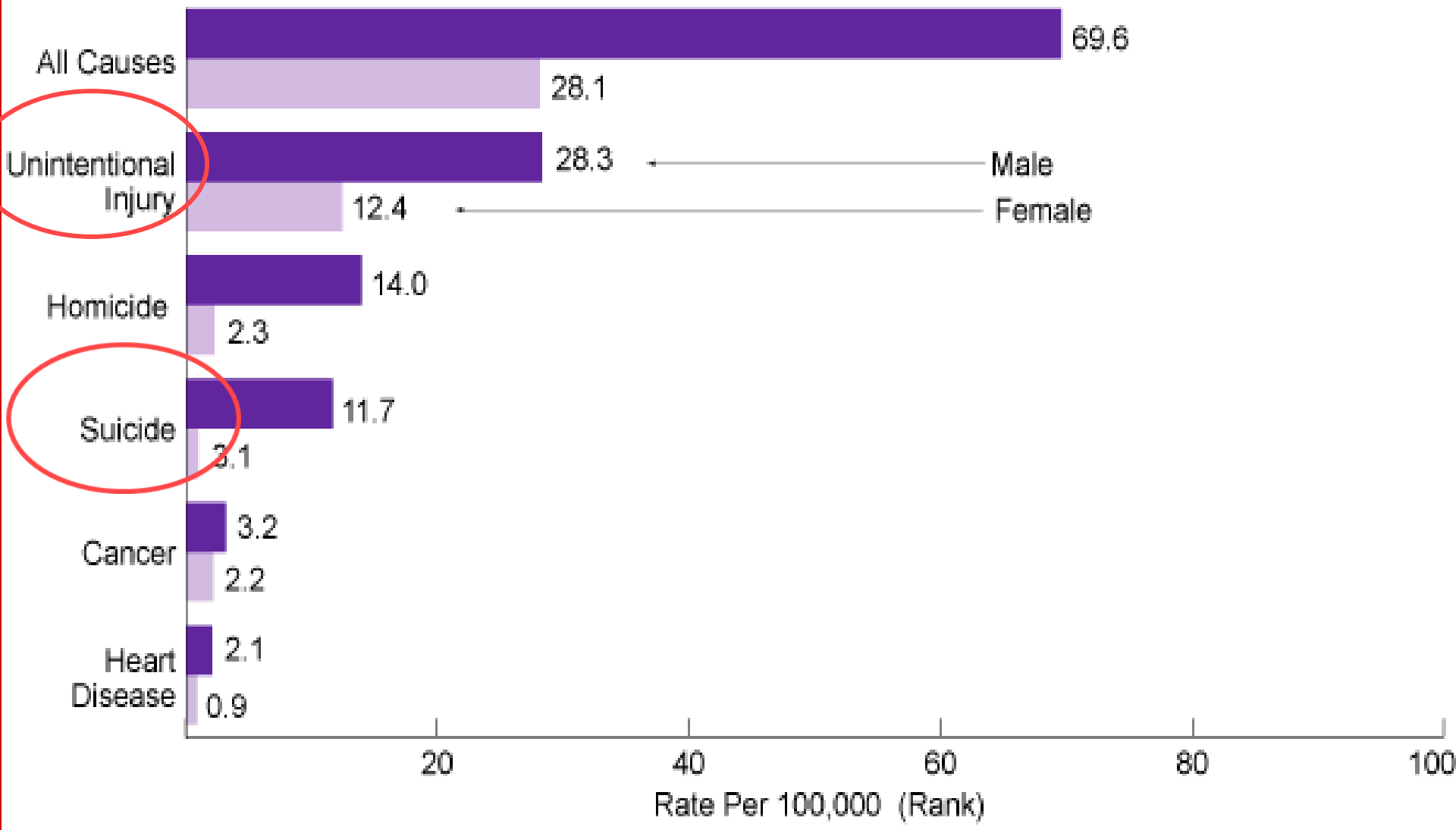
Data Source: CDC. National Youth Risk Behavior Survey (YRBS) 2013

Effects on Performance, Health and Safety





Mortality Rates Among Adolescents Aged 15–19 Years, by Selected Leading Cause of Death 2010



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.

Impact on the Brain

- "Deficient" sleep (insufficient sleep for sleep needs and circadian mis-timing) negatively impacts:
  - Cognitive function (decision-making, problem solving, planning, organization and other "executive functions")
  - Attention
  - Memory
  - Learning of new tasks
  - Emotional regulation
  - Risk-taking behaviors and misinterpretation of relative rewards/consequences

Neuroprotective Role of Sleep

- Sleep loss affects neuronal functions
  - Neuronal "plasticity": ability of the brain to change structure/function in response to the environment
  - Gene activation/expression
  - Brain cell protection/repair from stress
- Recent research has found evidence of a "glympathic system" which eliminates toxins in the brain during sleep and allows the brain to have a "clean slate" from which to work

Impact on Health

- "Deficient" sleep (insufficient sleep for sleep needs and circadian mis-timing) is associated with:
  - Risk of obesity
  - Poor cardiovascular health
  - Metabolic dysfunction (eg, type 2 diabetes)
  - Depression and suicidal thoughts
  - Alcohol and substance use

Impact on Safety

- Drowsy driving:
  - Drivers 16-25 years are involved in more than 50% of the 100,000 police-reported fatigue-related traffic crashes each year
  - National poll: 68% of HS seniors have driven while drowsy; 15% at least 1x/wk
  - Sleep loss impairments are equal or greater than those due to alcohol intoxication (ie, 3-4 beers)
- Lower use of seatbelts, bicycle helmets, increased texting and driving, drinking and driving

Impact on Safety

- Sleep loss is associated with an increased risk of pedestrian injuries in children
- Sleep loss is associated with increased sports-related injuries in high school students
- Sleep loss is associated with almost 3x risk in adolescents of work-related injury requiring medical care

Impact on Performance

- Academic performance
  - GPA
    - Especially first period classes
  - Standardized test scores
  - Tardiness and attendance rates
  - Graduation rates

AAP Recommendation: Delay School Start Time until 8:30 am or Later

American Academy of Pediatrics

DEDICATED TO THE HEALTH OF ALL CHILDREN™

Let Them Sleep: AAP Recommends Delaying Start Times of Middle and High Schools to Combat Teen Sleep Deprivation

8/25/2014

For Release: August 25, 2014

Studies show that adolescents who don't get enough sleep often suffer physical and mental health problems, an increased risk of automobile accidents and a decline in academic performance. But getting enough sleep each night can be hard for teens whose natural sleep cycles make it difficult for them to fall asleep before 11 p.m. – and who face a first-period class at 7:30 a.m. or earlier the next day.

Pediatrics 2014;134:642-649.

Brief History of School Start Times

- BUT less than 1 in 5 middle and high schools in the US (N=40,000) start at the recommended 8:30am or later*
- In **MA**, average SST in 2015 for public middle and high schools was 7:37am (from 7:53am 2011-12) and only 2 schools (1%) of start at 8:30am or later*
  - >80% start before 8am
- Students in earlier starting schools more likely to belong to an ethnic minority, be eligible for free lunches and have less educated parents

*MMWR 2015

Outcomes: Sleep*

- Bedtimes remain the same or in some studies actually shift earlier
- Students obtain significantly more sleep
  - More morning sleep
  - The later the start time, the greater the sleep amounts
  - But even a 30 minute delay results in improvements
- Students report less daytime sleepiness (falling asleep in class, doing homework)
- ≥8:30am the sleep and circadian "sweet spot"?

*Wheaton AG et al. *J School Health* 2016
Review of 38 reports examining the association between school start times, sleep, and behavioral, health and academic outcomes among adolescent students

Outcomes: School Performance*

- Attendance improves
- Tardiness rates drop
- Drop-out rates decline
- Standardized test scores improve
  - In one study SAT scores for the top 10% of students increased by more than 200 points
- Grades improve
  - 5/6 schools showed significant increase in GPA pre-post in English, math, science and SS
  - Disadvantaged students may benefit more
    - Larger effects of start times at lower end grade distribution**
    - Effects of 1st period classes larger for black students***

**Wheaton AG et al 2016 **Edwards 2012 ***Cortes et al 2012*

Outcomes: Health & Safety

- Delayed SST are associated with improvements in:
  - Mood (fewer report feeling unhappy, depressed)
  - Health (decreased health center visits)
  - 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)
    - Virginia: Adolescent crash rates VA Beach (7:20a) vs Chesapeake (8:40a) 40% higher and peak 1 hour earlier
    - CDC study (2014): Reduction crash rates in 16-18yo by as much as 65-70% (Minnesota, Colorado, Wyoming)

Outcomes: $$$

- RAND Corporation report (2017)*
  - Potential *significant economic gains of a state-wide shift in start times to ≥8:30am* related to improved academic performance of students resulting in increased lifetime earning potential and reduced car crashes
  - Economic gain [modeled across 47 US states] estimated annual gain of ~ $9.3 billion
    - Roughly the annual revenue of MLB

*Hafner, Marco, Martin Stepanek and Wendy M. Troxel. Later school start times in the U.S.: An economic analysis. https://www.rand.org/pubs/research_reports/RR2109.html.

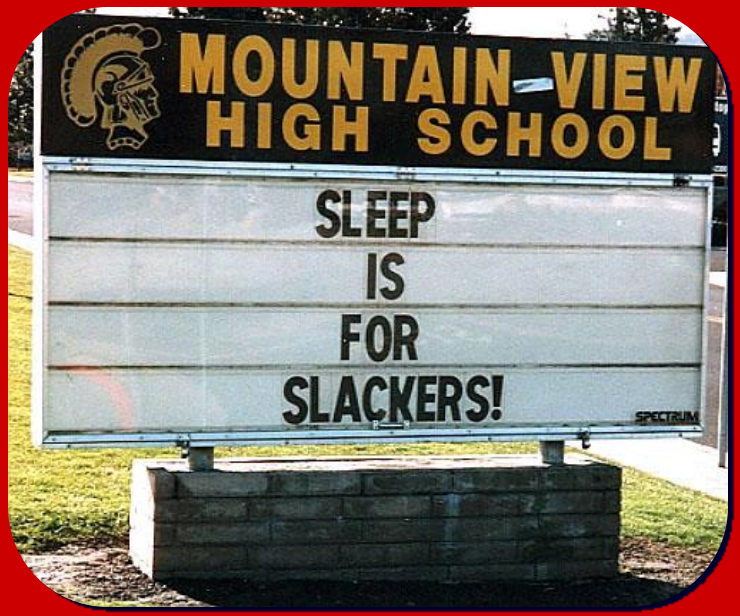
Elementary School Start Times

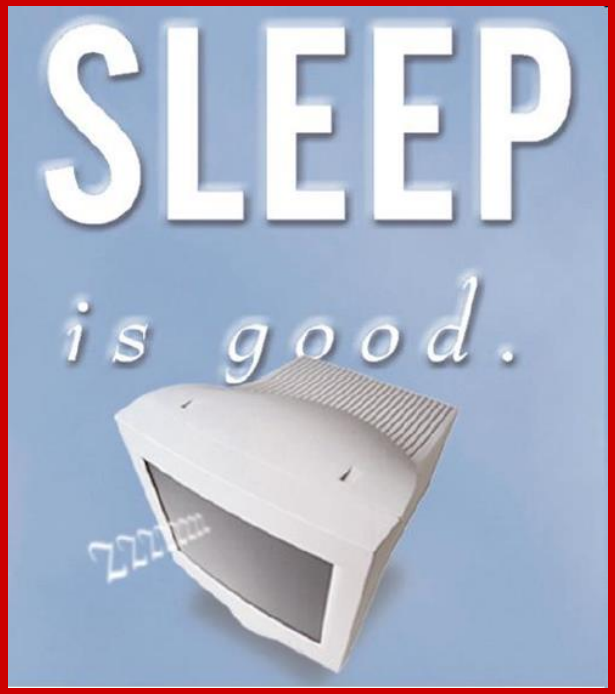
- Sleep needs: 9-12 hrs*
- Circadian preference (chronotype): owl vs lark**
- School, activities, electronic media, later bedtimes, earlier rise times, irregular sleep/wake schedules contribute to deficient sleep
- However, as opposed to adolescents, they are biologically, environmentally and socially more amenable to manipulation of bedtimes (ie, to move sleep onset earlier) if required
- Is there a sweet spot?
  - Data is mixed but suggest 7:30-9am
  - Earlier start times more impact on academics, behavior
  - Issues of civil twilight, safety concerns

*AASM 2016

**But most school-aged (pre-pubertal) children have a "morningness preference"

What is your vote?





Thanks for your attention!

Elementary School Start Times: The "Flip"

- Impact of School Start Time Changes:
- HS students delayed from 7:30am to 8:15am
- Students in grades 3-5 advanced from a start time of 8:20am to 7:45am
- HS students got 35 minutes more sleep
- 3rd graders also got more sleep (+24 minutes) after the change
- Sleep duration changes in 4-5th graders negligible
- No differences in behavior measures post-change

Grade	SST 1 BT/WT (SD HH:MM)	SST 2 BT/WT (SD HH:MM)	Sleep Duration Difference (Min)
3	8:37p/6:49a (10:11)	8:22p/6:57a (10:35)	**+24***
4	8:52p/6:56a (10:03)	8:22p/6:22a (9:59)	**-4**
5	9:10p/6:59a (9:49)	8:43p/6:23a (9:40)	**-9**
10	(7:42)	(8:17)	**+35****

Appleman et al. School start time changes and sleep patterns in elementary school students. Sleep Health, 1(2) (2015), 109-114.

*Largely accounted for by earlier bedtimes

**Completely accounted for by later rise times; 0 min difference bedtimes

Lessons Learned

- District superintendent support and leadership critical
- School board involvement key
- School leadership (ie, principals) and teacher support vital
- Importance of middle/elementary school principal, teacher, parent involvement
- Importance of student engagement
- Critical role of community *education*
  - Health, safety *and* academics
- Critical role of community *engagement*
  - Identification and involvement of key stakeholders

Lessons Learned

- Critical to allow adequate time for families to become informed and make sufficient plans prior to implementation
- Each community faces different, unique challenges
  - But you don't have to "reinvent the wheel"
- Not all students will benefit equally
  - The goal is to provide "the greatest good for the greatest number of students"
- Anticipation often worse than reality (impact on athletics, teacher retention, after-school programs, childcare issues)
- Initial challenges reduced over time