



Science of Adolescent Sleep and School Start Times



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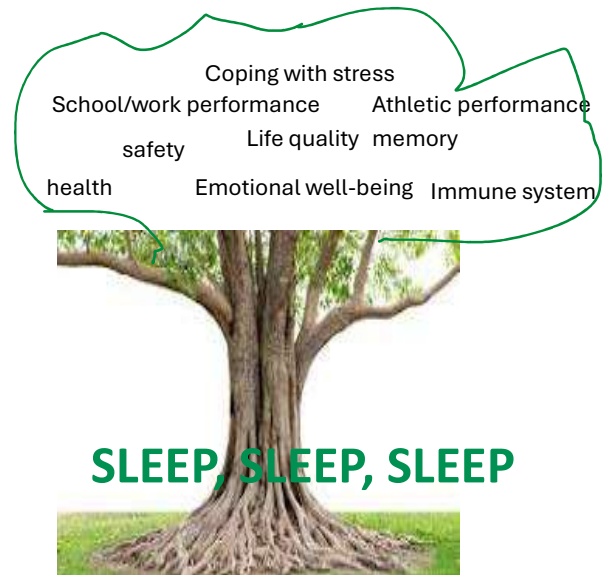
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Sleep is Foundational

- Key to health, emotional well being, performance, memory, learning, safety, and quality of life!
- As essential as good nutrition and exercise to optimal health!
- As necessary as the water we drink, the air we breathe and the food we eat to function and live at our best!



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Adolescent Sleep Myths (True or False?)

- Adolescents need less sleep than young children.
- Adolescents would go to sleep earlier if parents just made them.
- Adolescents can make up lost sleep by sleeping in on weekends or going to school later one day/week.
- If school starts later, adolescents will just stay up later!
- Adolescents who don't get enough sleep on a regular basis have a greater risk of depression.
- Driving while sleepy is almost as dangerous as driving while drunk.
- Falling asleep in class demonstrates a lack of motivation, not sleepiness.
- If you study all night before a test, you will remember the information better.

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Factors Affecting Sleep Patterns

Behavior and Circumstances

e.g., family life-style, health, sports, school schedule, socializing, digital technology use, etc.

Biological Processes

Process S: Sleep Pressure

Process C: Circadian Timing

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Two-Process Model of Sleep Regulation (Borbely, 1982)

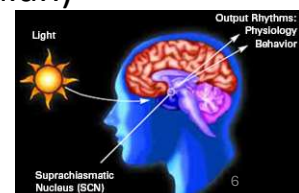
- Sleep propensity increases as waking accumulates and dissipates during sleep

(Process S)

- Sleep propensity governed by biological (circadian) clock

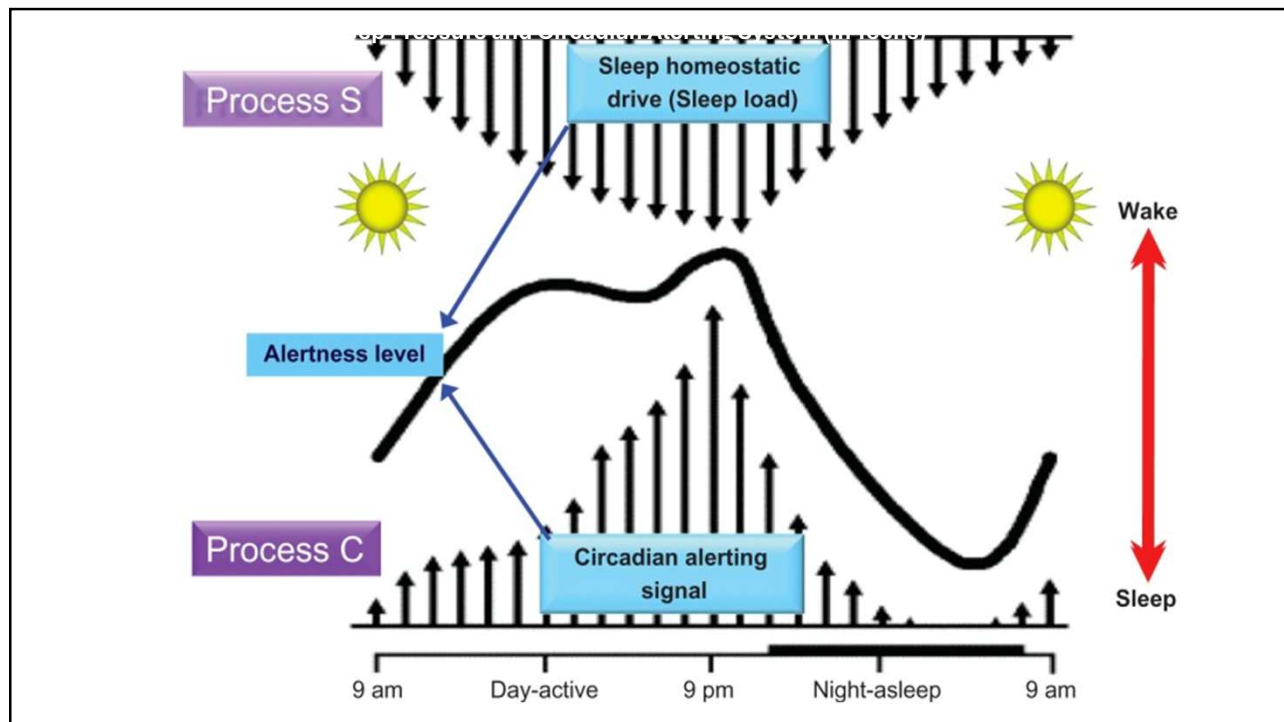
(Process C)

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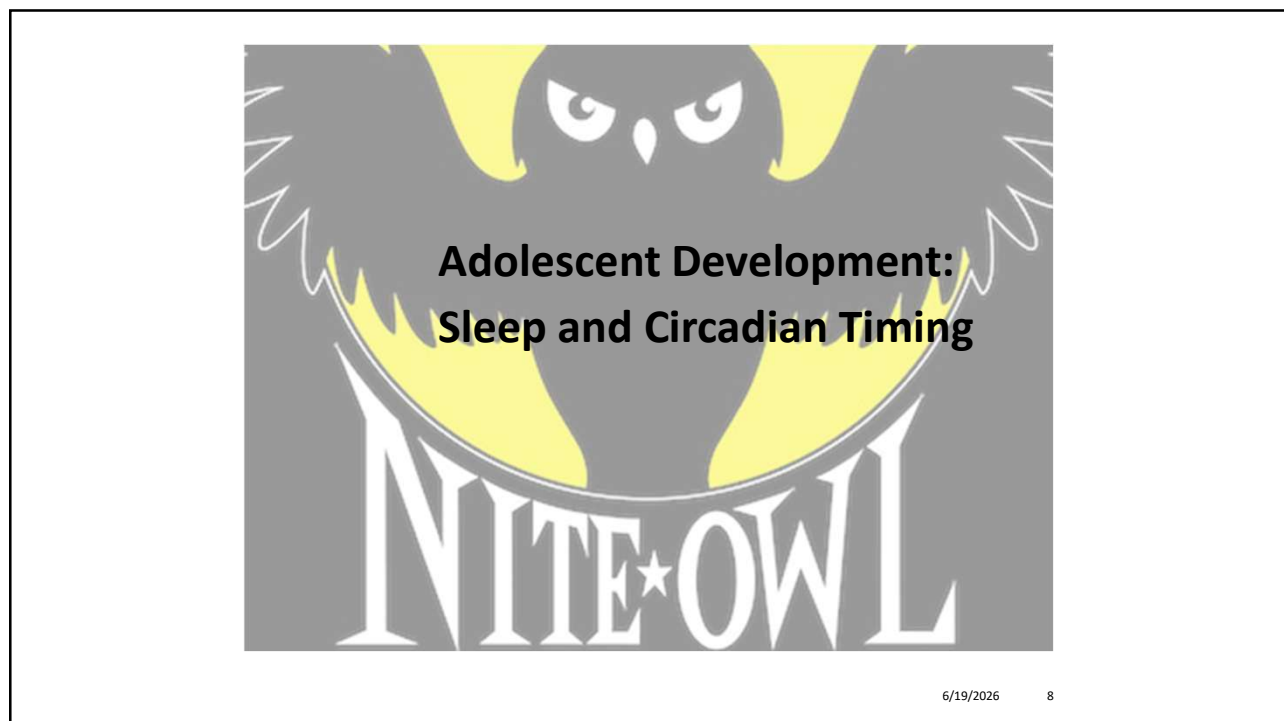


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Sleep Regulation Changes During Puberty

- Process S: Homeostatic Sleep System

- Balances sleep and wake
- Pressure for sleep builds more slowly in older vs. younger
- Sleep need still 8-10 hours (optimal 9 hours)



- Process C: Circadian (~24-hour) Clock

- Internal clock that signals sleep and wake
- Needs bright days and dark nights
- Circadian clock runs later in older vs. younger

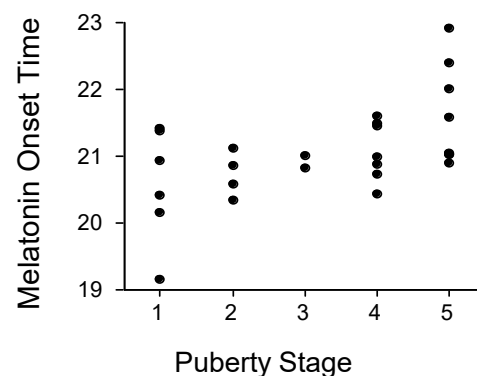


...adolescents have difficulty falling asleep early

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Circadian Clock Shifts Later

- Controlled conditions
- Circadian cue for sleep shifts later with puberty



(Carskadon et al., Ann. N.Y. Acad. Sci., 2004)

Figure from M. Carskadon

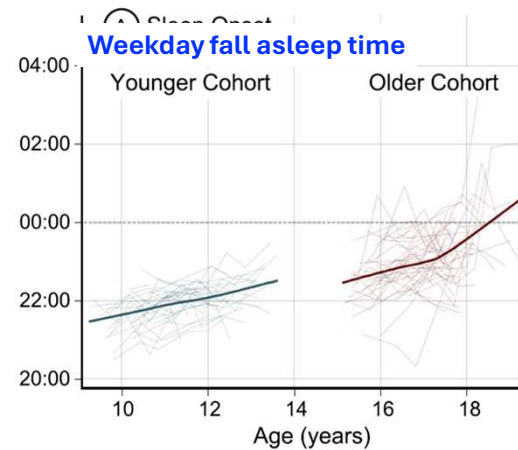
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Adolescent sleep schedule shifts later

- Largely driven by sleep regulatory changes in brain during puberty.
- Older adolescent who used to fall asleep at 9:00 PM will now be unable to fall asleep until 11:00PM or later.
- Also, means waking 2 hours later in morning.



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Crowley et al (2014). PLOS One 9(11):e112199

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Insufficient School Night Sleep

- Biological factors contribute to late bedtimes.
- Early school start times force students awake on weekday mornings



But, Sleep Need: 8 – 10 hours/night (optimally 9)

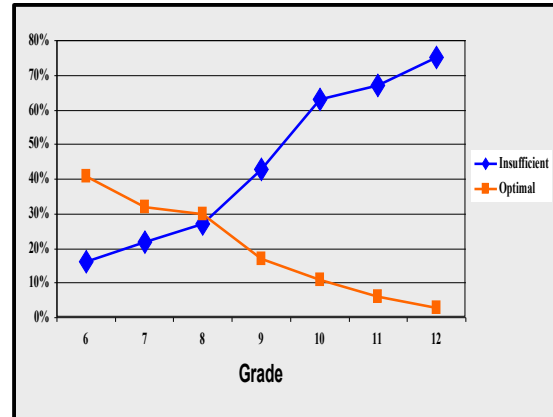
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Sleep and Sleep Behaviors Deteriorate...

- BT & RT misaligned with early school start times.
- Erratic school vs. weekend sleep patterns.
- Jet Lag effect or **Social Jet Lag** every Monday morning!



Result: Total Sleep Duration declines!

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Adolescents' "Real World" Sleep Schedules



Report less sleep than younger children.



Report different school vs. weekend-night schedules, known as social jetlag.



Report markedly delayed bed and rise times, especially weekends.



Report school rise times based on school start times and commute times.



School-night sleep duration declines over adolescent years, weekend sleep changes less.



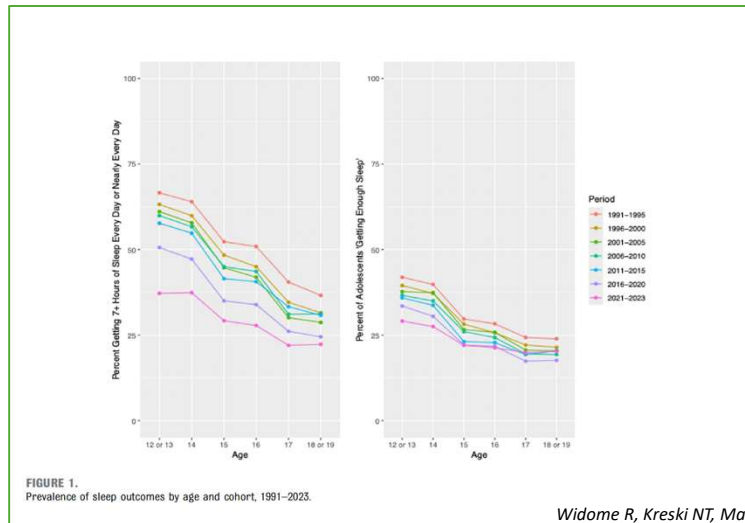
Size of school-night-to-weekend discrepancy & insufficient sleep tied to poor academic performance, depressed mood, other negative outcomes.

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Sleep Duration for Adolescents: '91-'23



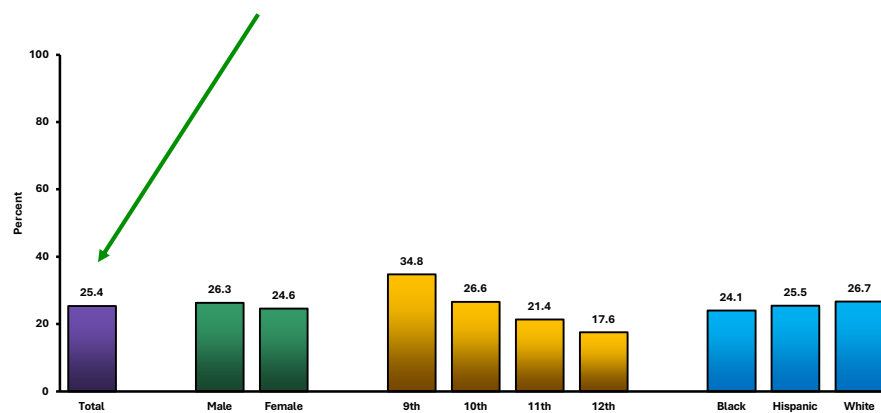
Widome R, Kreski NT, Masłowski J, et al. Sleep Duration Among US Adolescents, 1991–2023. *Pediatrics*. 2026

Disparities in sleep duration

- Black & white adolescents in '91–'95 equally likely to report 7+ hours sleep, but by 2023, Black teens were less likely to report.
- Adolescents from families with college education more likely to obtain sufficient sleep.
- Males > females reporting 7+ hours sleep

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Percentage of High School Students Who Got 8 or More Hours of Sleep on Average School Night by Sex, Grade,[†] and Race/Ethnicity



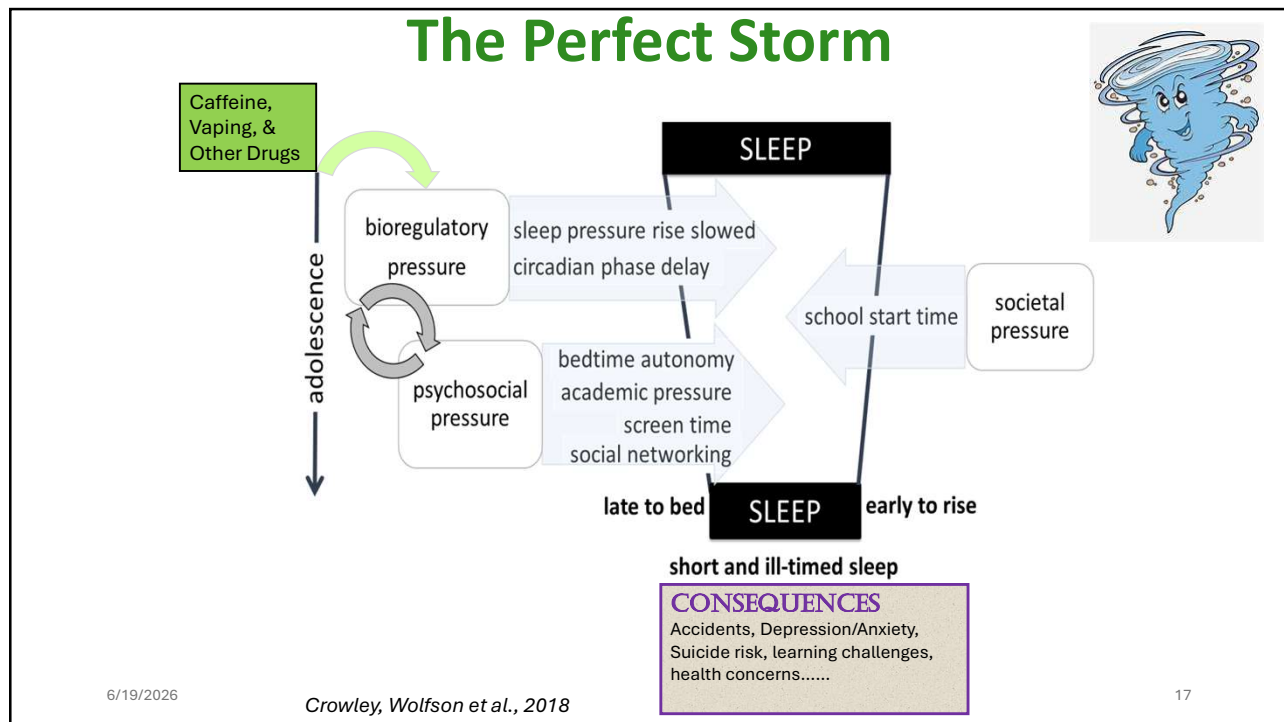
[†]9th > 10th, 9th > 11th, 9th > 12th, 10th > 11th, 10th > 12th, 11th > 12th (Based on t-test analysis, $p < 0.05$.)
All Hispanic students are included in the Hispanic category. All other races are non-Hispanic.
Note: This graph contains weighted results.

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CDC, National Youth Risk Behavior Survey, 2017

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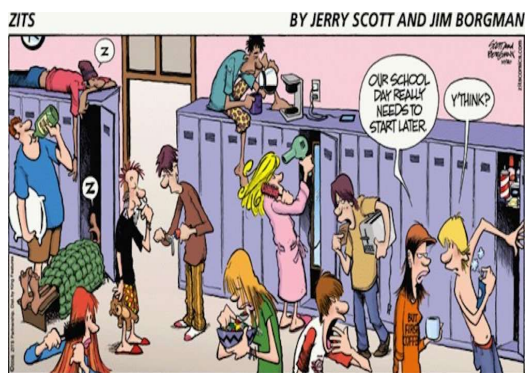
From Adolescent Sleep & CR Science to Later School Start Times for Adolescent Health

1993: Carskadon et al
landmark study:
association between more
mature pubertal
development and later
circadian preference

"[T]he starting time of
school puts limits on the
time available for sleep.
This is a nonnegotiable
limit established largely
without concern for sleep."

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Thank You and Questions?!



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