# Adolescent Sleep and Late School Start Times

Gita Gupta MD, MS
University of Michigan
Sleep Medicine, Pediatric Pulmonology

C.S. MOTT CHILDREN'S HOSPITAL
MICHIGAN MEDICINE

1

- Consequences of insufficient sleep
- What modulates our sleep patterns?
- How much sleep are adolescents getting? How much do they need?
- What are circadian rhythms? How is this different in adolescents?
- What can be done to improve adolescent sleep?
- What is the current state?
- What is the effect of delaying school start times for adolescents?
- What can we do as a state-level to improve the sleep of adolescents?

2

## Consequences of insufficient sleep

- Depression, increased risk-taking behaviors, suicidal ideation
- Metabolic disorders: Diabetes mellitus, insulin resistance, hypertension, obesity, obstructive sleep apnea
- Increased mortality and morbidity
- Among others!

Hanson JA et. al, 2021 Jun 26. In: StatPearls [Internet]

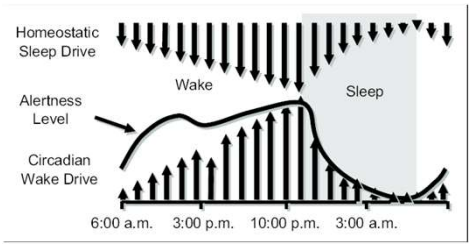
An H et al, Psychiatry Res. 2010; 177 (3):318-322

3

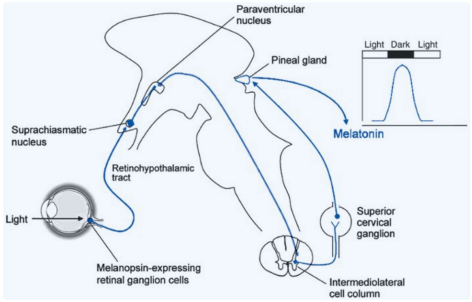
## What modulates our sleep patterns?

4

## Two-process model of sleep regulation

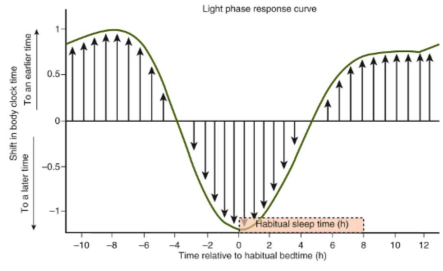



5



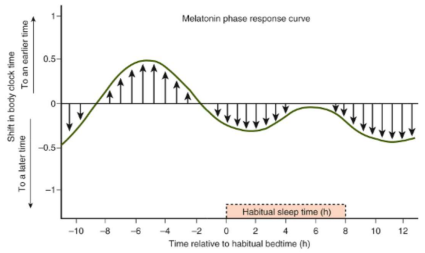

Sleep Medicine Pearls, 3rd Ed.

6



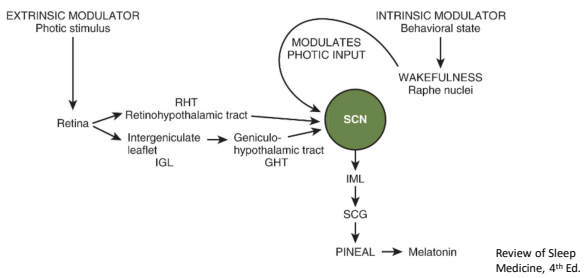

Review of Sleep Medicine, 4th Ed.

7



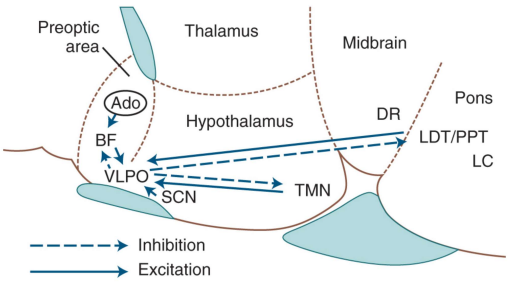

Review of Sleep Medicine, 4th Ed.

8




Review of Sleep Medicine, 4th Ed.

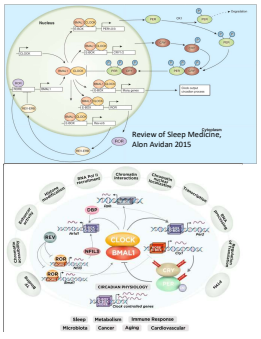
9




10

## Systemic circadian impact

- Cardiovascular, aging, microbiota, cancer Rijo-Ferreira F et. al, Geome Med. 2019 Dec 17; 11(1):82
- Mood, metabolism, neurodevelopment Burgess HJ, J Sleep Res. 1999 Jun; 8 (2):113-22
- Suprachiasmatic nucleus (central body clock) regulates transcription of over 80% of protein-coding genes, including fundamental housekeeping genes. Mure LS et al, Science 2018 Mar 16; 359 (6381)




11

How much sleep do adolescents need? How much sleep are they getting? Why aren't they getting enough sleep?

12

## Appropriate sleep duration

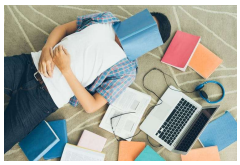
- 8-10 hours: AASM

Paruthi S et. al J Clin Sleep Med. 2016;12(6):785–786.

13

## Causes of insufficient sleep

- **Circadian rhythm**
- **Slower accumulation of sleep pressure**, therefore an intrinsic drive to stay awake longer
- **Lifestyle**: homework, school responsibilities, work responsibilities, extra-curricular activities, socialization, electronics use, social media use
- **Social media**: increased time awake, delay of circadian phase with prolonged nighttime light exposure
- Caffeine use, substance abuse, chronic illness



Owens J et al, Pediatrics. 2014 Sep; 134(3):e921-32

14

## Epidemiology of insufficient sleep

- "Increase proportion of students in grades 9 through 12 who get sufficient sleep" (defined as ≥ 8 hours) – Healthy People 2020
- National Sleep Foundation Poll – 75% of 12th graders report getting < 8 hours of sleep/night (compared to 16% of 6th graders)
- Difference between weekend and weekday sleep is typically ≥2 hours
- Similar pattern worldwide: most stark in South Korean adolescents
- Ethnic minorities, low-income families at increased risk

Owens J et al, Pediatrics. 2014 Sep; 134(3):e921-32

15

What can be done to improve adolescent sleep? What has already been done, and what has been its impact?

16

- Delay school start times - (Relatively) easily modifiable factor
- Sleep hygiene optimization - e.g. electronics use, caffeine intake

17

## Effect of delaying school start times

- Increased total sleep time by at least one hour (bedtimes were not delayed). Zeitzer JM et al, J Physiol. 2000; 526 (pt3): 695-702
- Decrease in motor vehicle accidents caused by Kentucky teenagers by 16.5% compared to the state as a whole which had an increase Danner F et al, J Clin Sleep Med 2008; 4 (6): 533-535
- Fewer attention difficulties, increased academic performance Epstein R et al, Sleep. 1998; 21(3):250-256, Wolfson AR et. al Behav Sleep Med. 2007; 5(3): 194-209
- Decreased daytime sleepiness Dexter D et al, WMJ 2003; 102 (1): 44-46
- Decrease in depressed mood, fatigue, and first-period tardiness Owens JA, Arch Pediatr Adolesc Med. 2010; 165 (7):608-614


18

SLEEP, 2021, 1–14

doi: 10.1093/sleep/zsab048
Advance Access Publication Date: 15 April 2021
Original Article

ORIGINAL ARTICLE

## Changing school start times: impact on sleep in primary and secondary school students

Lisa J. Meltzer[1,*], Kyla L. Wahlstrom[2], Amy E. Plog[3] and Matthew J. Strand[1]

[1]National Jewish Health, Denver, CO, USA [2]University of Minnesota, Minneapolis, MN, USA and [3]Cherry Creek School District, Greenwood Village, CO, USA

*Corresponding author. Lisa J. Meltzer, National Jewish Health, 1400 Jackson Street, G311, Denver, CO 80206, USA. Email: meltzerl@njhealth.org.

19

### Abstract

**Study Objectives:** To examine the impact of changing school start times on sleep for primary (elementary school: ES) and secondary (middle and high school: MS/HS) students.

**Methods:** Students (grades 3–12) and parents (grades K-12) were surveyed annually, before and for 2 years after school start time changes (ES: 60 min earlier, MS: 40–60 min later; HS: 70 min later). Student sleep and daytime sleepiness were measured with school-administered student surveys and parent-proxy online surveys.

**Results:** Approximately 28,000 students annually completed surveys (~55% White, ~21% free/reduced lunch [FRL]). One-year post-change, weekday bedtimes and wake times were slightly earlier for ES students, with an 11-min decrease in sleep duration. MS and HS students reported slightly later weekday bedtimes, significantly later wake times, and significantly longer sleep duration (MS: 29 min; HS: 45 min). The percent of ES students reporting sufficient sleep duration, poor sleep quality, or daytime sleepiness did not change, but the percent of MS and HS students reporting sufficient sleep duration significantly increased and clinically significant daytime sleepiness decreased. All results were maintained at the 2-year follow-up. Benefits of later start times were similar across racial and free/reduced lunch groups.

**Conclusions:** This is the first large scale, longitudinal, and representative study to concurrently examine the impact of changing school start times across students in primary/secondary school. Findings suggest a minimal impact of earlier start times on ES students' sleep or daytime sleepiness, while further supporting the significant benefits of delaying MS and HS start times on student sleep and daytime sleepiness.

20

| | Middle school (Grades 6–8) | | | High school (Grades 9–12) | | |
|---|---|---|---|---|---|---|
| | Pre-change | Post-change | Follow-up | Pre-change | Post-change | Follow-up |
| Total N | 8,414 | 9,619 | 9,915 | 6,275 | 9,849 | 10,516 |
| % Enrolled | 69.6 | 79.1 | 75.7 | 51.9 | 59.8 | 60.4 |
| % Female | 51.0 | 49.8 | 49.1 | 52.6 | 51.2 | 51.3 |
| % FRL | 20.2 | 24.6 | 18.1 | 17.8 | 21.3 | 15.3 |
| Grade | | | | | | |
| % 6th | 35.3 | 31.8 | 33.3 | | | |
| % 7th | 32.8 | 34.3 | 33.8 | | | |
| % 8th | 31.9 | 34.0 | 32.9 | | | |
| % 9th | | | | 39.7 | 30.1 | 26.9 |
| % 10th | | | | 33.0 | 28.6 | 26.2 |
| % 11th | | | | 27.3 | 24.6 | 26.0 |
| % 12th | | | | | 16.7 | 20.9 |
| Race/ethnicity | | | | | | |
| % White | 58.7 | 56.6 | 53.1 | 57.0 | 56.4 | 52.0 |
| % Black | 10.3 | 11.2 | 10.4 | 11.2 | 11.3 | 11.3 |
| % Hispanic | 15.1 | 16.7 | 20.5 | 15.4 | 16.9 | 19.9 |
| % Asian | 8.9 | 8.2 | 8.8 | 9.8 | 9.7 | 10.1 |
| % MR/AIAN/NHOPI | 6.9 | 7.2 | 7.3 | 6.5 | 6.6 | 6.8 |

FRL, free or reduced lunch status; MR/AIAN/NHOPI, mixed race/American Indian or Alaskan Native/Native Hawaiian or Other Pacific Islander.

21

**Table 2.** Means (95% CIs) and differences for sleep outcome variables across years using descriptive analytical methods

| | | | | *Difference* | |
|---|---|---|---|---|---|
| | Pre-change | Post-change | Follow-up | Post–Pre | Follow-up–Post |
| | High school (Grades 9–12) | | | | |
| Bedtime[a] | | | | | |
| Weekday | 22:23 (22:21–22:25) | 22:37 (22:36–22:39) | 22:46 (22:44–22:47) | +14 min | +9 min |
| Weekend | 23:47 (23:45–23:50) | 00:02 (00:01–00:04) | 00:06 (00:05–00:08) | +15 min | +4 min |
| Wake time[a] | | | | | |
| Weekday | 05:46 (05:45–05:47) | 06:46 (06:45–06:47) | 06:45 (06:44–06:46) | +60 min | –1 min |
| Weekend | 09:16 (09:14–09:19) | 09:27 (09:25–09:29) | 09:27 (09:25–09:29) | +11 min | No change |
| Duration[a] | | | | | |
| Weekday | 7.39 h (7.36–7.41) | 8.14 h (8.12–8.17) | 7.99 h (7.97–8.01) | +45 min | –9 min |
| Weekend | 9.48 h (9.44–9.52) | 9.41 h (9.38–9.44) | 9.34 h (9.31–9.37) | –4 min | –4 min |
| Weekend oversleep[b,†] | 2.05 h (2.01–2.09) | 1.21 h (1.18–1.24) | 1.28 h (1.25–1.31) | –77 min | +4 min |
| % Sufficient sleep[c] | 30.4% | 62.7% | 57.6% | +32.3% | –5.1% |
| % Poor sleep quality[d] | 43.1% | 31.2% | 35.3% | –11.9% | +4.1% |
| % Daytime sleepiness[d] | 76.2% | 55.2% | 62.0% | –21.0% | +6.8% |

h = hours, min = minutes.
[a]Data are presented as mean (95% CI), with military time used for bedtimes and wake times.
[b]Weekend oversleep is the difference between weekday and weekend sleep duration.
[c]Sufficient sleep defined as an average of at least 9 h for ES and MS, and at least 8 h for HS[9].
[d]Poor sleep quality defined as T ≥ 60 on PROMIS Pediatric Sleep Disturbance items.
[e]Daytime sleepiness defined as T ≥ 60 on PROMIS Pediatric Sleep Related Impairment items.

22

**Table 5.** Means and 95% CI for weekday and weekend sleep duration main effects in FRL status models (hours; year means averaged across FRL status, FRL status means averaged across years)

| | Later elementary (Grades 3–5) | | Middle school (Grades 6–8) | | High school (Grades 9–12) | |
|---|---|---|---|---|---|---|
| | Weekday | Weekend | Weekday | Weekend | Weekday | Weekend |
| Year | | | | | | |
| Pre-change | 9.84 (9.80–9.88) | 10.22 (10.18–10.27) | 8.63 (8.58–8.68) | 9.84 (9.77–9.91) | 7.41 (7.34–7.49) | 9.51 (9.38–9.63) |
| Post-change | 9.65 (9.61–9.68) | 10.22 (10.18–10.27) | 9.14 (9.09–9.19) | 9.82 (9.76–9.88) | 8.17 (8.12–8.23) | 9.49 (9.40–9.58) |
| Follow-up | 9.62 (9.58–9.66) | 10.23 (10.17–10.28) | 9.06 (9.01–9.11) | 9.79 (9.73–9.85) | 8.01 (7.95–8.07) | 9.38 (9.28–9.48) |
| FRL status | | | | | | |
| FRL | 9.63 (9.59–9.68) | 10.24 (10.19–10.29) | 8.95 (8.90–8.99) | 9.84 (9.78–9.91) | 7.89 (7.83–7.96) | 9.50 (9.37–9.64) |
| Not FRL | 9.77 (9.75–9.80) | 10.21 (10.18–10.23) | 8.94 (8.90–8.99) | 9.79 (9.74–9.84) | 7.84 (7.80–7.88) | 9.41 (9.31–9.51) |

[a]The ecological modeling approach was used to obtain results.

23

## Local initiatives, next steps

- Multiple school districts have trialed later school start times in MI with success:
- e.g. Flushing, Ypsilanti, South Lake, Berkley, Sturgis.
- Similar outcomes to the studies mentioned
- Practical considerations with bussing, availability of personnel, impact on elementary school and middle school children, extra-curricular activities
- MSMS resolution

24

## Thank you!

- Resources: School Start Times | American Academy of Sleep Medicine (aasm.org)
- gigu@umich.edu

25