The Science Behind Changing School Start Times

Lisa J. Meltzer, Ph.D., CBSM

Overview

- Adolescents and sleep
- Consequences of insufficient sleep
- Outcomes from districts that have made changes
- Elementary school start times research
Adolescents need 8.5 to 9.25 hours of sleep per night.

7 out of 10 adolescents in the US get 7 hours or less per night.


So?

Sleep doesn’t matter

I sleep less than that and do just fine

Sleep is for slackers
WRONG!!
You have to breathe
You have to eat
You have to sleep!
Sleep is not a passive state and is essential for health, daytime functioning, and well-being.
Well if teens just turned off their phones and went to bed earlier, then they wouldn’t have any problems waking up
Process C - Circadian Rhythm

Borbely (1982); Carskadon et al. (1980, 2002)

Circadian Misalignment

Borbely (1982); Carskadon et al. (1980, 2002)
Faces of Deficient Sleep

- Mood and affect changes
- Behavior problems
  - Non-compliance
  - Aggression
  - Hyperactivity
  - Poor impulse control
- Risk taking behaviors and increased accidents

Beebe (2011); Gruber et al. (2012); Owens et al. (2014)
Deficient Sleep in Children/Adolescents

- Neurocognitive deficits
  - Attention
  - Memory
  - Executive functioning
- Weight gain
  - Increased caloric intake
  - Increased consumption fats and carbs

Beebe et al. (2010); Beebe et al. (2013); Gruber, Wiebe et al. (2012); Gruber, Michaelsen et al. (2012); Hart et al. (2013); Sadeh et al. (2003)

Signs of Deficient Sleep

- Needs to be awakened in morning
- Sleeps 2+ hours on weekends or vacations than weekdays
- Falls asleep in school or other inappropriate times
- Behavior/mood differ following nights of increased sleep
Extrinsic Sleep Disruptors

Later School Start Time Outcomes

- Multiple studies have demonstrated the benefit of changing to a later school start time...
- Students getting > 8 hours sleep/night
- Better academic outcomes
- Better attendance rates
- Higher graduation rates
- Reduced tardiness
- Less depression
- Less caffeine use
- Fewer car crashes

Boergers et al. (2014); Danner & Phillips (2008); McKeever et al. (2017); Owens et al. (2010); Wahlstrom (2002); Wahlstrom et al. (2014); Wolfson et al. (2007)
Fayette County, KY

- Started school 1 hour later
  - 7:30am to 8:30 am
  - 8:00am to 9:00am
- Increased total sleep time
  - 8+ hours: 36% to 50%
- 16.5% decrease in number of motor vehicle crashes
- No changes in # hours spent on homework, jobs, sports/activities

What about here in Colorado?

- Fairview High School
  - 7:35 am to 8:05 am
  - Went from 33.6% to 42.5% of students getting > 8 hours of sleep
  - Tardies down from 2.44 to 2.15
  - Overall GPA increased
    - 1st period class most notable change, increasing between 0.2 and 0.3 for 11th and 12th graders
  - Current start time 8:00 am

Danner & Phillips (2008)

Wahlstrom et al. (2014)
What about here in Colorado?

- **Boulder High School**
  - 7:30 am to 8:00 am (9:00 on Wed)
  - After change 42.5% of students getting > 8 hours of sleep
  - Tardies down from 3.7 to 3.16
  - GPA increased

- **Academy School District 20**
  - 7:05 to 7:45 a.m.
  - Combined middle and high school students on same buses
  - Eliminated bus routes with few students
  - Fewer tardies and “happier students”
  - Did not affect athletics or after-school activities
If teens have later start times, they will simply go to bed later

Bedtimes don’t significantly change

- Students do not stay up later, but wake later

Boergers et al. (2014); Danner & Phillips (2008); Owens et al. (2010); Wahlstrom (2002); Wahlstrom et al. (2014); Wolfson et al. (2007)
Increased sleep due to wake times

- Homeschool students wake same time as public schools start
- Cumulative sleep debt (49 m/day = 4 h/wk = 144h/yr)

And what about sports?

- Wilton, CT changed start times with strong opposition from coaches
  - Next year high school had the best season, winning several state championships
  - Increased extra-curricular participation across grades
- Stanford athletes increased time in bed to 10 hrs/night
  - Basketball
    - Faster sprint (0.7 seconds)
    - Free throws 9% more accurate
    - Improved mood, decreased fatigue

Meltzer, et al. (2015)
And what about sports?

- Football
  - 20 yard shuttle went from 4.71 to 4.61 seconds
  - 40 dash improved from 4.99 to 4.89 seconds

- Swimming
  - 15 meter sprint 0.51 seconds faster
  - Reacted 0.15 seconds quicker of the blocks
  - Improved turn time by 0.10 seconds

*Michael Phelps won a gold medal by 0.01 seconds*

Mah et al. (2008); Mah et al. (2010)

That’s nice, but what about elementary school students? Won’t starting earlier cause them to get less sleep?
Change to Start Time in Northeast Elementary School

3rd grade: 9:10 a.m. → 7:45 a.m.
4th/5th grade: 8:20 a.m. → 7:45 a.m.

Minneapolis School District

- School start times changed from 8:40 → 7:40 a.m.
- Students were more alert at start of day and remained energized throughout day
- Students had fewer morning transitions and were more ready to learn
- Teachers and students were more patient and productive in the afternoon
- Fewer behavior problems
- Increased participation in school activities
- Buses were on time at start and end of day

Appleman et al. (2015)

Wahlstrom (1998)
### CCSD Historical Trends by Start Time

#### Reading Standards

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<thead>
<tr>
<th>School Year Grouping</th>
<th>School Year (year)</th>
<th>Grade Level (group)</th>
<th>Grade Level</th>
<th>Reading Standards</th>
<th>Math Standards</th>
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CCSD Historical Trends by Start Time

Circadian Rhythms and Elementary School Aged Children

- Change in melatonin onset doesn’t begin until between ages 11 and 13
- Self-reported circadian preference changes between ages 12 and 13

Crowley et al. (2014); Russo et al. (2007)
### Weekday Sleep Driven by Wake Time

(Which is driven by school start times)

- **Bedtimes increase steadily with increasing grade**
  - ES → MS: 40 m, MS → HS: 34 m

  ![Graph showing increasing bedtimes with grade]

- **Wake times consistent across school level**

  ![Graph showing consistent wake times across school levels]

### Wake Time and Difference WD to WE

- **Wake times consistent across school level**

  ![Graph showing wake time and difference between weekdays (WD) and weekends (WE)]
But what about all those studies showing how earlier start times are bad for elementary school students?

References:

Kentucky Study
9-11 hours
Avg 9.3 hr +27m vs -54m
Kentucky Study
8 hrs 1st/2nd
6.5 hrs >3rd
Kentucky Study

9h: 9:30p-6:30a
10h: 8:30p-6:30a
11h: 7:30p-6:30a
Avg 9.3 hr
+27m vs -54m

Kentucky Study

8 hrs 1st/2nd
6.5 hrs >3rd
Sleep and Academic Performance

- Statistical models to predict how school start times impact academics and behavior
- Start time calculated as minutes since midnight (so no comparison of early vs. late starting schools)

\[ \text{Start time} \quad 8:05 \text{ AM (35 min)} \]
\[ \text{NAPDMATH}_t = B_{35} + B_{31} (\text{STARTTIME}) + B_{32} (\text{FREELUNCH}) + B_{33} (\text{TIMELUNCH}) \]
\[ + B_{34} (\text{AFRICAN AMERICAN}) + B_{35} (\text{HISPANIC}) + B_{36} (\text{TSRATIO}) \]

Keller et al. (2014)

Table 3
Model Results for Interactions Between Elementary School Start Times and Fraction of Students Receiving Free or Reduced-Cost Lunches

<table>
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<tr>
<th>Variable</th>
<th>Language</th>
<th>Reading</th>
<th>Math</th>
<th>Science</th>
<th>Social Studies</th>
<th>Writing</th>
<th>School rank</th>
<th>Attendance rate</th>
<th>Retention rate</th>
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<tbody>
<tr>
<td>Intercept ((\beta_0))</td>
<td>68.145***</td>
<td>62.875***</td>
<td>62.481***</td>
<td>90.430***</td>
<td>80.10***</td>
<td>57.719***</td>
<td>52.937***</td>
<td>95.718***</td>
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<td>TS RATIO</td>
<td>1.520***</td>
<td>1.103***</td>
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<td>.851***</td>
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<td>-.001</td>
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<td>Intercept ((\beta_4))</td>
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Note: Columns indicate the dependent variable being predicted. Statistical notation provided in parentheses corresponds to the equations provided in the analysis section.

\* \( p < .05 \) \quad \* \* \( p < .01 \) \quad \* \* \* \( p < .001 \)

Keller et al. (2014)
**Sleep and Academic Performance**

**Conclusion:** Earlier school start times can be associated with poorer school performance in elementary schools.

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**Table 4**

*Results of Probing Interactions Between School Start Times and Percentage of Students Receiving Free or Reduced-Cost Lunches*

<table>
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<tr>
<th>Effects and differences of start times</th>
<th>Language</th>
<th>Reading</th>
<th>Math</th>
<th>Science</th>
<th>Social Studies</th>
<th>Writing</th>
<th>School rank</th>
<th>Attendance rate</th>
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<td>.088**</td>
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<td>.091**</td>
<td>.098***</td>
<td>.233****</td>
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<td>1.50</td>
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*Note.* The first two rows show the simple slopes for the effect of school start time on the dependent variable (see column heading) for lower and higher values of the moderator (FREELUNCH). The bottom two rows illustrate the expected difference in the dependent variable for schools starting 1 hr later than another school.

*p < .05. **p < .01. ***p < .001.*

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**Keller et al. (2014)**
Sleep and Behavior

- Low base rate of 3% of students K-6
  - 1.6% of incidents were in 6th graders
  - Outcomes driven by 6th graders? If yes, more reason to change middle school start times...
- One study, has not been replicated
  - MANY studies showing negative impact of early start times on adolescents
  - MANY studies showing benefits for adolescents of later start times
Take Home Message

- Sleep essential for learning, growth, development
- Adolescents significantly sleep deprived, with school start times as one of the strongest contributing factors
- Changing start times is not coddling students, but setting them up for success in life
- Evidence base limited for benefits or consequences of elementary schools starting earlier

Recommendation to start middle/high schools no earlier than 8:30 a.m.

- American Academy of Pediatrics
- Centers for Disease Control and Prevention
- American Medical Association
- American Academy of Sleep Medicine
- American Academy of Child and Adolescents Psychiatrists
- American Psychological Association
- National Association of School Nurses
- American Thoracic Society
- National Sleep Foundation
“If sleep doesn't serve an absolutely vital function, then it is the greatest mistake the evolutionary process ever made”

Dr. Allan Rechtschaffen

Questions?

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