The Impact of School Start Time Change on Adolescents’ Sleep, Health, Safety, and School Functioning

Robert C. Whitaker, MD, MPH
Professor of Epidemiology, Biostatistics and Pediatrics
Temple University
Philadelphia, PA
I. Design of an ongoing quasi-experimental study:
   – The impact of school start time change on adolescents’ sleep, health, safety, and school functioning

II. Results of a cross-sectional analysis:
   – The relationship of self-regulation to sleep duration, daytime sleepiness, and chronotype
Acknowledgements

• Funding:
  – Robert Wood Johnson Foundation

• Collaborators:
  – Child Trends, Inc. (Bethesda, MD)
  – Children’s National Medical Center (Washington, DC)
  – Boston Children's Hospital (Boston, MA)
  – Temple University (Philadelphia, PA)
I. DESIGN OF A QUASI-EXPERIMENTAL STUDY

The Impact of School Start Time Change on Adolescents’ Sleep, Health, Safety, and School Functioning
Rationale

• Chronic sleep loss is common among US adolescents and impacts health, safety, and academic achievement
• Later school start time, with relief of “social jet lag,” is a key modifiable factor
• No prospective study has examined the impact of later school start times in a diverse sample of middle and high school students
• One of the nation’s largest school districts, which has >80,000 students in grades 7-12
• 18-month community engagement period before changing school start times in the current school year
  – 50-minutes later (7:20→8:10) for high schools (9<sup>th</sup>-12<sup>th</sup>) and secondary schools (7<sup>th</sup>-12<sup>th</sup>)
  – 30-minutes earlier (8:00→7:30) for middle schools (7<sup>th</sup>-8<sup>th</sup>)
Design

• Quasi-experimental design: 2 cross-sectional surveys
• Baseline survey in the control period
  – March-June 2015 before start time changes
  – 19 schools (8 high, 3 secondary, 8 middle)
  – Online survey of 2,017 students and parents
• Follow-up survey in the intervention period
  – March-June 2016 after start time changes
  – Same 19 schools and online surveys
• Analysis using propensity score matching
Conceptual Framework for Impact Evaluation

- Socioeconomic Status & Chronotype
- Health & Safety: Self-rated health, BMI, physical activity, drowsy driving, injuries
- School Start Time Changes
- Sleep Duration/Timing & Daytime Sleepiness
- Mood & Self-Regulation
- School Functioning: Standardized test scores, grades, absences, extracurricular activities
Design Challenges

- Lack of randomization and concurrent controls
- Cross-sectional vs. longitudinal sampling
- Obtaining representative samples
  - obtain parent consent
  - no in-class survey administration
  - no direct email or texting contact with students
II. RESULTS OF A CROSS-SECTIONAL ANALYSIS

The relationship of self-regulation to sleep duration, daytime sleepiness, and chronotype
Among adolescents, what is the association between school-night sleep duration, daytime sleepiness, chronotype, and self-regulation?

- Short Sleep Duration
- Greater Daytime Sleepiness
- More Eveningness Chronotype
- Poorer Self-Regulation

2,017 students in 7th to 12th grade
Self-Regulation

The process by which inner states or responses are altered or modulated

– To modulate the intensity, frequency, and duration of verbal and motor acts in social settings
– To initiate and cease activities according to situational demands
– To postpone acting upon a desired object or goal
– To generate socially-approved behavior in the absence of external monitors

Kopp CB. Dev Psychol. 1982;18:199-214
Measurement of Self-Regulation

- 12-item Screening Self-Report Form of the Behavior Rating Inventory of Executive Function, (2nd Ed)
- Asks students if they have “had problems with certain behaviors over the past 6 months”
  - **Cognitive (6 items):** working memory, task completion, planning and organizing
  - **Emotional (4 items):** emotional control and shift
  - **Behavioral (2 items):** inhibition
School-Night Sleep Duration

- Differences in hours between usual school-night bedtime and school-day wake time
- Mean (SD) = 7.7 h (1.2)

<table>
<thead>
<tr>
<th>Duration</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;7 h</td>
<td>22</td>
</tr>
<tr>
<td>7 to &lt;8 h</td>
<td>29</td>
</tr>
<tr>
<td>8 to &lt;9 h</td>
<td>33</td>
</tr>
<tr>
<td>9+ h</td>
<td>16</td>
</tr>
</tbody>
</table>
Daytime Sleepiness

• 10-item Sleepiness Scale from the Sleep Habits Survey (Carskadon)

• Asks students if, in the last 2 weeks, they have “struggled to stay awake or fallen asleep in 10 situations”
  – While in class at school?
  – While in a face-to-face conversation with someone?

• Tertiles for analyses: low, medium, high
Chronotype

- Phase preference—propensity of the individual to sleep or feel most awake at a particular time during a 24-hour period
- Behavioral manifestation of underlying circadian rhythm
- Shift towards a more eveningness chronotype with puberty
Measurement of Chronotype

• 10-item Morningness-Eveningness Scale for Children (Carskadon)
• Asks students how they might organize the timing of activities, if they were “free to plan their day according to when they feel their best”
  – When do you have the most energy to do your favorite things
  – When does your body tell you it’s time for bed?
• Tertiles for analysis: morningness, intermediate, eveningness
## Student Characteristics

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age 12-14</td>
<td>53</td>
</tr>
<tr>
<td>Female</td>
<td>54</td>
</tr>
<tr>
<td>Non-Hispanic white</td>
<td>61</td>
</tr>
<tr>
<td>Parent completed college</td>
<td>88</td>
</tr>
<tr>
<td>Receives free or reduced-price school meals</td>
<td>8</td>
</tr>
<tr>
<td>Anxiety and/or mood disorder</td>
<td>6</td>
</tr>
<tr>
<td>Attention-deficit hyperactivity disorder</td>
<td>11</td>
</tr>
</tbody>
</table>
Greater Daytime Sleepiness

Shorter Sleep Duration

Poorer Self-Regulation

More Eveningness Chronotype

Unadjusted Bivariate Correlations Between Sleep Parameters and Self-Regulation

- Shorter Sleep Duration: 0.34
- Greater Daytime Sleepiness: 0.42
- More Eveningness Chronotype: 0.44
- Poorer Self-Regulation: 0.14
- Poorer Self-Regulation: 0.36
- Poorer Self-Regulation: 0.30
## Adjusted Predictors of Self-Regulation

<table>
<thead>
<tr>
<th></th>
<th>Total Score</th>
<th>Cognitive Subscore</th>
<th>Emotional Subscore</th>
<th>Behavioral Subscore</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>p</td>
<td>B</td>
<td>p</td>
</tr>
<tr>
<td>Intercept</td>
<td>1.36</td>
<td>&lt;.001</td>
<td>1.22</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Sleep duration, h</td>
<td>0.00</td>
<td>.92</td>
<td>0.00</td>
<td>.69</td>
</tr>
<tr>
<td>Medium sleepiness</td>
<td>0.15</td>
<td>*</td>
<td>0.16</td>
<td>*</td>
</tr>
<tr>
<td>High sleepiness</td>
<td>0.25</td>
<td>*</td>
<td>0.30</td>
<td>*</td>
</tr>
<tr>
<td>Intermediate chronotype</td>
<td>0.06</td>
<td>*</td>
<td>0.08</td>
<td>*</td>
</tr>
<tr>
<td>Evening chronotype</td>
<td>0.15</td>
<td>*</td>
<td>0.18</td>
<td>*</td>
</tr>
<tr>
<td>$R^2$</td>
<td>.24</td>
<td></td>
<td>.25</td>
<td></td>
</tr>
</tbody>
</table>

* $p < .01$, Higher self-regulation scores mean poorer self-regulation
Adjusted Self-Regulation by School-Night Sleep Duration and Daytime Sleepiness

**Cognitive**
- Low Sleepiness: 1.55, 1.61, 1.53
- Medium Sleepiness: 1.72, 1.76, 1.67
- High Sleepiness: 1.85, 1.84, 1.65

**Emotional**
- Low Sleepiness: 1.55, 1.61, 1.53
- Medium Sleepiness: 1.71, 1.76, 1.69
- High Sleepiness: 1.85, 1.84, 1.67

**Behavioral**
- Low Sleepiness: 1.51, 1.64, 1.51
- Medium Sleepiness: 1.65, 1.71, 1.69
- High Sleepiness: 1.69, 1.72, 1.67
Adjusted Self-Regulation by School-Night Sleep Duration and Chronotype

Cognitive
- Morningness
- Intermediate
- Eveningness

Emotional
- Morningness
- Intermediate
- Eveningness

Behavioral
- Morningness
- Intermediate
- Eveningness
Conclusions

• Among adolescents, evening chronotype and increased daytime sleepiness have greater impact on self-regulation than short sleep duration, especially for cognitive and emotional self-regulation.

• Efforts to improve adolescent self-regulation by altering sleep habits may involve more than increasing sleep duration.