BELL TIME ANALYSIS TASK FORCE

Sleep and Behavior – Research Review

1) Examining the Impact of Later High School Start Times on the Health and Academic Performance of High School Students: A Multi-Site Study


- Reviewed Automobile Crash data
  - Crash Data request from Minnesota and Wyoming is of 16-18 year old drivers for the school year months of September through May for the school year before the start time delay and the school year after the start time delay; Data was not analyzed for Colorado due to limited availability of data

Discussion of Car Crash Results

In two of the four communities for which we had crash data and which had instituted a later start time for their high schools, the rate of car crashes for high school age drivers dropped by 65-70%. Another district saw a slight decrease of 5%, and the fourth experienced an increase of 9%. The district with the increase, St. Louis Park, is a first-ring suburb of Minneapolis. St. Louis Park contains many major highway routes between the city of Minneapolis and other neighboring second- and third-ring suburbs. This may be a contributing factor in the increase in crash rates there, as those crashes may involve teens who attend local high schools in other nearby districts with earlier start times. The data that were provided did not enable us to identify which high schools the teens involved in crashes were attending.

2) Changing Times: Finding from the First Longitudinal Study of Later High School Start Times


- Results of Sleep Habits Survey
  - “Before the later school start time was instituted, many parents and administrators expressed a fear that students would merely use the later morning start time as an excuse to stay up an hour later on school nights. The data, however, show that this did not happen. Students continued to go to bed at the same time (approximately 15 minutes before 11 p.m.)...Minneapolis students slept about an hour more each school night (due to the later school start time) than their peers whose school began at 7:30 a.m.”
  - “The students whose high schools started at 8:30 a.m. or later reported statistically significant less depressive feelings on those questions [asked on the Sleep Habits Survey] than did the early start students (p ranged from <.05 to <.001.)”
  - “Similarly, scores on questions measuring daytime sleepiness, the struggle to stay awake in class, and sleepiness while doing homework all showed statistically better outcomes for the students whose school day started later. For example, students in late-start schools reported being less likely to arrive late to class because of oversleeping, or to fall asleep in a morning or..."
afternoon class because of oversleeping, or to feel sleepy while taking a test. They also reported statistically significant fewer feelings of sleepiness when at a computer, reading, or studying.”

<table>
<thead>
<tr>
<th>Survey items/scales</th>
<th>Minneapolis high schools (8:40 a.m. start)</th>
<th>District B (7:30 a.m. start)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( N = 467 )</td>
<td>( N = 169 )</td>
</tr>
<tr>
<td>School day rise time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1997–1998</td>
<td>7:12 a.m.***</td>
<td>6:13 a.m.***</td>
</tr>
<tr>
<td>2000–2001</td>
<td>6:40 a.m.</td>
<td>6:19 a.m.</td>
</tr>
<tr>
<td>School night bedtime</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1997–1998</td>
<td>11:19 p.m.*</td>
<td>11:05 p.m.*</td>
</tr>
<tr>
<td>2000–2001</td>
<td>10:41 p.m.</td>
<td>11:18 p.m.</td>
</tr>
<tr>
<td>School night sleep total</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1997–1998</td>
<td>7 hr, 53 min***</td>
<td>7 hr, 7 min***</td>
</tr>
<tr>
<td>2000–2001</td>
<td>7 hr, 59 min</td>
<td>7 hr, 1 min</td>
</tr>
<tr>
<td>Daytime sleepiness</td>
<td>2.21**</td>
<td>2.50**</td>
</tr>
<tr>
<td>Sleepiness (10-item total)</td>
<td>15.38***</td>
<td>17.37***</td>
</tr>
<tr>
<td>Struggled to stay awake or fell asleep</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reading, studying, doing homework</td>
<td>1.97***</td>
<td>2.39***</td>
</tr>
<tr>
<td>During a test</td>
<td>1.32**</td>
<td>1.48**</td>
</tr>
<tr>
<td>In a class at school</td>
<td>2.06***</td>
<td>2.45***</td>
</tr>
<tr>
<td>Doing work on a computer or typewriter</td>
<td>1.23</td>
<td>1.34</td>
</tr>
<tr>
<td>Sleep behavior (15-item total)</td>
<td>21.82*</td>
<td>23.26*</td>
</tr>
<tr>
<td>In the last 2 weeks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arrived late to class because overslept(a)</td>
<td>4.11**</td>
<td>3.77**</td>
</tr>
<tr>
<td>Fallen asleep in a morning class(a)</td>
<td>4.32***</td>
<td>3.90***</td>
</tr>
<tr>
<td>Fallen asleep in an afternoon class(a)</td>
<td>4.31</td>
<td>4.14</td>
</tr>
<tr>
<td>Depression (6-item total)</td>
<td>10.37*</td>
<td>10.89*</td>
</tr>
<tr>
<td>Days home sick over 2 weeks</td>
<td>0.75*</td>
<td>1.03*</td>
</tr>
</tbody>
</table>

*Higher values indicate lower frequency.
*Row mean values significantly different, \( p \leq .05 \).
**Row mean values significantly different, \( p < .01 \).
***Row mean values significantly different, \( p < .001 \).

3) **Adolescent Sleep, School Start Times, and Teen Motor Vehicle Crashes**


- “To assess the effects of delayed high school start times on sleep and motor vehicle crashes, a survey of the sleep habits of the students from an entire county-wide school district was administered before and after a change in school start times. There was only 1 school district in this county, and the students from the entire district participated. State-collected
measure of collisions statistics by age and residence of driver were used to compute crash rates per 1000 licensed drivers for teen drivers before and after the change in school start times in both the county in which the start times changed and in the rest of the state, where start times remained unchanged.

RESULTS

Average hours of sleep per night during Year 1 and Year 2 are presented in Figure 1. These data reflect group average comparisons rather than individual students tracked over time. Students in Year 2 averaged from 12 minutes (Grade 9) to 30 minutes (Grade 12) more self-reported sleep, compared with students in Year 1. T-tests on these changes in average amount of sleep at each grade level indicate that these Year 1 to Year 2 gains were significant at all 4 grades (all p values < .001). The percentage of students who got at least 8 hours of sleep per weeknight increased significantly from 35.7% to 50.0% (p < .01), and the percentage who got at least 9 hours of sleep increased significantly from 6.3% to 10.8% (p < .01). The average amount of additional sleep on Friday nights, compared with school nights, served as a crude proxy for sleep deprivation, as catch-up sleep on the weekends is a logical response to the build-up of a sleep debt during the week. The average amount of this additional weekend sleep significantly decreased from 1.9 hours to 1.1 hours (p < .001), and this drop in extra catch-up sleep by grade level is illustrated in Figure 2. Consistent with this indication of a reduced sleep debt, average scores on the Epworth Sleepiness Scale decreased from 8.9 to 8.2 (p < .001) from Year 1 to Year 2, and the proportion of teens who scored 10 or higher dropped from 43.3% to 37% (p < .001).

There was little evidence of change from Year 1 to Year 2 on any other measure collected from the adolescents’ self-reports. There was a slight increase in the percentage who reported working 10 hours or more per week (28% vs 31%), but there were no significant differences in hours spent on homework, school sports, organized community sports, music activities, volunteer work, or hanging out with friends.

Auto crash data per 1000 licensed drivers for those aged 17 and 18 are presented in Figures 3 and 4. Figure 3 presents all 5 years of available crash data and Figure 4 compares average crash rates for the 2 years prior to the change in school start times to those for the 2 years after the change. The year 1998 was dropped from Figure 4, as this was a transitional year during which the school district and the adolescents had to rearrange
transportation to and from school. The county crash rates were considerably higher than the rest of the state prior to the change in school start times. This may have been because the study county is in the center of a rapidly expanding metropolitan area, with all of its attendant traffic congestion. Despite rapid population growth, the rate of crashes in the county dropped after the change in school start time. The average crash rates in the 2 years after the change in school start times, as shown in Figure 4, reflect a significant decrease of 16.5% in the study county (p < .01), whereas there was a significant increase of 7.8% across the same time period in the rest of the state (p < .01).

![Graph showing crash rates before and after change in school start times.]

**Figure 4**—Number of motor vehicle crashes per 1000 drivers aged 17 or 18 years during the 2 years before and 2 years after a change in school start times.

4) **School Start Times and Teenage Driver Motor Vehicle Crashes**


- “Monthly time series were compiled corresponding to the overall rate of crashes on school days adjusted for changes in the 16- and 17-year-old population. An intervention time series analysis was applied to determine whether the change in school start time was accompanied by a downward shift.
in the level of the crash rate series. To control for possible confounding factors, comparable statistics were also compiled, using the same analyses, for several other counties where there was no change in school start times.”

- “For Forsyth County, NC there was a decrease in crash rates corresponding to the change in school start time, though the statistical significance of the effect is only moderate (one–sided p-value=.04). No corresponding effect was observed for three comparable counties of North Caroline. For Fayette County, KY there was no evidence of a statistically significant change in crash rates. Because of anomalous data in the one available comparable county, we were unable to derive meaningful results for a comparison county in Kentucky.”

- “We conclude that there is mild evidence that the change in school start times in Forsyth County, NC had a beneficial effect, but there is no corresponding evidence for Fayette County, KY.

5) Sleep Schedules and Daytime Functioning in Adolescents


- “Clinical experience shows that adolescents who have trouble adapting to new school schedules and other changes (e.g. new bedtimes and rise times, increased activities during the day, increased academic demands) may develop problematic sleeping behaviors leading to chronic sleepiness. Several studies indicate an association between sleep and stress.”

- “The chief goal of this study is to document the association between adolescents’ sleep/wake habits and daytime sleepiness, high school grades, depressed mood, and other daytime behaviors. Our study has three objectives: (1) to describe age, sex, and school differences in sleep / wake patterns; (2) to characterize the relation between self-reported high school grades and sleep / wake schedules; and (3) to compare daytime functioning in students on schedules we define a priori as adequate versus those adopting less than adequate schedules.”
Overall, adolescents who were in the groups defined as less than adequate sleep habits reported increased behavioral difficulties in comparison to those we defined as adequate sleepers. Thus, students in the short total sleep group reported more sleep/wake behavior problems, such as arrived late to class because of oversleeping, tired or dragged out nearly every day, needed more than one reminder to get up, ps < .01, higher levels of depressive mood, ps < .001, and greater sleepiness, ps < .001, than those in the long sleep group. Similarly, adolescents in the large weekend delay group described more sleep/wake behavior problems, ps < .01, and greater daytime sleepiness, ps < .05, but no difference in depressed mood from those with small weekend delays. One exception was that the female students with large weekend delays reported increased depressive mood levels, p < .05. Adolescents in the high weekend oversleep group reported more sleep/wake behavior problems, p < .001, but no differences in depressed mood or sleepiness from those in the low oversleep group. No sex differences were found in self-reported sleep/wake behavior problems; however, females reported higher levels of depressed mood: females, M = 11.04, SD = 2.91 versus males, M = 9.20, SD = 2.68, p < .001, and daytime sleepiness: females, M = 15.26, SD = 3.59 versus males, M = 14.67, SD = 4.16, p ≤ .01, than did males.

- Caveat:
- “First, it is difficult to evaluate how representative the sample was, although the congruence between our findings and those from prior research...strong suggest that the sample was quite typical. Whether our results hold for adolescents drawn from a wider socioeconomic and cultural background is an important issue for future studies. Second, the results of this study are based entirely on the adolescents’ self-reports and suffer limitations because data are retrospective, based only on the last 2 weeks, and subjective...Our previous experience in laboratory studies indicate that such self-report data are well correlated with data obtained from daily sleep diaries or continuous activity monitoring, although we have not made a formal comparison.”
- “Third, because the survey was conducted in one geographic area, some caution should be taken in generalizing the findings. Fourth, because the study design was cross-sectional, no conclusions about long-term development and ramifications of inadequate sleep can be drawn.”
6) Impact of Delaying School Start Time on Adolescent Sleep, Mood, and Behavior


- “Conclusion: A modest delay in school start time was associated with significant improvements in measures of adolescent alertness, mood, and health. The results of this study support the potential benefits of adjusting school schedules to adolescents’ sleep needs, circadian rhythm and developmental stage.”
- “The study site was an independent coeducational college preparatory boarding and day school serving grades 9 to 12 and located in southern New England...190 students (53.2%) were girls, 291 (81.5%) were boarders, and 66 (18.5%) were day students. Boarders come from more than 30 states and 20 foreign countries; about 12% are international students, and 18% are nonwhite.”
  - Used the Sleep Habits Survey (8-page self-report survey that has been administered to more than 3000 high school students in Rhode Island)

The results of this survey study of students from an independent school support those of previous research studies examining the impact of delaying high school start times in public high schools settings. A modest (i.e., 30-minute) start time delay was associated with a significant increase in self-reported sleep duration and a decrease in a number of ratings of daytime sleepiness. Perhaps more important, students rated themselves as less depressed and more motivated to participate in a variety of activities and were less likely to seek medical attention for fatigue-related concerns in conjunction with the change in start times. Furthermore, as in previous studies, depressive symptoms overall were negatively correlated with reported sleep duration and increased in groups of students (i.e., 11th- and 12th-grade students and girls) who reported getting less sleep or being more sleepy or both. Given the recent concerns raised regarding the relationship between insufficient sleep and both depressive symptoms and suicidal ideation in adolescents, this positive effect on mood associated with delaying the start time is particularly noteworthy.

- “Clearly, the generalizability of these findings is limited by the setting in which they occurred; that is, there are limited parallels between a relatively small, independent, largely boarding school and the average American public high school.”
- “Finally, the study was also based on retrospective subjective self-report data rather than objectively measured sleep variables.”
7) The behavioral and health consequences of sleep deprivation among U.S. high school students: Relative deprivation matters


- Methods: 2011 Youth Risk Behavior Survey data of high school students (N=15,364) were analyzed. Associations were examined on weighted data using logistic regression. Twelve outcomes were examined, ranging from weapon carrying to obesity. The primary independent variable was a self-reported measure of average number of hours slept on school nights.

- Results: Participants who reported deprivations in sleep were at an increased risk of a number of negative outcomes. However, this varied considerably across different degrees of sleep deprivation. For each of the outcomes considered, those who slept less than 5 h were more likely to report negative outcomes (adjusted odds ratios ranging from 1.38 to 2.72; p<.05 across all models) relative to sleeping 8 or more hours. However, less extreme forms of sleep deprivation were, in many instances, unrelated to the outcomes considered.

- “The National YRBS is a biennial, self administered and anonymous survey of high school students throughout the United States”

- Negative Outcomes examined:
  - Drunk driving
  - Weapon Carrying
  - Fighting
  - Contemplate suicide
  - Attempt suicide
  - Smoking
  - Alcohol use
  - Binge drinking
  - Marijuana use
  - Sexual risk-taking
  - Texting while driving
  - Obesity
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As with many studies focused on the consequences of sleep deprivation, the current study is limited by the fact that it is cross-sectional, which makes it difficult to establish whether several of the outcomes examined might have preceded sleep deprivation. Likewise, the non-experimental nature of the study and the limited set of potential confounders that can be accounted for using the YRBS data limit our ability to claim that sleep deprivation has a causal impact on each of the outcomes examined.

8) School Start Time and Its Impact on Learning and Behavior


9) Lack of Sleep Increases Injury Rate in Teenage Athletes


The study polled 160 adolescents in grades 7 through 12 at a school in California. It asked them questions about the number of sports they played, their time committed to sports, whether they used a coach, if they participated in strength training, how much sleep they got each night, and how much they enjoyed the athletics in which they were involved. Over a 21-month period, 57% of the athletes sustained injuries that were recorded, and 38% of all athletes suffered multiple injuries. The results of the study indicated that the hours of sleep each student got each night was significantly associated with a decreased likelihood of injury. Student athletes who said they slept less than eight hours per night were significantly more likely to suffer a sports injury. Additionally, the older or higher the grade level of the student, the higher the likelihood of injury (2.3 times greater for each additional grade in school). The study concluded that gender, weeks of participating in sports per year,
hours of participation per week, number of sports, strength training, private coaching, and whether or not the athlete enjoyed his/her sport were not significant variables that were associated with injury.”

10) Teens & Sleep: Impact of Inadequate Sleep on Adolescent Health

Beebe, D. W. (Director) Teens & Sleep: Impact of Inadequate Sleep on Adolescent Health. Lecture conducted from University of Minnesota Center for Applied Research and Educational Improvement in the College of Education and Human Development.

- Connection between getting less than 8 hours of sleep a night and obesity
  - Data looking at Causality
- “Short sleep is associated with certain types of sports injuries in youth (Luke et al., 2011)”
- “Even among elite teen athletes, less sleep is associated with less willingness to train hard. (Engle-Friedman et al, 2010)”
  - Data looking at Causality
- Connection between hours of sleep on school nights and missed/sick days in the past 2 weeks (Walhstrom, 2002)
  - Data looking at causality