

2013

# Early to Bed, Early to Rise: How Changing to an Earlier School Start Time Affects Sleep Patterns and Cognitive Functioning in School-Aged Children

Laura Pistorino

Follow this and additional works at: [http://vc.bridgew.edu/undergrad\\_rev](http://vc.bridgew.edu/undergrad_rev)



Part of the [Other Psychology Commons](#)

## Recommended Citation

Pistorino, Laura (2013). Early to Bed, Early to Rise: How Changing to an Earlier School Start Time Affects Sleep Patterns and Cognitive Functioning in School-Aged Children. *Undergraduate Review*, 9, 119-127.

Available at: [http://vc.bridgew.edu/undergrad\\_rev/vol9/iss1/25](http://vc.bridgew.edu/undergrad_rev/vol9/iss1/25)

# Early to Bed, Early to Rise: How Changing to an Earlier School Start Time Affects Sleep Patterns and Cognitive Functioning in School-Aged Children

LAURA PISTORINO



Laura Pistorino graduated with honors from BSU in May of 2012 with an undergraduate degree

in psychology. This pilot research began in 2011 as part of the Adrian Tinsley Program Summer Grant, mentored by Dr. Sandy Nearing. Laura has presented this pilot study at the 2011 Undergraduate Summer Research Symposium. Since graduating, Laura has completed the follow up study, which was presented at the National Sleep Foundation's Sleep Health & Safety Conference in Washington D.C. in March 2013. Laura is currently working as a research assistant at Boston University's Vision and Cognition Laboratory, with plans to apply to graduate programs in psychology.

**T**he purpose of this project was to elucidate the impact of earlier school start times on elementary school children. Research demonstrates that adolescents are chronically sleep deprived due to shifting biological rhythms and early school start times. As a result, some schools have restructured their schedules to allow for later start times for middle and high school students. This change has inadvertently resulted in earlier start times for the elementary school students. Although studies demonstrate a positive impact of later start times for adolescents, no studies have examined younger children. This project, therefore, examined the effect of an earlier start time on the sleep patterns of elementary school students, as well as assessed correlations between sleep and cognitive functioning. Two groups of second graders (an experimental and control group) were followed for one-year; one experienced an earlier school start time in third grade, and the other did not. Measures of actigraphy and survey data were obtained. Results demonstrated that changing to an earlier school start time may cause school-aged children to obtain less quality of sleep, and experience a higher rate of daytime sleepiness. Because of the limited sample size included in this study, results are dependent on a larger scale experiment which will be completed within the next year.

Sleep is an essential aspect of daily human functioning playing an important role in health and cognition. Psychologists and medical professionals have proposed various theories pertaining to the significance of sleep. The repair and restoration theory and the information consolidation theory are among the most commonly investigated and supported (Magee, 2010; Park, 2010; Stickgold, 2005; Durrant, 2011). These theories suggest that we sleep in order to regain health and consolidate information, respectively. As such, when we experience sleep deprivation, both physiological functioning and cognitive performance suffer (Chee, 2010). This is especially true during the teenage years when a sleep shift takes place (Carskadon, 1993). A shift in sleep may occur as the result of a biological change, which accompanies adolescence, thereby altering circadian rhythms (Wolfson, 1996). As the circadian rhythm is thrown off course, sleeping schedules begin to change.

A number of researchers have examined how this shift affects cognitive functioning in adolescents. For example, Randazzo (1998) assigned adolescents (aged 10-14) to one of two groups: the control group (sleeping 11 hours for one night), or the experimental group (sleeping 5 hours for

one night). Differences between the two groups were found on the Wisconsin Card Sorting Test (WCST), which is a measure of executive function after a single night of restricted sleep. Also, Wolfson's (1998) research demonstrated that a dramatic decrease in total sleep time for adolescents was associated with significant cognitive deficits. Students who described themselves as struggling or failing school (receiving grades of C's, D's, or F's) reported that on school nights they received 25 minutes less sleep and went to bed an average of 40 minutes later than students who received A's or B's for grades.

Because of the abundance of research supporting that a sleep shift occurs in adolescents, keeping these teenagers awake longer into the night (Mindell, 1999; Beebe 2009; Carskadon et al. 1993; Wolfson 1996), many school administrations have pushed an earlier high school start time to a later start time. This change allows the adolescent students to receive a more adequate amount of sleep, which in turn is believed to reduce cognitive deficits apparent in this group due to lack of sleep. One community who decided to make this change was Duxbury, Massachusetts. However, because Duxbury, like many local communities, has a tiered bus system, pushing the high school start time to a later slot inadvertently placed the elementary school in Duxbury (grades 3-5) to the early slot that the high school students once occupied. The elementary school now has an earlier start time than the early education school (grades K-2) and the junior and senior high schools. While 2<sup>nd</sup> graders in Duxbury begin their school day at 9:10 A.M., 3<sup>rd</sup> grade students now start school at 7:45 A.M.

As these children in Duxbury enter 3<sup>rd</sup> grade, their parents are concerned that the earlier school start time in elementary school will alter the sleep and cognitive functioning of the students, similar to the effect seen in adolescents start school early. However, little research has been conducted on the effect of an earlier school start time on school-aged children. Some studies suggest that, similar to general sleep findings, sleep quantity and quality are associated with cognitive performance in children (Lavigne, 1999; Suratt, 2007; Tremaine, 2010). However, there is a gap in the literature on how sleep patterns in school-aged children are affected by changes in school start time.

Students at the elementary school in Duxbury, Massachusetts, grades 3-5, now start school at 7:45 A.M., however the younger students (K-2<sup>nd</sup> grade) start school at 9:00 A.M. This is a dramatic shift in start times. The present research aimed to elucidate the effects that changing to an earlier school start time has on the sleeping patterns and cognitive functioning of school-aged children. To do this, the sleep and cognitive functioning of a sample of Duxbury students was evaluated as

they transitioned from 2<sup>nd</sup> to 3<sup>rd</sup> grade (experimental group), with a sample of students from Pembroke, Massachusetts, where the 2<sup>nd</sup> grade students started school at 9:00 A.M., and did not experience a shift in start times in 3<sup>rd</sup> grade (control group). Measures of sleep were gathered through an actigraphy device (a watch-like device that detects movement to gather sleep/wake activity). Cognitive functioning was assessed through tests of executive functioning. Both groups were tested twice, once while in 2<sup>nd</sup> grade (Time 1), and again while in 3<sup>rd</sup> grade (Time 2). Although this study primarily focused on measures of sleep and actigraphy data, correlations were examined between these measures and cognitive performance. Because it was unknown whether the shift in school start time would adversely affect the experimental group, this experiment was tested as a two-tailed hypothesis.

## METHOD

### Participants

Participants included a total of 10 students: four Duxbury 2<sup>nd</sup> grade students (0 males, 4 females), who served as the experimental group, and six Pembroke 2<sup>nd</sup> grade students (3 males, 3 females), who served as the control group. The original pilot project contained 11 participants, however one female from Duxbury dropped out of the study due to schedule conflicts. The age range of the participants was 7-10 years old. Participants were tested twice, once in the spring of 2011 (Time 1 – 2<sup>nd</sup> grade) and once in the spring of 2012 (Time 2 – 3<sup>rd</sup> grade). They were recruited as a convenience sample, contacted through friends and family, who suggested children that they knew would qualify for the study. The town of Pembroke is very similar in socioeconomic structure to Duxbury, and was also chosen because the school's start time for 2<sup>nd</sup> grade students is very similar. Duxbury's school start time for 2<sup>nd</sup> graders is 9:00 A.M., and Pembroke's 2<sup>nd</sup> grade students start at 9:10 A.M. Once the Duxbury students go on to 3<sup>rd</sup> grade, they begin school at the now altered start time of 7:45 A.M., while Pembroke students return to school in the 3<sup>rd</sup> grade with the same school start time as the previous year.

Children were excluded from the study based on parent report of a neurodevelopmental disorder or a psychiatric disorder based on the Child Behavior Checklist, report of sleep disordered breathing based on the Children's Sleep Habits Questionnaire, and/or report of child taking medications that impact sleep (psychostimulants). Informed parental consent and child assent approved by the Boston University Medical Center Campus Institutional Review Board was obtained for this project.

## Sleep Measures and Procedures

The primary measures for this study examined sleep using an actigraph and sleep questionnaires.

**Actigraph.** Ambulatory Actigraphy (AW-64, Respironics, Bend, CO) (Sadeh, 1989) is a watch-like device that is worn on the non-dominant wrist and is used to collect and download continuous, objective, long-term sleep/wake data. The actigraph works by detecting movements. For every 1-minute period, the actigraph sums up the number of movements, the data of which are displayed on a graph. The actigraphy device and software allows researchers to collect data on sleep objectively. This is important for obtaining unaltered results. Many early sleep studies, as well as sleep studies today, have participants sleep in a lab. The participant is taken away from his or her natural sleeping environment, which can make it difficult to obtain reliable and valid results. The sleep measures provided by the actigraphy device and software have been validated against polysomnography (a medical sleep study) with agreement rates for minute-by-minute sleep/wake identification of higher than 90% (Sadeh, 1989). For these reasons, actigraphy devices were used in this study, as it may provide more accurate and realistic sleep data than if participants were instructed to sleep in a lab.

The children and parents who participated in this study were educated briefly on how to wear the watch continuously for the three-day period, and to maintain their regular sleeping schedule as much as possible. The actigraph is completely waterproof, so participants were instructed not to remove it even when showering or bathing. After wearing the device for three days, the actigraph was collected from the participants. Sleep variables obtained from the actigraphy device that were examined in the current project included: Sleep Efficiency, and Sleep Fragmentation. Sleep Efficiency is the percentage of total sleep time divided by actual sleep period. Sleep Fragmentation happens when there are several disturbances in sleep that last a brief duration. Sleep disturbances throughout the night reduces the total amount of time spent in deeper levels of sleep. Sleep Fragmentation as seen on an actigraphy data graph appear as random spikes of movement among periods of very few spikes, or sleeping periods. These measures of sleep were chosen because of their relevance to quality of sleep and measure of sleep patterns, as shown through previous research (Banks, 2007; Sadeh, 2002).

**Child Sleep Habits Questionnaire.** To obtain subjective sleep data, the participants' parents completed the Children's Sleep Habits Questionnaire (or CSHQ) (Owens, 2000). Variables provided by the CSHQ include: Sleep Duration, Night Wakings, and Daytime Sleepiness. Sleep Duration was assessed

using the parent's responses (scaled as "usually," "sometimes," or "rarely") to several prompts, including: child sleeps too little, child sleeps the right amount, and child sleeps the same amount each day. Night Wakings were scored the same way in response to the following prompts: child moves to other's bed at night, child awakes once during the night, and child awakes more than once during the night. Similarly, Daytime Sleepiness was assessed based on parent's responses ("usually," "sometimes," or "rarely") to the following: child wakes by himself, child wakes up in a negative mood, others wake child, child has a hard time getting out of bed, child takes a long time to be alert, child seems tired, during the past week child appears tired or falls asleep watching television, and during the past week child appears tired or falls asleep while riding in the car. The parent also reports if each item is a problem for the child. Responses were scored, allowing for the assessment of children's sleep on six measures (three from the actigraphy device and three from the CSHQ).

The children also received the Child Behavior Checklist (Achenbach, 2001) to screen for any neurodevelopmental or psychiatric conditions. The parents completed the questionnaires as their children were fitted with the actigraphy devices. All children performed normally on this measure so no children were excluded based on their responses.

## Cognitive Measures and Procedures

After wearing the actigraph for three days, each child was met by a laboratory staff member for the neuropsychological testing. The battery was 15-20 minutes in order to minimize participant burden and contained standard tests of executive functioning and sustained attention. Measures of executive function and sustained attention were used in this study as they have been shown to be cognitive measures that are sensitive to sleep (Beebe et al., 2009; Zerouali, 2010). Two tests were used for the current study, the Conner's Continuous Performance Test (CPT-II) and the Digit Symbol Coding subtest from the Wechsler Intelligence Scale for Children, 4<sup>th</sup> edition. Although results of the cognitive measures are not discussed in this paper, descriptions of the measures are given below as the results include the correlation analysis between the sleep measures and cognitive performance.

**CPT II.** The CPT-II is a computerized test of sustained attention and response inhibition. The children are instructed to press the spacebar every time a letter is shown on the screen, except for the letter "X." They are told to work as quickly as possible while still being as accurate as possible. The test lasts about 15 minutes. Participants complete a practice test beforehand to ensure that they understand what they are being asked to do. The CPT-II measures assessed in this study include: *Omission*

*Errors*, i.e. responding to the “X” (test-retest reliability .84), *Commission Errors*, i.e. not responding to letters other than “X” (test-retest reliability .65), and *Hit Reaction Time* (test-retest reliability .55; Corkum, 1993).

**Digit Symbol Coding Test.** The Digit Symbol Coding Test is a test of attention and speed of processing. The present study used a written version of this test. The children were given a paper, the top of which has boxes with the numbers 1-9. Below the row of numbers are boxes with symbols that are paired with each number. The children are taught that each number corresponds to a unique symbol. At the bottom of the paper are more rows of boxes with numbers in random order, but below them the boxes are blank. The children are instructed to fill in the blank boxes with the corresponding symbol. Once the participants understand the test, they complete a practice section. Again, participants are told to work as fast and accurately as possible. Once ready, they begin the real test, and keep working for a total of 120 seconds, when they are told to stop. After, they are asked to write down as many of the symbols as they can remember. The Digit Symbol Coding Test measures average response latency (in seconds). For this study, performance on the Digit Symbol Coding subtest was measured using two variables: *Total Correct Responses* and *Total Incorrect Responses*.

## RESULTS

### Between-Group Comparisons

Because this was a pilot study with a small number of participants, nonparametric tests were used to analyze the data. The control and experimental groups were compared across all measures of sleep using the Mann-Whitney U test. They were compared on three measures of the CSHQ and three measures of the Actigraph at two different times: when both groups were in 2nd grade and when both groups were in third grade. Given that school times were equivalent in 2nd grade, one would not expect to see any group differences between the control and experimental participants. If school start times do affect measures of sleep, differences between groups should be observed when both are in 3rd grade, given the different school start times for each group. See the top half of Table 1 for a summary of the following results.

**Comparisons on the CSHQ.** While in 2nd grade, Sleep Duration in control participants (*Mdn*= 3.00) did not differ significantly from participants in the experimental group (*Mdn*= 3.00),  $U= 12.00, z = .00, p = 1.00$ . When in 3rd grade, Sleep Duration in the control group (*Mdn*= 3.00) did not differ significantly from the experimental group (*Mdn*= 4.00),  $U= 4.50, z = -1.83, p = .07$ . While not significant, the experimental

**Table 1. Summary of Results**

	Control vs Experimental Time 1	Control vs Experimental Time 2
<b>CSHQ</b>		
Sleep Duration	n.s.	$p = .067$ (lower in controls)
Night Wakings	n.s.	n.s.
Daytime Sleepiness	n.s.	$p < .05$ (lower in controls)
<b>Actigraph</b>		
Sleep Efficiency	n.s.	n.s.
Sleep Fragmentation	n.s.	n.s.
	Time 1 vs Time 2 Control	Time 1 vs Time 2 Experimental
<b>CSHQ</b>		
Sleep Duration	n.s.	n.s.
Night Wakings	n.s.	n.s.
Daytime Sleepiness	n.s.	n.s.
<b>Actigraph</b>		
Sleep Efficiency	$p < .05$ (higher in Time 2)	n.s.
Sleep Fragmentation	$p < .05$ (lower in Time 2)	n.s.

participants were sleeping slightly longer than controls ( $p = .07$ ). See Figure 1.

Night Wakings in control participants (*Mdn*= 3.00) did not differ significantly from the experimental group (*Mdn*= 3.50) during 2nd grade,  $U= 7.50, z = -1.19, p = .24$ . Night Wakings in 3rd grade were not significantly different between control (*Mdn*= 3.00) and experimental (*Mdn*= 3.00) groups,  $U=9.00, z = -1.23, p = .22$ . See Figure 2.

During 2nd grade, the experimental group (*Mdn*= 9.50) did not differ significantly from the control group (*Mdn*= 8.00) on measures of Daytime Sleepiness,  $U= 5.00, z = -1.61, p = .11$ . However, Daytime Sleepiness in the control group (*Mdn*= 8.50) was significantly lower than the experimental group (*Mdn*= 11.00) while in 3rd grade,  $U= 1.00, z = -2.41, p < .05, r = -.76$ . See Figure 3.

**Comparisons on the Actigraph.** While in 2nd grade, Sleep Efficiency did not differ significantly between control (*Mdn*=

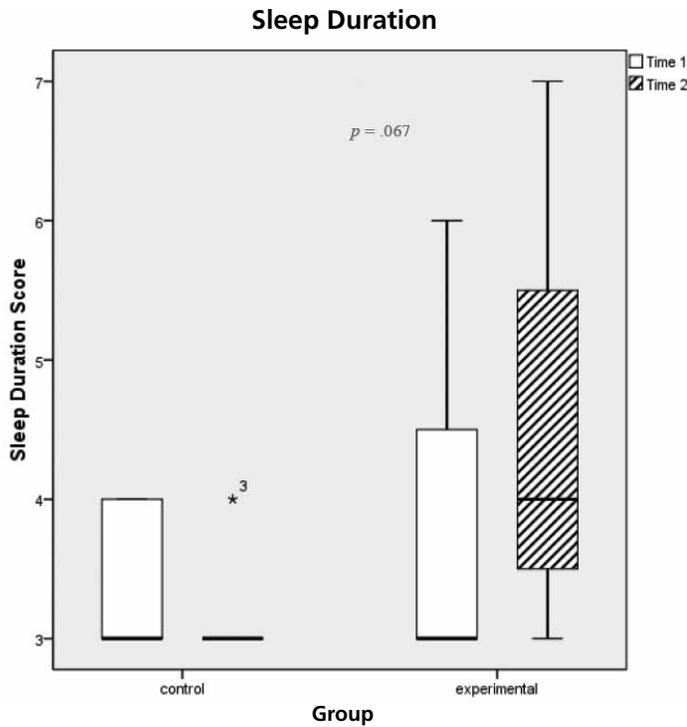


Figure 1. Here a boxplot graph is used to graph the nonparametric distribution of our sample. The thick line inside of the box represents the median. The lines above and below the colored boxes show the maximum and minimum scores, respectively. Sleep Duration was scored using the parent reported answers on several questions of the Child Sleep Habits Questionnaire. A higher score represents longer sleep duration. During Time 2, all of the control participants scored a 3, except for one participant who scored a 4 (as shown by the black asterisks). No significant differences were found in Sleep Duration, however a trend ( $p = .067$ ) was found between control and experimental groups during Time 2 (as marked by the red connecting line).

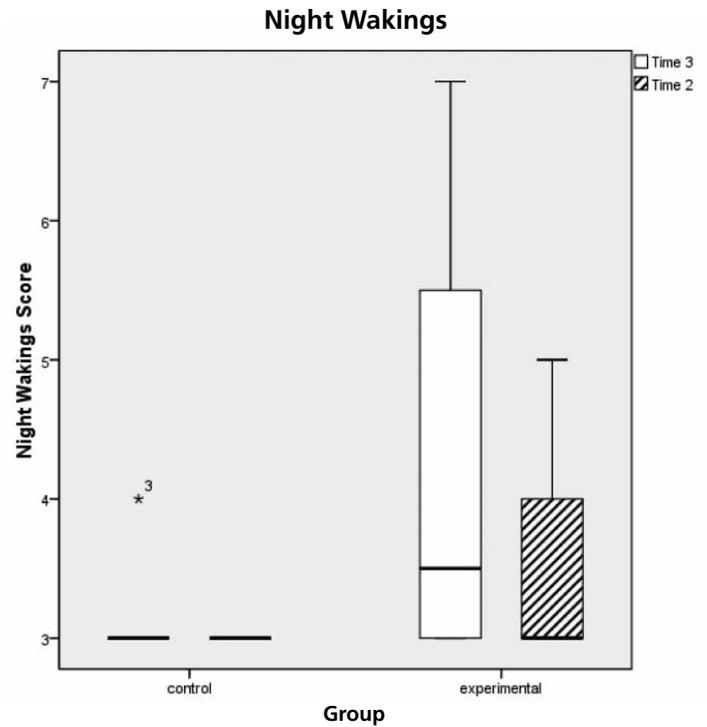


Figure 2. Night Wakings was scored using the parent reported answers on several questions of the Child Sleep Habits Questionnaire. A higher score represents a higher frequency of waking during a night of sleep. All of the control participants scored a 3 during both Time 1 and Time 2, except for one participant who scored a 4 (as shown by the black asterisks). No significant differences were found in Night Wakings.

75.04) and experimental ( $Mdn = 66.56$ ) groups,  $U = 7.00$ ,  $z = -1.07$ ,  $p = .29$ . On measures of Sleep Efficiency, control participants ( $Mdn = 83.08$ ) were not significantly different from experimental participants ( $Mdn = 80.96$ ) during 3<sup>rd</sup> grade,  $U = 4.00$ ,  $z = -1.29$ ,  $p = .20$ . (See Figure 4). Note that each figure consists of the between groups results reported here and the within group results reported in a later section.

Sleep Fragmentation in control participants ( $Mdn = 20.30$ ) was not significantly different from experimental participants ( $Mdn = 23.78$ ) during 2<sup>nd</sup> grade),  $U = 7.00$ ,  $z = -1.07$ ,  $p = .29$ . During 3<sup>rd</sup> grade, control participants ( $Mdn = 16.77$ ) did not differ significantly from experimental participants ( $Mdn = 14.90$ ) on measures of Sleep Fragmentation,  $U = 6.00$ ,  $z = -.78$ ,  $p = .44$ . (See Figure 5).

### Within-Group Comparisons

To examine how each group (control and experimental)

changed in their sleep performance from 2<sup>nd</sup> grade to 3<sup>rd</sup> grade, a series of nonparametric tests were performed for each sleep variable. Because school-start times remained the same for the control group from 2<sup>nd</sup> to 3<sup>rd</sup> grade, no significant differences should be found. For the experimental group, if changes in school-start times adversely affected the children, poorer sleep performance should be noted in 3<sup>rd</sup> grade compared to 2<sup>nd</sup> grade. The Wilcoxin Signed-Rank Tests was used to compute these comparisons. See the bottom half of Table 1 for a summary of the following results.

**Comparisons on the CSHQ.** Sleep Duration for the control group did not significantly differ between 2<sup>nd</sup> grade ( $Mdn = 3.00$ ) and 3<sup>rd</sup> grade ( $Mdn = 3.00$ ),  $z = -.58$ ,  $p = .56$ . The experimental group did not have any significant differences in Sleep Duration from 2<sup>nd</sup> grade ( $Mdn = 3.00$ ) to 3<sup>rd</sup> grade ( $Mdn = 4.00$ ),  $z = -.74$ ,  $p = .46$ . See Figure 1.

The control group also did not differ significantly on measures of Night Wakings between 2<sup>nd</sup> grade ( $Mdn = 3.00$ ) and 3<sup>rd</sup> grade ( $Mdn = 3.00$ ),  $z = -1.00$ ,  $p = .32$ . Night Wakings were also not significantly different from 2<sup>nd</sup> grade ( $Mdn = 3.50$ ) to

**Daytime Sleepiness**

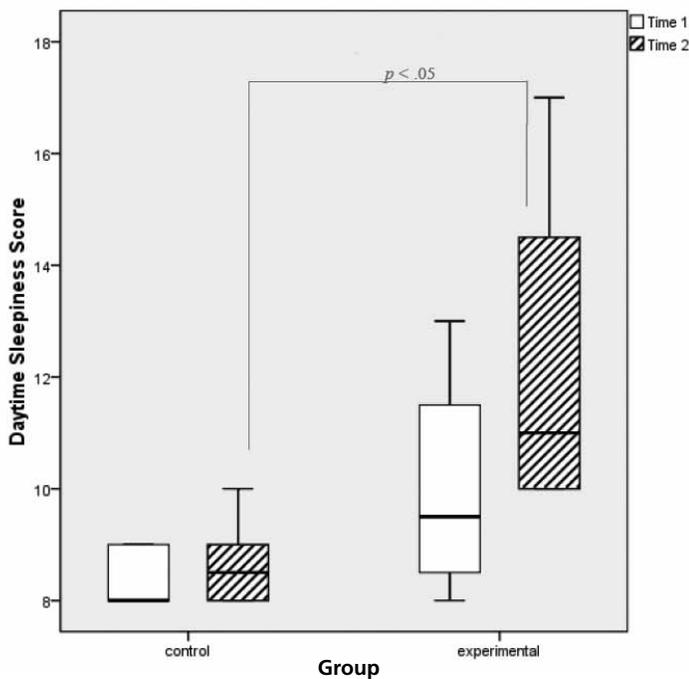


Figure 3. Daytime Sleepiness was also scored using the parent reported answers on several questions of the Child Sleep Habits Questionnaire. A higher score represents more sleepiness during the daytime hours. The only significant difference found was between control and experimental groups during Time 2 (as marked by the red connecting line), where controls were experiencing less Daytime Sleepiness.

3<sup>rd</sup> grade ( $Mdn= 3.00$ ) in the experimental group,  $z = -1.34$ ,  $p = .18$ . (See Figure 2).

Daytime Sleepiness did not differ significantly from 2<sup>nd</sup> grade ( $Mdn= 8.00$ ) and 3<sup>rd</sup> grade ( $Mdn= 8.50$ ) for the control participants,  $z = -1.00$ ,  $p = .32$ . Experimental participants did not significantly differ on measures of Daytime Sleepiness between 2<sup>nd</sup> grade ( $Mdn= 9.50$ ) and 3<sup>rd</sup> grade ( $Mdn= 11.00$ ),  $z = -1.07$ ,  $p = .29$ . (See Figure 3).

**Comparisons on the Actigraph.** Control participants had significantly higher Sleep Efficiency during 3<sup>rd</sup> grade ( $Mdn= 83.08$ ) than during 2<sup>nd</sup> grade ( $Mdn= 75.04$ ),  $z = -1.99$ ,  $p < .05$ ,  $r = -.63$ . In the experimental group, Sleep Efficiency was not significantly different between 2<sup>nd</sup> grade ( $Mdn= 66.56$ ), and 3<sup>rd</sup> grade ( $Mdn= 80.96$ ),  $z = -1.60$ ,  $p = .11$ . (See Figure 4).

Sleep Fragmentation was significantly lower in 3<sup>rd</sup> grade ( $Mdn= 16.77$ ) than in 2<sup>nd</sup> grade ( $Mdn= 20.30$ ) for control participants,  $z = -2.20$ ,  $p < .05$ ,  $r = -.70$ . Sleep Fragmentation was not significantly different between 2<sup>nd</sup> grade ( $Mdn=$

**Sleep Efficiency**

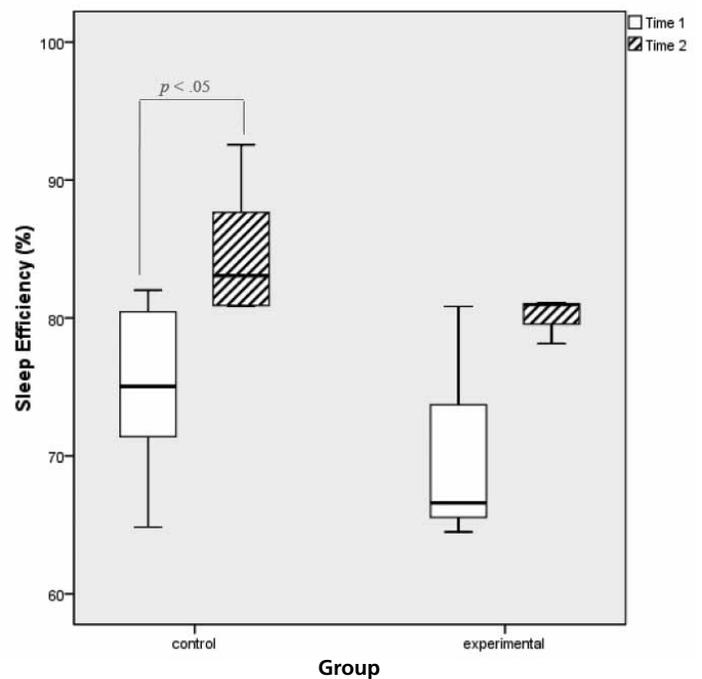


Figure 4. Sleep Efficiency was calculated using the actigraphy device, and is the percentage of total sleep time divided by actual sleep period. A higher percent represents more time asleep during a sleeping period. The only significant difference found was between Time 1 and Time 2 for the control participants, where controls in Time 2 had a higher Sleep Efficiency.

23.78) and 3<sup>rd</sup> grade ( $Mdn= 14.90$ ) in the experimental group,  $z = -1.60$ ,  $p = .11$ . (See Figure 5).

**Correlations Between Sleep and Cognition**

To compare the sleep variables in the present project with the cognitive variables, a series of Spearman Rho correlations for each group was performed: experimental 2<sup>nd</sup> grade, experimental 3<sup>rd</sup> grade, control 2<sup>nd</sup> grade, and control 3<sup>rd</sup> grade. It was expected that some significant correlations would be noted between sleep and cognition.

No significant correlations using Spearman’s Rho were found between sleep and cognition in the experimental group in either 2<sup>nd</sup> or 3<sup>rd</sup> grade. However, while in 2<sup>nd</sup> grade, the experimental participants showed a trend in the correlation between Night Wakings and scores on the CPT-II: *Hit Reaction Time* ( $p = .051$ ;  $r = .95$ ), *Omission Errors* ( $p = .051$ ;  $r = .95$ ) and *Commission Errors* ( $p = .051$ ;  $r = -.95$ ). While in 3<sup>rd</sup> grade, the experimental group showed another trend between Sleep Duration and *Commission Errors* ( $p = .051$ ), and between Sleep Duration and *Hit Reaction Time* ( $p = .051$ ).

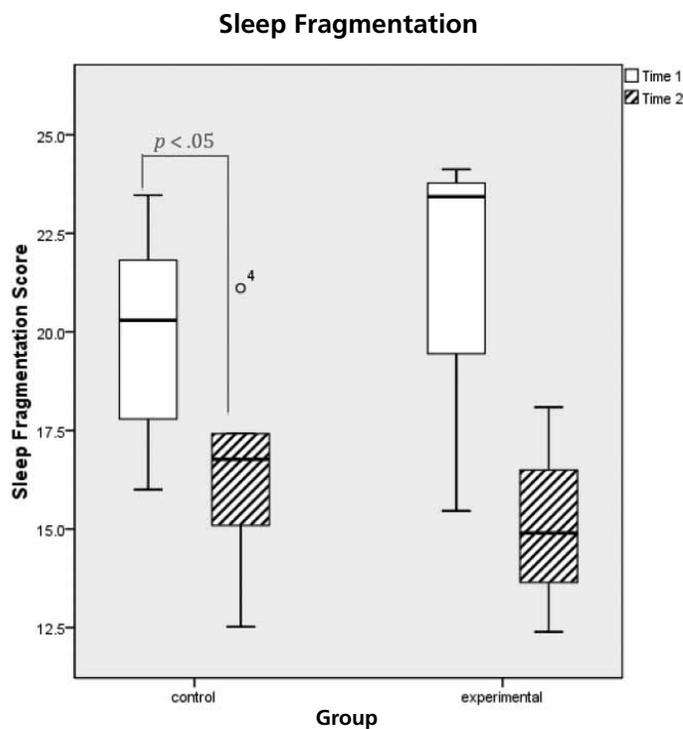


Figure 5. Sleep Fragmentation happens when there are several disturbances in sleep that last a brief duration. Sleep disturbances throughout the night reduce the total amount of time spent in deeper levels of sleep, and is measured using the actigraphy device. There was one outlier in the control group during Time 2 (marked by the circle). There was a significant difference between Time 1 and Time 2 for the control group, where controls had less Sleep Fragmentation during Time 2.

No significant correlations were found between sleep and cognitive performance in the control group during 2<sup>nd</sup> grade. However, during 3<sup>rd</sup> grade, the *Hit Reaction Time* of control participants was positively significantly correlated with Daytime Sleepiness ( $p < .04$ ).

## Discussion

Despite the small sample included in this pilot study, some interesting results were found that need to be further examined. The analysis showed no significant results between control and experimental groups during Time 1 (2<sup>nd</sup> grade). This implies that the two groups were equal on measures of sleep before the manipulation of school start times during Time 2. This is important because if the two groups were not equally matched it would not be possible to compare them after changing school start times.

During Time 2, sleep in the experimental group differed significantly from the control group. The experimental participants, after experiencing a change to an earlier start time, displayed a significantly higher rate of Daytime Sleepiness, and,

though not significant, a trend ( $p = .07$ ) toward a longer Sleep Duration than the control participants. While the experimental group may have been sleeping longer to compensate for the earlier start time, they demonstrated poorer quality sleep, leading to a higher rate of Daytime Sleepiness. These results indicate that starting school at an earlier time decreases the quality of sleep obtained by school-aged children. It may be that because there is a change in their daytime schedule, the experimental participants are not able to reach a deeper level of sleep during the night. Sadeh et al. (2002) suggests that, in adults, Daytime Sleepiness may be an adverse factor resulting not from less quantity of sleep, but rather from a decrease in deeper and more restorative sleep stages. This may explain why the experimental group is trending toward a longer Sleep Duration, but has significantly increased Daytime Sleepiness; however this has never been fully examined in children this age. Future studies should examine the underlying sleep stages during a night of “poor quality” sleep in children, and its effect on daytime functioning.

Epstein’s (1998) results further support this finding. He evaluated the sleep and daytime functioning of 811 fifth grade students using actigraphy devices, as well as self-report questionnaires. Those children who were considered “early risers” (starting school at 7:10 A.M.) reported a higher rate of daytime fatigue, and sleepiness than those children who were “regular risers” (starting school at 8:00 A.M.). This finding is particularly interesting and may be vital information for parents, caregivers, and school faculty to be aware of. People may assume that because their child is sleeping an appropriate amount, they are obtaining adequate sleep. However, these preliminary results suggest that this may be false – sufficient quantity of sleep may not always indicate sufficient quality of sleep.

Results also provided some evidence that the control group experienced an improvement in sleep between Time 1 and Time 2, as Sleep Efficiency increased, and Sleep Fragmentation decreased. However, the experimental group did not show any significant changes in sleep between Time 1 and Time 2 (see Table 1). Instead of a decrease in quantity or quality of sleep, a lack of improvement (like the one seen in the control group) was observed in the experimental group between 2<sup>nd</sup> and 3<sup>rd</sup> grade. While this finding is not addressed in the literature on children’s sleep habits, it has been shown that children do not experience a major biological shift, such as puberty at adolescence, their circadian rhythms are not altered, and their sleep is unaltered. This finding may implicate that this age group should be obtaining improved quality and quantity of sleep as they develop before adolescence. Literature shows that children can begin altering their sleep patterns as early

as 11 years of age (Wolfson et al., 1996; Paavonen, 2010). School-aged children may compensate for the sleep phase shift that they will soon experience as they near adolescence with improvements in sleep, such as the ones experienced by the control participants.

Although many researchers have found correlations linking sleep with cognition (Stickgold, 2005; Durrant, 2011; Wolfson, 1998; Carskadon, 1981), very few significant associations were found among our sample. The control group experienced a significant correlation during Time 2. An increase in Daytime Sleepiness was associated with a slower *Hit Reaction Time* on the CPTII.

The experimental group also experienced correlations between sleep and reaction time and other factors of cognition. During Time 1, increased Night Wakings was associated with an increase in *Omission Errors*, and a decrease in *Hit Reaction Time* on the CPT II. Accordingly, during Time 2, the experimental group showed a correlation between increased Sleep Duration and faster *Hit Reaction Time*. This is consistent with Kribbs' (2002) research, which implies that sleep loss may accelerate the degradation of a vigilance task. When a participant was sleep deprived, he or she did not seem to be able to sustain attention enough to maintain peak performance speeds. Interestingly, however, increased Night Wakings was also associated with a decrease in *Commission Errors* during Time 1, and an increase in Sleep Duration trended toward an increase in *Commission Errors* during Time 2. These findings go against many research findings and may be a result of a very small sample size.

The results of this project will be further examined in the upcoming year with the completion of the full experiment. The full experiment follows a similar protocol to the present pilot study, however, there are several differences. The number of participants used for the full study includes 11 Duxbury, MA participants, and 15 Norwell, MA participants. Norwell was chosen to be the control group for the full study because it is a town that is better matched on socioeconomic status, and we were able to obtain a high rate of participant involvement. In the full study, participants wear the actigraphy devices over a period of one week, allowing the device to collect more accurate measures of sleep/wake activity. With a higher number of participants and more sleep data collected, one is better able to examine the sleep habits across a wider variety of variables, including sleep onset latency, wake after sleep onset, bedtime resistance, sleep anxiety, and parasomnias. The full experiment will be improving on the limitations of this pilot study.

One of the major limitations of this pilot study was the sample size of the population collected. Originally we planned to

recruit participants through the school systems; however, we encountered various obstacles. The solution was to recruit the students as part of a convenience sample, making it much more difficult to obtain a preferred number of participants. Problems also arose with participants dropping out of the study, wearing the actigraphy watches incorrectly, or taking the device completely off. Because of a mix of all of these factors, our sample size was cut down to ten total participants. While it would be preferred to have a larger sample, having ten participants was enough to run a pilot study and obtain preliminary results. While recruitment in general was challenging for this pilot, obtaining a gender-balanced sample was also difficult. While this pilot study has provided some preliminary evidence, the full experiment will further elucidate any effect that this change in school start time has on the sleep habits and cognitive functioning of a much larger sample of school-aged children. If the full study supports the results from this pilot study, and provide evidence that changing to an early school start time negatively affects the sleep and cognition of these children, many communities will have to rethink the scheduling of their schools' start times. It is important for parents and education professionals to understand the consequences that daytime schedules have on sleep functioning in this age group, and even more important, how poor sleep can affect children's health, cognition, and academic performance at this age in development. With this knowledge, parents and school administrators can work together to find a school schedule that helps each age group – children and adolescents – obtain the best possible sleep, improving their health and ability to perform well in school.

---

## References

- Banks, S., & Dinges, D. (2007). behavioral and physiological consequences of sleep restriction. *Journal of Clinical Sleep Medicine*, 3, 519-528.
- Beebe, D. W., Di Francesco, M. W., Tlustos, S. J., McNally, K. A., & Holland, S. K. (2009). Preliminary fMRI findings in experimentally sleep-restricted adolescents engaged in a working memory task. *Behavioral And Brain Functions*, 5.
- Carskadon, M. A., Harvey, K., & Dement, W. C. (1981). Acute restriction of nocturnal sleep in children. *Perceptual And Motor Skills*, 53(1), 103-112.
- Carskadon, M.A., Harvey, K., and Dement, W.C. (1981). Sleep loss in young adolescents. *Sleep*, 4, 299-312.
- Carskadon, M.A., Vieira, C., and Acebo, C. (1993). Association between puberty and delayed phase preference. *Sleep*, 16(3), 258-262, 1993.

- Carskadon, M.A., Wolfson, A.R., Acebo, C., Tzischinsky, O., & Seifer, R. (1998). Adolescent sleep patterns, circadian timing, and sleepiness at a transition to early school days. *Sleep*, 7421, 871-881.
- Chee, M. L., Tan, J., Parimal, S., & Zagorodnov, V. (2010). Sleep deprivation and its effects on object-selective attention. *NeuroImage*, 49, 1903-1910.
- Corkum, P. V., & Siegel, L. S. (1993). Is the Continuous Performance Task a valuable research tool for use with children with Attention-Deficit-Hyperactivity Disorder? *Journal of Child Psychology and Psychiatry and Allied Disciplines*, 34, 1217-1239.
- Durrant, S. J., Taylor, C., Cairney, S., & Lewis, P. A. (2011). Sleep-dependent consolidation of statistical learning. *Neuropsychologia*, 49, 1322-1331.
- Kribbs, N., & Dinges, D. (1994). Vigilance decrement and sleepiness. In R. D. Ogilvie, J. R. Harsh, R. D. Ogilvie, J. R. Harsh (Eds.), *Sleep onset: Normal and abnormal processes* (pp. 113-125). Washington, DC US: American Psychological Association.
- Lavigne, J. V., Arend, R., Rosenbaum, D., Smith, A., Weissbluth, M., Binns, H. J., & Christoffel, K. K. (1999). Sleep and behavior problems among preschoolers. *Journal of Developmental and Behavioral Pediatrics*, 20, 164-169.
- Magee, C. A., Caputi, P., & Iverson, D. C. (2010). Relationships between self-rated health, quality of life and sleep duration in middle aged and elderly Australians. *Sleep Medicine*, 12, 346-350.
- Mindell, J. A., Owens, J. A., & Carskadon, M. A. (1999). Developmental features of sleep. *Child and Adolescent Psychiatric Clinics of North America*, 8, 695-725.
- Owens J., Nobile C., McGuinn M., Spirito A. (2000). The Children's Sleep Habits Questionnaire: Construction and validation of a sleep survey for school-aged children. *Sleep*, 23(8), 1043-51.
- Paavonen, E.J., Raikkonen, K., Pesonen, A., Lahti, J., & Komsu, N. (2010). Sleep quality and cognitive performance in 8-year-old children. *Sleep Medicine*, 11, 386-392.
- Park, S., Cho, M., Chang, S., Bae, J., Jeon, H., Cho, S., & ... Hong, J. (2010). Relationships of sleep duration with sociodemographic and health-related factors, psychiatric disorders and sleep disturbances in a community sample of Korean adults. *Journal of Sleep Research*, 19, 567-577.
- Randazzo A.C., Schweitzer P.K., Walsh J.K.. (1998). Cognitive function following 3 nights of sleep restriction in children ages 10-14. *Sleep*, 21, 249
- Sadeh, A., Alster, J., Urbach, D., & Lavie, P. (1989). Actigraphically based automatic bedtime sleep-wake scoring: Validity and clinical applications. *Journal of Ambulatory Monitoring*, 2, 209-216.
- Sadeh, A., Gruber, R., & Raviv, A. (2002). Sleep, neurobehavioral functioning, and behavior problems in school-age children. *Child Development*, 73, 405-417.
- Stickgold R. (2005). Sleep-dependent memory consolidation. *Nature*, 437, 1272-8.
- Suratt P.M., Barth J.T., Diamond R, et al. (2007). Reduced time in bed and obstructive sleep-disordered breathing in children are associated with cognitive impairment. *Pediatrics*, 119, 320-9.
- Tremaine, R. B., Dorrian, J., & Blunden, S. (2010). Subjective and objective sleep in children and adolescents: Measurement, age, and gender differences. *Sleep and Biological Rhythms*, 8, 229-238.
- Wolfson, A. R. (1996). Sleeping patterns of children and adolescents: Developmental trends, disruptions, and adaptations. *Child and Adolescent Psychiatric Clinics of North America*, 5, 549-568.
- Wolfson, A. R. and Carskadon, M. A. (1998). Sleep schedules and daytime functioning in adolescents. *Child Dev*, 69, 875-887.
- Zerouali, Y., Jemel, B., & Godbout, R. (2010). The effects of early and late night partial sleep deprivation on automatic and selective attention: An ERP study. *Brain Research*, 13, 887- 99