

**THE IMPACT OF A DELAYED SCHOOL START-TIME  
ON HIGH SCHOOL STUDENTS' SLEEP**

By

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## **ABSTRACT**

Research has consistently demonstrated that high school students are chronically sleep-deprived. Consequently, public high schools have utilized delaying school start-times in order to increase sleep duration. However, additional research is needed to investigate the long-term efficacy of this type of sleep intervention in the private school setting.

Therefore, the present pre-post study investigated the impact of a 40-minute start-time delay on boarding school students' sleep. Students in grades 9 through 12 completed an electronic self-report survey regarding their sleep on three occasions: pre-intervention ( $n = 349$ ), post-intervention 1 ( $n = 357$ ), and post-intervention 2 ( $n = 332$ ). Results indicated that, in comparison to pre-intervention sleep, self-reported sleep duration increased significantly across grade levels for post-intervention 1 and post-intervention 2. This provides support for the stability of the sleep intervention across time. Self-reported sleep facilitators and barriers are also discussed.

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## **CHAPTER I.**

### **INTRODUCTION**

Multiple health organizations such as the National Sleep Foundation (2006), the American Academy of Pediatrics (2014), the Centers for Disease Control and Prevention (2015), the National Heart, Blood, and Lung Institute (2012), and the Nationwide Children's Hospital (n.d.) recommend that adolescents obtain nine or more hours of sleep per night to maintain optimal functioning. Despite these recommendations, multiple studies indicate that adolescents are chronically sleep deprived (Carskadon, 1990; Eaton et al., 2010; Morrison, McGee, & Stanton, 1992; Strauch & Meier, 1988). Adolescents generally receive well under the nine hours of sleep that is recommended to perform optimally (Maslowsky & Ozer, 2013; Price, Coates, Thorenson, & Grinstead, 1978; Roberts, Roberts, & Duong, 2009; Roberts, Roberts, & Xing, 2011; Wolfson & Carskadon, 1998). For example, The National Sleep Foundation (2006) conducted a national poll, titled, "Sleep in America," and found that 69% of adolescents reported receiving less than seven hours of sleep each weeknight. Likewise, Keyes, Maslowsky, Hamilton, and Schulenberg (2015) reported that between 20% and 45% of teenage students surveyed over a 21-year period reported that they typically received less than seven hours of sleep per night. Eaton et al., (2010) conducted a follow-up to the 2006 Sleep In America poll (National Sleep Foundation) and reported that 92% of high school students are sleeping less than nine hours per night: 69% reported insufficient sleep (less than seven hours), and 23% reported borderline sleep (between eight and nine hours).



Generally, these and other studies suggest that teens are receiving approximately 6.50 hours of sleep per night in the U.S., which is well under the recommended nine hours.

In an attempt to better understand adolescent sleep, researchers have investigated a variety of factors such as gender, geographical location, and socioeconomic status. Regarding gender, multiple studies have documented males and females are equally at-risk for sleep deprivation (Carskadon, 1990; Chen et al., 2014; Eaton et al., 2010; Loessl et al., 2008; Matthews, Hall, & Dahl, 2014; Pereira, Louzada, & Moreno, 2010; Roberts, Roberts, & Duong, 2009; Roberts, Roberts, & Xing, 2011; Short et al., 2012).

Sleep studies also generally suggest that teen sleep deprivation is widespread internationally. For example, Loessl et al. (2008) reported that German teenage students received less than nine hours of sleep on average: 12 and 13 year-olds reported 8.63 hours, 14 and 15 year-olds reported 8.03 hours, and students who were 16 and older reported 7.83 hours, regardless of attending a school in an urban or rural area. Likewise, Chen et al. (2014) reported that Chinese students, ranging in age from 11 to 20 years old, obtained 7.60 hours of sleep on average each school night. Merdad, Merdad, Nassif, El-Derwi, and Wali (2014) reported that adolescents in Saudi Arabia slept an average of 7.00 hours each night. In addition, Short et al. (2012) cross-culturally compared sleep factors between Australian and US adolescents. Results indicated that both groups of teens received less than the recommended nine hours of sleep per night, although Australian adolescents received more sleep (8.28 hours) than US students (7.36 hours).

Multiple studies have also demonstrated that teens from families who exhibit indicators of lower socioeconomic status, such as living in urban areas, educational level

of parent(s), single-parent households, and earning lower income (< \$30,000 per year) are more likely to suffer from shorter sleep durations (Grandner et al., 2010; Marco, Wolfson, Sparling, & Azujae, 2012; Owens, Stahl, Patton, Reddy, & Crouch, 2006; Stamatkis, Kaplan, & Roberts, 2007). Researchers explain that factors such as these are linked to teens having less parental supervision regarding bedtimes (Gangwisch et al., 2010; Short et al., 2011) and living in areas with more sound and light pollution (Hill, Burdette, & Hale, 2009; Moore et al., 2011). Overall, these and other studies suggest that many adolescents, males and females, internationally, are chronically sleep deprived. That is, they receive well under the recommended nine hours or more of sleep per night, averaging about 6.50 hours. Furthermore, these findings appear to be stable over time regardless of geographical location, gender, and socioeconomic status.

Adolescent sleep deprivation is now recognized as a serious health concern. Insufficient sleep and daytime sleepiness is associated with a host of negative outcomes related to teen physical health, neurocognitive functioning, and emotional-mental health. Regarding physical health, studies have documented that insufficient teen sleep is related to increased obesity/body mass index (Al-Hazzaa, Musaiger, Abahussain, Al-Sobayel, & Qahwaji, 2012; Countryman, Saab, Llabre, Penedo, McCalla, & Schneiderman, 2013; Lytle et al., 2013; Noland, Dake, & Telljohan, 2009; Snell, Adam, & Duncan, 2007), increased risk of developing type 2 diabetes (Beebe et al., 2007; Martinez,-Gomez, et al., 2011), high blood pressure (Javaheri, Storfer-Isser, Rosen, & Redline, 2008; Narang et al., 2012;), high cholesterol (Gangwisch et al., 2010; Narang et al., 2012), an increased risk of contracting common illnesses (Chen, Wang, & Jeng, 2006; Roberts, Roberts, &

Chen, 2001), and somatic problems such as sleepiness, dizziness, fatigue, headaches, neck pain, lower back pain (Auvinen et al., 2010; Bruni et al., 2008; Paiva, Gaspar, & Matos, 2015).

Sleep deprivation in adolescents has also been linked to a variety of neurocognitive functioning deficits such as: decreased sustained attention (Beebe, 2011; Louca & Short, 2014), working memory problems (Curcio, Ferrara, DeGennaro, 2006; Kopasz et al., 2010), increased impulsivity and risk-taking (O'Brien & Mindell, 2005; Telzer, Fuligni, Lieberman, & Galvan, 2013), delays in reaction time (Louca & Short, 2014), and poor affect/regulation of emotions (Baum et al., 2014; Dagsys et al., 2012; Dahl & Lewin, 2002; Talbot, McGlinchey, & Kaplan, 2010). Moreover, these neurocognitive decreases appear to correlate with negative teen behavioral outcomes such as poor academic performance due to deficits in attention and memory (Beebe, Rose, & Amin, 2010; Curcio et al., 2006; Dewald-Kaufman, Meijer, Oort, Kerkhof, & Bogels, 2010; Dewald-Kaufman, Oort, Bogels, & Meijer, 2013; Wolfson and Carskadon, 1998; Wolfson & Carskadon, 2003), an increased chance of involvement in motor vehicle accidents due to a delay in reaction time and processing speed (Dahl, 2008; Garner et al., 2015; Martiniuk et al., 2013; Shope & Bingham, 2008), and illegal substance and alcohol abuse due to increases in impulsivity (Fakier & Wild, 2011; Mednick, Christakis, & Fowler, 2010; Roane & Taylor, 2008).

Pertaining to adolescent mental health, a variety of studies have documented that adolescent sleep deprivation is correlated with, and exacerbates, a variety of conditions and symptoms related to depression (Coulombe, Reid, Boyle, & Racine, 2010; Roberts

and Duong, 2014; Shanahan, Copeland, Angold, Bondy, & Costello, 2014), generalized anxiety disorder (Coulombe et al., 2010; Sarchiapone et al., 2014; Shanahan et al., 2014), oppositional defiant disorder (Mayes et al., 2008; Shanahan et al., 2014), and attention-deficit hyperactivity disorder (Lufi & Tzischinsky, 2014; Mayes et al., 2008). Overall, this body of research suggests that sleep deprivation during adolescence negatively implicates several aspects of physical, neurocognitive, and emotional/mental health.

Historically, the propensity for teens to fall asleep later at night has been viewed as a behavioral, social, and cultural artifact (Carskadon, Wolfson, Acebo, Tzischinsky, & Seifer, 1998). More recently however, this sleep shift is explained more in terms of the transition from childhood to adolescence, during which many sleep drive, hormonal, and brain changes occur. These puberty-related changes alter the adolescent sleep-wake cycle and appear to promote a late-to-bed and late-to-wake sleep schedule known as a phase delay (Carskadon, Viera, & Acebo, 1993; Crowley, Acebo, and Carskadon, 2007). Studies have documented a variety of variables associated with this teen phase delay (Crowley, et al., 2007; Hagenauer, Perryman, Lee, & Carskadon, 2009). One potential factor is a slower homeostatic sleep drive for sleep. This sleep drive, or the internal regulation of sleep, has been demonstrated to be slower in older adolescents in comparison to younger children and adults (Jenni, Achermann, & Carskadon, 2005; Taylor, Jenni, Acebo, & Carskadon, 2005). That is, teens may experience more difficulty falling asleep after long periods without sleep. This is recognized as contributing to the late-to-bed and late-to-wake pattern (Carskadon & Acebo, 2002; Crowley et al., 2007; Jenni, Acherman, & Carskadon, 2005).

Another associated factor contributing to a late-to-bed sleep schedule for teens is a delay in melatonin secretion during evenings. Melatonin, the hormone that is involved in the sleep and wake cycles of humans is released later in the evening for adolescents when compared to children or adults (Carskadon et al., 1998; Crowley, Acebo, Fallone, & Carskadon, 2006). Accordingly, the onset of sleepiness occurs later (Carskadon, Acebo, Richardson, Tate & Seifer, 1997; Carskadon & Acebo, 2002; Crowley et al., 2006; Crowley et al., 2007). In addition, adolescence is also marked by a period of rapid physical development in which sex, growth, and stress hormones are released (Colrain & Baker, 2011; Yurgelun-Todd, 2007; National Institute of Mental Health, 2011). Furthermore, the volume of grey matter in the brain decreases during this developmental period as a result of synaptic pruning and certain areas of the brain maturing (National Institute of Mental Health, 2011). These neurological changes are hypothesized to increase the requirement of sleep during the adolescent years, also contributing to phase delay (Dahl & Lewin, 2002). The combination of these sleep drive, hormonal, and brain changes appear to contribute to teens needing more sleep than adults and also naturally preferring to obtain said sleep in a delayed way.

In addition to the physiological changes mentioned, US adolescents are also faced with a variety of time-constraining activities that compete for their sleep. Researchers have identified many noteworthy barriers that, among others, include: electronic media use, academic homework, extra-curricular activities (i.e. sports, clubs), and employment. Regarding electronic media, multiple studies report that increases in electronic media use have an adverse impact on teen sleep duration (Arora, Broglia, Thomas, & Taheri, 2014;

Cain & Gradisar, 2010; Hale & Guan, 2015). Hysing et al. (2015) documented that adolescent sleep decreased the longer electronic devices were used before bed. Moreover, according to the Sleep in America poll (National Sleep Foundation, 2006), 97% of teens reported at least one electronic device in their bedroom and older teens were more likely to have more than one device. Regarding these devices, music players were the most common (90%), followed by: phones (68%), televisions (57%), video game consoles (43%), and computers (28%). Academic homework is also recognized as a sleep barrier. During the high school years, there is an increase in the quantity and difficulty of homework leaving less time for sleep (Adam, Snell, & Pendry, 2007). Participation in extra-curricular activities, such as sports and clubs during the high school years has also been correlated with decreased sleep duration. Teens often report going to bed at 11:00 p.m. or later due to the time-constraining activities (Carskadon, 1989; Dahl & Lewin, 2002; Wolfson & Carskadon, 1998). A number of other studies have identified teen employment as yet another factor contributing to teen sleep loss (Lalonde, Ledoux, Auclair, & Gaudreault, 2014; Millman, 2005; Wolfson & Carskadon, 1998; Carskadon, 1989). Students who are employed part-time generally receive less sleep per night than students without jobs (Lalonde et al., 2014). In general, these and other studies document the many potential activities that contend with teen sleep.

School is also a time-constraining activity that impacts teen sleep. Specifically, high school start-times have been identified by a number of national organizations as a strong contributing factor to teen sleep deprivation. For example, the Centers for Disease Control and Prevention (2015) recently reported that 75% to 100% of high schools in 42

states began school prior to 8:30 a.m.; specifically, the average high school start-time for the 2011-2012 school year was 7:59 a.m. (U.S. Department of Education, 2012). In addition, studies have documented that U.S. high schools generally start earlier than middle and elementary schools (Nudel, 1993). Noting the apparent mismatch between early school start-times and teen's later sleep propensities, a number of national organizations have advocated for changes in school scheduling. For example, the National Sleep Foundation (n.d.), Centers for Disease Control and Prevention (2015), and the American Academy of Pediatrics (2014) have all recommended that high schools delay school start-times as a way to increase sleep duration in teens. Specifically, the American Academy of Pediatrics (2014) recently recommended that middle and high schools start at 8:30 a.m. or later to assist adolescent students in adopting a sleep schedule that more fully matches their later sleep propensities.

The recommendations to delay high school start-times are based, in part, on studies that link early school start-times to a variety of problematic outcomes such as: sleep deprivation, decreases in academic performance, increases in behavior problems, and emotional instability (Carskadon et al, 1998; Hansen, Janssen, Schiff, Zee, & Dubocovich, 2005). More importantly, these recommendations are based on a growing body of research that systematically documents the association between delayed high school start-times and positive outcomes. For example, Wahlstrom (2002) conducted one of the first major studies regarding the impact of a delayed high school start-time. During the 1997-1998 school year, seven high schools in the Minneapolis School District delayed their start-times from 7:15 a.m. to 8:40 a.m. and, correspondingly, pushed back

dismissal-times from 1:45 p.m. to 3:20 p.m. The change affected approximately 51,000 students. The impact of the 85-minute school start delay was analyzed three years following its implementation, through the 1999-2000 school year, and compared with data collected 3 years prior to the implementation of the delayed start. Data regarding enrollment, attendance, grades, and sleep habits were examined. Regarding sleep habits, 1,200 students were twice administered the School Sleep Habits Survey (Bradley Hospital, 1996): first in 1997, and second in 2001. Results indicated that high school students were not only sleeping more (39 minutes on average), but there was also an increase in attendance, improved conduct and improvement in grades. The author concluded that the delayed school start-time resulted in several benefits for the students and the schools involved. Most importantly, the Minneapolis Public School District high school students demonstrated a continued increase in sleep in comparison to students in other districts where school start-times were not delayed.

Likewise, Wahlstrom, Dretzke, Gordon, Peterson, Edwards, and Gdula (2014) published a related study that further investigated the positive outcomes of delaying public school start-times. Researchers implemented a delayed school start-time across three different states (Minnesota, Colorado, Wyoming), in eight public high schools affecting approximately 9,000 students. Data were collected pertaining to the students' sleep time, grades, attendance, tardiness, performance on state/national tests, and car crash data for the participating school's community. Additionally, students were administered the Teen Sleep Habits Survey (University of Minnesota, 2011) after the start-time delay had been implemented to assess self-reported sleep patterns, sleep



quality, and daytime sleepiness. Although the delay in start-time for each participating school varied between 30 to 80 minutes, results indicated that students, on average, obtained an increase of 42 minutes of sleep time and experienced significant improvements in attendance, test scores, and grades. The authors concluded that the study demonstrated the efficacy of a delayed start-time and recommended that all high schools implement start-times at 8:30 a.m. or later.

In another study, Danner and Phillips (2008) examined the effects of a later school start-time on a large, county-wide public school district located in Kentucky during the 1998-1999 school year. School start-times in the selected county were moved from 7:30 a.m. to 8:25 a.m., a delay of 55 minutes. Correspondingly, school dismissal was pushed back from 2:20 p.m. to 3:15 p.m. Researchers surveyed approximately 10,500 students who each completed the Epworth Sleepiness Scale (Johns, 1991) before and after the implementation of the delayed start-time. Results indicated that, on average, students reported sleeping 12 to 30 minutes more after the delay in school start-time. Additional positive effects were documented that included attendance improvements in the school district and a reduction of automotive crashes in the county when compared with the rest of the state. In addition to the reported sleep increases, the authors suggested that delaying school start-times appears to be an appropriate strategy to increase domains of public safety such as teen driving.

Although the majority of the scientific research regarding delayed high school start-times has been conducted in public schools, private schools have also been examined in terms of the impact of a delayed school start-time. For example, Owens,

Belon, and Moss (2010) surveyed 357 high school students attending a Rhode Island boarding school before and after a delay in school start-time was implemented. During the 2008-2009 school year, the daily school start-time was delayed by 30 minutes, specifically, it was changed from 8:00 a.m. to 8:30 a.m. Students ( $n = 201$ ) completed The Sleep Habits Survey (Wolfson & Carskadon, 1998) before and after the delay, in order to assess sleepiness under certain conditions, general sleep-related problems, and depressed mood. Additionally, health outcomes were assessed by analyzing the number of visits to the school's health center. Attendance was measured by tracking first-period absences or tardiness. Results indicated that students' sleep duration increased by an average of 45 minutes. Furthermore, students' reported attendance increased, the number of visits to the school's health center decreased, and self-reported depression decreased. The authors generally concluded that the results mirrored previous public school sleep research. This is, delayed school start-times were associated with teen sleep increases and a number of physical and mental health improvements. The researchers also noted that the school faculty members were initially apprehensive about the scheduling changes. However, after implementation and the documented positive outcomes, the faculty voted to keep the late school start schedule in place.

In another private school study conducted by Boergers, Gable, and Owens (2014), the school start-time for a New England boarding school was delayed from 8:00 a.m. to 8:25 a.m. during the 2010-2011 school year. The School Sleep Habits Survey (Bradley Hospital, 1996) was completed by 197 students before and after the 25-minute delay in start-time was implemented. Results indicated that there was a reported increase in total

sleep time (29 minutes on average), as well as a decrease in self-reported depression and caffeine use. The authors generally concluded that the delayed school start-time was associated with multiple physical and mental health benefits, as has been demonstrated in previous research across both public and school settings. Additionally, the authors noted how even a modest delay in school start-time can result in many meaningful positive outcomes for students. Furthermore, the authors noted that the delay in school start-time appeared to have the most benefit for students in the lower grades (9<sup>th</sup> and 10<sup>th</sup> grade) as well as for those with lower baseline sleep durations. Overall, the researchers recommended that public policy should take into consideration how the later school schedule aligned more closely with the natural sleep habits of adolescents.

Owens, Droblich, Baylor, and Lewin (2014) conducted a meta-analysis based on quantitative and qualitative data in order to summarize what is already known about delaying school start-times as well as provide a basis for other school districts who are considering this type of intervention. Researchers reviewed the existing scientific literature on the subject, conducted telephone interviews with stakeholders in three school districts, and administered an internet-based survey, the National School Start Time Survey, to school districts who have implemented school start-time changes. Data from both public and private high schools were examined. Overall, the results indicated that delayed start-times significantly increased students' total sleep time and were associated with several benefits such as: decreased absences, improved academic performance, and decreased negative affect. The authors concluded that delaying school start-times is an

effective primary intervention that can be utilized to by schools to increase total sleep time in teens.

### **Purpose of Study**

Despite the existing research that supports delayed high school start-times, there are a number of aspects about this type of sleep intervention that require additional research (Dexter, Bijwadia, Schilling, & Applebaugh, 2003). First, there appears to be a shortage of delayed school start-time studies that have been conducted in a private school setting. Private schools are generally recognized as a valuable setting to conduct sleep research (Owens et al., 2010). In comparison to public school settings, private schools generally provide a more uniform sleep environments (e.g., beds, rooms), greater consistency in bed and wake-times, less variability in after-school demands (i.e., employment) and more stability in the number of students enrolled per academic year (Boergers et al., 2014). In this sense, more studies involving private schools delaying start-times are needed.

Second, more studies are needed to investigate the impact of longer-duration school start-time delays in the private school setting. Currently, most of the delayed school start-time studies conducted in private schools investigate the impact of a 25 to 30-minute delay. For example, Owens et al (2010) incorporated a 30-minute delay in start-time and Boergers et al. (2014) incorporated a 25-minute delay. Although both studies reported that there was an increase in sleep duration as well as other positive outcomes among the samples, more research is needed that investigates whether a longer

delay in school start-times, such as those that have been implemented in public school settings, will result in similar or dissimilar outcomes.

Third, more research is needed to investigate the long-term effects of delayed school start-times. Very few of the studies regarding delayed school start-times include a long-term follow-up regarding the stability of positive sleep duration effects. Many of the studies reviewed here include both a before and after treatment evaluation to compare effects approximately one year after the delay is implemented (Wahlstrom et al., 2014; Danner & Phillips, 2008; Owens et al., 2010; Boergers et al., 2014). In contrast to the one-year post-evaluation, Wahlstrom (2002) conducted a longer-term evaluation for the public school setting over a period of three-years after implementation. Although these studies offer important information regarding treatment outcomes, more research is needed that includes a longer-term evaluation in order to more accurately assess the long-term impact that this type of intervention has, particularly in the private school setting.

Fourth, there is a lack of qualitative research that directly asks teens to self-report what they perceive is preventing and facilitating their sleep. Noland et al. (2009), administered a sleep habit questionnaire to teens ( $n = 384$ ) regarding their sleep habits. Students indicated that the most common reason for not getting enough sleep was too much homework (46%). Other common factors included: too much stress in life (42%), watching TV (39%), hanging out with friends (30%), temperature of room (29%), noise (24%), after school sports (24%), chores at home (23%), and part-time job (20%). More studies are needed that investigate other common teen sleep barriers. Moreover, there is a

lack of research that reports the common strategies that adolescents utilize to improve and facilitate their sleep.

## **Hypotheses**

**Hypothesis one.** It is hypothesized that teens' sleep duration will significantly increase, as a result of the delay in school start-time, measured by a modified version of the BEARS self-report survey. As has been demonstrated in previous research, delaying school start-times has a number of positive effects, one of the primary effects being an increase in total sleep duration (Owens et al., 2014).

**Hypothesis two.** It is hypothesized that the increase in total sleep duration per student will remain stable six or more months after the initial implementation of a delayed start-time. Very few studies have implemented long-term follow-up regarding this type of intervention. This is an important strategy to assess the potential long-term efficacy of a sleep intervention. Theoretically, initial changes in behavior after an intervention may be a result of the novelty of the intervention (Gravetter and Forzano, 2011). In this sense, it is important to investigate effects after the intervention has been in place for a duration of time. Increases in sleep time should remain many years after continued maintenance of a delayed start (Wahlstrom, 2002).

**Hypothesis three.** It is hypothesized that students in the 9<sup>th</sup> grade will benefit the greatest from a delayed school start by reporting a larger increase in total sleep duration, when compared to students in the 10<sup>th</sup>, 11<sup>th</sup>, and 12<sup>th</sup> grade. Research has consistently demonstrated that the need for sleep peaks during the early teen years, which typically coincides with puberty and the onset of adolescence (Carskadon, Viera, & Acebo, 1993).

As a result, it is implied that students in the early teen years of life, such as students enrolled in 9<sup>th</sup> grade, would benefit the most from a delayed school start-time in order to increase their sleep duration. Furthermore, Boergers et al. (2014) recently reported that high school students in the lower grades (9<sup>th</sup> and 10<sup>th</sup>) benefitted the most from a delay in high school start-time, experiencing more of an increase in sleep duration than high school students in the higher grades (11<sup>th</sup> and 12<sup>th</sup>).

**Hypothesis four.** It is hypothesized that high school students will report a combination of academic (i.e., homework), emotional (e.g., relationships, stress), and physical factors (e.g. technology use, caffeine, extra-curricular activities) that serve as sleep barriers, preventing them from falling asleep. Conversely, it is anticipated that teens will report a variety of physical (e.g., exercise, music, temperature of room) factors that they use facilitate their sleep. Very little research has been conducted regarding qualitative indicators of sleep prevention. Of the research that has been reported, homework, stress in life, and watching TV were among the most commonly reported as barriers by teens to falling asleep at night, whereas watching TV, making bedroom very dark, and having a comfortable temperature in bedroom were the most commonly reported as facilitators to teens falling asleep at night (Noland et al., 2009).

## **CHAPTER II.**

### **METHODOLOGY**

#### **Participants**

Participants in the present study were high school students enrolled in a college preparatory boarding school in the Midwestern U.S., serving both males and females and grades nine through twelve. Participation in the study was voluntary and consent was obtained for each student prior to collecting data. Data were collected in three phases: pre-intervention in 2008, post-intervention 1 in 2009, and post-intervention 2 in 2010. A total of 1,038 students were participants over the course of the present study, 55% of participants were male ( $n = 573$ ) and 45% were female ( $n = 465$ ): 349 students participated in the pre-intervention phase, 357 students participated in the post-intervention 1 phase, and 332 students participated in the post-intervention 2 phase. Regarding grade level, there were 203 students represented from the freshman class, 280 students represented from the sophomore class, 283 students represented from the junior class, and 272 students represented from the senior class.

#### **Materials**

A 49-item electronic self-report survey modeled after questions on the BEARS sleep screening tool (Mindell & Owens, 2003) was constructed and sent to students via e-mail. Possible response styles to questions included: entering in answers, selecting yes or no, selecting all options that apply, and rating oneself on a 5-point Likert style scale. Among several demographic-related questions, the primary question to be asked for the purposes of the present study across all three phases of the study included “How many



hours of sleep do you usually get on school nights?” During data collection for post-intervention 2 only, students were also asked about their perceptions of sleep barriers, “What do you believe is preventing you from getting enough sleep at night?” and facilitators, “What strategies do you use to help yourself fall asleep at night?” Students were then presented with 20 potential sleep barriers (e.g., homework or studying, too much caffeine, talking on phone/cell-phone) presented in 4 survey items, and were instructed to indicate all that they experienced. Likewise, students were presented with 21 sleep facilitators (e.g., read a book, white noise, take a hot shower) presented in 4 survey items, and were instructed to indicate all that they experienced. Please refer to Appendix A for a list of relevant questions.

### **Procedure**

During the pre-intervention phase of the present study, in the spring term of 2008, the school schedule required students to start classes at 7:50 a.m. and wake up by 6:30 a.m. Each student for which parental consent was obtained was sent an e-mail with a link to an electronic self-report sleep survey, by the head of schools. During the post-intervention 1 phase, in the fall term of 2009, the school start-time had been delayed by 40 minutes, which pushed the school start-time back from 7:50 a.m. to 8:30 a.m. and required students to wake up by 7:30 a.m. Once again, each student for which parental consent was obtained was sent an e-mail with a link to an electronic self-report sleep survey by the head of schools. During the post-intervention 2 phase in the spring term of 2010, the 40-minute implemented during post-intervention 1 remained in place. Students were e-mailed the same survey a third time being asked to answer the same questions as

before as well as two new questions pertaining to perceptions of sleep barriers and facilitators.

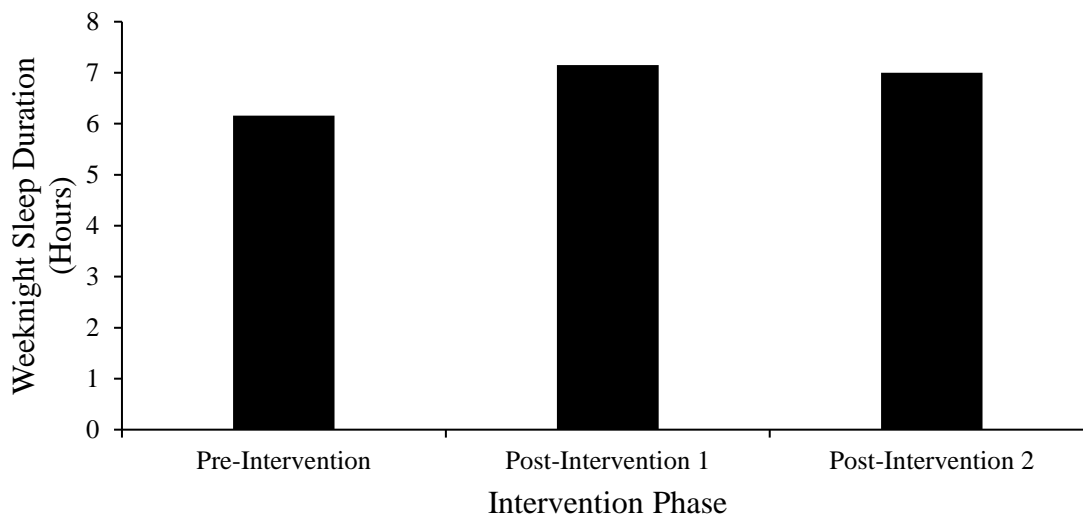
## CHAPTER III.

### RESULTS

Sample sizes, means, and standard deviations regarding weeknight sleep duration in hours for each grade level across every phase of the intervention are presented in Table 1, located in Appendix B. A two-way factorial (3 X 4) ANOVA was conducted in order to measure the efficacy of the delayed school start-time intervention and the differences between grade levels in weeknight sleep duration as well as the interaction between the intervention phase and grade level on weeknight sleep duration. Intervention phase included three levels (pre-intervention, post-intervention 1, post-intervention 2), and grade level consisted of four levels (freshmen, sophomore, junior, and senior). An alpha level of .05 was used for all statistical tests.

This study's first and second hypotheses were concerning the efficacy and stability of the intervention both initially and across time. Regarding the first hypothesis, there was a statistically significant main effect of the delayed school start-time on the duration of weeknight sleep obtained by students,  $F(2, 1026) = 90.67, p = .00$ . Bonferroni post-hoc tests revealed that weeknight sleep duration significantly increased after the delayed start-time was implemented for both of the post-intervention 1 ( $M = 7.19, p = .00$ ) and the post-intervention 2 ( $M = 7.01, p = .00$ ) samples, indicating that student's sleep duration increased as a result of the implementation of the intervention. There was not a significant difference in weeknight sleep duration between the post-intervention 1 and post-intervention 2 samples ( $p = .16$ ), indicating that the effect of the intervention was stable in between measurements, which is in line with the second

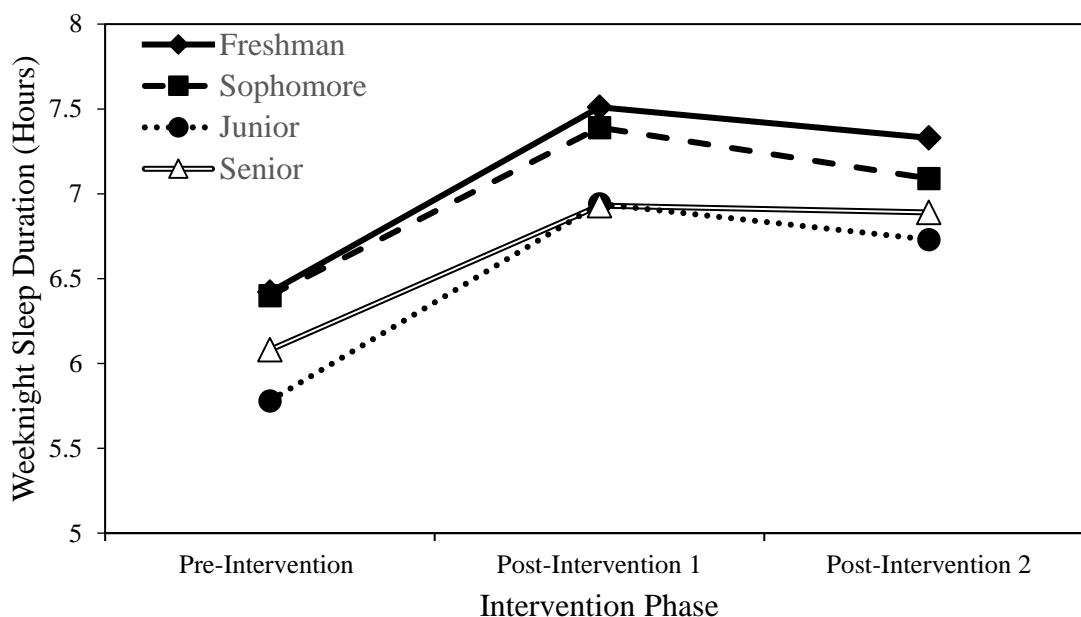
hypothesis. See Figure 1 for a graphical representation of the effects of each intervention phase.



*Figure 1.* Mean hours of weeknight sleep obtained across all subjects for each intervention phase.

This study's third hypothesis concerned the effects of the intervention for each grade level, with the prediction that the freshmen grade level would benefit more from the intervention than sophomores, juniors or seniors. Regarding this hypothesis, there was a statistically significant main effect of grade level on the duration of weeknight sleep obtained,  $F(3, 1026) = 17.64, p = .00$ . Bonferroni post-hoc tests revealed that the weeknight sleep duration in freshmen ( $M = 7.09, SD = 1.08$ ) was significantly longer when compared to both juniors ( $M = 6.50, SD = 1.33, p = .00$ ) and seniors ( $M = 6.61, SD = 1.07, p = .00$ ); sleep duration in sophomores ( $M = 6.95, SD = 1.06$ ) was also significantly longer when compared to both juniors ( $p = .00$ ) and seniors ( $p = .00$ ). There

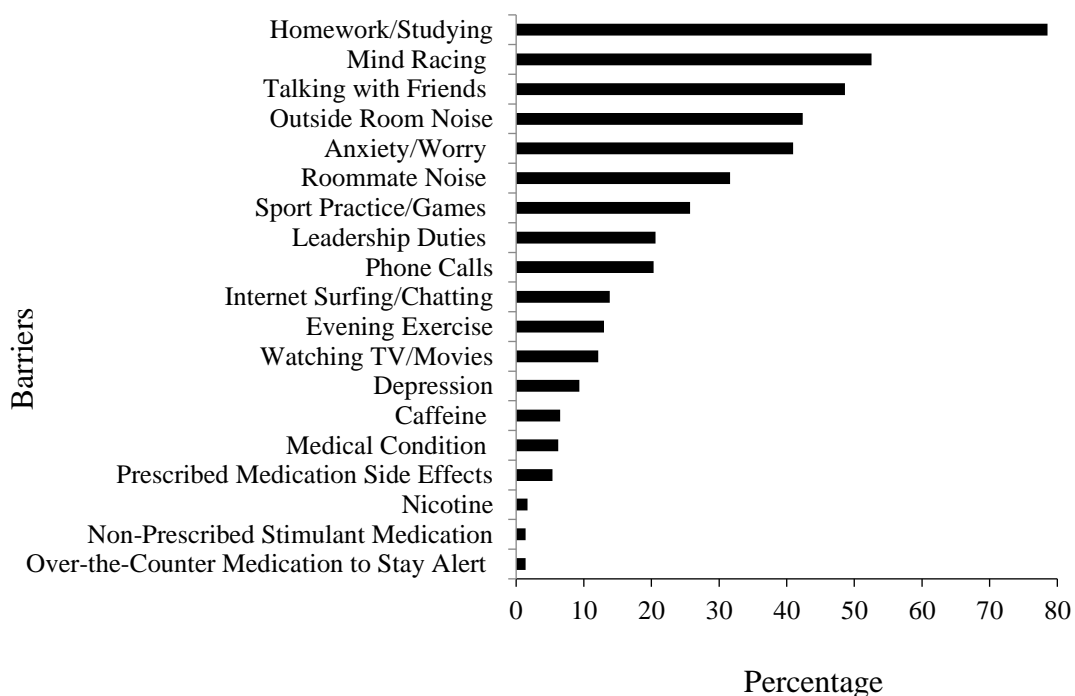
was not a significant difference in weeknight sleep duration between sophomores and freshmen ( $p = .84$ ) or between juniors and seniors ( $p = 1.00$ ). See Figure 2 for a graphical representation of the effects of each intervention phase for each grade level. The interaction between grade level and intervention phase, however, was not found to be statistically significant,  $F(6, 1026) = .586, p = .74$ , indicating that no grade level had more of a benefit than the others across the three intervention phases.



*Figure 2.* Mean hours of weeknight sleep obtained for each grade level across each intervention phase.

This study's fourth purpose and hypothesis was to examine the qualitative sleep facilitators and barriers that would be identified by the student participants. Regarding sleep barriers, homework/studying (78%) was the most commonly reported reason preventing students from falling asleep at night, followed by: mind racing (52%), talking

with friends (48%), outside room noises (42%), anxiety/worry (40%), roommate noise (31%), sports practice/games (25%), leadership duties (20%), phone calls (20%), and internet surfing/chatting (13%). See Figure 3 and Table 2 (Appendix B) for a graphical representation of the perceived sleep barriers.



*Figure 3.* Perceived sleep barriers by percentage of selection.

Regarding sleep facilitators, relaxing music (41%) was the most commonly reported reason helping students fall asleep at night, followed by: consistent bedtime routine (35%), hot shower (35%), deep breathing (29%), socializing (27%), computer movies/media (25%), prayer (25%), reading a book (24%), white noise device (23%), and

visual imagery (18%). See Figure 4 and Table 3 (Appendix B) for a graphical representation of the perceived sleep facilitators.

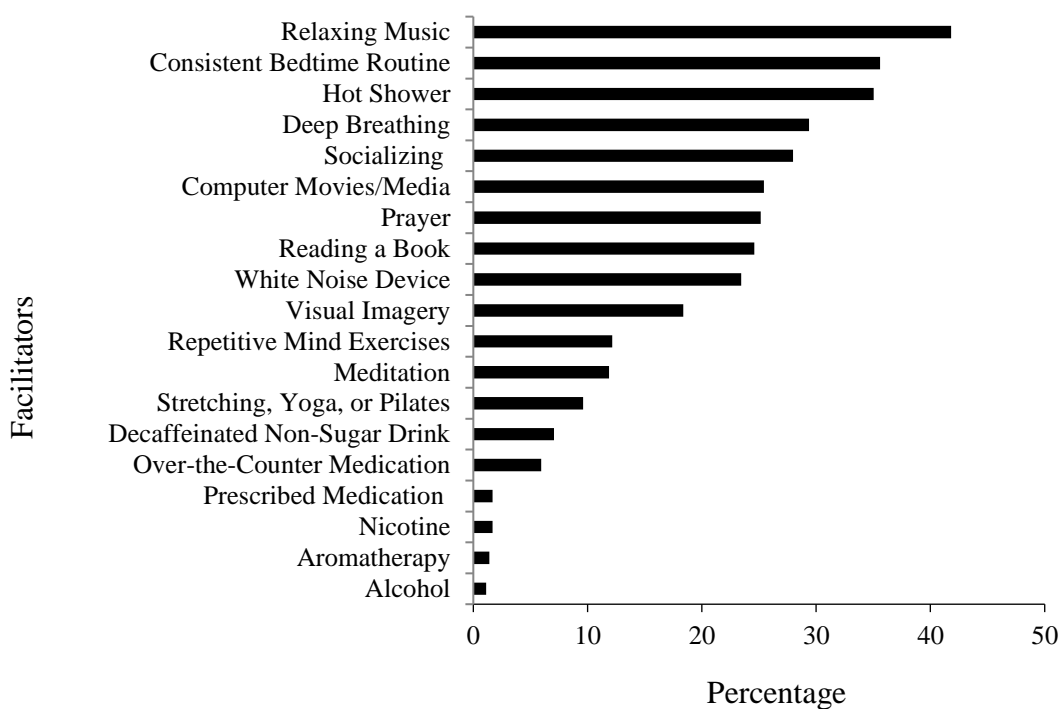


Figure 4. Perceived sleep facilitators by percentage of selection

## **CHAPTER IV.**

### **DISCUSSION**

The primary purpose of this pre-post study was to examine the impact of a 40-minute delayed school start-time on high school students' weeknight sleep. As hypothesized, high school students' sleep duration on weeknights increased as a result of the delayed school start-time. After the implementation of the intervention (delayed school start-time), students reported receiving an average of 60 minutes of additional sleep each weeknight. This finding is consistent with and substantiates previous research that documents teen-sleep increases when public and private high schools delay school start-times (Boergers et al., 2014; Danner & Phillips, 2008; Owens et al., 2010; Wahlstrom, 2002; Wahlstrom et al., 2014). However, it is noted that the current study investigated a comparatively longer delay in school start-time, namely, a 40-minute delay. Previous research has investigated shorter delays. For example, Boergers et al. (2014) implemented a 25-minute delay that resulted in an approximate 30-minute increase in sleep duration. Furthermore, Owens et al. (2010) implemented a 30-minute delay, which resulted in an approximate 45-minute increase in sleep duration. Our findings demonstrated a 40-minute delay that increased sleep duration by approximately 60 minutes. Taken together, these studies and ours conducted in boarding schools highlight an important trend. That is, there are increased sleep returns based on longer delays in school start-times.

Delayed school start-time research conducted in public schools has been documented as an effective sleep intervention, however the pattern of sleep returns



appears more variable in comparison to the boarding school sleep studies. For example, Wahlstrom (2002) found that a delay of 85 minutes resulted in an increase in total sleep duration of 39 minutes; Danner and Phillips (2008) found that a 55-minute delay resulted in total sleep duration of 30 minutes; Wahlstrom et al. (2014) found that a 30 to 80-minute delay resulted in an increase in total sleep duration of an average of 42 minutes. In general, public school results suggest that the sleep returns are typically less than the amount of time school is delayed. On the other hand, boarding school results suggest that the sleep returns are, on average, more than the amount of time school is delayed. This finding may be an artifact of the less and more controlled sleep environments that are inherent in public and boarding schools, respectively.

The second purpose of this study was to examine the longevity of the delayed school start-time intervention over time. As hypothesized, students' increased sleep remained stable across post-interventions 1 and 2. This suggests that the sleep increases were not a short-term artifact perhaps based on the novelty of the schedule change. Rather, the sleep increases appear to be sustaining over time, which is an important component of a pre-post study. Previous studies conducted in private boarding schools have generally neglected to assess for the long-term maintenance of this type of intervention (Boergers et al., 2014; Owens et al., 2010). Stability findings from our study are somewhat consistent with previous public school sleep research. For example, Wahlstrom (2002) reported that, three years after the implementation of an 85-minute delay, high school students sleep increases remained fairly stable. Overall, these findings

and ours demonstrate the long-term effectiveness of a delayed school start-time intervention.

The third hypothesis of the present study investigated the impact of the sleep intervention across student grade level. We postulated that after the delayed school start-time, younger students (i.e., freshman) would report receiving more sleep than older students (i.e., sophomores, juniors, and seniors). As hypothesized, after the 40-minute delay in school start-time, freshman students reported receiving the most sleep, followed by sophomores, seniors, and juniors. However, it is also important to note that the largest increases in weeknight sleep, from pre-intervention to post-intervention 1, were obtained by juniors. In other words, juniors received the most benefit from the intervention with a sleep increase of 64 minutes. This is important as the junior year has been identified as particularly demanding year as students prepare for college admissions by visiting and applying for colleges and taking required entrance exams (e.g., SAT and ACT). Freshman obtained the second-largest sleep increase of 60 minutes, and sophomores and seniors both obtained 50-minute increases.

To some extent, our findings match previous studies that document that freshman students obtained the most sleep when compared to other high school grades (Boergers et al., 2014; Owens et al., 2010). However, our finding that juniors benefited most from the delayed school start-time does not match other studies. For example, Owens et al. (2010) and Boergers et al. (2014) both reported that freshman students obtained the highest increases in weeknight sleep after the onset of the delayed school start-time, followed by

the other grades generally in order from youngest to oldest. More research is needed to further understand sleep benefits in terms of grade level.

The final purpose of this study was to qualitatively examine high school students' perceptions of their sleep barriers and facilitators. Regarding the variables that compete, prevent, and interrupt sleep, students indicated that homework/studying, mind racing, and talking with friends were their top three, respectively. Despite the limited research that investigates this, these findings coincide somewhat with Noland et al.'s (2009) results which indicated that students self-reported homework, stress in life, and watching TV as the top barriers. Regarding facilitators or the variables that help with sleep, students in the current study indicated that relaxing music, a consistent bedtime routine, and a hot shower were their top three, respectively. Noland et al. (2009) also investigated self-perceived facilitators and reported that watching TV, making a bedroom dark, and a comfortable temperature were most important to students. Overall, these self-reported barriers and facilitators provide an important glimpse at teen sleep hygiene. Moreover, these results may provide a valuable starting point for students, parents, teachers, administrators, and those in various health professions to discuss common teen sleep practices and strategies for improvement.

## **Conclusion**

The present pre-post study documented that a 40-minute school start-time delay significantly increased high school students' weeknight sleep across grades 9-12. Additionally, the longevity of the delayed school start-time intervention was supported as increases in sleep duration remained stable across two post-intervention data collection

phases. Of the four grades levels, juniors reported the largest increases in sleep duration from pre- to post-intervention, although freshman reported the longest sleep duration overall. Students also reported a variety of sleep barriers and facilitators that are important to consider when addressing teen sleep and designing interventions to increase sleep in this generally sleep-deprived population.

### **Limitations and Future Research**

**Limitations.** Several limitations are noteworthy in the current study. First, each of the three phases of data collection (pre-intervention, post-intervention 1, and post-intervention 2) cannot be assumed to be entirely independent due to a number of factors such as: advancement in grade level, graduation, transfers in and out of the school, and new enrollment. A second limitation pertains to the study setting. Although the private boarding school setting offers many advantages over the public school setting for conducting this type of research (i.e., control over certain extraneous variables), results obtained from the current study are not directly generalizable to other private or public school settings; there may be unique environmental aspects that may account for outcomes. A potential third limitation may be the use of the self-report sleep survey, which is more subjective in comparison to other means to directly observe and record sleep. A fourth limitation of the present study is the lack of a control group. Without a control-group comparison, it is difficult to attribute the sleep duration increases solely to the delay in start-time.

**Future research.** Future delayed school start-time research may consider a number of approaches. First, future research should focus on determining if a predictable

correspondence exists between the length of start-time delay and its impact on subsequent sleep duration. Clarification could assist public and private schools in better understanding the graded benefits of such a sleep intervention. Second, future research should further examine the grade-level discrepancies in sleep duration in private and public school setting as to better explain the differences noted between freshmen and juniors in the present and previous studies. Finally, future research should focus on obtaining additional qualitative information concerning the often-overlooked sleep barriers and facilitators that adolescents' experience.

## REFERENCES

- Adam, E.K., Snell, E.K., & Pendry, P. (2007). Sleep timing and quantity in ecological and family context: A nationally representative time-diary study. *Journal of Family Psychology, 21*(1), 4-19.
- Al-Hazzaa, H.M., Musaiger, A.O., Abahussain, N.A., Al-Sobayel, H.I., & Qahwaji, D.M. (2012). Prevalence of short sleep duration and its association with obesity among adolescents 15- to 19-year olds: A cross-sectional study from three major cities in Saudi Arabia. *Annals of Thoracic Medicine, 7*(3), 133-139.
- American Academy of Pediatrics. (2014). Policy statement: School start times for adolescents. Elk Grove Village, IL: Author.
- Arora, T., Broglia, E., Thomas, G.N., & Taheri, S. (2014). Associations between specific technologies and adolescent sleep quantity, sleep quality and parasomnias. *Sleep Medicine, 15*, 240-247.
- Auvinen, J.P., Tammelin, T.H., Taimela, S.P., Zitting, P.J., Jarvelin, M., Taanila, A.M., & Karppinen, J.I. (2010). Is insufficient quantity and quality of sleep a risk factor for neck, shoulder and low back pain? A longitudinal study among adolescents. *Eur Spine J, 19*(4), 641-649.
- Baum, K.T., Desai, A., Field, J., Miller, L.E., Rausch, J., & Beebe, D.W. (2014). Sleep restriction worsens mood and emotion regulation in adolescents. *Journal of Psychology and Psychiatry, 55*(2), 180-190.

- Beebe, D.W. (2011). Cognitive, behavioral, and functional consequences of inadequate sleep in children and adolescents. *Pediatric Clinical North America*, 58(3), 649-665.
- Beebe, D.W., Lewing, D., Zeller, M., McCabe, M., MacLeod, K., Daniels, S.R., & Amin, R. (2007). Sleep in overweight adolescents: Shorter sleep, poorer sleep quality, sleepiness, and sleep-disordered breathing. *Journal of Pediatric Psychology*, 32(1), 69-79.
- Beebe, D.W., Rose, D., & Amin, R. (2010). Adolescent health brief: Attention, learning, and arousal of experimentally sleep-restricted adolescents in a simulated classroom. *Journal of Adolescent Health*, 47(5), 523–525.  
doi:10.1016/j.jadohealth.2010.03.005.
- Boergers, J., Gable, C.J., & Owens, J.A. (2014). Later school start time is associated with improved sleep and daytime functioning in adolescents. *Journal of Developmental & Behavioral Pediatrics*, 35(1), 11-17.
- Bradley Hospital. (1996). School Sleep Habits Survey [Measurement instrument].
- Bruni, O., Russo, P.M., Ferri, R., Novelli, L., Galli, F., & Guidetti, V. (2008). Relationships between headache and sleep in a non-clinical population of children and adolescents. *Sleep Medicine*, 9, 542-548.
- Cain, N., & Gradisar, M. (2010). Electronic media use and sleep in school-aged children and adolescents: A review. *Sleep Medicine*, 11(8), 735-742.
- Carskadon, M.A. (1989). Adolescent sleepiness: Increased risk in a high-risk population. *Alcohol, Drugs & Driving*, 5(4), 317-328.

- Carskadon, M.A. (1990). Patterns of sleep and sleepiness in adolescents. *Pediatrician*, *17*, 5-12.
- Carskadon, M.A., & Acebo, C. (2002). Regulation of sleepiness in adolescents: Update, insights, and speculation. *Sleep*, *25*(6), 606-614.
- Carskadon, M.A., Acebo, C., Richardson, G.S., Tate, B.A., & Seifer, R. (1997). An approach to studying circadian rhythms of adolescent humans. *Journal of Biological Rhythms*, *12*, 278-289.
- Carskadon, M.A., Viera, C., & Acebo, C. (1993). Association between puberty and delayed phase preference. *Sleep*, *16*(3), 258-262.
- 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*, *21*(8), 871-881.
- Centers for Disease Control and Prevention. (2015). How Much Sleep Do I Need? Retrieved May 20, 2015, from [http://www.cdc.gov/sleep/about\\_sleep/how\\_much\\_sleep.htm](http://www.cdc.gov/sleep/about_sleep/how_much_sleep.htm)
- Chen, M., Wang, E.K., & Jeng, Y. (2006). Adequate sleep among adolescents is positively associated with health status and health-related behaviors. *BMC Public Health*, *6*(59).
- Chen, T., Wu, Z., Shen, Z., Zhang, J., Shen, X., & Li, S. (2014). Sleep duration in Chinese adolescents: Biological, environmental, and behavioral predictors. *Sleep Medicine*, *15*, 1345-1353.



- Colrain, I.M., & Baker, F.C. (2011). Changes in sleep as a function of adolescent development. *Neuropsychology Review*, *21*, 5-21.
- Coulombe, J.A., Reid, G.J., Boyle, M.H., & Racine, Y. (2010). Concurrent associations among sleep problems, indicators of inadequate sleep, psychopathology, and shared risk factors in a population-based sample of healthy Ontario children. *Journal of Pediatric Psychology*, *35*(7), 790-799.
- Countryman, A.J., Saab, P.G., Llabre, M.M., Penedo, F.J., McCalla, J.R., & Schneiderman, N. (2013). Cardiometabolic risk in adolescents: Associations with physical activity, fitness, and sleep. *Annals of Behavioral Medicine* *45*(1), 121-131.
- Crowley, S.J., Acebo, C., Fallone, G., & Carskadon, M.A. (2006). Estimating dim light melatonin onset (DLMO) phase in adolescents using summer or school-year sleep/wake schedules. *Sleep*, *29*(12), 1632-1641.
- Crowley, S.J., Acebo, C., & Carskadon, M.A. (2007). Sleep, circadian rhythms, and delayed phase in adolescence. *Sleep Medicine*, *8*(6), 602-612.
- Curcio, G., Ferrara, M., & DeGennaro, L. (2006). Sleep loss, learning capacity, and academic performance. *Sleep Medicine Reviews*, *10*, 323-337.
- Dagys, N., McGlinchey, E.L., Talbot, L.S., Kaplan, K.A., Dahl, R.E., & Harvey, A.G. (2012). Double trouble? The effects of sleep deprivation and chronotype on adolescent affect. *Journal of Child Psychology and Psychiatry*, *53*(6), 660-667.
- Dahl, R.E. (2008). Biological, developmental, and neurobehavioral factors relevant to adolescent driving risks. *American Journal of Preventative Medicine*, *35*.

- Dahl, R.E., & Lewin, D.S. (2002). Pathways to adolescent health: Sleep regulation and behavior. *Journal of Adolescent Health, 31*, 175-184.
- Danner, F., & Phillips, B. (2008). Adolescent sleep, school start times, and teen motor vehicle crashes. *Journal of Clinical Sleep Medicine, 4*(6), 533-535.
- Dewald-Kaufman, J.F., Meijer, A.M., Oort, F.J., Kerkhof, G.A., & Bogels, S.M. (2010). The influence of sleep quality, sleep duration and sleepiness on school performance in children and adolescents: A meta-analytic review. *Sleep Medicine Reviews, 14*, 179-189.
- Dewald-Kaufman, J.F., Oort, F.J., Bogels, S.M., & Meijer, A.M. (2013). Why sleep matters: Differences in daytime functioning between adolescents with low and high chronic sleep reduction and short and long sleep durations. *Journal of Cognitive and Behavioral Psychotherapies, 13*(1a), 171-182.
- Dexter, D., Bijwadia, J., Schilling, D., & Applebaugh, G. (2003). Sleep, sleepiness and school start times: A preliminary study. *Wisconsin Medical Journal, 102*(1), 44-46.
- Eaton, D.K., McKnight-Eily, L.R., Lowry, R., Perry, G.S., Presley-Cantrell, L., & Croft, J.B. (2010). Prevalence of insufficient, borderline, and optimal hours of sleep among high school students- United States, 2007. *Journal of Adolescent Health, 46*, 399-401.
- Fakier, N., & Wild, L.G. (2011). Associations among sleep problems, learning difficulties and substance use in adolescence. *Journal of Adolescence, 34*, 717-726.

- Gangwisch, J.E., Babiss, L.A., Malaspina, D., Turner, J.B., Zammit, G.K., & Posner, K. (2010). Earlier parental set bedtimes as a protective factor against depression and suicidal ideation. *Sleep: Journal of Sleep and Sleep Disorders Research*, 33, 97-106.
- Gangwisch, J.E., Malaspina, D., Babiss, L.A., Opler, M.G., Posner, K., Shen, S., ... Zammit, G.K., Ginsberg, H.N. (2010). Short sleep duration as a risk factor for hypercholesterolemia: Analyses of the National Longitudinal Study of Adolescent Health. *Sleep*, 33(7), 956-961.
- Garner, A.A., Miller, M.M., Field, J., Noe, J., Smith, Z., & Beebe, D.W. (2015). Impact of experimentally manipulated sleep on adolescent simulated driving. *Sleep Medicine*, 16, 796-799.
- Grandner, M.A., Patel, N.P., Gehrman, P.R., Xie, D., Sha, D., Weaver, T., & Gooneratne, N. (2010). Who gets the best sleep? Ethnic and socioeconomic factors related to sleep complaints. *Sleep Medicine*, 11, 470-478.
- Gravetter, F., & Foranzo, L. (2011). *Research methods for the behavioral sciences*. Belmont, CA: Wadsworth.
- Hagenauer, M.H., Perryman, J.I., Lee, T.M., & Carskadon, M.A. (2009). Adolescent changes in the homeostatic and circadian regulation of sleep. *Developmental Neuroscience*, 31(4), 276-284. doi:10.1159/000216538
- Hale, L., & Guan, S. (2015). Screen time and sleep among school-aged children and adolescents: A systematic literature review. *Sleep Medicine Reviews*, 21, 50-58.

- Hansen, M., Janssen, I., Schiff, A., Zee, P.C., & Dubocovich, M.L. (2005). The impact of school daily schedule on adolescent sleep. *Pediatrics*, *115*(6), 1555-1561.
- Hill, T.D., Burdette, A.M., & Hale, L. (2009). Neighborhood disorder, sleep quality, and psychological distress: Testing a model of structural amplification. *Health Place*, *15*, 1006-1013.
- Hysing, M., Pallesen, S., Stormark, K.M., Jakobsen, R., Lundervold, A.J., & Siversten, B. (2015). Sleep and use of electronic devices in adolescence: Results from a large population-based study. *BMJ Open*, doi: 10.1136/bmjopen-2014-006748
- Javaheri, S., Storfer-Isser, A., Rosen, C.L., & Redline, S. (2008). Sleep quality and elevated blood pressure in adolescents. *Circulation*, *118*(10), 1034-1040.  
doi:10.1161/CIRCULATIONAHA.108.76641
- Jenni, O.G., Achermann, P., & Carskadon, M.A. (2005). Homeostatic sleep regulation in adolescents. *Sleep: Journal of Sleep and Sleep Disorders Research*, *28*, 1446-1454.
- Johns, M.W. (1991). A new method for measuring daytime sleepiness: the Epworth Sleepiness Scale. *Sleep*, *14*(6), 540-55.
- Keyes, K.M., Maslowsky, J., Hamilton, A., & Schulenberg, J. (2015). The great sleep recession: Changes in sleep duration among US adolescents, 1991-2012. *Pediatrics*, *135*(3). doi:10.1542/peds.2014-2707
- Kopasz, M., Loessl, B., Hornyak, M., Rieman, D., Nissen, C, Piosczyk, & Voderholzer, U. (2010). Sleep and memory in healthy children and adolescents- a critical review. *Sleep Medicine Reviews*, *14*, 167-177.

- Laberge, L., Ledoux, E., Auclair, J., & Gaudreault, M. (2014). Determinants of sleep duration among high school students in part-time employment. *Mind, Brain, and Education, 8*(4), 220-226.
- Loessl, B., Valerius, G., Kopasz, M., Hornyak, M., Rieman, D., & Voderholzer, U. (2008). Are adolescents chronically sleep-deprived? An investigation of sleep habits of adolescents in the southwest of Germany. *Child: Care, Health, and Development, 34*(5), 549-556.
- Louca, M., & Short, M.A. (2014). The effect of one night's sleep deprivation on adolescent neurobehavioral performance. *Sleep, 37*(11), 1799-1807.
- Lufi, D., & Tzischinsky, O. (2014). The relationships between sensory modulation and sleep among adolescents with ADHD. *Journal of Attention Disorders, 18*(8), 646-653.
- Lytle, L.A., Murray, D.M., Laska, M.N., Pasch, K., Anderson, S.E., & Farbaksh, K. (2013). Examining the longitudinal relationship between change in sleep and obesity risk in adolescents. *Health Education Behavior, 40*(3), 362-370.
- Marco, C.A., Wolfson, A.R., Sparling, M., & Azuaje, A. (2012). Family socioeconomic status and sleep patterns of young adolescents. *Behavioral Sleep Medicine, 10*, 70-80.
- Martinez-Gomez, D., Eisenmann, J.C., Gomez-Martinez, S., Hill, E.E., Zapatera, B., Veiga, O.L., & Marcos, A. (2011). Sleep duration and emerging cardiometabolic risk markers in adolescents. The AFINOS study. *Sleep Medicine, 12*(10), 997-1002.

- Martiniuk, A.L.C., Senserrick, T., Lo, S., Williamson, A., Du, W., Grunstein, R.R., ...  
Stevenson, M. (2013). Sleep-deprived young drivers and the risk for crash: The  
DRIVE prospective cohort study. *JAMA Pediatrics*, *167*(7), 647-655.
- Maslowsky, J., & Ozer, E.J. (2013). Developmental trends in sleep duration in  
adolescence and young adulthood: Evidence from a national United States  
sample. *Journal of Adolescent Health*, *54*, 691-697.
- Matthews, K.A., Hall, M., & Dahl, R.E. (2014). Sleep in healthy black and white  
adolescents. *Pediatrics*, *133*(5), 1189-1196.
- Mayes, S.D., Calhoun, S.L., Bixler, E.O., Vgontzas, A.N., Mahr, F., Hillwig-Garcia, J.,  
Elamir, B., ... Parvin, M. (2008). ADHD subtypes and comorbid anxiety,  
depression, and oppositional-defiant disorder: Differences in sleep problems.  
*Journal of Pediatric Psychology*, *34*(3), 328-337.
- Mednick, S.C., Christakis, N.A., & Fowler, J.H. (2010). The spread of sleep loss  
influences drug use in adolescent social networks. *PloS One*, *5*(3), e9775.
- Merdad, R.A., Merdad, L.A., Nassif, R.A., El-Derwi, D., & Wali, S.O. (2014). Sleep  
habits in adolescents of Saudi Arabia; distinct patterns and extreme sleep  
schedules. *Sleep Medicine*, *15*, 1370-1378.
- Millman, R.P. (2005). Excessive sleepiness in adolescents and young adults: Causes,  
consequences, and treatment strategies. *Pediatrics*, *115*(6), 1774-1786.
- Mindell, J.A. & Owens, J.A. (2003). *A clinical guide to pediatric sleep: Diagnosis and  
management of sleep problems*. Philadelphia: Lippincott Williams & Wilkins.

- Moore, M., Kirchner, H.L., Drotar, D., Johnson, N., Rosen, C., & Redline, S. (2011). Correlates of adolescent sleep time and variability in sleep time: The role of individual and health related characteristics. *Sleep Medicine, 12*, 239-245.
- Morrison, D. N., McGee, R., & Stanton, W. R. (1992). Sleep problems in adolescence. *Journal of the American Academy of Child & Adolescent Psychiatry, 31*(1), 94-99. doi:10.1097/00004583-199201000-00014
- Narang, I., Manlhiot, C., Davies-Shaw, J., Gibson, D., Chahal, N., Stearne, K., ... McCrindle, B.W. (2012). Sleep disturbance and cardiovascular risk in adolescents. *CMAJ*, doi:10.1503/cmaj.111589
- National Institute of Mental Health. (2011). The teen brain: Still under construction. Retrieved September 21, 2015, from [http://www.nimh.nih.gov/health/publications/the-teen-brain-still-under-construction/teen-brain\\_141903.pdf](http://www.nimh.nih.gov/health/publications/the-teen-brain-still-under-construction/teen-brain_141903.pdf)
- National Heart, Lung, and Blood Institute. (2012). How Much Sleep Is Enough? Retrieved May 20, 2015, from <http://www.nhlbi.nih.gov/health/health-topics/topics/sdd/howmuch>
- National Sleep Foundation. (2006). Sleep in America poll: Summary findings. Retrieved May 16, 2015, from <http://sleepfoundation.org/sleep-polls-data/sleep-in-america-poll/2006-teens-and-sleep>
- National Sleep Foundation. (n.d.). Eight major obstacles to delaying school start times. Retrieved April 2, 2016, from: <https://sleepfoundation.org/sleep-news/eight-major-obstacles-delaying-school-start-times>

- Nationwide Children's Hospital. (n.d.). Sleep in adolescents (13-18 years). Retrieved June 17, 2015, from <http://www.nationwidechildrens.org/sleep-in-adolescents>
- Noland, H., Price, J.H., Dake, J., & Telljohann, S.K. (2009). Adolescents' sleep behaviors and perceptions of sleep. *Journal of School Health, 79*(5), 1746-1561.
- Nudel, M. (1993). The schedule dilemma. *American School Board Journal, 180*(11), 37-40.
- O'Brien, E.M., Mindell, J.A., (2005). Sleep and risk-taking behavior in adolescents. *Behavioral Sleep Medicine, 3*(3), 113-133.
- Owens, J.A., Belon, K., & Moss, P. (2010). Impact of delaying school start time on adolescent sleep, mood, and behavior. *Arch Pediatric Adolescent Medicine, 164*(7), 608-614.
- Owens, J., Droblich, D., Baylor, A., & Lewin, D. (2014). School start time change: An in-depth examination of school districts in the United States. *Mind, Brain, and Education, 8*(4), 182-213.
- Owens, J.A., Stahl, J., Patton, A., Reddy, U., & Crouch, M. (2006). Sleep practices, attitudes, and beliefs in inner city middle school children: A mixed-methods study. *Behavioral Sleep Medicine, 4*(2), 114-134.
- Paiva, T., Gaspar, T., & Matos, M.G. (2015). Sleep deprivation in adolescents: Correlations with health complaints and health-related quality of life. *Sleep Medicine, 16*, 521-527.
- Pereira, E.F., Louzada, F.M., & Moreno, C. RC. (2010). Not all adolescents are sleep deprived: A study of rural populations. *Sleep and Biological Rhythms, 8*, 267-273.



- Price, V.A., Coates, T.J., Thorenson, C.E., & Grinstead, O.A. (1978). Prevalence and correlates of poor sleep among adolescents. *American Journal of Diseases of Children, 132*, 583-586.
- Roane, B.M., & Taylor, D.J. (2008). Adolescent insomnia as a risk factor for early adult depression and substance abuse. *Sleep, 31*(10), 1351-1356.
- Roberts, R.E., & Duong, H.T. (2014). The prospective association between sleep deprivation and depression among adolescents. *Sleep, 37*(2), 239-244.
- Roberts, R.E., Roberts, C.R., & Chen, I.G. (2001). Functioning of adolescents with symptoms of disturbed sleep. *Journal of Youth and Adolescence, 30*(1), 1-18.
- Roberts, R.E., Roberts, C.R., & Duong, H.T. (2009). Sleepless in adolescence: Prospective data on sleep deprivation, health and functioning. *Journal of Adolescence, 32*, 1045-1057.
- Roberts, R.E., Roberts, C.R., & Xing, Y. (2011). Restricted sleep among adolescents: Prevalence, incidence, persistence, and associated factors. *Behavioral Sleep Medicine, 9*, 18-31.
- Sarchiapone, M., Mandelli, L., Carli, V., Iosue, M., Wasserman, C., Hadlaczky, G., Hoven, C.W., ... Wasserman, D. (2014). Hours of sleep in adolescents and its association with anxiety, emotional concerns, and suicidal ideation. *Sleep Medicine, 15*, 248-254.
- Shanahan, L., Copeland, W.E., Angold, A., Bondy, C.L., & Costello, E.J. (2014). Sleep problems predict and are predicted by generalized anxiety/depression and

oppositional defiant disorder. *Journal of the American Academy of Child & Adolescent Psychiatry*, 53(5), 550-558.

Shope, J.T., & Bingham, C.R. (2008). Teen driving: Motor-vehicle crashes and factors that contribute. *American Journal of Preventative Medicine*, 35, doi: 10.1016/j.amepre.2008.06.022.

Short, M.A., Gradisar, M., Lack, L.C., Wright, H.R., Dewald-Kaufman, J.F., Wolfson, A.R., & Carskadon, M.A. (2012). A cross-cultural comparison of sleep duration between U.S. and Australian adolescents: The effect of school start time, parent-set bedtimes, and extracurricular load. *Health Education & Behavior*, 40(3), 323-330.

Short, M.A., Gradisar, M., Wright, H., Lack, L.C., Dohnt, H., & Carskadon, M.A. (2011). Time for bed: Parent-set bedtimes associated with improved sleep and daytime functioning in adolescents. *Sleep: Journal of Sleep and Sleep Disorders Research*, 34, 797-800.

Snell, E.K., Adam, E.K., & Duncan, G.J. (2007). Sleep and the body mass index and overweight status of children and adolescents. *Child Development*, 78(1), 309-323.

Stamatkis, K.A., Kaplan, G.A., & Roberts, R.E. (2007). Short sleep duration across income, education, race/ethnic groups: Population prevalence and growing disparities during 34 years of follow-up. *Ann Epidemiol*, 17, 948-955.

Strauch, I., & Meier, B. (1988). Sleep need in adolescents: A longitudinal approach. *Sleep*, 11, 378-386.

- Talbot, L.S., McGlinchey, E.L., & Kaplan, K.A. (2010). Sleep deprivation in adolescents and adults: Changes in affect. *Emotion, 10*(6), 831-841.
- Taylor, D.J., Jenni, O.G., Acebo, C., & Carskadon, M.A. (2005). Sleep tendency during extended wakefulness: Insights into adolescent sleep regulation and behavior. *Journal of Sleep Research, 14*, 239-244.
- Telzer, E.H., Fuligni, A.J., Lieberman, M.D., & Galvan, A. (2013). The effects of poor quality sleep on brain function and risk taking in adolescence. *Neuroimage, 71*, doi:10.1016/j.neuroimage.2013.01.025.
- University of Minnesota. (2011). Teen Sleep Habits Survey [Measurement instrument].
- U. S. Department of Education, National Center for Education Statistics. (2012). Public school data file, 2011-2012. *Schools and Staffing Survey (SASS)*. Retrieved from: [https://nces.ed.gov/surveys/sass/tables/sass1112\\_201381\\_s1n.asp](https://nces.ed.gov/surveys/sass/tables/sass1112_201381_s1n.asp)
- Wahlstrom, K. (2002). Changing times: Findings from the first longitudinal study of later high school start times. *NASSP Bulletin, 86*(633), 3-21.
- Wahlstrom, K., Dretzke, B., Gordon, M., Peterson, K., Edwards, K., & Gdula, J. (2014). Examining the impact of later school start times on the health and academic performance of high school students: A multi-site study. Center for Applied Research and Educational Improvement. St Paul, MN: University of Minnesota.
- Wolfson, A.R., & Carskadon, M.A. (1998). Sleep schedules and daytime functioning in adolescents. *Child Development, 69*(4), 875-887.

- Wolfson, A.R., & Carskadon, M.A. (2003). Understanding adolescents' sleep patterns and school performance: A critical appraisal. *Sleep Medicine Reviews*, 7(6), 491-506.
- Yurgelun-Todd, D. (2007). Emotional and cognitive changes during adolescence. *Current Opinion in Neurobiology*, 17, 251-257.

**APPENDICES**

## APPENDIX A

### ELECTRONIC SELF-REPORT SLEEP SURVEY QUESTIONS

1. Sex:
  - Male
  - Female
2. Grade:
  - 9
  - 10
  - 11
  - 12
3. How many hours of sleep do you usually get on school nights?
4. What do you believe is preventing you from getting enough sleep at night? Please check all that apply:
  - Homework or studying
  - Leadership duties
  - Time needed to play sports
  - Mind is racing
  - Noise in dorm/barrack
  - Side effects of a prescribed medication
5. What do you believe is preventing you from getting enough sleep at night? Please check all that apply:
  - Too much caffeine (e.g., coffee, energy drink)

- Social activities, such as talking with friends
  - Noise made by roommate
  - Anxiety or worry
  - Consumption of an over-the-counter medication taken to stay alert
  - Internet surfing or on-line chatting.
6. What do you believe is preventing you from getting enough sleep at night? Please check all that apply:
- Medical condition (e.g., sleep apnea, asthma, allergies)
  - Depression
  - Nicotine (e.g., cigarettes, chewing tobacco)
  - Exercise too late in the day.
  - Watching TV, DVD, etc.
  - Talking on phone/cell-phone
7. What do you believe is preventing you from getting enough sleep at night? Please check all that apply:
- Consumption of someone else's prescribed stimulant medication
  - Other (please describe)
8. If you answered Other – please describe
9. What strategies do you use to help yourself fall asleep at night? Please check all that apply:
- Read a book
  - Take a prescribed medication for sleep

- Meditation
- Drinking warm milk, tea, or other decaffeinated non-sugar beverages.
- Listen to soothing/relaxing music
- Take an over-the-counter medication

10. What strategies do you use to help yourself fall asleep at night? Please check all that apply:

- Drink alcohol
- Socialize (e.g., on phone, with roommate)
- Watch DVD or other media program on my computer.
- Take someone else's prescribed medication for sleep
- Aromatherapy
- Stretching, Yoga, or Pilates

11. What strategies do you use to help yourself fall asleep at night? Please check all that apply:

- Prayer
- Visual Imagery
- Deep Breathing
- Repetitive mind exercises (e.g., counting backwards by 8, counting sheep)
- White noise machine, fan, or other device used to control the noise level in your room
- Consistent bedtime routine



12. What strategies do you use to help yourself fall asleep at night? Please check all that apply

- Take a hot shower
- Nicotine (e.g., cigarettes, chewing tobacco)
- Other

13. If you answered Other – please describe:

## APPENDIX B

### TABLES

*Table 1.* Sample Size (*N*), Means (*M*), and Standard Deviations (*SD*) for Each Grade Level across Each Intervention Phase

Grade Level	Pre-Intervention			Post-Intervention 1			Post-Intervention 2			Total		
	<i>N</i>	<i>M</i>	<i>SD</i>	<i>N</i>	<i>M</i>	<i>SD</i>	<i>N</i>	<i>M</i>	<i>SD</i>	<i>N</i>	<i>M</i>	<i>SD</i>
Freshman	66	6.42	1.02	64	7.51	.84	73	7.33	1.03	203	7.09	1.08
Sophomore	98	6.40	1.14	91	7.39	.78	91	7.10	.97	280	6.95	1.06
Junior	89	5.78	1.58	101	6.94	1.03	93	6.73	1.05	283	6.50	1.33
Senior	96	6.08	1.10	101	6.93	.99	75	6.89	.85	272	6.61	1.07
Total	349	6.16	1.26	357	7.15	.96	332	7.00	1.00	1038	6.77	1.17

*Table 2.* Number and Percentage of Students who Reported Specific Sleep Barriers

Sleep Barrier	Students	Percentage
Homework/Studying	278	78.5
Mind Racing	186	52.5
Talking with Friends	172	48.6
Outside Room Noise	150	42.4
Anxiety/Worry	145	41.0
Roommate Noise	112	31.6
Sport Practice/Games	91	25.7
Leadership Duties	73	20.6
Phone Calls	72	20.3
Internet Surfing/Chatting	49	13.8
Evening Exercise	46	13.0
Watching TV/Movies	43	12.1
Depression	33	9.0
Caffeine	23	6.5

Table 2. (continued)

<u>Sleep Barrier</u>	<u>Students</u>	<u>Percentage</u>
Medical Condition	22	6.2
Prescribed Medication Side Effects	19	5.4
Nicotine	6	1.7
Non-Prescribed Stimulant Medication	5	1.4
Over-the-Counter Medication to Stay Alert	5	1.4

Table 3. Number and Percentage of Students who Reported Specific Sleep Facilitators

<u>Sleep Facilitators</u>	<u>Students</u>	<u>Percentage</u>
Relaxing Music	148	41.8
Consistent Bedtime Routine	126	35.6
Hot Shower	124	35.0
Deep Breathing	104	29.4
Socializing	99	28.0
Computer Movies/Media	90	25.4
Prayer	89	25.1
Reading a Book	87	24.6
White Noise Device	83	23.45
Visual Imagery	65	18.4
Repetitive Mind Exercises	43	12.1
Meditation	42	11.9
Stretching, Yoga, or Pilates	34	9.6
Decaffeinated Non-Sugar Drink	25	7.1
Over-the-Counter Medication	21	5.9
Prescribed Medication	6	1.7
Nicotine	6	1.7
Aromatherapy	5	1.4
Alcohol	4	1.1

**APPENDIX C**

**PERMISSION FOR USE OF ARCHIVAL DATA**

## PERMISSION FOR USE OF ARCHIVAL DATA

June 17, 2016

Kevin MacNeil, Ph.D.  
Culver Academies  
1300 Academy Road  
Culver, IN 46511

Dear Dr. MacNeil:

My graduate students and I, working in Psychology Department at Middle Tennessee State University are requesting permission to use archival sleep data that was previously collected at your institution, Culver Academies, during the following years: 2008, 2009, and 2010. If you agree to this use, please confirm your agreement by completing the acknowledgment included below.

Thank you for collaborating with us.

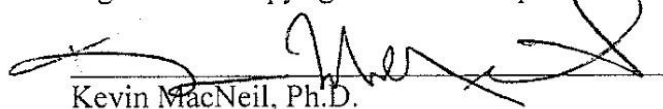
Sincerely,

Seth J. Marshall, Ph.D.  
Assistant Professor  
Middle Tennessee State University  
Department of Psychology  
seth.marshall@mtsu.edu  
(615) 898-2581

#### Agreement

I have authority to grant permission for the use requested above and I grant permission to Dr. Seth Marshall to analyze the archival sleep data collected at the Culver Academies for the delayed-school-start sleep project expressly for the research project titled, "The Impact of a Delayed School-Start Time on High School Students' Sleep." This data was collected anonymously. Students completed an anonymous online sleep survey and their responses did not link to their identities or personal information. The sleep data includes information regarding: grade level (9th, 10th, 11th, and 12th), gender (male or female), self-reported hours of sleep on weeknights and weekends, and self-indicated sleep barriers and facilitators.

Signature of copyright holder or representative:



Kevin MacNeil, Ph.D.  
Kevin.MacNeil@culver.org  
Academic Dean  
Culver Academies  
Date: (yyyy/mm/dd)