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Characteristics associated with Sleep Duration, Chronotype, and Social jet lag in Adolescents

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Abstract

Sleep is a complex behavior with numerous health implications. Identifying socio-demographic and behavioral characteristics of sleep are important for determining those at greatest risk for sleep-related health disparities. In this cross-sectional study, general linear models were used to examine socio-demographic and behavioral characteristics associated with sleep duration, chronotype, and social jet lag in adolescents. One hundred fifteen participants completed Phase I (self-reported sleep measures); 69 of these participants completed Phase II (actigraphy-estimated sleep measures). Black adolescents had shorter free night sleep than Hispanics. Youth with later chronotypes ate fewer fruits and vegetables, drank more soda, were less physically active, and took more daytime naps. Based on these findings, recommendations for individual support and school policies are provided.

Keywords

sleep duration; chronotype; adolescence

Introduction

Sleep is essential for the health, well-being, and academic success of adolescents (M. Hall et al., 2015; Noland, Price, Dake, & Telljohann, 2009). There are multiple dimensions of healthy sleep, including sufficient duration, regular sleep-wake patterns, efficiency, alertness, and satisfaction (Blunden & Galland, 2014). Insufficient sleep (less than eight hours) and irregular sleep-wake patterns are associated with depressed moods, risk taking behaviors, cardiovascular disease risk, and obesity (Arora & Taheri, 2015; Hall, Lee, & Matthews, 2015; Randler, 2011b; Wittmann, Dinich, Merrow, & Roenneberg, 2006). Yet, 62% of high school students report insufficient sleep (National Sleep Foundation, 2006b). Early school start times are incongruent with developmental shifts towards later sleep-wake times, or later chronotypes (Carskadon, Acebo, & Jenni, 2004; National Sleep Foundation, 2006b). This leads to irregular sleep-wake patterns, coined social jet lag, which are characterized by variations in school day and free day sleep-wake timing (Wittmann et al., 2006). Elucidating characteristics associated with insufficient sleep, later chronotype, and social jet lag in adolescents are important because life-long habits are established during this developmental period (Dahl, 2004).

Several socio-demographic characteristics have been associated with sleep in adolescents. Age and puberty-related declines in sleep duration, delays in chronotype, and increases in social jet lag have been consistently reported (Knutson, 2005; Olds, Blunden, Petkov, & Forchino, 2010). Evidence that Black adolescents report shorter sleep than other racial/ ethnic groups is also emerging (Maslowsky & Ozer, 2013; Organek et al., 2015). However, conflicted evidence for sex differences in sleep duration exist and few studies have examined associations between poverty and sleep in adolescents (Lowry et al., 2012; Marco, Wolfson, Sparling, & Azuaje, 2011; Moore et al., 2011; Olds et al., 2010). Studies with objective sleep measures have rarely included Hispanic adolescents or chronotype and social jet lag sleep parameters (Marco et al., 2011; Moore et al., 2011). Elucidating socio-demographic differences in objectively measured adolescent sleep, inclusive of the growing Hispanic population and across multiple dimensions of sleep, is important because sleep disparities may be an important link to health disparities in adulthood (Ennis, Rios-Vargas, & Albert, 2011; Grandner, Chakravorty, Perlis, Oliver, & Gurubhagavatula, 2014).

Determining how sleep clusters with other behaviors is important for informing multi-behavioral approaches for improving sleep and health. Although chronotype is partially determined by biology, typical adolescent behaviors, such as late-night technology use, late–night socializing, and high fat diets may shift chronotypes later by delaying melatonin onset and lengthening the circadian cycle (Kohsaka et al., 2007; Roenneberg, Kuehnle, et al., 2007). This may have implications for health because late meal times (after 8pm) are associated with obesity risk and less successful weight loss interventions in adults (Baron, Reid, Kern, & Zee, 2011; Garaulet et al., 2013). Limited evidence of associations between sleep and other lifestyle behaviors (e.g. eating habits) in adolescents exists (Garaulet et al., 2011; Kauderer & Randler, 2013; Schaal, Peter, & Randler, 2010).

The purpose of this study was to examine socio-demographic and behavioral characteristics associated with sleep duration, chronotype, and social jet lag among racially/ethnically diverse 9th and 10th grade students using subjective (self-report) and objective (actigraphy) measures. The aim was to examine whether socio-demographic characteristics (age, race/ ethnicity, sex, poverty, puberty) and behavioral characteristics (eating habits, physical activity, screen time) predicted short sleep, late chronotype, or social jet lag.

Methods

Study Design

This cross-sectional study examined predictors of sleep duration and chronotype and other lifestyle characteristics in 9th and 10th grade students. In Phase I, participants completed questionnaires to assess socio-demographic characteristics, sleep habits, eating habits, physical activity, and pubertal development. Phase I participants were invited to participate in Phase II for a more detailed assessment of sleep duration with seven days of wrist actigraphy. The University of Pennsylvania Institutional Review Board approved this study and the school district provided letters of support. Written parent/guardian informed consent and written student assent were obtained prior to participation.

Participants

Participants were recruited from a four-year comprehensive public high school located in a northeast US coastal city. Phase I recruitment took place during compulsory health and physical education classes, back to school night, and prior to selected winter sports practices between October 2013 and January 2014. Data were collected during this same time period. Phase II recruitment took place between January 2014 and April 2014. Data for Phase II were collected between February 2014 and June 2014. The time between Phase I and II varied between participants depending on student availability. See Table 1 for Phase I and II exclusion criteria.

Measures

Sleep duration

Phase I: The Sleep Habits Survey is part of the School Sleep Habits Survey (Wolfson & Carskadon, 1998). Six items query students about their usual sleep-wake behavior over the previous two weeks. Questions about sleep duration on school nights and free nights (Friday and Saturday nights) require the participant to record the number of hours and minutes slept, not including time awake in bed (e.g. 8 hours 30 minutes). The Sleep Habits Survey has been validated with actigraphy in adolescents (Wolfson et al., 2003).

Phase II: Participants wore non-invasive watch-like devices to measure rest and activity on their non-dominant wrist (Acti-watch 2) and maintained a sleep diary concurrently for seven continuous days (Acebo et al., 1999; Sadeh, Sharkey, & Carskadon, 1994). Sleep diary information included duration of naps, bedtime, time sleep was attempted, time needed to fall asleep, frequency and duration of wake after sleep onset, actual morning wake time, desired morning wake time, time out of bed for the day, sleep quality (very poor to very good), and any other comments (e.g. illness, medication use). Diary based sleep data were used as a validity check for actigraphy based data. Discrepancies were reconciled with each participant using an established protocol. Briefly, participants were queried using open-ended questions for discrepancies greater than 15 minutes in diary and actigraphy data for sleep onset or sleep offset, nocturnal activity indicating wakefulness in actigraphy data, and daytime non-activity indicating rest in actigraphy data (excluding diary indicated watch removal or daytime nap).

Downloaded actigraphy data were analyzed using the manufacturer's supplied software. Sleep duration was calculated as [(sleep onset – sleep offset) – sleep onset latency]. Sleep onset and sleep offset are proxy measures for the beginning and end of sleep. Sleep onset latency is a proxy measure for how long it took the participant to fall asleep. Average school night (Sunday through Thursday) and free night sleep durations (Friday and Saturday) were used in the analyses. Intraclass correlation coefficients (ICC) for wrist actigraphy and polysomnogram in adolescents range from 0.2 to 0.6 (Johnson et al., 2007). The investigator called participants each evening to encourage retention and adherence to the protocol. Ninety nine percent of participants had actigraphy data for at least seven nights (range 4 – 14 nights).

Total night sleep was calculated as [(mean school night sleep duration × 5) + (mean free night sleep duration × 2) / 7] from both questionnaire data for Phase I and actigraphy data for Phase II. Sleep durations were further categorized as insufficient (less than eight hours), borderline (eight to less than nine hours), and optimal (greater than or equal to nine hours) (National Sleep Foundation, 2006a). Continuous sleep duration variables were used in all analyses. School nights and free nights were also analyzed separately to compare sleep duration on school nights versus free nights. Free night actigraphy data was not available in one subject, reducing the sample size in Phase II free night , chronotype, and social jet lag analyses to 68.

Naps—In Phase I, two questions were added to the Sleep Habits Survey by the investigator because 38% of high school students have reported at least two naps in a two week period (National Sleep Foundation, 2006a). Participants responded "yes" or "no" to each question: "During the past 2 weeks, have you slept during the day on weekends?" and "During the past 2 weeks, have you slept during the day on school days?" In Phase II, actigraphy identified naps (rest periods between 6am and 6pm) and self-reported naps from sleep diaries were verified with each participant.

Chronotype—Chronotype preference was measured using the Morningness/Eveningness Questionnaire. Chronotype was measured by calculating the midpoint of sleep from the Munich Chronotype Timing Questionnaire (Phase I) and from actigraphy data (Phase II).

Morningness/Eveningness Questionnaire: The 10-item Morningness/Eveningness Questionnaire (M/E Q) estimates activity/rest preferences by querying participants about preferred timing for activities such as tests, physical activity, bedtimes etc. (Carskadon, Vieira, & Acebo, 1993; Giannotti, Cortesi, Sebastiani, & Ottaviano, 2002). Scores range on a continuum from 10 (extreme late) to 43 (extreme early). Cut-off scores for early and late chronoptypes have not been established, but some investigators have used the 10^{th} and 90^{th} centiles to determine early and late chronotypes (Giannotti et al., 2002). The M/E Q has been validated in children and adolescents (Carskadon et al., 1993; Giannotti et al., 2002).

Midpoint of sleep: The midpoint of sleep estimates chronotype based on sleep-wake timing (Roenneberg, Wirz-Justice, & Merrow, 2003). This estimate was corrected using the formula described by others to account for the fact that people often sleep longer on free days to compensate for shorter sleep on school days (Roenneberg, Allebrandt, Merrow, &

Vetter, 2012). The midpoint of sleep has been validated with dim light melatonin onset in adolescents (Crowley, Acebo, Fallone, & Carskadon, 2006). In Phase I and II, the midpoint of sleep was calculated from participant responses to questions about sleep-wake timing from Munich Chronotype Timing Questionnaire (MCTQ) and actigraphy data respectively (Roenneberg et al. (2012).

Social jet lag—Social jet lag is the absolute difference in midpoints of sleep between school nights and free nights. Data from the MCTQ (for Phase I) and actigraphy (for Phase II) were used to calculate social jet lag (Wittmann et al., 2006).

Eating habits—Eating habits refer to the type of foods eaten and patterns of eating. This was measured using nine questions from the 2013 Youth Risk Behavior Survey that queried specific food intake (e.g. fruit consumption) and eating patterns (e.g. breakfast skipping) over the previous seven days (Centers for Disease Control and Prevention, 2014a). Servings per day were calculated for fruit juice, fruit and vegetables, soft drinks, and milk. Participants completed this survey during Phase I. Results were used in Phase I and Phase II analyses. Other types of self reported food intake questionnaires have been validated with 24-hour diet recalls in youth ($r = 0.54$) (Rockett et al., 1997).

Physical activity—Physical activity was measured using four questions from the 2013 Youth Risk Behavior Survey. These questions asked about moderate/vigorous physical activity, sports participation, and screen time (Centers for Disease Control and Prevention, 2014a). Participants completed this survey during Phase I. Results were used in Phase I and Phase II analyses. Self reports may underestimate the percentage of youth meeting moderate activity recommendations and overestimate the percentage of youth meeting vigorous activity recommendations compared to accelerometry data (Troped et al., 2007). Test-retest intra-class correlation coefficients range from 0.51 (moderate activity) to 0.46 (vigorous activity) (Troped et al., 2007). Self reported TV viewing questions have been validated with seven-day logs (Schmitz et al., 2004). Screen time data was missing on one participant, reducing the sample size for Phase I screen time analysis to 114.

Pubertal Category—The five to six item Pubertal Self Rating Scale estimates pubertal status in settings where Tanner staging by physical examination is not appropriate (e.g. schools). Questions about body hair growth, deepening voice, and facial hair growth for males or body hair growth, breast growth, and menstruation (yes/no) for females are used to estimate pubertal categories (Carskadon & Acebo, 1993). Responses range from “barely started” to “seems complete”. “Don’t know” was also a response option. Categories created from this scale are similar to Tanner stages where pre-pubertal and post-pubertal are comparable to Tanner Stage 1 and Tanner Stage 5 respectively (Brooks-Gunn, Warren, Rosso, & Gargiulo, 1987). Agreement rates with Tanner’s Sexual Maturation Scale (images used to depict Tanner’s five stages of pubertal development) range from 82% (males) to 88% (females). If individual items were missing, the average of the non-missing items were used to fill in the missing values for each participant (Olinsky, Chen, & Harlow, 2003).

Free/reduced lunch participation—Free/reduced lunch, available through the National School Lunch Program, is a federally assisted meal program administered through Food and

Nutrition Service at the federal level and state education agencies at the state level. Family income must be less than or equal to 130% of the poverty level to qualify for free meals or between 130% and 185% of the poverty level to qualify for reduced price meals. In 2012 - 2013, a family of four with an income less than or equal to $29,965 would qualify for free meals and a family of four with an income less than $42,643 would qualify for reduced-price meals (US Department of Agriculture Food and Nutrition Services, 2012). Participation data was obtained from official school records and used as a proxy measure for poverty. Participant's who "did not apply" for free/reduced lunch were coded as non-participants.

Race/ethnicity—Data were obtained from official school records that were based on parent/guardian report of the student's race/ethnicity as White, Black, Hispanic, or Asian. Hispanics were chosen as the reference population based on the distribution of the cohort.

Sex—Participants self-reported as male or female.

Analysis

Descriptive statistics were calculated on all outcome and predictor variables of interest. Continuous variables were described as means and standard deviations and categorical variables as frequencies and percentages. Phase II midpoints of sleep, social jet lag, and sleep duration parameters were highly correlated because they were derived from the same actigraphy-estimated data. Thus, separate models were developed to test these relationships in Phase II analyses. Independent sample *t* tests, ANOVAs, Pearson's product moment correlations, and Spearman correlations were used as appropriate to assess bivariate associations between independent variables (e.g. race/ethnicity, screen time) and dependent variables of interest (e.g. sleep duration, chronotype). Next, general linear models were used to build more formal multivariable models. Only variables significant at alpha level of 0.2 from the bivariate analysis were included in the final adjusted models. Statistical significance was set at an alpha level of 0.05 based on the two-tailed test. SPSS was used for statistical analysis (SPSS, version 22).

Results

Sample Characteristics

Written parent/guardian consent and written student assent was received from approximately 21% of 9th and 10th grade students (N=116) for Phase I. One student with an implausible midpoint of sleep (3:00 pm) was excluded leaving 115 participants [Hispanic (n = 43), White (n = 35), Black (n = 33), Asian (n = 4)]. Sixty percent of this sample provided written parent/guardian consent and written student assent to participate in Phase II (N = 70). One student, diagnosed with Type 2 diabetes, was excluded leaving 69 participants [Hispanic (n = 25), White (n = 26), Black (n = 15), Asian (n = 3)]. Each racial/ethnic group comprised about one third of the sample. Most participants were females (Phase I: 70%, Phase II: 66%), and approximately 65% participated in the free/reduced lunch program. The mean age of participants was 15.4 (range 13.4 – 16.8) for Phase I and 15.5 (range 13.7 – 16.9) for Phase II. Sample characteristics are presented in Table 2. Most participants reported insufficient sleep on school nights (less than eight hours) and optimal sleep on free nights (greater than or equal to 9 hours) (National Sleep Foundation, 2006a). Most participants did not meet the recommended guidelines for milk intake, fruit/vegetable intake, physical activity, or screen time (Centers for Disease Control and Prevention, 2012; US Department of Agriculture & US Department of Health and Human Services, 2010; US Department of Health and Human Services, 2008). See Table 3.

Socio- Demographic Characteristics associated with Sleep

Race/ethnicity was a predictor of self-reported and actigraphy-estimated free night sleep duration. Black participants reported sleeping 1.3 hours less on average on free nights than Hispanic participants ($p < 0.01$) and 1.2 hours less when estimated by actigraphy ($p = 0.01$). Although not reaching statistical significance, there was a similar trend for shorter self-reported and actigraphy-estimated free night sleep duration in Black compared to White participants. No other statistically significant racial/ethnic differences for any self-reported or actigraphy-estimated sleep duration parameters were found. Age, sex, poverty, and pubertal category were not significantly associated with any self-reported or actigraphy-estimated sleep duration parameters. See Table 4.

Age was a predictor of chrontoype preference (M/E Q). Older ages predicted later chronotype preferences. For every one-month increase in age, M/E Q scores decreased 1 unit ($p = 0.03$). See Table 5. Poverty, pubertal category, and sex were not significantly associated with chronotype preference in Phase I or II.

Sex was a predictor of chronotype (midpoint of sleep). Males had 0.7 hours later midpoints of sleep than females (Phase I: $p = 0.02$). Poverty, pubertal category, and age were not significantly associated with chronotype in Phase I or II.

Behavioral Characteristics associated with Sleep

Eating habits—Eating more fruits and vegetables was a predictor of shorter self-reported free night sleep duration. For every one serving increase in fruit/vegetable servings per day, free night sleep duration decreased 0.2 hours ($p = 0.02$). See Table 4. Fruit and vegetable consumption was not significantly associated with actigraphy-estimated free night sleep ($p = 0.06$).

Drinking more soda and eating fewer fruits and vegetables were predictors of later chronotype preferences. For every additional serving of soda per day, M/E Q scores decreased approximately 1 unit (Phase I and II: $p = 0.05$). For every one less serving of fruits/vegetables per day, M/E Q scores decreased 0.5 units (Phase II only: $p = 0.03$). See Table 5.

Physical activity—Reporting less physical activity was a predictor of later chronotype preferences and later chronotypes. For every additional day *not* physically active during the week, M/E Q scores decreased 0.3 units (Phase I: $p = 0.05$, see Table 5) and midpoints of sleep were 0.13 hours later (Phase I: $p = 0.02$). Although not reaching statistical significance, there was a similar trend for later midpoints of sleep, computed from actigraphy, and less physical activity.

Other Sleep Behaviors—Reporting less social jet lag was a predictor of shorter self-reported free night sleep duration. For every one-hour decrease in social jet lag, free night sleep duration decreased 0.3 hours ($p = 0.05$). See Table 4.

Taking naps on school days was a predictor of shorter actigraphy-estimated total night sleep. Adolescents taking naps on school days had 0.4 hours less total nocturnal sleep compared to adolescents not taking naps ($p = 0.04$). Although not reaching statistical significance, there was a similar trend for school day naps and shorter self-reported total night sleep.

Taking naps was a predictor of later chronotype preferences and later chronotypes. Participants reporting free day naps had 3 units lower M/E Q scores than non-nappers (Phase I only: $p < 0.001$). See Table 5. Participants who napped on school days had a 0.6-hour later midpoint of sleep ($p = 0.02$). A similar trend was also evidence for later midpoints of sleep, computed from self-report, and more school day napping.

Discussion

Only nine percent of study participants reported the recommended number of hours sleep on school nights compared to 11% (10th grade) and 17% (9th grade) nationally. Irregular sleep-wake times were also evident in study participants with 40% to 68% having greater than or equal to two hours of social jet lag. Additionally, over 40% reported school day naps. These data corroborate extensive findings of unhealthy sleep in adolescents that includes school night sleep duration falling short of the recommended 9 to 10 hours per night (Centers for Disease Control and Prevention). Socio-demographic predictors of short free night sleep and late chronotype were identified. Our findings also indicate that youth with later chronotypes engage in less healthy eating habits and physical activity behaviors. If these behavioral patterns persist over time, youth with later chronotypes may be at greater risk for obesity.

Black participants had significantly shorter free night sleep than Hispanic participants and there was a similar trend for shorter free night sleep in Black compared to White participants. This is consistent with previous reports of shorter subjectively and objectively measured school night and total night sleep in Black compared to White adolescents and shorter subjectively measured sleep in Black compared to Hispanic adolescents (Lowry et al., 2012; Matthews, Hall, & Dahl, 2014; Moore et al., 2011; Organek et al., 2015) Other studies have reported longer self-reported sleep in Black compared to White adolescents and no differences between Black and Hispanic adolescents (Organek et al., 2015; Williams, Zimmerman, & Bell, 2013). Disparate self-reported findings may stem from parent-reported versus self-reported sleep, total sleep (potentially including naps) versus nocturnal sleep, and one versus two sleep duration questions (Lauderdale, 2014; Short, Gradisar, Lack, Wright, & Chatburn, 2013). Blacks, but not Whites, have typically reported different sleep durations on weeknights and weekends (Lauderdale, 2014). The lack of statistical significance between Black and White youth in this study may have been driven by the small sample size. There were no significant racial/ethnic differences in free night sleep duration between White and Hispanic participants or other self-reported or actigraphy-estimated nocturnal sleep parameters.

These data contribute to the limited evidence of racial/ethnic differences in adolescent sleep duration and identify that differences may stem from differences in free night sleep. It is interesting that shorter free night sleep was also associated with more positive health behaviors (e.g. more fruits/vegetables, less social jet lag). Longer free night sleep in other racial/ethnic groups might represent greater compensation for short school night sleep, yet racial/ethnic differences in social jet lag were not evident. Hence whether shorter free night sleep in Black adolescents is less healthy is uncertain.

Results from this study also support nuanced sex differences in chronotype. The lack of sex differences in psychological preferences for later chronotypes, despite differences in sleep-wake times (e.g. males reporting later chronotypes) is consistent with earlier reports (Borchers & Randler, 2012; Koscec, Radosevic-Vidacek, & Bakotic, 2014; Randler, 2011a). It has been speculated that adolescent females may have greater restriction on late-night activities and/or have greater parental/guardian expectations for domestic help (i.e. babysitting younger siblings on weekends) that undergird these behavioral differences in sleep-wake times for chronotype but not psychological preferences in chronotype (Borchers & Randler, 2012).

Results for this study are consistent with one earlier study indicating that poverty was not a predictor of short sleep or irregular sleep patterns in adolescents (Moore et al., 2011). A broader socio-economic estimate, beyond parental income, may be necessary to elucidate factors that contribute to differences in adolescent sleep, such as parent education and parent employment status (Marco et al., 2011).

There is limited evidence that adolescents with later chronotypes are more likely to engage in unhealthy behaviors than adolescents with earlier chronotypes (Fleig & Randler, 2009; Schaal et al., 2010; Urban, Magyarodi, & Rigo, 2011). This study extends this evidence to racially diverse high school students. Similar to previous studies, eating fewer fruits/vegetables and drinking more soda predicted later chronotypes (Arora & Taheri, 2015; Fleig & Randler, 2009). Drinking more caffeinated beverages may help youth with later chronotype adapt better to daytime hours (Giannotti et al., 2002).

This study also found that less physical activity (days per week) predicted subjectively measured later chronotypes and a trend towards objectively measured later chronotypes. These findings are consistent with previous findings in Japanese and German adolescents (Gaina et al., 2006; Schaal et al., 2010). Lack of statistical significance with objectively estimated chronotype might have been due to the smaller sample size.

It was surprising that having a later chronotype did not predict greater social jet lag as reported in adults (Wittmann et al., 2006). However, having a later chronotype did predict more daytime naps. This is consistent with findings that Tiawanese and Italian adolescents with later chronotypes nap more than their earlier counterparts (Gau & Soong, 2003; Giannotti et al., 2002).

Although screen time was associated with later chronotypes in the univariate analyses, it did not predict later chronotypes in the multivariable models. This finding is inconsistent with one study reporting greater screen time in adolescents with later chronotypes (Kauderer & Randler, 2013). Disparate findings may be related to our small sample size.

Limitations

Compared to a nationally representative sample of high school students, this study enrolled more female participants (Davis, September 2013). There was also greater participation in the National School Lunch program (free/reduced lunch) compared to a nationally representative sample of students and a state-wide representative sample of students (Department of U.S. Department of Education, Institute of Education Sciences, & National Center for Education Statistics). Hence, the generalizability of these findings to male adolescents and more affluent socio-economic groups may be limited. Also, as a small cross-sectional study, the short and long term health implications of these sleep patterns and racial/ethnic differences in sleep duration remain undetermined.

Other factors that may have biased our findings are as follows. Recruitment efforts were undertaken through the athletic department to increase male participation. Written parent/ guardian consent may have limited participation from some students (Tigges, 2003). Low reliability of the Pubertal Development Scale (Cronbach's alpha 0.3 – 0.6) and the Mornigningness/Evenigness Questionnaire (Cronbach's alpha 0.6) may have limited our ability to detect differences. Information on other factors that may have influenced sleep such as melatonin, parent/guardian employment, and depression was not collected.

Implications for School Nurses

School nurses have a vital role in improving adolescent sleep by intervening at the individual, local school, community, and national levels. At the individual level, school nurses can assess sleep duration in all adolescents using brief questionnaires, such as the Sleep Habits Survey, during health class or individual health visits. Nurses need to ask about school night *and* free night sleep. Importantly, sleep disparities that persist into adulthood are associated with hypertension, heart disease and increased mortality (Duggan, Reynolds, Kern, & Friedman, 2014; Grandner et al., 2014).

School nurses must advocate that recommendations to delay school start times be put into local school policies and participate in future research to further elucidate optimal school start times (Adolescent Sleep Working Group, 2014). Recommendations to delay school start times until 8:30 has been based on evidence that 8:30 start times are associated with longer school night sleep duration, improved attendance, reduced tardiness, and less daytime sleepiness (Danner & Phillips, 2008; Owens, Belon, & Moss, 2010; Short, Gradisar, Lack, Wright, Dewald, et al., 2013; Wahlstrom, 2002). Recent evidence from a geographically diverse sample of U.S. high schools, suggests that delays after 8 am may not lead to appreciable gains in sleep duration and that adolescent males in metropolitan areas reap the greatest gains in school start time delays (Paksarian, Rudolph, He, & Merikangas, 2015). Although the authors conclude with supporting 8:30 start time recommendations, this evidence underscores the need for more research to identify optimal start times for specific populations. Regardless, 86% of over 18,000 public high schools started school before 8:30 during the 2011-2012 school year (US Department of Education & National Center for

Education Statistics). Hence, delaying school start times is a promising intervention for increasing school night sleep duration for a large number of adolescents. Initial steps include identifying barriers faced by school districts striving to implement these changes and networking with others to develop resources in overcoming these barriers (Center for Applied Research and Educational Improvement, 1998).

Innovative strategies to adapt schedules based on chronotype should be undertaken in conjunction with efforts to mitigate further shifts towards lateness. Nurses must educate school administrators, teachers, parents/guardians, and students about biological, developmental, and environmental factors that influence chronotype. Sleep education that includes chronotype, must be adequately represented in the health curriculum and presented to parents/guardians. Findings that youth with later chronotypes report poorer eating habits and less physical activity suggest that they may be at greater risk for health problems than their earlier chronotype counterparts. If replicated in future studies, strategies aimed at aligning daily activities with the later sleep-wake patterns characteristic of youth with later chronotypes and preventing shifts towards lateness may be important for future health.

To accomplish this, school nurses can work with health educators to help students determine their chronotype by completing the Morningness/Eveningness Questionnaire during health class. This information can be used to help students determine times that they will feel and perform best for certain activities, including exercise. For example, youth with earlier chronotypes will be best suited for morning physical activity, whereas, youth with later chronotypes will be better suited for afternoon physical activity. Advocating for innovative ways to integrate this type of flexibility into the physical education curriculum can influence adherence to regular physical activity regimes and attitudes towards participating in sports programs (Brown, 2008; Vitale, 2013). Together with delaying school start times; these changes will benefit youth with later chronotypes who may be combating sleepiness by drinking caffeinated beverages, such as soda, and being less physically active (Tran et al., 2014).

Changes in modern lifestyles are contributing to greater shifts towards lateness at the population level (Roenneberg, Kumar, & Merrow, 2007). Greater time spent indoors has dampened the strength of light/dark stimuli critical to regulating sleep-wake timing. Increasing exposure to outdoor daylight and limiting exposure to night-time light may mitigate shifts towards lateness (Vollmer, Michel, & Randler, 2012; West et al., 2011). Two hours of outdoor light exposure per day is needed to shift sleep-wake timing one hour earlier (Roenneberg & Merrow, 2007). Strategies to increase outdoor light exposure for adolescents include scheduling weekend athletic events during the day, promoting short times between classes and during lunch to be outdoors during the school day (Harada, 2002), and designing school buildings that enhance light exposure and increase outdoor spaces.

These interventions must be combined with limiting light at night exposure. Urban planning committees should seek innovative ways to reduce ambient light at night exposure, including the lighting of school athletic fields. School nurses should educate adolescents, parents/guardians, teachers, and school information technology personnel about strategies for reducing light exposure from electronic media. Although one study found that one-hour exposure to electronic media at night did not delay sleep-wake times in adolescents, most students report far greater media use (Centers for Disease Control and Prevention, 2014b; Heath et al., 2014). Limiting electronic devices in bedrooms, installing software programs to adjust computer screen displays based on the time of day, and adjusting screen settings to white text on black for night reading are other possible interventions (Calamaro, Mason, & Ratcliffe, 2009; Calamaro, Yang, Ratcliffe, & Chasens, 2012).

Parent/guardian monitoring over bedtimes, typically decline as adolescents progress through high school. Yet, adolescents whose parents/guardians enforce bedtimes have earlier sleep-wake times during the week (Randler & Bilger, 2009). Nurses should educate and encourage parents/guardians to enforce bedtimes throughout high school, including weekends.

Conclusion

Findings from this study corroborate extensive findings that adolescents do not sleep enough on school nights. School nurses should spearhead and support initiatives to delay high school start times, ensure sleep education is adequately represented in the health curriculum, and routinely assess school night and free night sleep. The Sleep Habits Survey is a brief, validated questionnaire that will identify youth at greatest risk for short school night and free night sleep.

Less healthy eating habits and physical activity patterns reported by youth with later chronotypes forebode poorer health if these behaviors persist into adulthood. The Morningness/Eveningness Questionnaire may be completed and scored briefly during health class. School nurses, together with health educators, can help students identify their chronotype preference relative to their peers. If these findings are replicated in larger studies, innovative individual and environmental strategies aimed at aligning activities with the later sleep-wake patterns characteristic of youth with later chronotypes and preventing further shifts towards lateness may be warranted.

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Table 1

Exclusion Criteria

Phase I	Phase II
Not a full time 9th or 10th grade student	Not a full time 9th or 10th grade student
Restricted school based physical education	Restricted school based physical education
	Pregnancy (self-reported)
	Diagnosed sleep disorder (obstructive sleep apnea, restless leg syndrome)
	Diagnosed medical condition affecting growth
	Diagnosed physical conditions affecting diet/activity levels or making measurement completion difficult
	Developmental disorder
	Acute illness/infection within one week prior to the study (seven days or less prior to measurements)

Table 2

Sample Characteristics

Characteristic	Phase I (N = 115) n (%) or *M (SD)*	Phase II (N = 69) n (%) or *M (SD)*
Age *(M [SD])*	15.41 (0.70)	15.50 (0.65)
Sex (male)	35 (30.43)	18 (26.09)
Race/ethnicity		
Hispanic	43 (37.39)	25 (36.23)
White	35 (30.43)	26 (37.68)
Black	33 (28.70)	15 (21.74)
Asian	4 (3.48)	3 (4.35)
Free/ reduced lunch participation (yes)	75 (65.22)	44 (63.77)
Pubertal category		
mid	16 (13.91)	10 (14.49)
late	18 (15.65)	7 (10.14)
post	81 (70.43)	52 (75.36)
Sleep duration		
School nights *(M [SD])*	7.32 (1.41)	7.07 (0.79)
Free nights *(M [SD])*[a, b]	9.38 (2.00)	8.11 (1.53)
Total night time *(M [SD])*[b]	7.91 (1.22)	7.28 (0.76)
Naps (yes)		
School days	51 (44.34)	28 (40.58)
Free days	68 (59.65)	8 (11.76)
Chronotype		
Morningness/Eveningness *(M [SD])*	26.55 (2.88)	26.88 (4.24)
Midpoint of sleep (corrected *[M [SD]]*[a, b]	3:56 (1:28)	3:39 (1:11)
Social jet lag: hours *(M [SD])*[a, b]	2.56 (1.42)	1.31 (0.91)

Note. M = mean. *SD* = standard deviation.

[a] n = 114 for Phase I,

[b] n = 68 for Phase II.

Table 3

Participants meeting Recommendations for selected Health Behaviors

Recommendation	**Phase I** n (%)	**Phase II** n (%)
Sleeping habits (≥ 9 hours)		
school nights	10 (8.7)	0 (0.0)
free nights	78 (67.8)	16 (23.5)
Eating habits		
Eats ≥ 4 servings of fruit and vegetables per day		
including servings of juice	59 (51.3)	23 (33.3)
without servings of juice	25 (21.7)	15 (21.7)
Drinks ≥ 3 cups milk/day	5 (4.3)	4 (5.8)
Does not drink soda	37 (32.2)	23 (33.3)
Eats breakfast 7 days/week	35 (30.4)	25 (36.2)
Physical activity		
Physically active for 60 minutes 7 days/week	25 (21.7)	15 (21.7)
Played on at least one sports team per year	75 (65.1)	44 (63.8)
Screen time ≤ 2 hours/day	17 (14.7)	12 (17.4)

Table 4

Adjusted Model for the Predictors of Self-reported Free Night Sleep Duration by Demographic Characteristics, Behavioral Characteristics, and Chronotype: Phase I (N = 114)

Parameter	*b*	95% CI	*p*
Race/Ethnicity (reference: Hispanic)			**0.026**
White	−0.40	−1.31, 0.51	0.390
Black	−1.29	−2.16, −0.43	0.009
Asian	−1.25	−3.28, 0.78	0.225
Free/reduced lunch (reference: yes)	0.59	−0.29, 1.42	0.160
school days	0.48	−0.22, 1.18	0.177
free days	−0.63	−1.34, 0.08	0.080
Eating Habits			
fruit/vegetables	−0.21	−0.39, −0.03	**0.024**
soda	−0.01	−0.56, 0.39	0.717
breakfast	0.11	−0.03, 0.24	0.132
Physical Activity			
days active	0.12	−0.04, 0.27	0.150
Social jet lag	0.25	0.00, 0.511	**0.053**

Note. CI = confidence intervals.

Table 5

Adjusted Model for the Prediction of the Morningness/Eveningness Questionnaire by Demographic and Behavioral Characteristics: Phase I (N = 115)

Parameter	***b***	**95% C**	***p***
Age	−0.09	−0.16, −0.01	**0.027**
Sex (reference: females)	−0.25	−1.62, 1.12	0.722
Pubertal category (reference: post)			
Naps (reference: yes)			
school days	0.33	−0.91, 1.57	0.596
free days	3.04	1.80, 4.27	**0.000**
Eating Habits			
fruit/vegetables	0.30	−0.17, 0.61	0.063
soda	−0.63	−1.25, −0.02	**0.045**
breakfast	0.15	−0.09, 0.39	0.208
Physical Activity			
screen time[a]	−0.20	−0.46, 0.07	0.144
days active	0.30	0.00, 0.60	**0.047**
sports	0.17	−0.42, 0.75	0.578

Note. CI: confidence intervals.

[a]N = 114