Published in final edited form as:

J Adolesc Health. 2014 March ; 54(3): 350–356. doi:10.1016/j.jadohealth.2013.09.004.

The Effects of Bedtime and Sleep Duration on Academic and Emotional Outcomes in a Nationally Representative Sample of Adolescents

Lauren D. Asarnow, Eleanor McGlinchey, and Allison G. Harvey

Department of Psychology, University of California, Berkeley

Abstract

Purpose—The overall aim was to clarify and better characterize the sleep/circadian patterns of adolescents in a nationally representative sample.

Methods—Three waves of data from the National Longitudinal Study of Adolescent Health (Add Health) was used to assess sleep/circadian patterns of 2700 adolescents (in grades 7–12).

Results—Late school year bedtime was associated with shorter total sleep time (TST) cross-sectionally, while late summertime bedtime was not. Moreover, late school year bedtime was not associated with late summertime bedtime cross-sectionally. Late school year bedtime in wave I (1994–1995) was associated with worse educational outcomes and emotional distress six to eight years later. Additionally, late summertime bedtime in wave II (1996) was associated with more emotional distress at wave III (2001–2002). Short TST was not associated longitudinally with changes in emotional and academic functioning. Across waves I and II, more than three quarters of adolescents who went to sleep at 11:15 p.m. or later during the school year or 1:30 a.m. or later during the summer reported sleeping fewer than the recommended nine hours.

Conclusions—These findings underscore the significance of evaluating and monitoring bedtime in adolescents and the importance of intervention strategies that target bedtimes in an effort to reduce associated functional impairments, and improve academic and emotional outcomes.

Keywords

eveningness; sleep; adolescents; academic outcomes; emotional outcomes

Teenagers report regular insufficient sleep and excessive daytime sleepiness. Estimates indicate that between 45 and 85% of 6th to 12th grade students report sleeping less than the recommended amount on school nights (1, 2) and 44% of students reporting difficulty staying awake during school (2).

The epidemic of insufficient sleep among adolescents is particularly alarming given the accumulating evidence that sleep is needed to support optimal cognitive and emotional functioning (3,4). In youth, more sleep is consistently associated with better grades in school

© 2013 Society for Adolescent Medicine. Published by Elsevier Inc. All rights reserved.

Please address correspondence concerning the manuscript to Allison G. Harvey, Ph.D., University of California, Berkeley, Department of Psychology, 2205 Tolman Hall #1650, Berkeley, CA 94720-1650, United States. Phone: (510) 642-7138. aharvey@berkeley.edu.

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

(5,6) and sleep quality and quantity are closely related to student learning and academic performance (7). In the emotional domain, prospective studies indicate that half of all lifetime mental disorders start by 14 years of age (8) and evidence indicates that sleep problems in teens predict *worse* mental health (9–13).

Importantly, evidence indicates that the quantity of sleep obtained is not the only contributor to burden. Approximately 40% of teens select later bedtimes, a pattern of behavior often referred to as an *evening* circadian preference (14–16). These evening preference adolescents exhibit a delayed sleep schedule, whereby teens increase activity later in the day and both go to sleep and get up later (17). Factors such as parental monitoring, social influences, academic pressure and technology use may influence bedtime selection in teens (1). However, evening preference has also been linked to the onset and progression of puberty (17). Researchers examined the circadian timing system by measuring the timing of melatonin secretion, demonstrating that more mature children showed a later phase of melatonin secretion offset (18). Consistently, research indicates that 45% of tenth through twelfth graders reported going to bed later than midnight during the school week (19). This tendency towards late bedtimes is problematic. Numerous cross-sectional studies indicate that later bedtimes are associated with adverse outcomes including worse academic performance and more emotional distress (13, 20). One goal of the present study was to evaluate the contributions of later bedtime and inadequate sleep quantity on outcomes in youth longitudinally into adulthood.

There is a critical and understudied distinction between late bedtime and sleep quantity. According to Borbély's two-process model, the sleep-wake cycle is regulated by two processes (21). The first process is the circadian system (Process C) which influences the internal organization of the timing of daily sleep-wake cycles. The second factor (Process S), the sleep homeostat, primarily regulates the length and depth of sleep (21). The two-processes are interrelated and overlapping but are independent. Taken together, this model points to three possible sources of sleep difficulties in adolescents: a circadian process; a sleep process; and the convergence of the two processes. One unique contribution of the present paper is to clarify the significance of these three possible sources of sleep difficulties in adolescents in a large longitudinal epidemiological study. Proxies for the three sleep/circadian variables of interest were utilized. Based on previous research using biological markers of circadian phase and the sleep homeostat the following correlates were used as estimates; summer time bedtime was used as a proxy for the circadian process (22), habitual total sleep time (TST) was used as a proxy for the sleep process (23), and school year bedtime was used as a proxy for the convergence of the sleep and circadian processes (22).

The overall aim of the present study was to better characterize the sleep/circadian patterns of adolescents in a nationally representative sample across three waves of data collection. The first aim was to describe sleep/circadian patterns cross-sectionally. The sleep variables used were: summer bedtime, habitual TST, and school year bedtime. Three hypotheses were tested 1) later school year bedtimes will be associated with shorter habitual TST, 2) later summer time bedtimes will be associated with shorter habitual TST, 3) and later school year bedtimes will be associated with later summertime bedtimes. Our predictions are based on the finding that 1) sleep deprivation in adolescents may be attributable to their bedtime preference and 2) summertime and school year sleep duration differed by 19 minutes on average (22). The second aim is to determine the longitudinal relationship between each sleep/circadian variable at waves I and II and overall cumulative GPA by wave III. We predicted that late summertime bedtime, late school year bedtime, and shorter TST in waves I and II will be associated with worse GPA by wave III. The third aim is to determine the longitudinal relationship between each sleep/circadian variable at waves I and II and emotional health at wave III. We predicted that late summertime bedtime, late school year

bedtime, and short TST in waves I and II will be associated with more emotional distress at wave III.

Methods

Sample

The National Longitudinal Study of Adolescent Health (Add Health) is a longitudinal study in the United States containing data on the health and behavior of adolescents across 3 waves of data collection (see Table 1). The present study included data from the public-use dataset of participants who participated in the first three waves of data collection. The collection of data followed informed consent procedures approved by the institutional review board at the University of North Carolina, Chapel Hill.

Measures

Demographic characteristics assessed included age, gender, race/ethnicity, welfare status and pubertal status. A proxy for *puberty* was obtained via self-reported menarche for girls and levels of voice change for boys (24).

Sleep/circadian variables were determined via self-report measures. *School year bedtime*, a proxy for the convergence of the sleep and circadian processes, was defined by response to the question “During the school year, what time do you usually go to bed on week nights?” The top tertile of school year bedtimes was defined as the *late school year bedtime* group while the middle tertile were defined as the *intermediate school year bedtime* group. The top tertile cutoff for school year bedtimes was later than 11:15 pm in waves I and II. The middle tertile cutoffs were between 10:15 p.m. and 11 p.m. in waves I and II. Participants who responded that they went to sleep between 12 p.m. and 7 p.m. during the school year were excluded from the present study. *Summertime bedtime*, a proxy for the circadian process, was defined by responses to the question, “During the summer, what time do you usually go to bed on week nights?” The top tertile of summertime bedtimes was defined as the *late summertime bedtime* group and the middle tertile was defined as the *intermediate summertime bedtime* group. Summertime bedtime was used in order to best represent adolescent sleep patterns when least constrained by school and/or work obligations (25, 26). Summertime bedtimes were not available for wave I data. The top tertile cutoff was later than 1:30 a.m. in wave II and the middle tertile was between 11:45 p.m. and 1 a.m. Adolescents with early bedtimes were not included in these analyses as we would expect different risk variables associated with those groups. *Total sleep time* (TST), a proxy for the sleep process, was defined by response to the question “How many hours of sleep do you usually get?” Based on empirical research by Carskadon and colleagues (27) indicating that the recommended quantity of sleep for adolescents is 9.2 hours of sleep, *short TST* was defined as adolescents who reported sleeping fewer than the recommended 9 hours of sleep habitually (27, 28). *Adequate TST* was defined as adolescents who reported sleeping 9 or more hours habitually.

The Adolescent Health and Academic Achievement (AHAA) transcript study links Add Health data to educational data. All wave III respondents were asked to complete a release form that authorized study personnel to collect official school transcripts. Academic achievement was measured by cumulative grade point average (GPA) for all years of high school completed by wave III (29). 2684 out of the total 2700 students had completed high school by wave III.

Emotional distress was defined as a composite of feeling sad, feeling depressed, feeling bothered by things that do not normally bother you, not being able to shake the blues for a

lot of the time over the past week and crying more than once a week over the past year (30). Participants who endorsed moderate levels of distress on 2 or more of the emotional distress variables were categorized as distressed.

Statistical Analyses

All analyses compared adolescents with late bedtimes to adolescents in the middle tertile of bedtimes and short TST to the remainder of the sample. Cross-sectional bivariate associations of late bedtimes with demographic characteristics were examined at waves I and II using χ^2 tests for categorical variables and adjusted Wald F tests for continuous variables. All analyses were performed using StataSE 12 (Stata Corp, College Station, TX) using methods for cluster design survey data. Covariates for all analyses included sex, race/ethnicity, welfare status, pubertal status, and age (31).

Sample Size

Of those with data across all three waves ($n = 3342$), 5 people were missing race, 215 were missing welfare status, 25 were missing pubertal status at wave II, and 1 additional respondent was missing bedtime during the summer in wave II. Moreover, 642 people were missing AHAA data. A total of 642 adolescents had missing AHAA or demographic data and therefore were excluded. Thus, the final sample included 2700 adolescents. No significant differences were observed between the group that was excluded due to missing values and those remaining in the sample.

Results

At wave I, 23% ($n = 772$) of the adolescent respondents reported going to bed at 11:15 p.m. or later during the school year. Additionally, at wave I, 73% ($n = 1792$) of the adolescent respondents reported “usually” sleeping fewer than the recommended 9 hours of sleep.

Table 2 provides descriptive data on the sample characteristics for wave I (1994–1995). When compared with the intermediate bedtime group, adolescents with late bedtimes during the school year in wave I were more likely to be older, male and sleep fewer hours per night habitually. When compared with the adequate TST group, adolescents with short TST in wave I were less likely to be Caucasian, more likely to be older, female, postpubertal, and have later school year bedtimes.

At wave II, 22% ($n = 733$) of the adolescent respondents reported going to bed at 1:30 a.m. or later during the summer. Additionally, 23% ($n=757$) of the adolescent respondents reported going to bed at 11:15 p.m. or later during the school year. Moreover, 80% ($n=2038$) report “usually” sleeping fewer than the recommended 9 hours of sleep.

Table 3 provides descriptive data on the sample characteristics for wave II (1996). When compared with the intermediate summertime bedtime group, adolescents with late summertime bedtimes did not significantly differ in any of the demographic characteristics. When compared with adolescents with intermediate school year bedtimes, adolescents with late school year bedtimes in wave II were less likely to be Caucasian, more likely to be older, have a parent who is receiving public assistance, and sleep fewer hours per night habitually. When compared with the adequate TST group, adolescents with short TST at wave II were more likely to be older, female, postpubertal, and go to sleep later during the school year.

Figure 1 displays the distribution of sleep among late and intermediate bedtime teens at waves I and II. Cross-sectional linear regression analyses of bedtime predicting TST, controlling for demographic characteristics were examined among waves I and II. At wave I,

77.64% of late school year bedtime adolescents reported sleeping less than the recommended 9 hours of sleep (Figure 1a) and later bedtime was associated with shorter TST ($B = -.03, p < .05$). In wave II, 91.15% of adolescents with a late school year bedtime got less than 9 hours of sleep (Figure 1b) and later bedtime was associated with shorter TST ($B = -.19, p < .001$). Although 80.49% of adolescents with a late summertime bedtime in wave II slept less than 9 hours (Figure 1c), later bedtime was not significantly associated with shorter TST ($B = -.01, p > .05$). Next, logistic regression analyses controlling for demographic characteristics indicate that school year bedtimes at wave II do not predict summertime bedtimes at wave II ($OR = 1.12, 95\% CI = .83-1.5$).

Table 4 presents linear regression analyses examining the contribution of sleep/circadian patterns in waves I and II prospectively on cumulative high school GPA by wave III controlling for demographic characteristics. Results indicate that late school year bedtimes in both waves I and II predicted a lower cumulative GPA by wave III. However, late summertime bedtime in wave II did not predict a lower cumulative GPA by wave III. Neither short TST in waves I or II predicted GPA by wave III.

Next, we examined whether sleep at waves I and waves II predicted emotional distress in wave III. Results from logistic regression analyses controlling for demographic characteristics are presented in Table 4. The results indicate that late school year bedtimes in wave I predict emotional distress in wave III. Late school year bedtimes in wave II do not predict emotional distress in wave III. However, late summertime bedtimes in wave II predict more emotional distress at wave III. Lastly, short TST in waves I or II did not predict emotional distress in wave III.

Discussion

The first aim was to describe sleep/circadian patterns cross-sectionally in waves I (1994–1995) and II (1996). Across waves I and II, more than three quarters of adolescents who went to sleep at 11:15 p.m. or later during the school year or 1:30 a.m. or later during the summer reported sleeping fewer than the recommended nine hours. Consistent with our first hypothesis, later school year bedtimes were associated with shorter TST in waves I and II. Contrary to our second hypothesis, late summertime bedtime was not associated with shorter TST in wave II. Contrary to our third hypothesis, later school year bedtimes were not associated with late summertime bedtimes in wave II. These findings clarify some important points. First, during the school year when adolescents are required to wake early for school, late bedtime is associated with less sleep. Second, during the summer when bedtimes are unconstrained by early school start times, late bedtime is not necessarily associated with shorter TST. Third, adolescents who go to bed late during the school year are not necessarily the same group of teens who go to bed late during the summer. These findings are consistent with previous research investigating adolescents with late bedtimes (18,19), however they highlight possible concerns with the use of school year bedtime as a marker of late circadian phase. Taken together, these findings point to the importance of the two-process model (21) in the study of adolescents' sleep/circadian patterns. Bedtimes and sleep are clearly interrelated and overlapping processes, but are also independent.

The second aim was to determine the longitudinal relationship between each sleep/circadian variable at waves I and II and overall cumulative GPA by wave III (2001–2002). In partial support of our hypothesis, late bedtime during the school year in waves I and II predicted worse overall academic performance. This result is consistent with previous findings that adolescents with later school year bedtimes reported worse academic outcomes (28). Additionally, previous research found that when adolescents with an evening preference were tested in the morning, they performed worse on cognitive tasks (20). The latter

provides a possible explanation for our finding that late school year bedtime is predictive of GPA. Therefore, late school year bedtimes appear to be a marker of risk within the domain of cognitive academic performance.

Our hypothesis was only partially supported. Contrary to our prediction, late summertime bedtime at wave II was not predictive of academic performance in wave III. Similarly, our prediction that short TST in waves I and II would predict worse cumulative academic performance at wave III was not confirmed. Our finding that short TST was not predictive of cumulative GPA between one and six years later was surprising. There are at least two possible explanations for this finding. First, although cross-sectional studies have indicated that acute sleep deprivation diminishes performance on cognitive tasks (3–4,32), there is a dearth of longitudinal studies on the long-term cognitive effects of sleep deprivation in adolescents. Second, some research suggests that, with maturation, adolescents experience a decrease in sensitivity to sleep deprivation and extended wakefulness (33, 34). Therefore, it is possible that the age of our sample (ages 13–18) represent a group who are less sensitive to sleep deprivation.

The third aim addressed the longitudinal relationship between each sleep/circadian variable at waves I and II and emotional health at wave III. In partial support of this hypothesis, late bedtime during the school year in wave I and late summertime bedtime in wave II predicted greater emotional distress in wave III. This finding is supported by several lines of evidence that indicate that later bedtime is associated with more emotional distress (11–13).

Recall that as part of our third aim we also hypothesized that late school year bedtime in wave II and short TST in waves I and II would predict increased emotional distress in wave III. Contrary to this hypothesis, late bedtime during the school year in wave II did not predict emotional distress in wave III. One possible explanation for this finding comes from research (16), which found that older adolescents with an evening preference (aged 16–18 years) adapt better to sleep irregularity and sleep restriction than younger adolescents (aged 14–16 years). In the present study, the mean age of the wave I late school year and the wave II late summertime bedtime group falls in the 14 to 16 years of age category. Whereas, the mean age of the wave II late school year bedtime group falls into the 16.1 to 18 years of age category. Thus, the older age of the wave II late school year bedtime group could potentially account for the finding that wave II adolescents with late school year bedtime were not at increased risk for emotional distress. Also contrary to the hypothesis, short TST in wave I or II did not predict emotional distress at wave III. Although the acute effects of sleep deprivation on emotion are well documented (3, 35), there has been a dearth of research on the long-term effects of chronic short TST in adolescents.

Taking together, a noteworthy pattern emerges. Later school year bedtime (a proxy for the convergence of the sleep and circadian processes) during the first wave of data collection appears to be the most consistent predictor of academic and emotional risk. Indeed, researchers have posited that adolescents who have difficulty shifting their weeknight bedtime to accommodate an early morning school schedule represent a particularly high-risk group (28). The results imply that future research should focus on school year bedtime, particularly in adolescents aged 14–16, as a prime target for preventative interventions in the emotional and academic domains.

The results of the present study should be interpreted within the confines of several limitations. First, gold standard measures were not used and bedtime during the summer was not assessed at wave I, disallowing comparisons of school year versus summer bedtimes on the wave III outcomes of interest. However, the Add Health questions used as proxies have been used previously (22, 25). Moreover, utilizing an 11:15 p.m. bedtime during the school

year (in waves I and II) and 1:30 a.m. bedtime during the summer (in wave II) as the cutoffs for late bedtimes in adolescents is consistent with previous research (16). Additionally, there are potential concerns with categorizing adolescents who slept fewer than 9 hours as the short TST group. In order to confirm that the results were not due to this cutpoint, we also conducted the analyses by dividing the sample into those who slept fewer than 7 hours¹. The results were similarly non-significant. Moreover, all of the data are based on self-report. While adolescents appear to be largely accurate and reliable on self-report measures (36), there is some concern about the accuracy of reporting. For example, participants may have been influenced by biases such as most recent night or most salient night sleep (37) and adolescents may have incorporated their weekend bedtimes and total sleep times into their assessment of what is “usual”. Although impractical in large data sets, future research in smaller samples should endeavor to use the ‘gold standard’ tools for the measurement of sleep/circadian rhythms such as sleep diaries, actigraphy (38) and/or forced desynchrony protocols (39). Lastly, given the high comorbidity between learning disorders and ADHD with late bedtimes (40) it is possible that the late school year bedtime group may struggle academically for reasons in addition to late bedtimes.

The present data underscore the significance of evaluating and monitoring bedtime in adolescents. Within the domain of academic performance, the data highlight that roughly one third of adolescents, who are unable to get to sleep before 11:30pm during the school year, will likely perform worse in school than their more phase advanced counterparts. Within the domain of emotional health, the data suggest that targeting adolescents (before age 16) with late bedtime patterns may be important. Attention now needs to extend to research on this high-risk group and to interventions designed to mitigate the deleterious consequences of late bedtimes in early adolescence.

Acknowledgments

This project was supported by a Lisa M. Capps Fellowship and a National Science Foundation Graduate Research Fellowship award to LDA, a National Institute of Child Health and Human Development (NICHD) Ruth L. Kirschstein National Research Service Award Predoctoral Fellowship F31-HD058411 awarded to ELM, and grant 1R01HD071065-01A1 from the Eunice Kennedy Shriver National Institute of Child Health and Human Development awarded to AGH.

This research uses data from Add Health, a program project designed by J. Richard Udry, Peter S. Bearman, and Kathleen Mullan Harris, and funded by a grant P01-HD31921 from the Eunice Kennedy Shriver National Institute of Child Health and Human Development, with cooperative funding from 17 other agencies. Special acknowledgment is due Ronald R. Rindfuss and Barbara Entwisle for assistance in the original design. Persons interested in obtaining data files from Add Health should contact Add Health, Carolina Population Center, 123 W. Franklin Street, Chapel Hill, NC 27516-2524 (addhealth@unc.edu). No direct support was received from grant P01-HD31921 for this analysis.

This research uses data from the AHAA study, which was funded by a grant (R01 HD040428-02, Chandra Muller, PI) from the National Institute of Child Health and Human Development, and a grant (REC-0126167, Chandra Muller, PI, and Pedro Reyes, Co-PI) from the National Science Foundation. This research was also supported by grant, 5 R24 HD042849, Population Research Center, awarded to the Population Research Center at The University of Texas at Austin by the Eunice Kennedy Shriver National Institute of Health and Child Development. Opinions reflect those of the authors and do not necessarily reflect those of the granting agencies.

¹Because the literature has found robust effects when short total sleep time is defined as fewer than 6 hours of habitual sleep (10), we also conducted analyses for aims 2 and 3 utilizing fewer than 6 hours as the cutoff for short total sleep time. 132 and 173 adolescents slept fewer than 6 hours habitually in waves 1 and 2 respectively. Sleeping less than 6 hours of sleep habitually at wave 1 ($B=-.3, p<.01$) and wave 2 ($B=-.3, p<.05$) was associated with worse academic outcomes at wave 3. However, sleeping less than 6 hours of sleep habitually at wave 1 ($B=1.3, p>.05$) and wave 2 ($B=1.46, p>.05$) was not associated with emotional distress at wave 3.

References

1. Carskadon MA, Mindell J, Drake C, MA. Contemporary sleep patterns of adolescents in the USA: results of the 2006 National Sleep Foundation Sleep in America poll. *J Sleep Res.* 2006; 5(Suppl 1): 1–93.
2. Calamaro CJ, Mason TB, Ratcliffe SJ. Adolescents living the 24/7 lifestyle: effects of caffeine and technology on sleep duration and daytime functioning. *Pediatrics.* 2009; 123:1005–10.
3. Dinges DF, Pack F, Williams S, et al. Cumulative sleepiness, mood disturbance, and psychomotor vigilance performance decrements during a week of sleep restricted to 4–5 hours per night. *Sleep.* 1997; 20:267–77. [PubMed: 9231952]
4. Drummond SP, Brown GG, Gillin JC, Stricker JL, Wong EC, Buxton RB. Altered brain response to verbal learning following sleep deprivation. *Nature.* 2000; 403:655–7. [PubMed: 10688201]
5. Link SC, Ancoli-Israel S. Sleep and the teenager. *Sleep Res.* 1995; 24:184.
6. Manber R, Pardee RE, Bootzin RR, et al. Changing sleep patterns in adolescence. *Sleep Res.* 1995; 24:106.
7. Spreen O. Prognosis of learning disability. *J Consult Clin Psych.* 1988; 56:836–842.
8. Newman DL, Moffitt TE, Caspi A, Magdol L, Silva PA, Stanton WR. Psychiatric disorder in a birth cohort of young adults: Prevalence, comorbidity, clinical significance, and new case incidence from ages 11–21. *J Consult Clin Psych.* 1996; 64:552.
9. Fredriksen K, Rhodes J, Reddy R, Way N. Sleepless in Chicago: tracking the effects of adolescent sleep loss during the middle school years. *Child Dev.* 2004; 75:84–95. [PubMed: 15015676]
10. Roberts RE, Roberts CR, Duong HT. Sleepless in adolescence: prospective data on sleep deprivation, health and functioning. *J Adolescence.* 2009; 32:1045–57.
11. Gau SF, Shang CY, Merikangas KR, Chiu YN, Soong WT, Cheng AT. Association between morningness-eveningness and behavioral/emotional problems among adolescents. *J Biol Rhythms.* 2007; 22:268–74. [PubMed: 17517916]
12. Chelminski I, Ferraro FR, Petros TV, Plaud JJ. An analysis of the “eveningness-morningness” dimension in “depressive” college students. *J Affect Disord.* 1999; 52:19–29. [PubMed: 10357014]
13. Gaspar-Barba E, Calati R, Cruz-Fuentes CS, et al. Depressive symptomatology is influenced by chronotypes. *J Affect Disord.* 2009; 119:100–6. [PubMed: 19285347]
14. Roenneberg T, Kuehnle T, Pramstaller, et al. A marker for the end of adolescence. *Curr Biology.* 2004; 14:R1038–R1039.
15. Carskadon MA, Acebo C, Richardson GS, Tate BA, Seifer R. An Approach to Studying Circadian Rhythms of Adolescent Humans. *J Biol Rhythms.* 1997; 12:278–289. [PubMed: 9181439]
16. Giannotti F, Cortesi F, Sebastiani T, Ottaviano S. Circadian preference, sleep and daytime behaviour in adolescence. *J Sleep Res.* 2002; 11:191–199. [PubMed: 12220314]
17. Carskadon MA, Vieira C, Acebo C. Association between Puberty and Delayed Sleep Phase Preference. *Sleep.* 1993; 16:258–262. [PubMed: 8506460]
18. Carskadon MA, Wolfson AR, Acebo C, Tzischinsky O, Seifer R. Adolescent sleep patterns, circadian timing, and sleepiness at a transition to early school days. *Sleep.* 1998; 21:871–881. [PubMed: 9871949]
19. Price VA, Coates TJ, Thoresen CE, Grinstead OA. Prevalence and correlates of poor sleep among adolescents. *Am J Dis Child.* 1978; 132:583–586. [PubMed: 655141]
20. Goldstein D, Hahn CS, Hasher L, Zelazo PD. Time of day, Intellectual Performance, and Behavioral Problems in Morning Versus Evening type Adolescents: Is there a Synchrony Effect? *Pers Individ Diff.* 2007; 42:1–9.
21. Borbély AA, Wirz-Justice A. Sleep regulation Introduction. *Human Neurobiology.* 1982; 1:195–204. [PubMed: 7185792]
22. Crowley SJ, Acebo C, Fallone G, Carskadon MA. Estimating dim light melatonin onset (DLMO) phase in adolescents using summer or school-year sleep/wake schedules. *Sleep.* 2006; 29:1632–41. [PubMed: 17252895]

23. Achermann P, Dijk DJ, Brunner DP, Borbély AA. A model of human sleep homeostasis based on EEG slow-wave activity: quantitative comparison of data and simulations. *Brain Res Bull.* 1993; 31:97–113. [PubMed: 8453498]
24. Ge X, Conger RD, Elder GH Jr. Pubertal transition, stressful life events, and the emergence of gender differences in adolescent depressive symptoms. *Dev Psychol.* 2001; 37:404–417. [PubMed: 11370915]
25. Roenneberg T, Wirz-Justice A, Mrosovsky M. Life between Clocks: Daily Temporal Patterns of Human Chronotypes. *J Biol Rhythms.* 2003; 18:80–90.
26. Harvey AG, Mullin BC, Hinshaw SP. Sleep and circadian rhythms in children and adolescents with bipolar disorder. *Dev Psychopathol.* 2006; 18:1147–1168. [PubMed: 17064432]
27. Carskadon MA, Harvey K, Duke P, Anders TF, Litt IF, Dement WC. Pubertal changes in daytime sleepiness. *Sleep.* 2002; 25:453–60.
28. Wolfson AR, Carskadon MA. Sleep schedules and daytime functioning in adolescents. *Child Dev.* 1998; 69:875–87. [PubMed: 9768476]
29. Goodman E, Caplan J. Depressive symptoms and cigarette smoking among teens. *Pediatrics.* 2000; 106:748–755. [PubMed: 11015518]
30. Resnick MD, Bearman PS, Blum, et al. Protecting adolescents from harm: Findings from the National Longitudinal Study on Adolescent Health. *JAMA.* 1997; 278:823–832. [PubMed: 9293990]
31. Knutson KL. The association between pubertal status and sleep duration and quality among a nationally representative sample of U S adolescents. *Am J Hum Biol.* 2005; 17:418–24.
32. Beebe DW, Rose D, Amin R. Adolescent Health Brief: Attention, Learning, and Arousal of Experimentally Sleep-Restricted Adolescents in a Simulated Classroom. *J Adolesc Health.* 2011; 47:523–525. [PubMed: 20970088]
33. Jenni OG, Achermann P, Carskadon MA. Homeostatic sleep regulation in adolescents. *Sleep.* 2005; 28:1446–1454. [PubMed: 16335485]
34. Taylor DJ, Jenni OG, Acebo C, Carskadon MA. Sleep tendency during extended wakefulness: insights into adolescent sleep regulation and behavior. *J Sleep Res.* 2005; 14:239–244. [PubMed: 16120098]
35. Zohar D, Tzischinsky O, Epstein R, Lavie P. The effects of sleep loss on medical residents' emotional reactions to work events: a cognitive-energy model. *Sleep.* 2005; 28:47–54. [PubMed: 15700720]
36. Winters KC, Stinchfield RD, Henly GA, Schwartz RH. Validity of adolescent self-report of alcohol and other drug involvement. *Int J Addict.* 1990; 25:1379–1395. [PubMed: 2132719]
37. Schacter, DL. *The Seven Sins of Memory: How the Mind Forgets and Remembers.* New York: Houghton Mifflin Harcourt; 2001.
38. Sadeh A, Hauri PJ, Kripke DF, Lavie P. The role of actigraphy in the evaluation of sleep disorders. *Sleep.* 1995; 18:288–302. [PubMed: 7618029]
39. Dijk DJ, Czeisler CA. Contribution of the circadian pacemaker and the sleep homeostat to sleep propensity, sleep structure, electroencephalographic slow waves, and sleep spindle activity in humans. *J Neurosci.* 1995; 15:3526–3538. [PubMed: 7751928]
40. Owens JA, Maxim R, Nobile C, McGuinn M, Msaal M. Parental and self-report of sleep in children with attention-deficit/hyperactivity disorder. *Arch Pediatr Adolesc Med.* 2000; 154:549. [PubMed: 10850500]

Implications and Contribution

The unique contribution of the present paper is to clarify the significance of late bedtime, sleep duration, and sleep constrained by school start times on academic and emotional outcomes. The data suggest that roughly one third of adolescents with late bedtimes perform worse in school and experience increased emotional distress than their more phase-advanced counterparts.

Figure 1.

Distribution of hours of sleep of adolescents with late and intermediate school year bedtimes in wave I (a), adolescents with late and intermediate school year bedtimes in wave II (b), and late and intermediate summertime bedtimes in wave II (c).

Table 1

Time points for three waves of data collection and variables used in each wave.

	Wave I (1995) Grades 7–12	Wave II (1996) Grades 8–12	Wave III (2001–2002) Ages 18–26
School Year Bedtime	X	X	
Summertime Bedtime		X	
Total Sleep Time	X	X	
Academic Achievement ^a			X
Emotional Distress			X

Note. X values indicate that the variable was available for that wave of data.

^aThe AHA transcript release form was signed during wave III of data collection, however the academic outcome data provided in wave III reflects overall cumulative high school GPA by wave III of data collection.

Table 2

Comparison of Adolescents with Late and Intermediate School Year Bedtimes, and Short and Adequate Total Sleep Times in Wave I (1994–1995)
Sample Characteristics

	School Year Bedtimes			Total Sleep Time		
	Late n=772		Intermediate n=1111	Short n=1792		Adequate n=908
	Mean (SD) or %	Mean (SD) or %	p	Mean (SD) or %	Mean (SD) or %	p
Age	15.67 (1.57)	15.2 (1.54)	.00	15.2 (1.62)	14.44 (1.44)	.00
Biological Sex						
Male/Female	48/52%	44/56%	0.05	43/57%	48/52%	0.01
Race/ Ethnicity						
Caucasian	57.07%	60.85%	0.09	60.03%	65.56%	.00
African American	26.46%	22.95%	0.08	23.77%	17.88%	.00
Hispanic/Latino	7.78%	8.19%	0.74	7.57%	8.17%	0.57
Asian/Pacific Islander	4.54%	4.32%	0.83	4.61%	3.09%	0.05
Native American	4.15%	3.69%	0.62	4.03%	5.30%	0.11
Parent receives public assistance	8.13%	7.86%	0.83	8.00%	9.26%	0.2
Postpubertal	74.84%	74.89%	0.94	74.78%	65.07%	.00
Hours of Sleep	7.5 (1.77)	7.7 (1.18)	0.02	7.27 (.95)	9.58 (.88)	.00
Bedtime	12:31 a.m. (1.13)	10:47 p.m. (.25)	.00	10:44 p.m. (1.18)	10:19 p.m. (1.34)	.00

Note. *p* values represent the results from chi-square analyses for categorical variables and students *t*-tests for continuous variables; all time values are hours and minutes (hh:mm); SD= standard deviation.

Table 3

Comparison of Adolescents with Late and Intermediate School Year Bedtimes, Late and Intermediate Summertime Bedtimes, and Short and Adequate Total Sleep Times in Wave II (1996) Sample Characteristics

	School Year Bedtimes				Summertime Bedtimes				Total Sleep Time			
	Late n=757		Intermediate n=1231		Late n=733		Intermediate n=1334		Short n=2038		Adequate n=662	
	Mean (SD) or %	p	Mean (SD) or %	p	Mean (SD) or %	p	Mean (SD) or %	p	Mean (SD) or %	p	Mean (SD) or %	p
Age	16.71 (1.54)		15.99 (1.58)	.00	15.93 (1.62)		15.89 (1.67)	0.69	15.99 (1.64)		15.43 (1.61)	.00
Male/Female	47/53%		46/54%	0.87	45/55%		45/55%	0.74	44/56%		48/52%	0.05
Race/ Ethnicity												
Caucasian	55.76%		63.04%	.00	62.16%		61.56%	0.79	61.19%		62.93%	0.42
African American	26.36%		21.85%	0.02	21.17%		21.62%	0.81	22.64%		20.27%	0.19
Hispanic/Latino	8.74%		7.96%	0.55	7.65%		7.88%	0.85	7.81%		7.41%	0.73
Asian/Pacific Islander	5.30%		3.09%	0.01	5.46%		4.35%	0.26	4.30%		3.78%	0.55
Native American	3.84%		4.06%	0.8	3.55%		4.58%	0.27	4.07%		5.60%	0.09
Receives public assistance	9.28%		6.14%	0.02	7.92%		7.86%	0.87	8.00%		9.82%	0.14
Postpubertal	79.09%		77.94%	0.61	76.79%		75.64%	0.59	77.75%		71.78%	.00
Hours of Sleep	6.88 (1.54)		7.54 (1.33)	.00	7.66 (1.34)		7.66 (1.41)	0.94	7.14 (.98)		9.64 (1.08)	.00
Bedtime												
School Year	12:42 a.m. (1.02)		10:46 p.m. (.25)	.00	10:34 p.m. (1.09)		10:36 p.m. (1.22)	0.52	10:44 p.m. (1.1)		10:06 p.m. (1.08)	.00
Summertime	12:16 a.m. (1.97)		12:10 a.m. (1.91)	0.31	2:42 a.m. (1.26)		12:25 a.m. (.47)	.00	12:14 a.m. (1.99)		12:14 a.m. (1.64)	0.92

Note. *p* values represent the results from chi-square analyses for categorical variables and students *t*-tests for continuous variables; all time values are hours and minutes (hh:mm); SD= standard deviation

Weighted beta coefficients, odds ratios, p values and 95% confidence intervals for all predictors from regression models predicting cumulative GPA and emotional distress at wave III

Table 4

	Wave III Cumulative GPA		Wave III Emotional Distress	
	β	p	OR	p
		95% CI		95% CI
School Year Bedtimes				
Wave I Late School Year Bedtimes	-.27	<.001***	1.35	<.05*
Wave II Late School Year Bedtimes	-.13	<.01**	1.26	>.05
Summertime Bedtimes				
Wave II Late Summertime Bedtimes	.01	>.05	1.4	<.01***
Total Sleep Times				
Wave I Short TST	.07	>.05	.95	>.05
Wave II Short TST	.08	>.05	1.13	>.05

Note. TST= total sleep time; OR= odds ratio; CI= confidence interval.

*
p < .05.

**
p < .01.

p < .001.