Social Ties and Adolescent Sleep Disruption

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Abstract

Teens tend go to bed later, get less sleep, and report more daytime sleepiness. Medical research emphasizes biological determinants of teens' disrupted sleep (i.e., the timing of puberty and resultant drops in melatonin), rarely or inadequately considering youths' social ties as a determinant of sleep behaviors. Sociologists recognize how social ties affect health behaviors but have generally neglected sleep, especially among teens. Drawing on a sample of 974 teens from the Study of Early Child Care and Youth Development, this study controls for developmental and social relational factors to predict changes in youths' sleep patterns between 12 and 15 years of age. In general, social relational factors outperform developmental factors in determining youths' sleep patterns, particularly pointing to the importance of parental, peer, and school ties in promoting healthy sleep behaviors. The implications of these findings for further research are briefly discussed.

Keywords

adolescents, health behaviors, longitudinal, sleep, social ties

Scholars are increasingly recognizing the importance of sleep for the behavioral and emotional health of adolescents. Studies show that insufficient sleep affects daytime cognitive and behavioral functioning (Sadeh, Gruber, and Raviv 2003), academic performance (Taras and Potts-Datema 2005), suffering from depression and obesity (Knutson and Lauderdale 2007; Mueller, Bridges, and Goddard 2011), and engaging in deviant behavior (Clinkinbeard et al. 2011). Although the long-term consequences of cumulative sleep debt are still unknown, one study suggests that dysfunctional sleep patterns in the teen years extend into adulthood (Calamaro, Mason, and Radcliffe 2009).

Whereas sleep is an important determinant of adolescent functioning, there is little social science research on sleep as an outcome. Medical research shows that in contrast to their rather stable and longer sleep schedules in childhood, teens go to bed later, get less sleep on school days, and sleep longer into the day on weekends (Carskadon 1990, 2002). Medical research focuses on developmental

factors as an explanation for changes in youths' sleep, specifically the decline in melatonin (a sleep-inducing hormone) that accompanies developmental changes in puberty. Although medical researchers do consider youths' lives in context, rarely do they conduct multivariate analyses examining the relative influence of youths' associations and activities on sleep. Social scientists have demonstrated that one's social relations (with spouses, parents, friends, etc.) determines health-related behaviors, mostly among adults (for a review, see Umberson, Crosnoe, and Reczek 2010), and including sleep (Burgard 2011; Burgard and Ailshire 2009; Maume, Sebastian, and Bardo 2009). However, there is a paucity of research on

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the social determinants of changes in youths' sleep. This is an important omission given the "long arm of childhood," or the idea that the trajectories of health behaviors in adolescence extend well into adulthood (Haas 2008).

This study draws on contributions from the medical and social science literatures to examine the determinants of youth sleep patterns. Focusing on the stage in the life course between the end of elementary school (grade 6) and the beginning of high school (grade 9), I examine the influence of social ties on shorter sleep duration and increased sleep disruption over the interval. Estimating a lagged model of sleep patterns that includes a control for biological development, this study poses the following research question: do the stresses, supports, and social control found in teens' social ties influence sleep behaviors?

BACKGROUND

The Medical Model of Adolescent Sleep

Adolescence is a time in the life course marked by changes in sleep patterns concurrent with significant growth in youths' autonomy and independence. Regarding sleep patterns, the average elementary school–age child goes to bed at 9 p.m. and arises at 7 a.m. to prepare for school, a sleep-wake pattern that he or she maintains on weekends and during the summer. In high school, teenagers tend to go to bed later and arise early to get to school (the average school start time is 7:30 a.m.; Carskadon 2002). On weekdays, adolescents still need 9 to 10 hours of sleep to function optimally (Dahl and Lewin 2002), but only one fifth of high school students get this much sleep on school nights (National Sleep Foundation 2006:7). In extreme cases, sleep-deprived teens exhibit levels of daytime sleepiness that approach those observed in adults suffering from narcolepsy and sleep apnea (Kothare and Kaleyias 2008; Wolfson and Carskadon 1998). On weekends (and in the summer), teenagers often go to bed much later (between midnight and 3 a.m.) and sleep until noon or later, a pattern called "delayed phase preference" (Carskadon 2002).

Over the past two decades, sleep researchers have come to believe that adolescent sleep patterns are governed by biological processes (Beebe 2008; Carskadon 2002). On one hand, normal aging affects sleep regulation in that newborns need about 16 hours of sleep per day, but adults need only about 8 hours of sleep (Anders, Sadell, and

Appareddy 1995). On the other hand, the marked decline in sleep duration suggests that adolescence is a unique point in the life course. Puberty is the obvious developmental factor associated with adolescence and altered sleep. Among other things, puberty is associated with alterations in circadian rhythms and changes in hormones affecting sleep (Dahl and Lewin 2002). In particular, sleep researchers have found lower levels of melatonin (a hormone that is secreted after dark that heightens feelings of fatigue and drowsiness) in teens at midpuberty (Carskadon, Vieira, and Acebo 1993; Kryger, Roth, and Carskadon 1994; Lewy and Sack 1989). These findings provide a biological explanation for adolescents' later bedtimes, and when combined with forced early-rise times to get to high school, this would account for why most teens get insufficient sleep (Carskadon 2002). Furthermore, teens' tendency to sleep longer into the day on weekends exacerbates the problem of sleep debt. Although teens shift rapidly their sleep-wake times between weekdays and weekends, the body's circadian systems are slower to adjust. Consequently, teens' bodies are taxed even further, leading to a vicious cycle of difficulties in falling asleep at night and early awakening on weekday mornings (Dahl and Lewin 2002). On the basis of these findings, some sleep researchers have become vocal proponents of starting high school 1 or 2 hours later to be more synchronous with teens' biological clocks (for a review of issues pertaining to high school start times, see Wahlstrom 2002).

Sleep researchers have not entirely ignored the role of social context in studying sleep patterns. Indeed, sleep researchers contend that because sleep involves the loss of most sensory perception of the environment, all species develop behaviors to ensure their safety when sleeping (e.g., burrowing, nests, niches free from predators). The anthropological record shows that the human brain evolved under conditions in which a close-knit social group facilitated constant vigilance against predators at all hours, providing a sense of safety and security necessary for sleeping at night (McKenna and Mack 1992). This argument is relevant to an understanding of human sleep, in that conflict or weak bonds with others trigger anxiety that disrupts sleep; conversely, strong feelings of love and acceptance in one's social circles will create a sense of safety that is conducive to healthy sleep (Dahl 2002). With this insight, sleep researchers do examine social influences on teen sleep, but often in weak analytic designs that fail to capture fully the complexity of youths' lives that would affect

their sleep. I elaborate on this point below, while also reviewing sociological research on social ties and health behaviors. Ultimately, synthesizing these two literatures fosters a comprehensive understanding of the determinants of changing sleep habits in adolescence.

Social Ties and Teen Sleep

Since Durkheim (1897) linked group variation in social integration and suicide rates, sociologists have long understood that social relationships affect health. In their review of the extensive literature on this association, Umberson et al. (2010) described several mechanisms by which the content of social ties affects health behaviors.[1] First, relationships provide individuals with social support, giving them a sense that that they are loved, listened to, and cared for and that group members will provide advice and assistance when individuals encounter life's challenges. Studies show that close ties to others have beneficial effects on physical health, lowering heart rates, blood pressure, and levels of stress (Cohen 2004; Uchino 2004). Given that sleep researchers posit that stress and elevated heart rates interfere with sleep (for reviews, see Beebe 2008; Dahl 2002), we may anticipate that close ties with important actors in one's life is linked to healthy sleep. Second, besides being emotionally sustaining, relationships have a "dark side," in that ties with others can be stressful, worrisome, and laden with conflict (Umberson and Montez 2010); if so, this should increase stress and physiological arousal that would interfere with sleep, particularly if stressful ties proliferate in youths' lives (Pearlin et al. 2005). Third, social relationships can control individuals by instilling in them a sense of responsibility or concern for others that is, in part, manifested in behaviors that protect their health. Furthermore, Umberson et al. contended that "it is the constellation of social ties, not any single tie, [that] matters most for health habits in adolescence" (2010:142), and they went on to show how various social ties influence a range of adolescent behaviors, including diet, exercise, and substance use. But because social scientists have generally ignored sleep as a health behavior, it is necessary to also draw on medical research on sleep to better understand how social ties affects teens' sleep.

The first and most important social tie in children's lives is to their families, with theory and research findings suggesting that families can be sources of stress and social support and provide the social control that shapes children's health behaviors. Much research has focused on changes in family structure with teens using substances to reduce the stressful effects of family dissolution due to death or divorce (Biblarz and Gottainer 2000); teens also suffer more stress and use more substances when a parent remarries (Cherlin 2009). Social scientists have also shown that warm connections with parents are an important deterrent to problem behaviors in adolescence (Hirschi 1969; Uchino 2004) and that parental social control, specifically keeping tabs on them and knowing their whereabouts, reduces teens' engagement in risky behaviors (Borawski et al. 2003; Soenens et al. 2006). Yet social scientists have not examined how the content of social ties affects teen sleep habits.

Sleep researchers have examined stress in the family (particularly poverty and divorce), showing that children's insecurity and anxiety grow when their parents break up or their families are economically distressed, and they suffer sleep disruption as a result (Dahl 2002; Nilzon and Palmerus 1997). Most of the family stress studies have focused on preadolescent children, but parental warmth and disciplinary standards have also been associated with improved sleep among teens (for a review, see Keller, Buckhalt, and El-Sheikh 2008). In their review of research on youths' sleep in family context, Keller et al. noted that most samples are small and use matched-sample designs. That is, after treating a sample of problem sleepers, analysts find a sample of healthy sleepers matched by age and then make comparisons between the two groups on measures of family structure and functioning. Of course, many potential confounding influences on sleep are not controlled in this research design; for example, economically distressed families are more unstable (Cherlin 2009), and it may be worry over the family's economic status that disrupts youths' sleep rather than the type of family they live in per se. A more comprehensive study (Adam, Snell, and Pendry 2007) measured sleep from time diaries and found that teens went to bed earlier on school nights when their parents were firm in setting rules for their behavior, yet other relational influences (particularly school ties and peer attachment) on teens' sleep were not examined in this study.

With regard to school, sleep researchers have shown that disrupted sleep is harmful to academic performance but have paid little attention to the reverse proposition that school stressors may disrupt sleep (Wahlstrom 2002). Studies have shown that compared with grades in elementary school,

grades in high school are lower, for which some blame the social organization of high schools (Eccles and Roeser 2009). In contrast to elementary school, where students can form close attachments to adult mentors who cared about them, the larger and more bureaucratic atmosphere in high school undermines a sense of community between teachers and students, and teens feel more alone and frustrated in trying to succeed in this environment (Bryk, Lee, and Holland 1989). Sleep researchers have generally ignored school contextual effects on teen sleep, but one study drawing on case reports found that the demands of homework are the modal reason why adolescents stay up late on school nights (Noland et al. 2009). Yet youths can bond with teachers and counselors who provide them with a sense of connectedness and security. Other studies identify attachment to schools as fostering the mental health of teens (McNeely and Falci 2004; Meadows 2007) and reducing substance use (Crosnoe 2006). Yet there is a paucity of studies examining the relative strength of academic-related stressors or school social support on teen sleep patterns.

There is much evidence that teens' peer associations are an important determinant of health-related behaviors (Gaughan 2006; Knoester, Haynie, and Stephens 2006), but the peer-sleep relationship has drawn much less attention from researchers. On one hand, sleep researchers recognize that networking with friends is a factor that leads to later bedtimes on school nights, and so too does watching television and using the computer. Indeed, medical case reports implicate interest in popular culture as the main reason why teens network on the computer and watch television on most nights and get insufficient sleep as a result (Carskadon 2002; Noland et al. 2009; Sadeh, Raviv, and Gruber 2000). Yet by definition, medical case reports selectively report associations with problems in sleeping and are not designed to rule out confounding influences on teen sleep patterns. In general, sleep researchers have failed to investigate how friendships affect teen sleep in models with appropriate controls. Social science research shows that having supportive friends reduces depression and other emotional problems (Bao, Whitbeck, and Hoyt 2000; Cornwell 2003), which would presumably increase teens' likelihood of sleeping well. Yet, to my knowledge, social scientists have not investigated the association between peer group ties and teens' sleep.

A final important social tie that may affect youths' sleep is employment. One study of adults showed that stress at work, particularly being frequently bothered or upset at work, reduced sleep quality (Burgard and Ailshire 2009). There is little to suggest that supports from work may facilitate healthy sleep; rather, social science research on youth work emphasizes employment's effects on substance use and emotional well-being. That is, work exposes youths to adult behaviors (both good and bad) among coworkers, and the "premature affluence" that comes from earning a paycheck affords teens the means to engage in adultlike deviance, such as using substances (Cullen 1994; Mortimer 2003), although it is not clear whether or how sleep moderates the relationship between work and deviance. It may be more useful to view work as sleep researchers do, that is, as an afternoon or evening activity that competes with other responsibilities (such as homework) that results in youths' getting less sleep. Two studies showed that high school students who work 20 or more hours per week had more episodes of oversleeping on school mornings and were more likely to fall asleep during school (Carskadon 1990; Carskadon, Mancuso, and Rosekind 1989). Yet little is known about the work-sleep link beyond these findings. One survey of the literature on work effects on sleep found a preponderance of studies of adults working the late shift, making little mention of youth work (Rosa 2002).

Summary and Assessment of Prior Studies

As the brief review above shows, disrupted sleep is a widespread and serious problem among teens, determined by both biological processes and social relational factors. Yet the extant literature on youth sleep is limited in two ways that suggest the need for further research. First, I am unaware of any study that examines the relative strength of developmental factors (i.e., going through puberty) and social ties in predicting teens' sleep. Sleep researchers emphasize the importance of biological processes in affecting teen sleep habits and either ignore or inadequately take into account the social context of youths' lives; sociologists have shown that social ties affect many health behaviors but have ignored sleep. The best study that bridges these literatures is that of Adam et al. (2007),

focusing on the sleep effects of family dysfunction and time use, but that study lacked measures of other key associations in youths' lives (e.g., peer support and school attachment), and the only control for development was the child's age. This study has direct measures of adolescents' pubertal stage development and delayed phase preference (both of which are associated with a decline in melatonin), which when combined with a comprehensive accounting of youths' social ties enable an assessment of the predictive power of biological versus social influences on teens' sleep patterns.

Second, almost all of the studies of youths' sleep cited above are methodologically limited, potentially biasing their findings. For example, much sleep research analyzes cases, searching for commonalities or differences among patients who seek treatment for a sleep problem. Not only are these studies not designed to rule out confounding effects on the social risk factors for sleep problems, but they sample on the dependent variable (i.e., those who seek medical help for sleep problems), threatening the external validity of their findings. Even studies using random samples and estimating comprehensive models of teen sleep (e.g., Adam et al. 2007) cannot rule out endogeneity biasing their findings. That is, it may be that as youths become "night owls" as they get older, relationships with friends and family deteriorate, as does academic performance, suggesting that it is sleep problems that affect teens' social relationships rather than the reverse associations being true. This study overcomes these concerns by sampling widely and using longitudinal data to model sleep patterns at time 2 as a function of sleep patterns at time 1, social relationships at time 1, and changes in social relationships between time 1 and time 2. The lagged model allows most of the variation in time 2 sleep habits to be accounted for by time 1 sleep habits, thereby statistically isolating the effects of social ties on teen sleep apart from past problems in sleeping. Furthermore, the longitudinal nature of the data enables a distinction in sleep effects between the prior context of youths' lives (time 1 measures) and more recent changes in their lives (changes between time 1 and time 2 measures). The design of this study increases the likelihood that significant social determinants of teens' sleep are both robust and causal.

DATA AND METHODS

Sample

This study draws on the Study of Early Child Care and Youth Development (SECCYD), a longitudinal study of children's physical, cognitive, and social development funded by the Eunice Kennedy Shriver National Institute of Child Health and Human Development. Mothers in 10 catchment areas were recruited into the study after giving birth in 1991. The original 1,364 families were representative of families in the geographic areas from which they were recruited. Although not representative of the U.S. population, the sample has comprehensive data on all aspects of a child's development until 15 years of age (for more details on the recruitment strategy, sampling, and representativeness of the SECCYD families, see NICHD Early Child Care Research Network 2001). Mothers were the primary source of information about their children's development (and their families' status)[2]; after fifth grade, children also reported their own attitudes, experiences, and behaviors. Furthermore, at periodic intervals children were examined and tested in clinics to assess their physical, social, and cognitive development.

As is often the case with large-scale longitudinal studies, attrition from the sample disproportionately occurs among those of lower socioeconomic status (NICHD Early Child Care Research Network 2001). By age 15 years, the sample consisted of 974 (of the original 1,364) focal children, half of whom were girls and 80 percent of whom were white. For this analysis, the analytic measures were taken from children at grade 6 (roughly age 12) and age 15 because at these ages, youths were reporting on their own life experiences, including their sleep patterns. Table 1 presents descriptive statistics (including percentage missing cases on predictor variables) on the measures used to analyze teens' sleep patterns.

Sleep Measures

In a module called "My Sleep," children reported on their own sleep habits at ages 12 and 15 years (the SECCYD did not ask about sleep patterns at ages 13 and 14). First, the SECCYD asked about times going to bed and arising on school days in

Table 1. Descriptive Statistics on Variables in the Analytic Model.

Variable	M	SD	Minimum	Maximum	% Missing
Sleep measures					
Hours of sleep on school nights, age 15	7.81	1.17	3.00	12.00	0
Hours of sleep on school nights, G6	9.23	.81	6.00	12.00	5.86
Sleep disruption index, age 15	21.64	5.20	8.00	40.00	0
Sleep disruption index, G6	19.50	5.04	8.00	36.00	2.67
Family status, stress, support					
Mother's partner leaves HH, G6 to age 15	.07	.25	0	1.00	6.67
Mother has new partner in HH, G6 to age 15	.03	.17	0	1.00	3.33
Income-to-needs ratio, G6	4.28	2.93	.11	12.00	6.37
Change in income-to-needs ratio, age 15	.38	1.74	−11.21	9.51	11.19
Parental bond index, G6	32.24	4.08	12.00	36.00	2.67
Change in parental bond index, age 15	−2.15	4.79	−20.00	17.00	2.67
Parental monitoring index, G6	3.52	.37	1.89	4.00	2.87
Change in parental monitoring index, age 15	−.33	.47	−2.22	1.44	3.08
Consistent set bedtime on school nights, G6 and age 15	.43	.49	0	1.00	0
School/peer stress and support					
Weekly hours of homework, G6	4.64	2.33	0	7.50	2.63
Change in weekly hours of homework, age 15	2.56	5.78	−7.50	25.00	2.63
School attachment index, G6	3.46	.51	1.20	4.00	4.52
Change in school attachment, age 15	−.16	.59	−2.60	2.40	5.44
Positive peer associations, G6	61.80	6.39	32.00	75.00	2.77
Change in peer associations, age 15	−4.59	7.95	−53.00	28.93	2.87
Time use					
Held a job in last year, age 15	.34	.47	0	1.00	.31
Hours per week watching TV, G6	17.41	10.15	0	42.00	2.77
Change in hours per week watching TV, age 15	.54	10.78	−42.00	42.00	2.98
Intensity of computer use, G6	14.05	8.83	0	32.00	2.77
Change in intensity of computer use, age 15	3.52	9.70	−32.00	32.00	3.18
Development and controls					
Pubertal development (1 = late, 4 = mature at age 13)	2.44	.81	1.00	4.00	10.47
Prefer later sleep, arise, and daytime activities, age 15	0	1.07	−3.00	2.98	0
Nonwhite	.50	.50	0	1.00	0
Female	.19	.39	0	1.00	0

Note: N = 974 children in the Study of Early Child Care and Youth Development; missing data were imputed using maximum likelihood. G6 = grade 6; HH = household.

broad 1-hour intervals. After recoding the time categories to their midpoints,[3] sleep duration on school nights was calculated as the difference between retiring and arising times. There may be two sources of error in this measure: (1) recalling retiring and arising times may not be as accurate as when recorded in daily time diaries (Adam et al. 2007), and (2) the difference between retiring and arising times may measure time in bed, which may be an overestimate of time asleep. Nevertheless, to

be consistent with many prior sleep analyses using recall measures (for reviews, see Carskadon 2002; Dahl 2002; Ivanenko 2008), this study uses this measure as a rough approximation of the duration of sleep on school nights. A second composite measure of sleep problems was constructed from questions on how often in the past month youths experienced eight common sleep problems ("have difficulty falling asleep on school nights," "woke up in the middle of the night and couldn't get back to sleep," "had trouble getting up on school mornings," "wish you could get more sleep," "feel tired on school days," and "worried about [homework/ friends/family] that kept you from falling asleep"); responses varied from 1 ("never") to 5 ("always"). The sleep disruption indices were the sum of the composite items and have an α reliability of .78 in both years.

The Content of Social Ties: Stress, Control, and Support

Except when noted, self-report measures of youths' social ties are taken at age 12 (or grade 6) to capture initial effects of social factors on sleep and the difference between age 15 and age 12 scores on social factors capture recent changes in youths' lives. Beginning with the family, past sleep studies have focused on changes in family structure and poverty as sources of stress that will disrupt youths' sleep. At regular intervals, the SECCYD asked mothers of focal children to report on their marital status and household composition. Between grade 6 and age 15, 90 percent of all children lived in households of constant composition (almost all of whom were either married-couple or single-mother households). Children in stable family types were the reference group for two binary family transitions over the interval, mother's partner left the household (mostly through separation or divorce; only a handful of mothers were widowed) or mother has new partner in the household (about half of whom were spouses and half live-in boyfriends). Regarding the family's economic status, SECCYD staff members calculated the income-to-needs ratio of total family income (from all sources) to the family's census-defined poverty threshold.[4] An income-to-needs ratio less than 1 indicates that a family is poor, whereas a ratio

greater than 5 indicates a relatively affluent family (outlier values were recoded to the 95th percentile score: 12 in grade 6 and 15 at age 15). The temporal difference in the ratios captured changes in the family's income status over the interval.

To capture parental support that may facilitate healthy sleep, youths were presented with nine items asking how often (1 = "never," 4 = "always") mothers and fathers acted with warmth and support (e.g., "tells you that s/he loves you"; nonresidential parents had missing data on all items).[5] The items were summed to create the parental bonds indices (α reliability > .9 in both years) for both parents, and the higher value of the mother or father's score was taken as the measure of parental support. Parental social control may also structure youths' behaviors, including sleep. To account for this, youths were presented with nine items asking how much their parents knew about their activities (e.g., "where you go right after school"); the parental monitoring indices were the mean of the items (α reliabilities > .8 in both years), with higher values (ranging from 1 to 4) indicating that teens' parents kept close tabs on them.[6] A final measure of parental control was a binary measure scored 1 when children's parents established a set bedtime for them when they were 12 years old and still insisted on a set bedtime at age 15; parents without set bedtimes at ages 12 and 15 or who were inconsistent in setting bedtimes over the interval were scored 0.

Just as family ties can be both stressors and supports for sleep, the stress of academic demands and support from school personnel may affect youths' sleep behaviors. Regarding academic stressors, youths were asked to report how often they did homework at home; responses were converted to weekly hours of homework.[7] To tap supportive school environments, youths responded to five statements about their schools (e.g., "I feel close to others at my school") with responses ranging from 1 ("not at all true") to 4 ("very true"); the school attachment index was the mean of the five items (α reliabilities exceeded .76 in both years).[8]

Much research shows that peers influence teen health behaviors for better or for worse. To account for this, youths were asked to describe their friends in terms of their academic (e.g., "they read books for fun") and moral (e.g., "they go to church")

behaviors. Responses ranged from 1 ("none of them") to 5 ("all of them"), and the sum of the 15 items yielded the positive peer associations index score (α reliabilities exceeded .84 in both years).[9]

Time Use

Given that time is finite, sleep researchers theorize that time for sleep is reduced with increases in time spent in after-school and evening activities. First, at age 15, youths reported if they had held jobs in the past year (1 = yes, 0 = no).[10] Second, the survey asked how many days per week and usual hours per day youths watched television (responses were converted to weekly hours of television viewing). Similarly, the intensity of computer use was the product of use in the prior month (0 = "never," 4 = "every day") and a checklist of eight reasons for using the computer (e.g., to do homework, send e-mail, visit chat rooms, send instant messages); the scale ranged from 0 to 32.

Pubertal Development and Controls

Sleep researchers regard puberty as the primary developmental factor affecting adolescent sleep patterns, because decreases in melatonin during puberty are associated with later bedtimes, shorter sleep durations, and more daytime dysfunction. Of course, puberty is not a categorical state but rather occurs over several years and is primarily marked by the maturation of secondary sexual characteristics (Tanner 1962). Beginning at age nine, and every year thereafter, nurses examined youths in a clinical setting, and the SECCYD asked mothers about their children's physical development. Using pictures, mothers and health professionals assessed the Tanner stage of pubic hair development, breast development in girls, and genital development in boys. The Tanner classification system ranges from 1 ("prepubertal") to 5 ("sexually mature"); in years when nurse assessments were missing, the mother's rating of the child's pubertal development was used.

Youths' pace of pubertal development was assessed using a latent class trajectory model, in which the repeated observations of Tanner stage score were modeled a function of age. This technique assumes that the sample is composed of a set
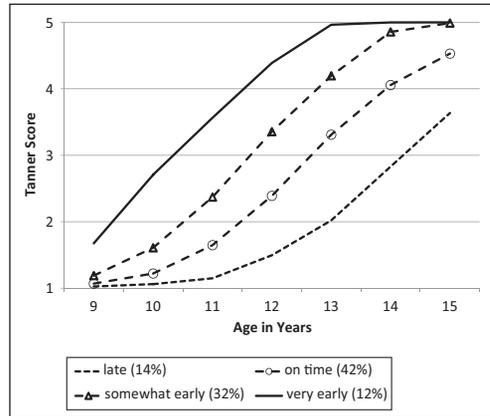

Figure 1. Trajectories of Pubertal Development by Age.

of discrete classes or groups with similar pubertal development trajectories as they age; the question for the analyst is how many different pubertal trajectory groups describe this sample of adolescents (and how large is each trajectory group). The Proc Traj user-defined software package (available in SAS) uses maximum likelihood procedures to answer this question (Jones, Nagin, and Roeder 2001). I first estimated a one-group solution, then two-, three-, four-, and five-group models; model fit was assessed by comparing likelihood ratio statistics and the Bayesian information criterion across models. The best fitting model was the four-group model shown in Figure 1. Starting with the trajectory group closest to the *x*-axis and moving up, group 1 includes the "late bloomers" who have not yet reached Tanner stage 4 at age 15 (14 percent of youths). Group 2, or the "on-timers," is the largest group (42 percent of the sample), having nearly reached full sexual maturity by age 15. The "somewhat early bloomers," group 3, reached Tanner stage 5 by age 14 (32 percent of youths), and group 4 (the "very early bloomers") had reached Tanner stage 5 by age 13 (12 percent of adolescents). In the analytic models, pubertal development group varies from 1 to 4, with higher values signifying an earlier completion of puberty. The earlier youths reached sexual maturity, the more likely they were to adapt to adultlike sleep patterns (Dahl and Lewin 2002); that is, the association between trajectory group value and sleep disruption should be negative.

An alternative development measure was delayed phase preference. That is, as youths suffer decreases in melatonin during puberty, they prefer to go to bed, arise, and do important things later rather than earlier in time. At the age 15 survey (but not at grade 6), youths were asked (1) what time they would prefer to get up if school were canceled (1 = "5-6 a.m." 5 = "after 11 a.m."), (2) their preferred bedtime if they had a choice (1 = "8-9 p.m." 5 = "2-3 p.m."), (3) the best time for them to take a test, (4) when they have the most energy to do their favorite things (1 = "in the morning," 5 = "in the late evening"), and (5) what it would be like for them if they had to get up at 6 a.m. every day (1 = "perfect for me," 5 = "impossible. I couldn't do it"). The delayed phase preference index was the mean of the five standardized (*z*-score) items (α = .6); sleep researchers have validated this scale as a measure of puberty status of youths and linked it to sleep behaviors (Carskadon and Acebo 1992; Carskadon et al. 1993).

With regard to control variables, some sleep studies control for race and ethnicity, because groups differ on ideas about the appropriate time to sleep (Adam et al. 2007; Carskadon and Acebo 2002). Thus, the analytic models include a binary control for being nonwhite. In addition, the models include a binary control for being female.

Imputing Missing Data

Because the measures above were drawn from children's self-reports, parents, and medical professionals, missing data plagued the assemblage of the analytic sample (i.e., from an original sample of 974 adolescents, only 734 remained in a regression analysis after listwise deletion of cases with missing data). Thus, missing data on the predictor variables were imputed using the estimation and maximization algorithm in the MI procedure in SAS (Allison 2002). This procedure used cases with valid data to estimate the values of missing data using a regression approach, iteratively adjusting imputed values on covariates until the estimated covariance matrix matched the observed covariance matrix as closely as possible. The analyses below were conducted with imputed data, although the results were substantively similar to results using listwise deletion of cases with

missing data (these and all other supplemental analyses described below are available to readers on request).

RESULTS

Before discussing the results, a few brief comments on the characteristics of the analytic sample are in order. First, as youths age from sixth grade to age 15, sleep duration on a school night declines from more than nine to a little less than eight hours per night; similarly, reports of disrupted sleep increase over the interval. Second, youths lived in families that were relatively stable (only a combined 10 percent experienced changes in family composition) and economically comfortable (an average family income more than four times the poverty level). Third, the average youth has strong ties to parents, schools, and peers (with grade 6 means on these indices close to the maximum values), although these bonds weaken as youths age (i.e., the mean change scores were negative). Relatedly, the average youth has parents who closely monitor his or her activities (i.e., a mean of 3.5 of a maximum score of 4), and more than 4 in 10 had parents who consistently set bedtimes for them on school nights. Finally, only one-third of youths worked in the year before the age 15 survey, and it is not clear that the average youth spends inordinate amounts of time watching television or using the computer (with means closer to the middle values in the distributions of these indices).

Determinants of Teen Sleep

Table 2 presents the determinants of youths' sleep patterns at age 15 controlling for prior sleep behaviors at grade 6, and initial levels and changes in the social context of youths' lives. Models 1 and 2 examine the determinants of sleep duration on school nights, varying only in the control for development (the pubertal trajectory group in Model 1 and delayed phase preference in Model 2); Models 3 and 4 similarly differ in their choice of control for biological development when predicting the sleep disruption index. The coefficients shown in Table 2 are standardized coefficients showing the proportional standard deviation increment or decrement in

Table 2. Standardized Determinants of Sleep Duration and Disruption at Age 15 (*n* = 974).

Predictor	Sleep Duration		Sleep Disruption	
	1	2	3	4
Family stress, support, and control				
Mother's partner leaves HH, G6 to age 15	−.06*	−.06*	.07*	.07*
Mother has new partner in HH, G6 to age 15	−.02	−.02	.05†	.05†
Income-to-needs ratio, G6	.02	.02	.00	.01
Change in income-to-needs ratio, age 15	.10*	.10*	−.01	−.01
Parental bond index, G6	−.02	−.02	.00	.01
Change in parental bond index, age 15	−.02	−.03	−.04	−.03
Parental monitoring index, G6	.11*	.11*	−.07†	−.07†
Change in parental monitoring index, age 15	.11*	.10*	−.11*	−.10*
Consistent set bedtime on school nights, G6 and age 15	.17*	.16*	−.04	−.02
School/peer stress and support				
Weekly hours of homework, G6	−.08*	−.08*	.05†	.05
Change in weekly hours of homework, age 15	−.04	−.04	.07*	.07*
School attachment index, G6	−.06	−.06	−.02	−.03
Change in school attachment, age 15	.00	.00	−.11*	−.11*
Positive peer associations, G6	.06	.05	−.17*	−.14*
Change in peer associations, age 15	.15*	.13*	−.17*	−.12*
Time use				
Held a job in last year, age 15	−.07*	−.07*	.05†	.07*
Hours per week watching TV, G6	−.03	−.01	.05	.03
Change in hours per week watching TV, Age 15	.06†	.07†	.06†	.05
Intensity of computer use, G6	−.10*	−.09*	.11*	.09*
Change in intensity of computer use, age 15	−.08*	−.07†	.11*	.10*
Development and controls				
Pubertal development (1 = late, 4 = mature at age 13)	.00	—	−.01	—
Delayed phase preference	—	−.07*	—	.17*
Nonwhite	−.10*	−.10*	.00	−.01
Female	.03	.04	.19*	.18*
Dependent variable, G6	.20*	.20*	.33*	.30*
r^2	.18	.18	.28	.31

Note: Missing values on predictor variables were imputed using maximum likelihood. G6 = grade 6; HH = household.
*p < .05 (two-tailed test). †p < .05 (one-tailed test).

change in sleep habits given a standard deviation increase in a predictor.[11] The bottom of Table 2 shows that the models explain approximately 18 percent of the variation in school-night sleep duration and 28 to 31 percent of the variation in sleep disruption. Not surprisingly, the strongest predictors of sleep behaviors at age 15 are their prior values at grade 6 (*B* = .2 in Models 1 and 2, *B* > .3 in Models 3 and 4), yet there is much sup-

port for the proposition that the social context of youth's lives affects their sleep habits.

With regard to family ties, the stress of seeing their parents break up is associated with youths' reporting shorter sleep on school nights (*B* < −.06 in Models 1 and 2) and more sleep disruption (*B* = .07 in Models 3 and 4); similarly, those whose mothers found new partners over the interval report marginally more sleep disruption at age 15. There is

also evidence that family resources affect sleep, in that youths whose family incomes are increasing (relative to the poverty line) over the interval report longer sleep on a school night. Parental social control improves youths' sleep habits (i.e., levels of parental monitoring at grade 6 significantly lengthen teens' sleep duration and marginally decrease levels of sleep disruption). Perhaps more important, as parents increase their monitoring efforts as youths move from elementary to high school, adolescents report longer sleep durations on school nights and less sleep disruption. One specific parental control affecting sleep is setting a bedtime, and youths whose parents consistently did so reported sleeping longer on school nights. Finally, there is no sleep effect from parental bonds, a finding that is inconsistent with a prior study showing that teens slept longer when they had strong bonds with their parents (e.g., Adam et al. 2007). In supplemental analyses not shown, increasing bonds with parents over the interval significantly reduced sleep disruption when the measures of parental monitoring were omitted from the model. This suggests that one aspect of the quality of bonds between parents and offspring is the parents monitoring teens' behaviors, including an insistence that youths go to bed at a reasonable hour.

Social ties with schools and friends differently affect sleep depending on whether the content of those ties is stressful or supportive. Regarding the stress of academic demands, youths who have long had heavy homework loads (at grade 6) report shorter sleep durations at age 15 ($B = -.08$ in Models 1 and 2), whereas an increasing homework load in high school significantly increases sleep disruption ($B = .07$ in Models 3 and 4).[12] With regard to supportive ties, the stronger effects appear to be those of peers. That is, both the initial levels and recent increases in positive peer associations (having friends who strive to do right and succeed in school) are associated with less sleep disruption, and recent increases in positive peer associations significantly lengthens sleep on school nights. Whereas school attachment at grade 6 (which is likely to be an elementary school) is not significantly related to sleep disruption, increasing attachment to school (i.e., as youths enter high school) is significantly related to lower levels of sleep disruption.

Patterns of time use also affect sleep. For example, working in the prior year is associated with shorter sleep duration on school nights ($B = -.07$ in Models 1 and 2) and more sleep disruption ($B = .05$ and .07 in Models 3 and 4, respectively), yet it is not clear (because of data limitations) whether this is because working is stressful and can disrupt sleep or because after work, teens stay up late to finish homework assignments for school. Television viewing has inconsistent effects on sleep; as teens increase their time in front of the television from grade 6 to age 15, they sleep marginally longer, yet they also report marginally higher levels of sleep disruption. The effects of using the computer are stronger and consistent with expectations. That is, initial levels and recent increases in computer use are associated with shorter sleep on school nights and increased sleep disruption.

Sleep researchers posit that going through puberty disrupts youths' sleep because the process of sexual maturation is associated with decreases in melatonin, turning teens into "night owls." There is mixed support for this proposition in Table 2. The developmental measure based on the pace of completing puberty has no impact on sleep duration or disruption, whereas delayed phase preference (youths who prefer going to bed later, arising later, and doing important things later in the day) is associated with significantly shorter sleep duration on school nights ($B = -.07$ in Model 2) and increased sleep disruption ($B = .17$ in Model 4).[13]

Finally, nonwhite youths report shorter sleep on school nights than white youths. Studies of minority families suggest that youths who have trouble sleeping are allowed to get up, whereas white youths are encouraged to stay in bed (Carskadon and Acebo 2002). If this is the case, then minority youths may get less sleep at night. Girls, on the other hand, report higher levels of sleep disruption than boys. One possible explanation for gender's strong effect on sleep disruption may be because several of the items mention things youths can "worry" about that would affect their sleep; because girls are socialized to be more communal and introspective than boys (Verbrugge 1989), this sleep measure taps this tendency in girls, possibly explaining their increased reports of sleep disruption compared with boys.

DISCUSSION

Despite the importance of sleep in fostering adolescent health and well-being, few social scientists have examined the determinants of sleep behaviors, an important omission because unhealthy sleep habits in adolescence likely extend into adulthood (Calamaro et al. 2009). The medical community has attempted to fill the gap in our knowledge of the causes of teen sleep disruption, emphasizing that going through puberty lowers melatonin levels, causing teens to go to bed later on school nights, and after arising early on school mornings, feeling tired and sluggish throughout the day. Often missing from this account is that teen sleep patterns (like other health behaviors) are responsive to the stresses, supports, and controls found in ties with significant others. Studies that do consider teens' lives in context when predicting sleep typically draw cross-sectional samples (thereby failing to rule out endogeneity between sleep habits and youths' social ties) or estimate analytic models with limited controls. There is a need for longitudinal research examining changes in teen sleep habits that accounts for the biological and social determinants of sleep patterns.

This study addresses these gaps in the research on teen sleep behaviors. Using a national longitudinal study of changes in youths' sleep habits, this study estimated analytic models that controlled for two developmental measures, a comprehensive set of youths' ties to family, peers, and schools and time use. In models with lagged sleep measures and measures of the stresses on and support of teens (both initial levels and recent changes at age 15), the social determinants of sleep were more important predictors of changes in sleep patterns than the development measures.

Generally, stressful social ties disrupt youths' sleep, as when family composition changes because of divorce or remarriage, families live closer to poverty, or schools pile on the homework. On the other hand, youths had healthier sleep (longer duration and of higher quality) when social ties were a source of support, such as when they felt part of the schools they attended or they were surrounded by academically oriented and prosocial friends. Strong bonds with parents had no effect on

teens' sleep habits, but this was because parental ties can also be characterized by the degree to which they control teens' behavior; parental monitoring of teen behavior (especially in setting a time for them to go to bed) strongly determined healthy sleep habits among teens. These findings reinforce social science theory and research findings suggesting that health is facilitated by individuals becoming embedded in multiple networks of positive associations with key actors in their lives. And, because the effects of social ties were approximately similar in magnitude, the results are consistent with the argument that for adolescents, it is not any one social tie but rather the "constellation of social ties [that] matters most for health habits in adolescents" (Umberson et al. 2010:142). Whereas much social science research has focused on the role of social ties in determining physical and mental health of adolescents, the findings of this study suggest that the stressful and supportive ties characterizing youths' lives similarly determine teen sleep behaviors.

The findings of this study also speak to the medical community, which roots the causes of unhealthy teen sleep in biological processes, necessitating a medical solution (most often prescription drugs but sometimes surgery) to arrest teen sleep problems. Yet the content of social ties was stronger than the developmental measures as predictors of teen sleep behaviors. This finding suggests more holistic treatment modalities for unhealthy sleep among teens, supplementing medical interventions (which can be costly and invasive) with counseling and advising to improve or strengthen teen bonds with their families, teachers, and friends (Umberson and Montez 2010). Finally, the findings of this study should reassure parents that in setting ground rules for children's behaviors—knowing their whereabouts during the day and that they go to bed at a reasonable hour at night—was among the most important determinants of promoting healthy sleep behaviors in children. The importance of parental monitoring for teen sleep was reinforced in a recent study of showing that although teens may sometimes resent the intrusiveness of parental supervision, teens also acknowledge that parents are their primary and most influential source of information and guidance on the importance of and the need to get adequate sleep (Orzech 2013).

Some limitations of this study should be noted in hopes of stimulating further research on teen sleep and well-being. First, teens' sleep duration on any given night is determined not only by their bedtimes but also by the times they arise to be on time for school. This study lacked a measure of what time school started for teens (as well as commute times to get to school). Currently, the evidence that school systems are delaying high school start times to be more synchronous with teens' biological clocks is scattered and anecdotal (Owens, Belon, and Moss 2010). However, in districts where school starts later, it is important to compare teen well-being with teens in early-start-time districts to build an evidential base informing policy on the optimal school start time that maximizes both student performance and health. Second, although television viewing and computer use had strong negative effects on sleep quality, these measures were imprecise and somewhat dated (i.e., the SECCYD lacked information about cell phone use). Future research should use time diaries to capture not only precise times sleeping, but also watching television, using the computer, and texting or talking with friends. The time-diary method has been fruitfully used to establish the link between using computers and children's physical and mental well-being (Attewell, Suazo-Garcia, and Battle 2003), and it should be applied to the study of teens' sleep as well.

Despite these limitations, this is the first longitudinal study to show that changes in teens' sleep habits are shaped by the content of their social ties. The findings reported here are provocative and broadly sociological, suggesting that the quality of teens' associations with parents, schools, and peers affects their sleep habits. With this insight, it is important for sociologists to look anew at sleep as a predictor of adolescent health and well-being, specifically obesity, substance use, and violence, all of which have been linked to sleep deficits in medical research. Yet prior research shares the same flaws as medical research on sleep (i.e., small and unrepresentative cross-sectional samples that cannot rule out reverse causality between sleep and well-being). Studies drawing on longitudinal and representative data to examine sleep effects on obesity, substance use, and deviance are needed to further establish the central role of sleep in promoting health and well-being during the turbulent adolescent years.

NOTES

1. Social ties may also be described by their structure, that is, by the quantity of ties and frequency of interaction and by position in multiple (and often overlapping) networks of group affiliations (Umberson et al. 2010:141). Data limitations preclude an analysis of the sleep effects of the structure of youths' social ties; rather, this study focuses on how the content of social ties affects teen sleep behaviors.

2. Early in the focal children's lives, mothers reported on their own employment and parenting practices and, if appropriate, those of their partners. Later in the children's lives, fathers were surveyed but, because of budgetary constraints, in only 6 of the 10 catchment areas. Thus, in approximately half the cases, fathers' data are missing at any point in the children's lives.

3. In addition, the latest time children could report going to bed on a school night was an open-ended response, "after 2 a.m.," as was the response time for getting up on a school morning, "after 8 a.m." These open-ended responses were recoded to 2:30 a.m. and 8:30 a.m., respectively. Unfortunately, the SECCYD did not ask youths what time school started.

4. An alternative measure of the family's status is parental education, which was measured only at the time of the child's birth. Controlling for the presence of a college-educated parent had no effect on youths' sleep and was omitted from the analyses shown in Table 2.

5. The question asked, "When you and your (mother/ father) spend time talking or doing things together, how often does your (mother / father) _____?" The

remaining items in the index were "listens carefully to your point of view," "understands the way you feel about things," "help you do something that is important to you," "let you know (s/he) really cares about you," "act supportive and understanding toward you," "act loving and affectionate toward you," "have a good laugh with you when something is funny," and "let you know that (s/he) appreciates you, your ideas, or the things you do."

6. Six of the nine items were in response to the question "How much does a parent or another adult in your home know about _____?" Responses ranged from 1 ("doesn't know at all") to 4 ("knows everything"). The other five items were "who you spend time with," "how you spend your free time," "how you spend your money," "where you go throughout the day on the weekend," and "problems you are having at school." In addition, youths were asked three other questions that were included in the index: (1) "When you leave your home to go somewhere, do you tell a parent or other adult where you are going?" (2) "If a parent or other adult isn't home and you leave the house, do you leave a note or call to say where you are going?" and (3) "When you are home without a parent or other adult, do you know how to get in touch with them?" Item response to these three questions ranged from 1 ("never") to 4 ("always").

7. At grade 6, youths could respond 1 ("never"), 2 ("once a week"), 3 ("a few times a week"), 4 ("1 hour or less per day"), or 5 ("1-2 hours per day"). On the assumption that youths did about an hour per day when they did do homework and five days of homework per week when they did homework every day, these responses were recoded to values of weekly homework hours of 0, 1, 2, 4, and 7.5 hours, respectively. Unfortunately, the SECCYD was inconsistent in the age 15 survey when it added two additional response categories for homework frequency, 6 ("2-4 hours per day") and 7 ("more than 4 hours per day") (which were recoded to weekly hours of 15 and 25, respectively). It is likely that SECCYD staff members anticipated that youths would be doing more homework in high school than in elementary school, yet 35 percent of grade 6 youths gave the maximum response of 1 to 2 hours per day (data not shown), and undoubtedly some fraction of these youths were likely doing more than 2 hours of homework per day. Despite this inconsistency in measuring time in homework, this variable was retained in the analysis

because it is the most direct measure of academic demands that are likely to conflict with sleep. An indirect measure of academic demands, attending a private school, had no effect on sleep and was omitted from the analytic models.

8. The other items in the index were "I am happy to be at my school," "I feel safe at school," "the teachers at my school treat students fairly," and "I feel like I am a part of my school."

9. Specifically, the question asked, "This set of questions is about the kids that you spend time with. You might know these kids from school, your neighborhood, or anywhere else. Think about these kids when you answer each of the questions." The other academic and moral items in the scale were (1) "they try to get away with things," (2) "I get into trouble when I am with them," (3) "they work hard at school," (4) "they get into a lot of trouble at school," (5) "they do well in school," (6) "they are good at sports," (7) "they are mean to other kids," (8) "they cheat on tests," (9) "they dislike school," (10) "they are respectful of teachers," (11) "they think being popular is more important than getting good grades," (12) "they are involved in a lot of activities outside of school (like lessons or sports)," and (13) "they make me do things I am ashamed of." When calculating the index of positive peer associations, items 1, 2, 4, 7, 8, 9, 11, and 13 were reverse coded.

10. Youths did not work at age 12, but states do allow minors to work at age 15 (though some states require age certification before hiring a teen). An additional control for usual hours worked had no effect on sleep and was dropped from the analytic model.

11. By definition, regressing a time 2 score onto a time 1 score and controls is equivalent to estimating a change score in the dependent variable. This is easily proven by subtracting time 1 from both sides of the lagged regression equation. The left-hand side of the equation, or the dependent variable, is now a change score; on the right-hand side of the equation, the lagged measure drops out, and the slopes for the predictors are exactly the same as in the lagged regression equation.

12. There may be some value in estimating sleep behaviors using stepwise regression (i.e., sequentially entering blocks of covariates into the sleep equations). In baseline models with controls (at the bottom of Table 2) the r^2 values for sleep duration were about .08 in Models 1 and 2, increasing to .14 with the

addition of the family ties measures, increasing to .16 with the addition of school and peer ties, and increasing to .18 in the full models. The corresponding r^2 values for the stepwise regression models for sleep disruption were .18 and .23 in Models 3 and 4 with baseline controls (differing because of the greater predictor power of delayed phase preference in Model 4), increasing by approximately 3 percent with the addition of each block of covariates until reaching the values of .28 and .31 for the full models shown in Table 2. Besides the change in explanatory power of the models, stepwise regression may identify intervening (a larger effect in a lower order model that is reduced or insignificant in the full model) or suppressor (an insignificant effect in a lower order model that is significant in the full model) variable effects among the predictors in Table 2. Yet supplemental analyses failed to detect any intervening or suppressor effects in the analysis of sleep duration (Models 1 and 2). That is, all nonsignificant determinants of sleep duration shown in Table 2 were insignificant in lower order models, and all significant covariate effects in the full model were significant and of similar magnitude in lower order models. The same is true for the analysis of sleep disruption, with one exception. In contrast to the marginal and insignificant effects shown in the full Models 3 and 4, respectively, weekly hours of homework at grade 6 had slightly larger ($B \sim .07$) but significant effects on sleep disruption when the time-use covariates (particularly the intensity of computer use) were omitted from the model.

13. One reviewer suggested that autonomous youths who resist parental rules on a set bedtime would be more likely to say that they prefer to go to bed later and arise later in the day. Indeed, in Model 4 for sleep disruption, the set bedtime measure is not significant in the presence of a strong effect of youths' delayed phase preference. But, if delayed phase preference was a measure of youths' autonomy rather a decline in melatonin, then omitting delayed phase preference from the model should strengthen the effect of parents setting a bedtime for youths. Yet in supplemental analysis, this result was not observed, nor was it the case that the delayed phase preference measure increased in size if the set bedtime measure was omitted from the model. From these results, I conclude that the delayed phase measure is indeed a measure of melatonin declines in youths affecting their sleep

habits, not a measure of youths' resistance to parental supervision.

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