**Pediatrician**
Editor-in-Chief: D.W. Kaplan, Denver, Colo.

**Reprint**
Publisher: S. Karger AG, Basel
Printed in Switzerland

Pediatrician 1990;17:5–12


0300–1245/90/0171–0005$2.75/0

# Patterns of Sleep and Sleepiness in Adolescents

*Mary A. Carskadon*

E.P. Bradley Hospital and Brown University, Providence, R.I., USA

**Key Words.** Adolescents · Sleepiness · School · Jobs

**Abstract.** Most studies of adolescent sleep habits show a pattern of decreasing total sleep time, a tendency to delay the timing of sleep, and an increased level of daytime sleepiness. Laboratory tests have shown that adolescents do not have a decreased need for sleep but probably need *more* sleep than prepubertally. A number of factors affect the development of adolescent sleep patterns. Puberty itself imposes a burden of increased daytime sleepiness with no change in nocturnal sleep. Parental involvement in setting bedtimes wanes, though they become increasingly involved in waking teenagers in the mornings. Curfews and school schedules also affect adolescent sleep patterns, seen most commonly as imposing earlier rise times as the school day begins earlier during the adolescent years. Part-time employment has a significant impact on the sleep patterns of teenagers: those who work more than 20 h each week sleep less, go to bed later, are more sleepy, and drink more caffeine and alcohol. Development of circadian rhythms may also play a role in the phase delay teenagers commonly experience. The primary conclusion is that many adolescents do not get enough sleep. The consequences of the chronic pattern of insufficient sleep are daytime sleepiness, vulnerability to catastrophic accidents, mood and behavior problems, increased vulnerability to drugs and alcohol, and development of major disorders of the sleep/wake cycle. Educational programs hold the promise of improving teenagers' sleep patterns through informing youngsters, parents, and pediatricians about proper sleep hygiene and the risks of poor sleep habits.

## Introduction

Among the multiplicity of changes that accompany adolescence are alterations in sleeping and waking patterns [1]. These changes arise from a number of sources: changing academic demands, expanding social opportunities, altered parent-child relationships, involvement in part-time jobs, increased access to drugs and alcohol, etc. Also important among factors resulting in changing adolescent sleep patterns are physiological processes [2]. Very few studies have directly examined specific factors that might influence the development of adolescent sleep patterns. As will be shown below, empirical studies may call into question the conventional wisdom. For example, it is a common perception and also a societal expectation that adolescents do not really *need* as much sleep as preadolescents. Our sleep laboratory data, however, suggest that older adolescents may actually have a physiological need for *more* sleep than preadolescents, not *less*. The cultural patterns in North America that promote shortened nocturnal sleep in teenagers conflict with the physiological imperatives requiring increased nocturnal sleep. Thus, adolescents may become increasingly at risk for excessive sleepiness, dysphoric mood, or even catastrophic accidents as a result of excessive daytime sleepiness [3].

## Sleep/Wake Patterns in Adolescents

Let us begin by inspecting what adolescents say about their sleep. Self-reported sleep/wake patterns of adolescents have been investigated by a number of groups, primarily using cross-sectional sleep habits surveys [4–15].

Table 1. Self-reported sleep patterns in adolescents

| | Age | Girls | | | Boys | | |
|---|---|---|---|---|---|---|---|
| | | bedtime | risetime | sleep time | bedtime | risetime | sleep time |
| *School nights* | 10[1] | 9:30 | 7:15 | 9h 45m | 9:09 | 7:00 | 9h 51m |
| | 11[1] | 9:30 | 7:05 | 9h 35m | 9:40 | 7:00 | 9h 20m |
| | 12[1] | 9:45 | 6:55 | 9h 10m | 9:50 | 7:05 | 9h 15m |
| | 13[1] | 10:06 | 6:50 | 8h 44m | 10:28 | 7:00 | 8h 32m |
| | 14[2] | 10:10 | 5:56 | 7h 46m | 10:16 | 6:15 | 7h 59m |
| | 15[2] | 10:24 | 6:05 | 7h 41m | 10:43 | 6:27 | 7h 44m |
| | 16[2] | 10:52 | 6:13 | 7h 21m | 11:08 | 6:38 | 7h 30m |
| | 17[2] | 10:58 | 6:26 | 7h 28m | 11:14 | 6:45 | 7h 31m |
| | 18[3] | 1:15 a.m. | 8:18 | 7h 3m | 1:30 a.m. | 8:36 | 7h 6m |
| *Weekend nights* | 10[1] | 10:25 | 8:10 | 9h 45m | 10:22 | 7:45 | 9h 23m |
| | 11[1] | 10:22 | 8:25 | 9h 3m | 10:50 | 7:45 | 8h 55m |
| | 12[1] | 10:55 | 8:35 | 9h 40m | 11:05 | 8:35 | 9h 40m |
| | 13[1] | 11:20 | 8:45 | 9h 25m | 11:42 | 8:45 | 9h 3m |
| | 14[2] | 11:57 | 9:14 | 9h 17m | 12:06 a.m. | 9:12 | 9h 6m |
| | 15[2] | 12:11 a.m. | 9:24 | 9h 13m | 12:27 a.m. | 9:25 | 8h 58m |
| | 16[2] | 12:28 a.m. | 9:21 | 8h 53m | 12:44 a.m. | 9:37 | 8h 52m |
| | 17[2] | 12:39 a.m. | 9:21 | 8h 42m | 12:51 a.m. | 9:29 | 8h 38m |
| | 18[3] | 2:48 a.m. | 10:39 | 7h 51m | 2:43 a.m. | 10:40 | 7h 57m |

[1,2] From previous surveys [8, 12].
[3] From college freshmen [18].

Two longitudinal survey studies [16, 17] have also been reported. The study of Strauch and Meier [17] is the most comprehensive longitudinal survey, covering a 10-year period (1975–1985) with surveys at 2-year intervals in a pool of 100–190 German (FRG) adolescents who were aged 10–14 years at the study inception. The cross-sectional surveys have focused primarily on somewhat narrow age ranges. Table 1 presents a representative sample of data about adolescent sleep by combining data from several of our surveys of youngsters attending public school [8, 12, 18]. As will become clear in subsequent sections, a number of factors influence such 'norms'.

Several major trends emerge from the various survey studies. First, self-reported nocturnal sleep time declines across the adolescent span. Second, bedtimes during high school grow later and rising times earlier. Furthermore, teenagers show increasingly large variations between weeknight and weekend sleep schedules. The Strauch and Meier [17] data, for example, showed that weekend sleep times averaged about 30 min less than weeknight sleep time in the 10- to 14-year-olds, and the difference increased to over 2 h by age 18 years. The timing of sleep on weekdays versus weekends also shows progressively greater variability across the second decade. For example, our survey of young adolescents [8] showed about an hour's weekend-weeknight difference in 10-year-olds, increasing to about 90 min at age 13. More recently, we have found rise time reports in high school students to average approximately 3 h later on weekends than on weekdays. In college freshmen, bedtimes and rise times both slide to later times on weekdays as well as weekends [18]. Given this background, let us now examine what is known about a number of the factors that affect adolescent sleep/wake patterns.

## Factors Affecting Adolescent Sleep/Wake Pattern Development

### *Puberty*

The effects of pubertal maturation were examined in a longitudinal study that looked at sleeping patterns and daytime alertness using sleep laboratory measures [1, 2, 19]. For this study, 27 normal control children (12 girls and 15 boys) were studied on a total of 109 sessions over the course of 7 days. (Only a few returned for all 7 years; 21 were studied on at least three occasions.) During each session, the adolescent received a 72-hour (3 nights and 3

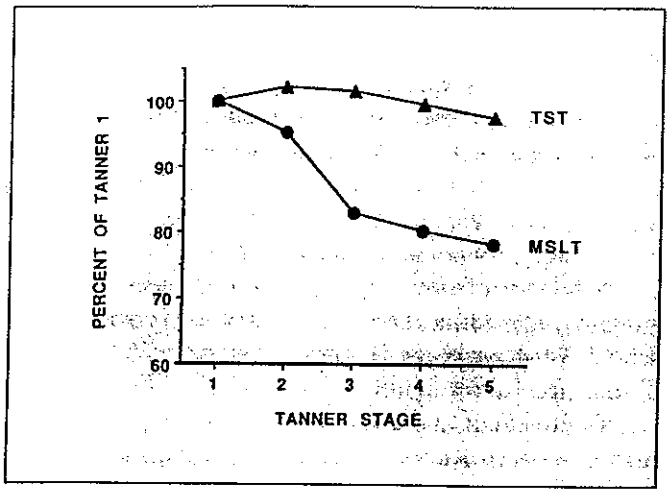



**Fig. 1.** This figure summarizes data from a 7-year longitudinal study of adolescent sleep and sleepiness, as described in the text. Data are grouped by Tanner stages and presented as a percentage of the Tanner stage 1 (prepubertal) average. Triangular symbols show the values for TST and round symbols show daily mean MSLT scores. TST showed no significant change from the Tanner 1 mean (about 9h 10m) across the Tanner stages, whereas MSLT declined significantly at Tanner stage 3 and remained low in Tanner stages 4 and 5. This finding suggests that older teens may have a physiological need for more sleep than younger adolescents.

days) evaluation at 'Sleep Camp'. The evaluation included overnight sleep recordings and daily measurements of daytime sleepiness using the Multiple Sleep Latency Test (MSLT) [20]. Maturational status was assessed using Tanner staging [21]. Overnight sleep recordings (with electroencephalogram, electro-oculogram, and electromyogram for analyzing sleep stages) were made on a constant schedule – 10:00 p.m. until 8:00 a.m. – across all years of the study. The MSLT measures daytime sleepiness as the speed of falling asleep based on physiological activity. Measures are taken at 2-hour intervals in a rigorous, standardized manner [20]. This test is now the most common measure for evaluating daytime sleepiness in experimental or clinical settings [22]. Tanner stages of maturation range from Tanner 1 – which reflects a prepubertal child – through intermediate pubertal development (Tanner stages 2, 3, and 4) to Tanner 5, the fully mature adolescent.

Figure 1 summarizes the relationships of nocturnal sleep patterns and daytime sleepiness to maturational level found in this longitudinal study. Two important findings stand out. First, the total amount of sleep (TST) at night remained constant across the developmental stages. Second, the MSLT showed a clear relationship to maturational stage, with a significant increase in sleep tendency during the daytime (greater sleepiness) at Tanner stages 3, 4, and 5. The children at Tanner stages 1 and 2 rarely fell asleep on this test. These findings were consistent across gender. It is important to keep in mind that the average TST at night was virtually identical for subjects at each Tanner stage, as figure 1 shows. Thus, the change in daytime sleep tendency across maturational stage was *not* related to a change in the amount of sleep at night. The implication of this study is that older adolescents become sleepy in the daytime, *even* when sleeping as much as younger adolescents. Therefore, if anything, older teens may *require more* sleep to maintain alertness than do younger teens.

*Parental Influence*

Among environmental factors that appear to influence the development of sleep/wake patterns early during adolescence is a change in the way parents regulate a child's sleep. Figure 2 illustrates the trends obtained in our survey of a younger adolescent group [10]. First, over half of the 10-year-old children reported that their parents set their bedtimes on school nights; by age 13, only 19% of parents set school-night bedtimes. Second, 19% of parents of 10-year-olds set bedtimes weekend nights, declining to 4% of the parents of 13-year-olds. Finally, rising times on school mornings were initiated by a parent or alarm in fewer than half the 10-year-olds versus 70% of 13-year-olds. These data suggested to us that one major early change in the organization of sleep/wake behavior in adolescents is an alteration in the nature of parental influences: parents of children and younger adolescents direct their attention to bedtime; in older adolescents, parental influence diminishes at bedtime and becomes more important to waking up.

*Curfews*

A related issue was examined by evaluating sleep/wake patterns in 9th and 10th grade students attending boarding schools with and without set curfews [23]. An interesting pattern of findings arose from this evaluation. First, as one would expect, the students given a curfew reported going to bed about an hour earlier on average than those with no curfew. Second, regardless of whether or not a curfew was imposed, all students in this study slept about the same amount on school nights (average = 7 h 15 min). Thus, even though the regulatory influence was present only at bedtime, the students who had a curfew also tended to get up about an hour earlier

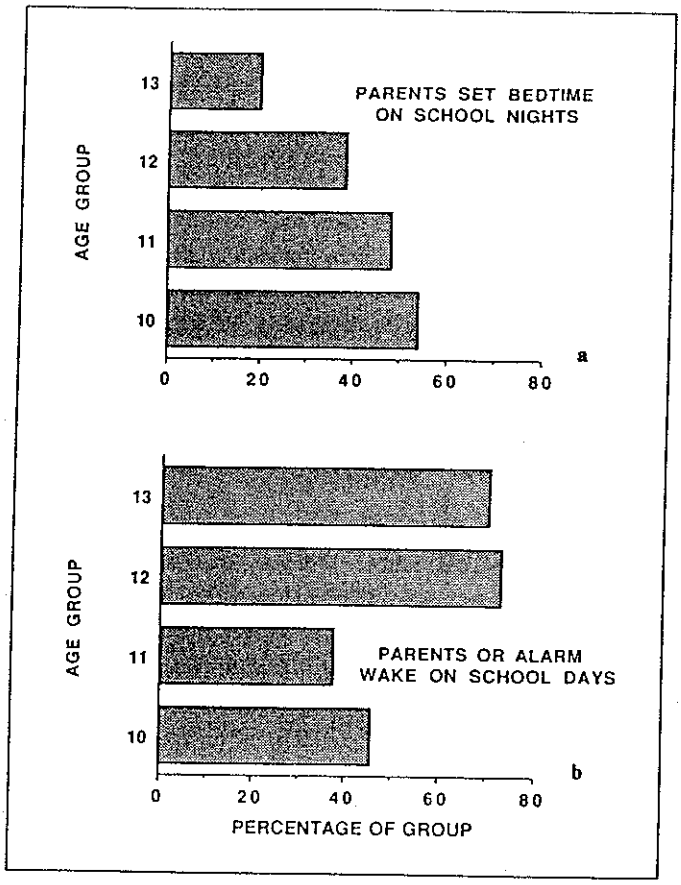



Fig. 2. This figure summarizes questionnaire response data from youngsters aged 10–13 years to questions asking what factor determines why they go to bed (a) and get up (b) on school mornings [10]. By age 13, less than 20% of the group reported that parents set their bedtimes. By age 12, over 70% of the group reported that they no longer wake spontaneously but required an alarm or parental awakening.

in the morning. Finally, the students with a curfew – those going to bed and getting up earlier – reported fewer symptoms of excessive sleepiness. Here again, it is clear that external agencies (or their absence) have a significant influence on adolescent sleep pattern.

*School Schedules*

The time that school begins in the morning has an obvious impact on setting sleep/wake schedules in adolescents, presumably strongest in its effect on the time youngsters arise in the morning. For example, the usual pattern in most public school districts call for earlier morning school sessions and consequently earlier rising times in older adolescents. Our data suggest that adolescents tend gradually to adjust to shifts in school start time over a series of years by narrowing the interval between getting up and going to school (table 1). The pattern of later rising times on weekend mornings also suggests that the school schedule impinges on the regulation of sleep/wake patterns on school mornings. Of course, as noted below, the weekday/weekend patterns may also be a response to insufficient sleep.

Another indication of the importance of the school schedule arises from our comparison of sleep habits in students attending private residential versus public school. We have recently surveyed about 1,500 students at four private residential high schools in Massachusetts and Connecticut and about 3,100 students in six public high schools in Rhode Island. One quite notable difference between the sleep patterns of public and private school (noncurfew) students was that public school students consistently reported going to bed and rising earlier (approx. 1 h) than private school students. This difference appears to relate to the differential commute distances; the private school students could all walk to their first morning class, whereas many of the public school students commuted by car or bus.

*Jobs*

Within the public high school survey population, part-time jobs appear to have a very strong influence on the sleep/wake patterns of adolescents. The sleep patterns of students who report working 20 or more hours per week (high-work) differ greatly from those who report working fewer than 20 h or not at all (low-work) [3, 24]. Table 2 presents several of the variables on which these groups differed. To summarize, the high-work students stayed up later and slept less than the low-work group on school nights and weekend nights. The high-work group also reported more symptoms of daytime sleepiness, including a greater tendency to get to school late because of oversleeping and greater difficulty staying awake in school. The high-work group also reported greater use of caffeine, alcohol, and tobacco. The high-work group comprised over one-quarter of the public high school sample. Thus, a pattern of low sleeping times, excessive sleepiness, and increased substance use may affect large numbers of students. There is a smaller number (4%) in whom the pattern is even more extreme: this is the group of students who work 20 h or more every week and who also take part in extracurricular activities 20+ h each week [3]. These teenagers report a chronic pattern of extremely short sleep along with symptoms of daytime sleepiness and increased use of stimulants and alcohol.

Table 2. Percentage of 11th and 12th graders reporting responses as a function of time spent on jobs

| Response | Girls | | Boys | |
|---|---|---|---|---|
| | low-work | high-work | low-work | high-work |
| School-night bedtime after 11:00 p.m. | 18.0 | 27.9 | 24.5 | 40.9 |
| Weekend bedtime after 1:00 a.m. | 27.6 | 37.6 | 32.9 | 50.0 |
| School-day rising time after 6:00 a.m. | 44.8 | 45.7 | 73.3 | 72.1 |
| Weekend rising time after 10:00 a.m. | 30.1 | 29.0 | 32.4 | 30.1 |
| Stay up past 3:00 a.m. at least once a week | 18.1 | 24.0 | 22.9 | 34.6 |
| Oversleep and arrive late for school at least once a week | 12.9 | 13.4 | 11.7 | 20.4 |
| Fall asleep in the morning at school at least once a week | 15.6 | 18.8 | 19.5 | 28.0 |
| Fall asleep in the afternoon at school at least once a week | 18.2 | 23.2 | 20.1 | 24.1 |
| Struggle to stay awake or fall asleep doing homework | 21.9 | 27.9 | 15.3 | 23.1 |
| Drink coffee or tea every day | 18.8 | 28.1 | 12.6 | 22.8 |
| Drink caffeinated soda pop every day | 55.8 | 55.7 | 52.8 | 60.4 |
| Drink alcohol every week | 15.5 | 18.4 | 16.7 | 25.5 |
| Smoke cigarettes every day | 24.4 | 33.9 | 14.0 | 26.4 |

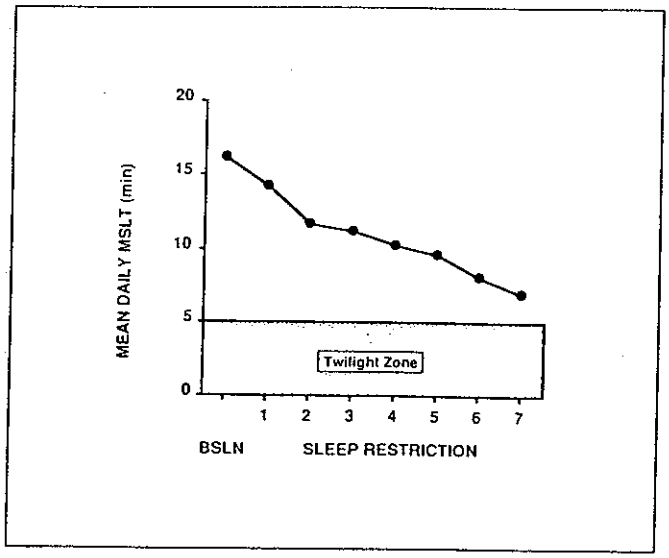
*Circadian Rhythms*

Another factor that emerges from currently available data – and may be related to a number of the factors above as well as to physiological processes involved in regulating and organizing circadian rhythms – is a tendency for older teens to delay sleep onset. In the first place, there seems to be a simple desire on the part of teenagers to stay up late. For example, Price et al. [9] noted that nearly two-thirds of 11th and 12th graders report that they 'enjoy staying up at night'. This is supported by data from across our various surveys [8, 12, 18] in which we have found a migration of bedtime on school nights from an average of about 9:00–9:30 p.m. in 10-year-olds, to 10:00–10:30 p.m. in 13-year-olds, to 11:00 p.m.–midnight in 17-year-old high school seniors, to 1:00–2:00 a.m. in 18-year-old college freshmen. In the younger groups, the reduction of bedtime setting by parents probably influences the bedtime shift. Other data suggest that the delay may reflect additional environmental circumstance, as well as the adolescent's freedom to self-select bedtime. Thus, as noted previously, when bedtime reports are compared between students who live at home or board at school [25], or between boarding students with and without a curfew [23], or in the high school-to-college transition [18], we find trends for bedtimes to be later in the 'freer' environment. Peer influences and socialization are also likely to be significant factors in this process.

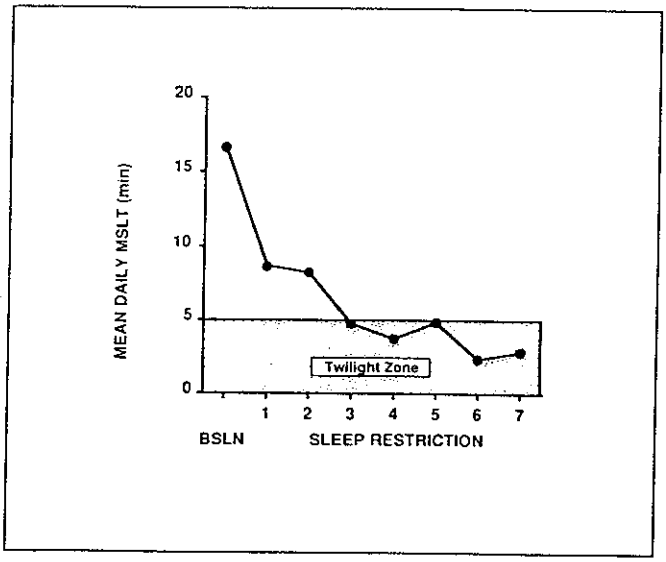
Cross-sectional data from our high school survey, as well as longitudinal data from our high school-to-college transition study [18], also show a progressive change in morningness/eveningness [26] scores, favoring greater numbers of 'evening' types in the older students. The morningness/eveningness or 'lark/owl' score is a measure of 'circadian type' that reflects the time of day at which an individual reports peak functioning. Such scores are related to sleep/wake patterns, as well as other daily rhythms, such as body temperature and food intake [27]. It is not clear, however, whether they measure a *response* to changing sleep/wake habits initiated by other factors or an alteration in the circadian rhythms driving the trend for delayed sleep/wake schedules in adolescence.

## Insufficient Sleep and Daytime Sleepiness

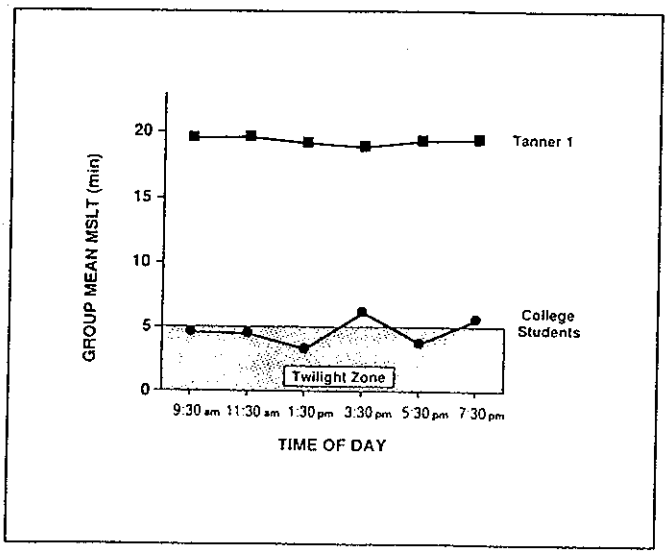
By far the most striking conclusion from the available information about adolescent sleep is that many adolescents do not get enough sleep. School schedules require waking up earlier and earlier, while academic work loads, social obligations, and work patterns obligate staying up later and later. Compressed between these daily bookends is an increasingly narrow window for sleep. What happens when sleep is chronically below an optimal level? In one experiment, we looked at this issue in a group of 10 college students [28]. To study their response, we brought them into the sleep laboratory for 10 nights. On the first 3 nights, we allowed them to sleep 10 h; then we reduced their sleep window to 5 h a night for the next 7 nights. Figure 3 illustrates the impact of this sleep restriction pattern on sleepiness as measured using the MSLT. The effect across the 7 days following




3




4




5

short sleep was additive; that is, the students got progressively more sleepy every day. Figure 4 shows the example of 1 student who actually became very sleepy on the day after the first short night and was extremely sleepy for the final 5 days. The 'twilight zone' shown in this figure corresponds to a score of 5 min or less on the MSLT, which has been shown to be associated with impaired performance in a number of studies [28–32]. All but 1 of the subjects in this sleep restriction study [28] were in the 'twilight zone' at some point, most for significant portions of every day.

The pattern that we see emerging from all this information is a twofold process that results in a significant level of daytime sleepiness in adolescents. First – whatever combinations of factors may be involved – there is trend for shorter and shorter sleep times across the adolescent span. In addition, puberty produces daytime sleepiness, even when sleep time does not change. Insufficient sleep, therefore, exacts an extra penalty during adolescence. Figure 5 compares sleepiness levels of a group of prepubertal (Tanner stage 1) youngsters sleeping their usual schedule (about 9.5 h a night) and a group of typical college students sleeping their usual 7 h a night. The contrast is striking: the children are maximally alert throughout the day, whereas the combination of factors – pubertal changes plus chronic insufficient sleep – puts the college students in the 'twilight zone' nearly all day long.

**Fig. 3.** MSLT data from a week-long sleep restriction protocol are summarized in this figure, taken from a study of 10 young adult college students asked to sleep 10 h a night for 3 nights followed by 5 h a night for 7 nights [28]. Baseline results are collapsed into the first data point (BSLN), which shows a high level of alertness before the sleep restriction. As measured by MSLT, sleepiness increased linearly with successive days of sleep restriction. These data highlight the additive impact of chronic sleep restriction.

**Fig. 4.** MSLT data from an 18-year-old male subject from the study presented in figure 3 are shown in this figure. This young man was very alert during baseline but became very sleepy after 1 night of sleep restriction. After 3 nights, he was extremely sleepy throughout the day and susceptible to lapses and performance decrements, as indicated by the 'twilight zone'. As shown in the summary figure, the decline in alertness was progressive across the sleep restriction days. In this subject, chronic sleep restriction might result in severe impairment.

**Fig. 5.** This figure summarizes the dual impact of pubertal changes and chronic sleep restriction by juxtaposing average MSLT profiles of children (ages 10–14 years, mean = 11.6) versus college students (ages 18–21, mean = 19.2). The children slept a little more than 9 h a night, whereas the college students slept about 7 h.

Adolescents are clearly variously affected by these factors, but it is important to realize that excessive sleepiness is a potentially serious problem. The scope of the problem has been paradoxically unrecognized in part because adolescent sleepiness is so widespread and obvious (observe any high school or college classroom) that it almost seems to be normal. Yet its consequences, if often subtle, are very real. To the extent that a teenager is excessively sleepy, he or she has an increased vulnerability to a number of poor outcomes. Excessive sleepiness, as mentioned above, is associated with performance failures and lapses. Such lapses impact unfavorably on learning and potentially catastrophically on such activities as automobile driving. The sleepy teenager is also at potentially greater risk to abuse drugs in an attempt to increase alertness by self-medication with caffeine and more potent stimulants. We have also noted evidence that increased alcohol use is related to insufficient sleep in teens, at least in the context of our high-work group. An additional risk arises because of the recently described synergistic interaction of hypersomnolence and alcohol, potentiating the sedative effects of alcohol [33–35]. The relationship of alcohol and insufficient sleep may be particularly hazardous for teenagers, due to the well-known tendency for adolescents to engage in experimentation with alcohol and other risk-taking behaviors. In this context, sleepiness may reduce an adolescent's safety margin for such experimentation [3].

Other areas of a teenager's daily life may also be impaired by the consequences of insufficient sleep. We are just beginning to obtain evidence that moodiness in adolescents is related to sleep patterns. In a recent study of sleep restriction in high school students [36], we asked 13 boys in 9th through 12th grades to reduce their sleep by 2 h a night over 5 consecutive nights. Each evening, they completed a mood checklist (based on the scale of Lubin et al. [37]) as part of a daily sleep/wake/activity diary. The checklist included three scales (positive, negative, depressed). At the end of each week, the students also filled out the Adolescent Depressive Mood Scale of Kandel and Davies [38]. The positive and negative daily mood scales and the weekly Adolescent Depressive Mood Scale all showed significantly dysphoric changes during the period of reduced sleep. Although only a small preliminary study, this finding suggests that a portion of the moodiness of adolescents may be a consequence of insufficient sleep. To the extent that such mood changes interfere with the teenager's ability to cope with daily stresses, poor sleep/wake patterns may represent another serious threat to an adolescent's well-being. Furthermore, chronic mood changes due to chronic insufficient sleep may impair the teenager's relationships with peers and with adults.

Another potentially serious complication of the typical trend for later bedtimes in older adolescents is development of the Delayed Sleep Phase Syndrome (DSPS), which appears to be caused by a defect in the brain's clock mechanism that sets the timing of virtually all of the body's biological functions [39]. In susceptible individuals, this clock can get set incorrectly at a position that causes biological functions (including sleep) to occur later than desired. Retiring and arising at late hours can initiate the appearance of this malfunction. The teenager with DSPS is not necessarily lazy or school phobic or acting out, but is utterly unable to fall asleep before 5:00 or 6:00 a.m. and impossible to wake up before 2:00 or 3:00 in the afternoon. Such a pattern is clearly untenable for a school-aged adolescent and requires special therapy through a sleep disorders center.

## Conclusion: Prevention and Intervention

No studies have looked at the possibility that preventive measures can alter patterns of sleep and wakefulness during adolescence. In terms of intervention, there are a few clinical studies in adolescents with DSPS showing successful results of chronotherapy [40, 41]. In terms of insufficient sleep, it is clear that the excessive sleepiness related to insufficient sleep can be eliminated by extending sleep at night [10, 42, 43]. The latter experiments were all conducted in laboratory settings and showed improved physiological alertness and performance with extended sleep. Translation of this approach to the everyday lives of teenagers may be more problematic. Perhaps the most useful approach may be one that combines education of children, parents, teachers, and pediatricians about the fundamental principles of proper sleep hygiene. The first goal of such a program might be to disabuse people about the notion that teenagers need less sleep.

## Acknowledgements

Original research presented in this paper was supported by funds from MH 34185 and the Donald B. Lindsley Trustee Grant from the Grass Foundation. I thank Mark R. Rosekind, Kate B. Herman, and Stephen S. Davis for their assistance with the data collection and analysis for the high school sleep restriction and high school-to-college transition studies.

## References


1 Carskadon MA: The second decade; in Guilleminault C (ed): Sleeping and Waking Disorders: Indications and Techniques. Menlo Park, Addison-Wesley, 1982, pp 99–125.
2 Carskadon MA, Harvey K, Duke P, et al: Pubertal changes in daytime sleepiness. Sleep 1980;2:453–460.
3 Carskadon MA: Adolescent sleepiness: Increased risk in a high-risk population. Alcohol Drugs Driving (in press).
4 Webb WB, Agnew HW: Sleep and Dreams. Dubuque, Brown, 1973.
5 Webb WB, Agnew HW: Are we chronically sleep deprived? Bull Psychon Soc 1975;6:47–48.
6 Strauch I, Dubral I, Struchholz C: Sleep behavior in adolescents in relation to personality variables; in Jovanovic UJ (ed): The Nature of Sleep. Stuttgart, Fischer, 1973, pp 121–123.
7 Zepelin H, Hamilton P, Wanzie FJ: Sleep disturbance in early adolescence. Sleep Res 1977;6:183.
8 Anders TF, Carskadon MA, Dement WC, et al: Sleep habits of children and the identification of pathologically sleepy children. Child Psychiatry Hum Dev 1978;9:56–63.
9 Price VA, Coates TJ, Thoresen CE, et al: Prevalence and correlates of poor sleep among adolescents. Am J Dis Child 1978;132: 583–586.
10 Carskadon MA: Determinants of Daytime Sleepiness: Adolescent Development, Extended and Restricted Nocturnal Sleep; doctoral dissertation, Stanford University, 1979.
11 White L, Hahn PM, Mitler MM: Sleep questionnaire in adolescents. Sleep Res 1980;9:108.
12 Petta D, Carskadon MA, Dement WC: Sleep habits in children aged 7–13 years. Sleep Res 1984;13:86.
13 Billiard M, Alperovitch A, Perot C, et al: Excessive daytime somnolence in young men: Prevalence and contributing factors. Sleep 1987;10:297–305.
14 Bearpark HM, Michie PT: Prevalence of sleep/wake disturbances in Sydney adolescents. Sleep Res 1987;16:304.
15 Henschel A, Lack L: Do many adolescents sleep poorly or just too late? Sleep Res 1987;16:354.
16 Klackenberg G: Sleep behaviour studied longitudinally. Acta Paediatr Scand 1982;71:501–506.
17 Strauch I, Meier B: Sleep need in adolescents: A longitudinal approach. Sleep 1988;11:378–386.
18 Carskadon MA, Davis SS: Sleep-wake patterns in the high-school-to-college transition: Preliminary data. Sleep Res 1989; 18:113.
19 Carskadon MA, Orav EJ, Dement WC: Evolution of sleep and daytime sleepiness in adolescents; in Guilleminault C, Lugaresi E (eds): Sleep/Wake Disorders: Natural History, Epidemiology, and Long-Term Evolution. New York, Raven Press, 1983, pp 201–216.
20 Carskadon MA, Dement WC, Mitler MM, et al: Guidelines for the multiple sleep latency test (MSLT): a standard measure of sleepiness. Sleep 1986;9:519–524.
21 Tanner JM: Growth at Adolescence. Oxford, Blackwell, 1962.
22 Carskadon MA: Measuring daytime sleepiness; in Kryger MH, Roth T, Dement WC (eds): Principles and Practice of Sleep Medicine. Philadelphia, Saunders, 1989, pp 1–684.
23 Carskadon MA, Mancuso J: Daytime sleepiness in high school adolescents: Influence of curfew. Sleep Res 1988;17:75.
24 Carskadon MA, Mancuso J, Rosekind MR: Impact of part-time employment on adolescent sleep patterns. Sleep Res 1989;18: 114.
25 Carskadon MA, Mancuso J: Sleep habits in high school adolescents: Boarding versus day students. Sleep Res 1988;17:74.
26 Horne JA, Östberg OA: A self-assessment questionnaire to determine morningness-eveningness in human circadian rhythms. Int J Chronobiol 1976;4:97–110.
27 Östberg O: Circadian rhythm of food intake and oral temperature in 'morning' and 'evening' groups of individuals. Ergonomics 1973;16:341–351.
28 Carskadon MA, Dement WC: Cumulative effects of sleep restriction on daytime sleepiness. Psychophysiology 1981;18:107–113.
29 Carskadon MA; Dement WC: Effects of total sleep loss on sleep tendency. Percept Mot Skills 1979;48:495–506.
30 Carskadon MA, Harvey K, Dement WC: Acute restriction of nocturnal sleep in children. Percept Mot Skills 1981;53:103–112.
31 Carskadon MA, Harvey K, Dement WC: Sleep loss in young adolescents. Sleep 1981;4:299–312.
32 Carskadon MA, Dement WC: Sleep loss in elderly volunteers. Sleep 1985;8:207–221.
33 Lumley M, Roehrs T, Asker D, et al: Ethanol and caffeine effects on daytime sleepiness/alertness. Sleep 1987;10:306–312.
34 Roehrs T, Lumley M, Asker D, et al: Ethanol and caffeine effects on daytime sleepiness. Sleep Res 1986;15:41.
35 Zwyghuizen-Doorenbos A, Roehrs T, Lamphere J, et al: Increased daytime sleepiness enhances ethanol's sedative effects. Neuropsychopharmacology 1988;1:279–285.
36 Carskadon MA, Rosekind MR, Galli J, et al: Adolescent sleepiness during sleep restriction in the natural environment. Sleep Res 1989;18:115.
37 Lubin A, Moses JM, Johnson LC, et al: The recuperative effects of REM and stage 4 sleep on human performance after complete sleep loss: experiment 1. Psychophysiology 1974;11:133–146.
38 Kandel DB, Davies M: Epidemiology of depressive mood in adolescence: An empirical study. Arch Gen Psychiatry 1982;39: 1205–1212.
39 Weitzman ED, Czeisler CA, Coleman RM, et al: Delayed sleep phase syndrome: A biological rhythm disorder. Sleep Res 1979; 8:221.
40 Thorpy MJ, Korman E, Spielman AJ, et al: Delayed sleep phase syndrome in adolescents. J Adolesc Health Care 1988;9:22–27.
41 Ferber R: Circadian and schedule disturbances; in Guilleminault C (ed): Sleep and Its Disorders in Children. New York, Raven Press, 1987, pp 165–179.
42 Carskadon MA, Dement WC: Nocturnal determinants of daytime sleepiness. Sleep 1982;5:73–81.
43 Timms V, Roehrs T, Zwyghuizen-Doorenbos A, et al: Sleep extension in sleepy and alert individuals. Sleep Res 1988;17:92.


Received: May 27, 1989

Mary A. Carskadon, PhD
Chronobiology/Sleep Research Laboratory
E.P. Bradley Hospital
1011 Veterans Memorial Parkway
E. Providence, RI 02915 (USA)