

Adolescent Sleepiness: Increased Risk in a High-Risk Population

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ABSTRACT

Patterns of sleep and wakefulness undergo significant changes during adolescence. Many of these changes stem from environmental factors that tend to reduce the amount of time available for sleeping. Thus, for example, social and academic demands, along with a lessening of parental guidance, contribute to reduce the adolescent's sleep. The reduction of sleep is associated with an increase in self-perceived daytime sleepiness by many of these youngsters. Furthermore, pubertal development per se is associated with increased daytime sleepiness, even when sleep at night remains at a fairly high level. Reduction of total sleep further potentiates this diurnal sleepiness. The combination of these factors may result in a large group of teenagers with a vulnerability for unintentional sleep episodes.

Introduction

Adolescence is a time of life when many are learning how to drive automobiles, beginning to explore alcohol and drug use, and engaging in risk-taking behaviors (Irwin and Millstein, 1986). The experimentation and limit-testing behaviors of adolescents, in association with decreased alertness, may contribute to a relatively high accident rate in this population (Adduci, 1988). Although the vulnerabilities that sleepiness imposes upon adults have been somewhat characterized (Mitler et al., 1988), we are just beginning to understand the extent to which similar problems may exist in youngsters.

Background

Cross-sectional surveys of sleep/wake patterns in adolescents indicate that nocturnal sleep declines across the adolescent years and that a pattern of reduced weekday sleep is compensated by extended weekend sleeping time (Anders et al., 1978; Bearpark and Michie, 1987; Billiard et al., 1987; Carskadon and Davis, 1989; Carskadon and Mancuso, 1987, 1988a, 1988b; Klackenberg, 1982; Price et al., 1978; White et al., 1980). Our laboratory-based longitudinal studies of sleep and waking behavior in adolescents have also shown a decrease in waking alertness occurring in mid-puberty (Carskadon, 1982; Carskadon and Dement, 1987; Carskadon et al., 1980, 1983). This finding is based upon laboratory-recorded sleep and sleepiness patterns of 24 youngsters studied for three nights and days across six or seven years. In this group, even though nocturnal sleep time

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remained unchanged at over nine hours a night, daytime sleep tendency increased significantly at a stage when physical correlates of maturation (Tanner, 1962) indicated mid-puberty.

The laboratory test of diurnal sleepiness used in this longitudinal study is called the Multiple Sleep Latency Test (MSLT). The MSLT measures speed of falling asleep (tendency to fall asleep) on several occasions at two-hour intervals across each day (Carskadon and Dement, 1982). When this measure falls to values in the range of five minutes or less, unintentional episodes of sleep and impaired performance have been reported in sleep-deprived normal controls, including adolescents (Carskadon and Dement, 1979, 1981; Carskadon et al., 1981, 1985). As Figure 1 shows, the level of daytime sleepiness associated with pubertal development does not fall within this zone of extreme vulnerability; nevertheless, pubescent sleepiness, when combined with a chronic insufficient sleep pattern, can lead to a highly vulnerable youngster. This is particularly true in the context of restricted nocturnal sleep during a teenager's typical week, wherein a cumulative sleep debt accrues resulting in a relentless increase in daytime sleep tendency. Figure 2 summarizes sleepiness data from 10 older adolescent students placed on a five-hour sleep schedule for one week. Only one of these students avoided the "vulnerability zone" entirely; all of the others reached the five-minute level, many for an uncomfortably lengthy portion of the experiment. Performance lapses associated with microsleep episodes were seen in these sleepy subjects (Carskadon and Dement, 1981).

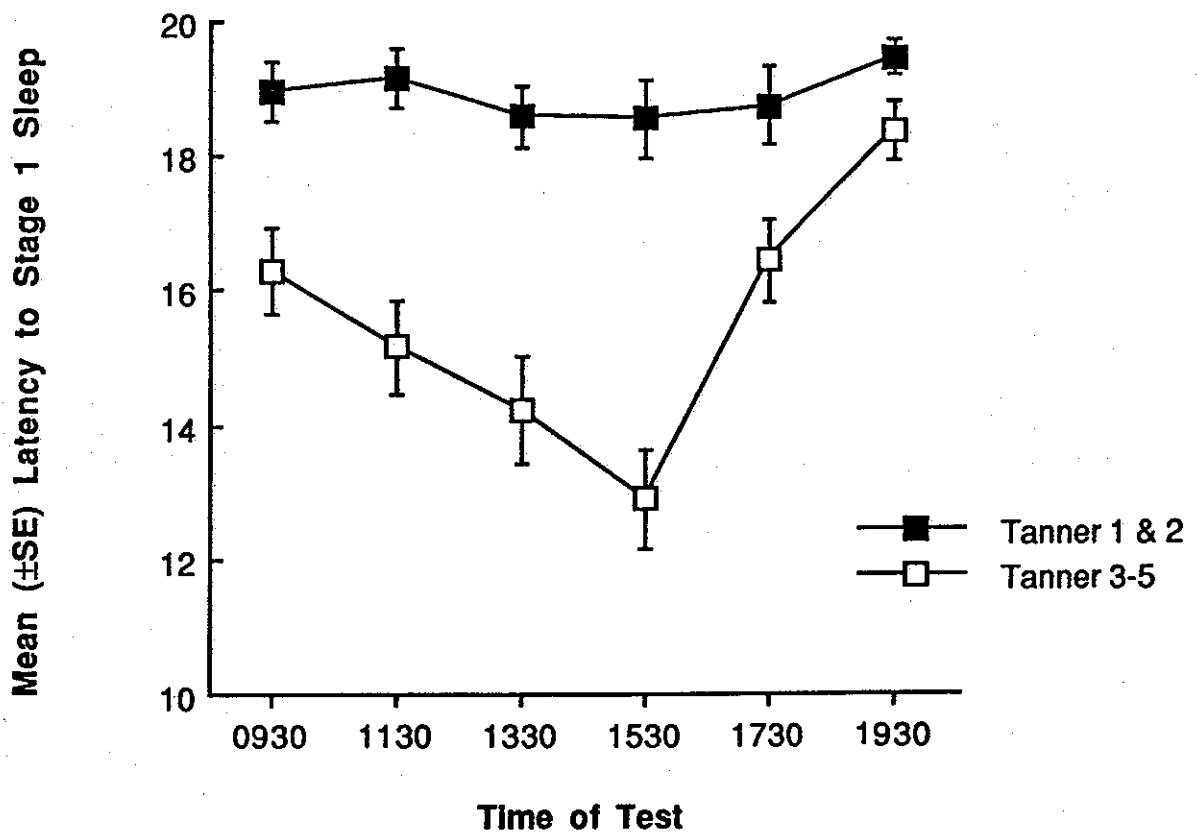


FIGURE 1

Latency to sleep onset on the Multiple Sleep Latency Test as a function of Tanner (1962) stage. Youngsters at Tanner stages 1 or 2 are pre- or early pubertal. Youngsters at Tanner stages 3, 4, or 5 are mid- or late pubescent. The subjects from whom these data were obtained were all sleeping over 9 hours per night. Thus, puberty—in the absence of a change in nocturnal sleep—produces an increase in daytime sleepiness.

Adolescent Sleepiness: Relation of Sleep/Wake Patterns to Working and Extracurricular Activities

We have recently evaluated adolescent sleep/wake patterns in a survey of Rhode Island high school students. Preliminary findings included striking relationships among part-time employment, restricted sleep, symptoms of sleepiness, and increased alcohol and drug use (Carskadon et al., 1989). Most (58.7%) high school students in our survey reported that they hold part-time jobs, and remarkably, 28.3% reported working 20 hours or more per week! Furthermore, quite a number of high school students reported spending a significant amount of time in extracurricular activities, such as sports, musical groups, clubs, service organizations, and so forth. In our sample, nearly 20% reported spending at least 20 hours per week in such extracurricular activities. We have begun to examine how these two types of time commitments—jobs and extracurricular activities—affect sleeping and waking patterns in teenagers and consequently may impact on the risk or vulnerability of these students to excessive sleepiness.

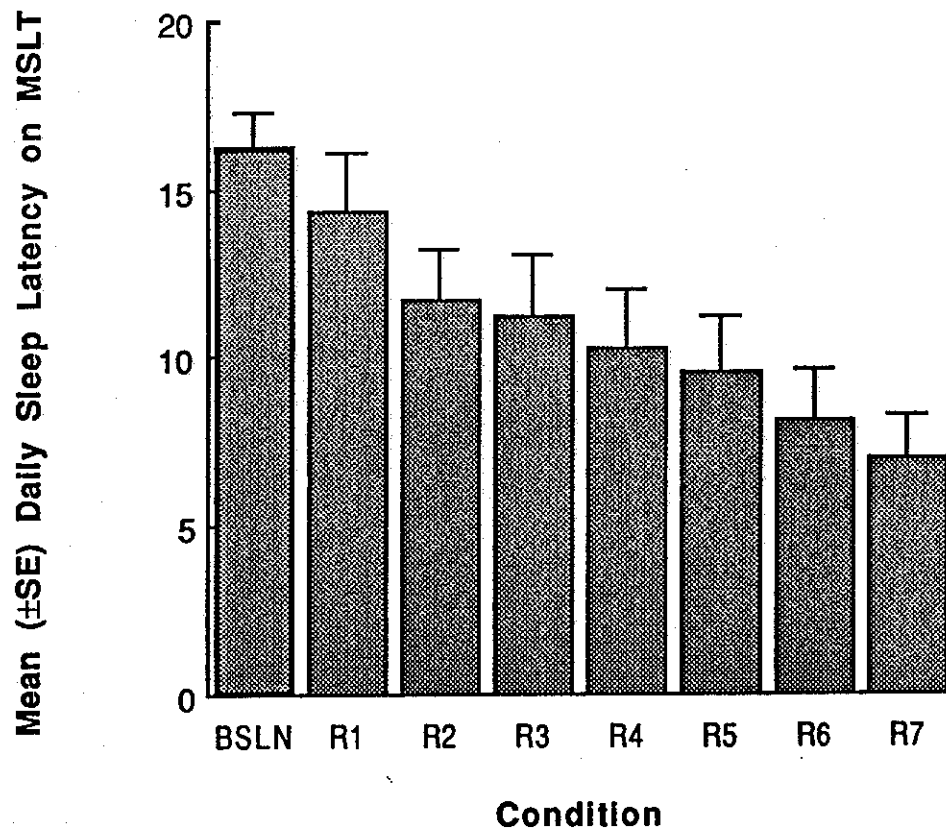


FIGURE 2

Average daily sleep latency on the MSLT for 10 older adolescent college students across a week of insufficient sleep. On a baseline (BSLN) schedule of 10 hours of sleep, these students were very alert, but became measurably and progressively sleepier over consecutive days when permitted to sleep only 5 hours each night (R1 through R7). Insufficient sleep at night, therefore, produces daytime sleepiness that is additive over days.

Methods

A seven-page sleep habits survey was given to ninth through twelfth grade students in six largely suburban public high schools in Rhode Island. The survey was completed anonymously by 1,528 girls (ages 13–19 years; mean age = 15.6 ± 1.2) and 1,566 boys (ages 12–19 years; mean age = 15.8 ± 1.3). For purposes of the present analysis, we have examined our survey data by grouping students according to their reports of hours per week spent in extracurricular activities and working at "a job for pay." Approximately 25% of the students failed to answer the items relating to these dimensions, and thus the final survey population is 2,293 students (1,108 girls and 1,185 boys). The following four groups were defined:

- **Group 1** = Students who report that they participate in extracurricular activities fewer than 20 hours per week and that they do not work or work fewer than 20 hours per week (low extracurricular, low work).
- **Group 2** = Students who report that they participate in extracurricular activities at least 20 hours per week and that they do not work or work fewer than 20 hours per week (high extracurricular, low work).
- **Group 3** = Students who report that they participate in extracurricular activities fewer than 20 hours per week and that they work at least 20 hours per week (low extracurricular, high work).
- **Group 4** = Students who report that they participate in extracurricular activities at least 20 hours per week and that they work at least 20 hours per week (high extracurricular, high work).

Results

Table 1 summarizes the time commitments of these groups along with their reported total sleep time on school nights and weekends. It is clear from this table that the out-of-school time commitments (extracurricular activities and jobs) of the latter three groups were great, averaging over 30 hours per week in Groups 2 and 3 and nearly 60 hours per week for Group 4. Furthermore, the amount of sleep these students reported varied as a function of group; that is, those students who reported working greater than 20 hours per week (Groups 3 and 4) accrued a significant sleep debt relative to those students who reported working fewer than 20 hours per week. One should also note that the girls consistently reported less sleep during the week than boys, with very little difference in weekend "rebound" sleep.

The differences in sleep times among groups were reflected in other life-style differences, beginning with bedtimes and rising times. In general, reported rising times both on school days and weekends were fairly consistent across the four groups. The one significant difference with regard to rise time was gender related: girls consistently reported getting up earlier than boys on school mornings. Thus, overall, 65% of the girls versus 38% of the boys reported that they usually get up before 6:00 a.m. on school mornings. The sex-related difference in rising times is likely the chief factor in lower reported total sleep times on school nights in girls than boys. Bedtimes, by contrast, varied significantly across the four groups of students. Figure 3 displays the percentage of students who reported going to bed later than 11:00 p.m. on school nights and those who reported going to bed later than 1:00 a.m. on weekends. Across sex, these data demonstrate that reported bedtimes in the groups spending more time on extracurricular activities and/or work were significantly later (girls Kruskal-Wallis = 73.39, $p < .001$; boys Kruskal-Wallis = 84.6, $p < .001$). There was also a nonsignificant trend for boys to report somewhat later bedtimes. Subjects in Group 4, whose out-of-school time commitments were greatest, reported the latest bedtimes overall.

The students were also asked how often they stay up past 3:00 a.m. Staying up late at least once a week was reported significantly more often by Groups 2, 3, and 4 than Group 1 for girls (Kruskal-Wallis = 20.66; $p < .001$) and boys (Kruskal-Wallis = 39.6; $p < .001$). The largest percentage reporting such late nights at least once a week were the boys in Group 4, of whom 45.1% reported this behavioral pattern. In spite of this pattern and although bedtimes were later overall in Groups 2–4 than Group 1, no significant differences were found for morningness/eveningness (Horne and Östberg, 1976).

TABLE 1

Hours Spent in Extracurricular Activities or Working:
Relationship to Reported Sleep Times and Sleep Need

	Group 1		Group 2		Group 3		Group 4	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
N	607	742	188	114	318	223	72	25
Extracurricular								
Mean hr/wk	8.5	7.2	28.6	30.4	7.6	6.2	27.2	29.9
SD	4.9	4.5	11.3	13.7	4.4	4.0	8.7	13.8
Work								
Mean hr/wk	5.5	5.3	4.6	5.0	26.9	24.7	27.5	28.2
SD	6.4	6.5	6.4	6.3	7.4	5.9	7.5	15.0
Total Sleep Time on School Nights								
Mean min/night	466.5	450.8	457.9	437.2	432.8*	424.2**	420.9*	396.0*
SD	58.9	68.5	62.8	63.6	81.8	67.8	86.8	58.6
Total Sleep Time on Weekend Nights								
Mean min/night	531.2	548.0	520.9	503.6*	489.6*	499.7*	485.4*	470.0***
SD	118.2	109.2	129.7	133.0	131.7	123.3	159.9	128.6

* Significantly less than Group 1 same sex, $p < .01$.

** Significantly less than Groups 1 and 2 same sex, $p < .01$.

*** Significantly less than Groups 1, 2, and 3 same sex, $p < .01$.

Reports of daytime sleepiness were greater in Groups 2, 3, and 4 compared to Group 1. As shown in Figure 4, the likelihood of students reporting falling asleep in morning or afternoon classes was significantly greater in those with the larger time commitments to extracurricular activities or jobs. Thus, for example, 24% of Group 4 girls versus 12.9% of Group 1 girls reported falling asleep in morning classes at least once per week; similarly, 22.5% of Group 4 boys versus 14.1% of Group 1 boys reported falling asleep in afternoon classes at least once per week. One of the most striking symptoms of sleepiness reported by these students was the report of struggling to stay awake or actually falling asleep while driving a car (at least once per week). Figure 5 illustrates the extent to which students reported these episodes. Boys were more likely to report falling asleep behind the wheel, while girls reported struggling to stay awake more frequently. Across gender, the groups with lowest sleep times (i.e., those with greatest extracurricular and work schedules) were also those who reported these symptoms with greatest frequency.

TABLE 2

Percentage of Groups Reporting Drug and Alcohol Use

	Group 1		Group 2		Group 3		Group 4	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
Coffee/Tea (daily)	10.6	14.3	14.8	18.8	21.6	27.6	22.5	40.0
Caffeinated Soda (daily)	57.5	55.9	66.5	54.9	63.2	60.1	63.4	66.7
Cocaine (weekly)	0.7	0.4	2.8	0.8	3.3	1.4	0.0	8.3
Marijuana (weekly)	7.6	4.3	10.5	4.5	15.0	9.7	11.6	21.7
Alcohol (weekly)	11.4	10.0	18.6	16.1	22.8	15.1	19.1	20.8
Cigarettes (daily)	10.3	17.7	12.4	25.0	19.5	26.7	20.0	37.5

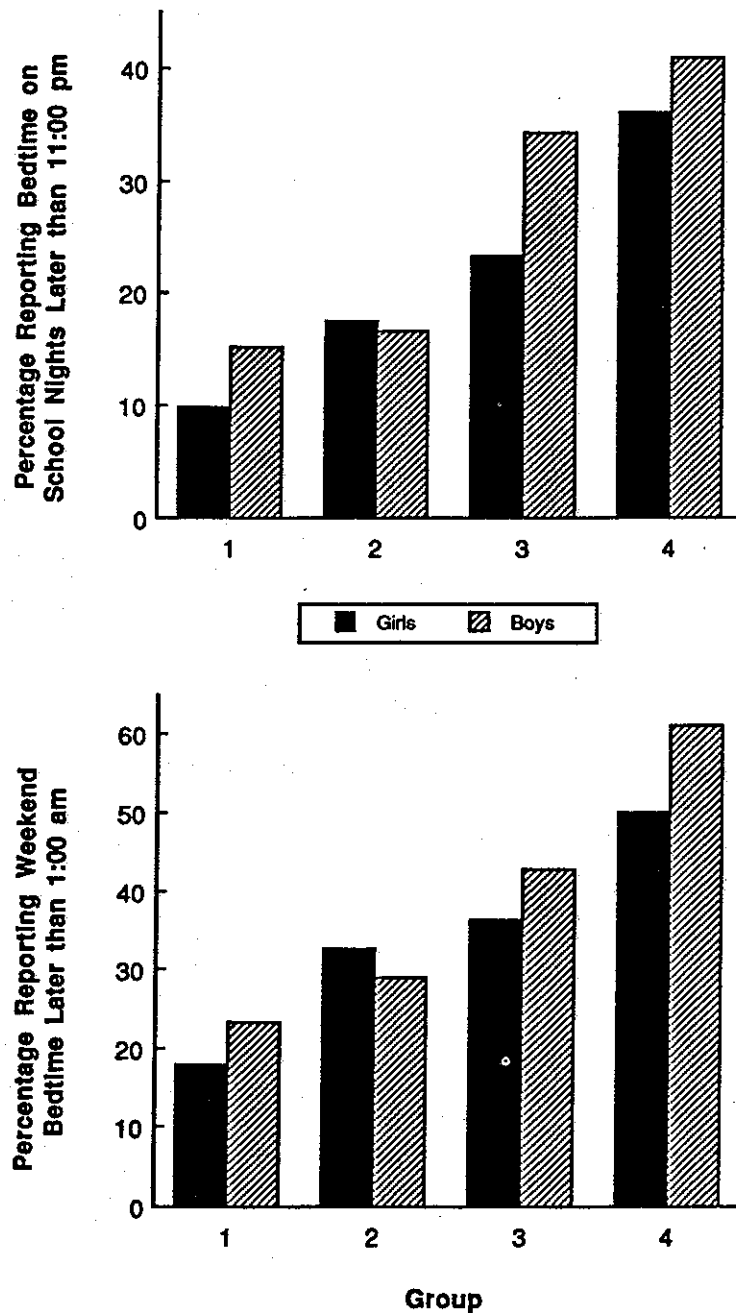


FIGURE 3

The upper panel shows the percentage of female (solid bar) and male (hatched bar) students who reported that their usual bedtime was later than 11:00 p.m. on school nights. The lower panel similarly depicts the percentage who reported a usual weekend bedtime later than 1:00 a.m. Both graphs indicate incrementally greater numbers of students reporting late bedtimes in the groups who reported spending the greatest amounts of time in extracurricular activities (Group 2), at work (Group 3), or both (Group 4).

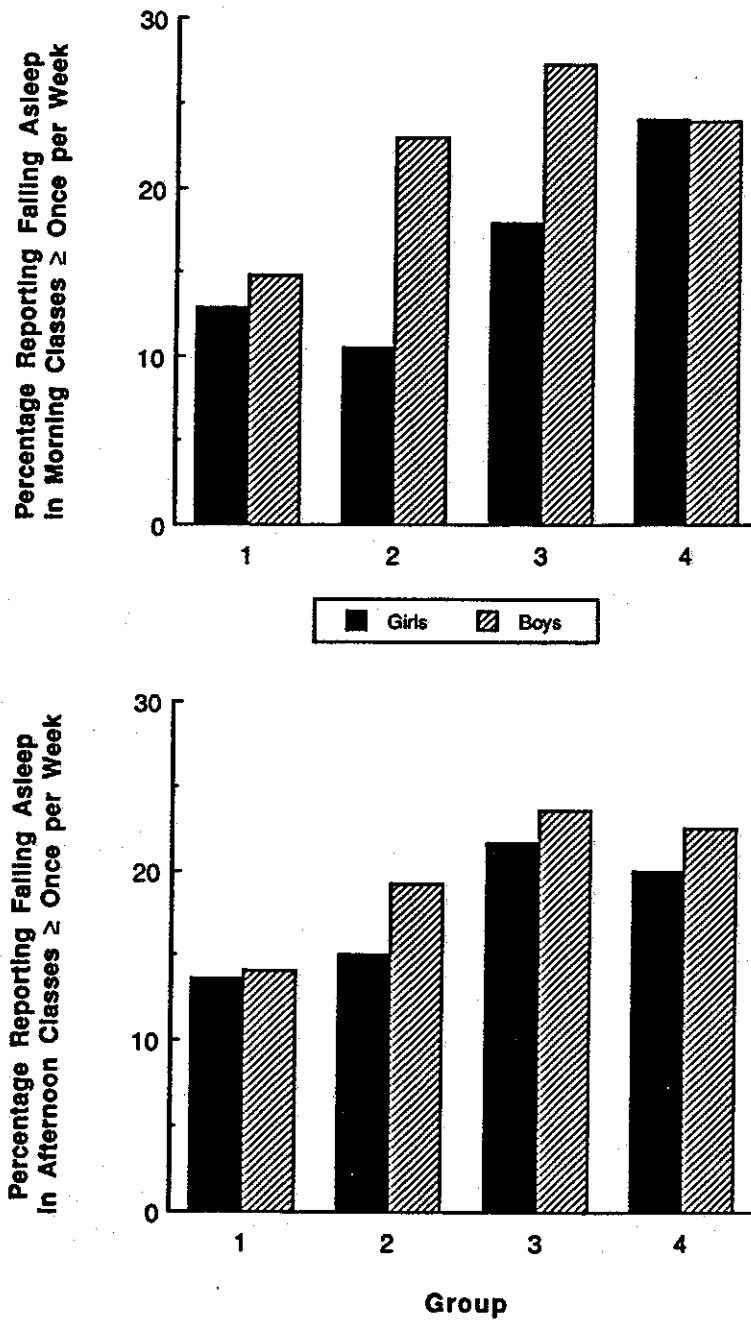


FIGURE 4

This figure illustrates the impact of increasing commitments to extracurricular activities and jobs on a major symptom of daytime sleepiness. The upper panel shows the percentage of students who reported falling asleep in a morning class at school and the lower panel those falling asleep in an afternoon class at least once per week. The analysis demonstrated that the percentage reporting these symptoms was greater in the groups with greater time commitments.

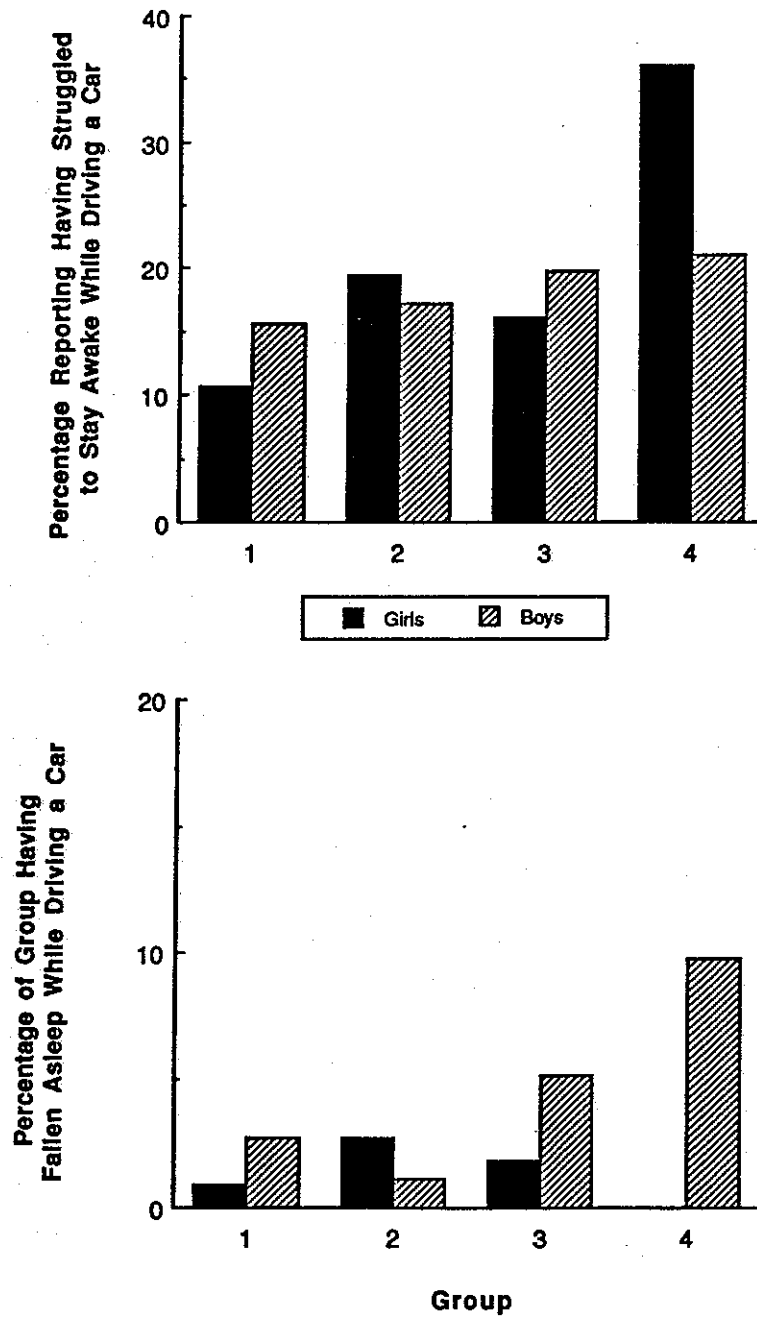


FIGURE 5

Figure 5 summarizes the students' reports of struggling to stay awake or actually falling asleep while driving a car. The upper panel demonstrates a significant increase in reports of struggling to stay awake as a function of Group, which is most prominent for the girls (solid bars). The lower panel, by contrast, shows that boys (hatched bars) in Groups 3 and 4 were significantly more likely to report having fallen asleep while driving.

Another set of questions we asked this group concerned the frequency of caffeine, alcohol, and other substance use. Table 2 summarizes these data. Reported daily coffee and tea use was significantly higher in the "high work" groups (3 and 4) than in the "low work" groups. Daily ingestion of caffeinated soda was very high and fairly stable across all four groups in both boys and girls. The number of students reporting weekly cocaine use was low throughout the population, although there was a statistically significant increase in frequency of reported cocaine use in the Group 4 girls (Kruskal-Wallis = 26.50; $p < .001$). [Keep in mind, however, that this reflects just two girls in Group 4 who reported weekly cocaine use.] Reported weekly marijuana use was significantly higher in the high work groups than in the high extracurricular groups in both sexes, with highest use reported by girls in Group 4. Reported alcohol and cigarette consumption were also lowest in Group 1 and higher in the groups reporting greater time commitments to extracurricular activities and work. As others have reported (Robinson et al., 1987), we found that reports of daily smoking were generally quite a bit greater in high school girls than boys.

Given this pattern of survey results, along with interviews of high school students, we have constructed profiles of adolescents whom we feel may have marked vulnerability due to sleepiness and related risk factors. Students in Group 1 (59% of the population) appear to have the fewest risk factors and are therefore not included in the descriptions below.

Portraits of Vulnerable Adolescents

Portrait 1: Group 2 (13%)

This student spends an average of nearly 30 hours a week in extracurricular activities, four or five hours at a paying job, and an unknown number of hours studying. He or she stays up late on school nights and (*she* especially) wakes up early to dress and get to school. Often she or he drives to and from school or car pools with similar students. This student copes well socially and academically with a fairly significant sleep debt and tends to oversleep on weekends to compensate. He or she is likely a member of a school sports team, and a reasonable sleep/wake schedule is therefore supported by the regulation of physical activity along with the coach's perception that sleep is important to athletic performance. This student functions at a high level and is likely to be enrolled in an advanced class at school. Exposure to drugs and alcohol is very limited by virtue of limited funds and associations with a circle of friends/peers that is resistant to drug use. Although this student is unlikely to use coffee or tea daily, she or he normally drinks caffeinated sodas on a daily basis. Falling asleep in classes is only an occasional problem for this student, and struggling to stay awake or actually falling asleep while driving a car may also occur occasionally. The limited exposure to alcohol and other depressant drugs limits the student's likelihood of confronting their synergy with sleepiness. Nevertheless, because of the significant sleep debt that accrues across the week, a beer or two at a weekend party greatly escalates the risk of driving.

Portrait 2: Group 3 (23%)

This student spends over 20 hours a week working at a part-time job, six or seven hours a week on extracurricular activities, and an unknown amount of time studying. He or she tends to stay up late on school nights and (especially *she*) to rise early on school days. Though not a frequent event, this student occasionally oversleeps and arrives late to school. He or she probably owns his/her own car and is responsible for insurance, gasoline, etc. Thus, the part-time job is a pivotal segment of the student's life. This student is sleepier than his or her friends who only work 10-20 hours each week. She drinks coffee most mornings to help get the day started, and he has a coke or two to keep the day going. About once each week, this student will be unable to stay awake in a morning or afternoon class. Furthermore, when this student drives the car for 20 minutes or so, he may nod off or she may find herself struggling mightily to remain awake. If not working on Friday or Saturday night, he or she will party and have beer or marijuana, making the drive home particularly risky. Because this student has an independent income, drugs, alcohol, and cigarettes are fairly available.

Portrait 3: Group 4 (4.2%)

This student spends 25–30 hours a week in extracurricular activities, 25–30 hours at a part-time job, and an unknown amount of time studying. He or she combines the worst sleep/wake patterns of the two sketches drawn above. A college-bound student, he or she works not only to support a car and other consumer needs, but also to save toward college expenses. This student goes to bed quite late on school nights and (*she* especially) gets up early on school mornings. He or she very rarely has time to catch up on sleep by oversleeping on the weekends. At least one night a week, this student stays up into the wee hours drinking coffee and finishing a homework assignment, or getting home from a late night at work, or coming home late from a party. Pressure to excel in academic and extracurricular activities is great, not only from parents, teachers, and peers, but also from the student's own expectations. The student may seek drugs or alcohol to cope with the very real pressures and stresses of his or her hectic life style. This student uses relatively high quantities of caffeine (or even cocaine) and may smoke cigarettes knowingly or unknowingly to self-medicate for excessive sleepiness. Alcohol and marijuana may seem a welcome and well-earned reward for this student's hard work. Vulnerability to accidents stemming from excessive sleepiness, drugs, and/or alcohol is very high. This vulnerability may manifest on the way to school in the morning, having been dragged out of bed after only six hours of sleep; or it may occur on the way from school to an after-school job, driving to work in the midst of the afternoon trough, which may be accentuated by a beer or two at a friend's house on the way; or a catastrophe may strike late at night on the way home from work or a party. This bright, energetic, young person may succumb to a life style that has set him or her up for disaster.

Portrait 4 (% unknown)

The "Drop-Out" no longer attends school at all. He or she has joined the work force on a permanent full-time basis or has simply dropped out entirely. At present no data are available to characterize this group.

Discussion

Teenagers confront a multitude of risks and vulnerabilities, not least among which is their own penchant for risk-taking and limit-testing behaviors. A largely unknown and unacknowledged, but potentially quite serious, threat to the health and safety of adolescents is their vulnerability to excessive sleepiness. This vulnerability manifests as a maturational increase in physiological sleep tendency (Carskadon et al., 1980) that is accentuated by cultural imperatives leading to insufficient sleep by militating against adequate organization of sleep/wake behaviors. The problems are accentuated when teenagers are exposed to other factors (e.g., drugs and alcohol) that impair waking alertness.

The background state of excessive sleepiness that is present in many teenagers represents an incremental risk in this already high-risk group, because it reduces the margin for safe experimentation. Thus, for example, a fully alert teenager might be able to cope adequately with a beer or two, whereas an already sleepy youngster is likely to be severely impaired due to the interaction of sleepiness and alcohol (Lumley et al., 1987; Roehrs et al., 1986; Zwyghuizen-Doorenbos et al., 1988). Our survey data suggest that it is the most active, hardest working, most involved students who may face the greatest risk of this invisible threat.

The current economic climate in the United States encourages teenagers to work—because so many jobs are available—and to spend—because so many goods are so desirable. As long as the common perception holds that adolescents "need" less sleep, as long as teenagers remain ignorant of the principles of proper sleep/wake function, as long as there is a failure to understand and acknowledge the risks of excessive sleepiness, so long will a large number of youngsters be needlessly vulnerable to tragic accidents.

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