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Age-Related Changes in Sleep/Wake Patterns Among Korean Teenagers

Chang-Kook Yang, MD, PhD*; Jung K. Kim, PhD‡; Sanjay Rajnikant Patel, MD§; and Jeong-Hyeong Lee, PhD‖

ABSTRACT. *Introduction.* **As children go through the transition from childhood to adolescence, many shifts occur in sleep/wake patterns related to intrinsic and extrinsic developmental changes. These shifts have been shown to result in corresponding shifts in sleep phase (later sleep onset) and sleep deprivation among teenagers in Western societies. However, the effect of these developmental changes on the sleep habits of Korean teenagers has not been analyzed. This study aims to quantify age-related changes in sleep/wake patterns among Korean teenagers and elucidate cultural and other factors causing these changes.**

Methods. **The School Sleep Habits Survey was administered in homeroom classes to students in grades 5 to 12 (mean age: 13.7 ± 2.4 years) selected via a 2-way stratification sampling method. The survey included items regarding usual sleep/wake patterns over the previous 2 weeks as well as measures of daytime sleepiness, sleep/wake-problem behavior, depressed mood, and morningness/eveningness.**

Results. **A total of 1457 students (52.9% male) completed the survey. The higher the grade, the later bedtime was found to be on both school days and weekends. There was a similar relationship between increasing grade and earlier wake time on school days, but higher grades were associated with later wake time on weekends. Total sleep time decreased by ~3 hours on school nights and 1 hour on weekend nights from grades 5 to 12. Adolescents were severely sleep deprived, with mean school-night total sleep times of 6.02, 5.62, and 4.86 hours for 10th-, 11th-, and 12th-graders, respectively. In the higher grades, there was a greater discrepancy between school nights and weekends in terms of bedtime and wake time, and the magnitude of weekend oversleep increased. Older students also reported more daytime sleepiness, more sleep/wake-problem behavior, more depressed mood, and more eveningness preference. The chief reasons students cited for their sleep deprivation differed across grades: Academic demands and entertainment (such as Internet and television) were reported by 5th- and 6th-graders, entertainment and then academic demands by 7th-, 8th-, and 9th-graders, and early school start time and academic demands by 10th-, 11th- and 12th-graders.**

Conclusions. **This study clearly demonstrates that Korean adolescents do not get adequate sleep and that they have profound discrepancies in their sleep/wake patterns between school and weekend nights. Compared with previous studies from other countries, Korean students display even greater sleep deprivation and also more irregular sleep/wake patterns. This study also demonstrates that academic demands/stress and early school start time are the most important contributing factors for sleep deprivation among Korean adolescents. These findings stress the need to promote awareness of the magnitude of adolescent sleep deprivation and its detrimental effects in Korean society.** *Pediatrics* **2005;115:250–256;** ***adolescent, preadolescent, sleep patterns, sleep deprivation.***

ABBREVIATION. TST, total sleep time.

Sleep/wake patterns change throughout life. In particular, childhood sleep patterns change dramatically from preadolescence to adolescence. As children go through the childhood-to-adolescence transition, marked changes occur in physiologic, psychologic, cognitive, and social domains, all of which have a substantial effect on sleep habits.

Several investigators have reported that many adolescents do not receive adequate sleep. These findings are important, because insufficient sleep in the teenage years has adverse effects on developmental processes, psychosocial function, and neurocognitive ability.[1–4] Many studies have also found a trend toward both longer sleep times and a sleep-phase shift to later hours on weekends as children become adolescents,[1,4] which is likely a reflection of both biological rhythm and sociobehavioral changes in adolescents, with many factors potentially contributing to their erratic sleep/wake patterns and insufficient sleep. Because most research in this field has been performed in Western nations, the generalization of these findings to other cultures with different social and behavioral mores is inexact.

For example, Korean society puts a special emphasis on education and also has a strong tradition of Confucianism, in which personal identity and success are linked to family honor. Therefore, performance on the college entrance examination taken at the end of high school carries enormous social and psychologic importance, placing high school, junior high school, and even elementary school students under tremendous academic pressure. In such a

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highly competitive atmosphere, most Korean students attend private educational institutions in the evening and/or night in addition to their daytime school, further impinging on time available for sleep. As a result, it is likely that inadequate sleep is an even greater problem among Korean adolescents than among their peers in the West. To date, however, no descriptive studies have examined the sleep habits of Korean adolescents. The aims of this study, therefore, were to quantify the prevalence and severity of inadequate sleep among Korean adolescents, define changes in sleep/wake patterns that occur across the teenage years, and elucidate factors that influence these sleep/wake patterns.

METHODS

Subjects

The city of Busan is the second largest city in Korea, with a population of ~4 million. We selected 7 elementary, 14 junior high, and 13 high schools by using a 2-way stratification sampling method.[5] Of 1487 students invited to participate in our survey of sleep habits, 1457 (98.0%) completed the questionnaire. Participants consisted of 268 5th-graders (18.4%), 257 6th-graders (17.6%), 135 7th-graders (9.3%), 208 8th-graders (14.3%), 145 9th-graders (10.0%), 106 10th-graders (7.3%), 199 11th-graders (13.7%), and 139 12th-graders (9.5%). There were 771 boys (52.9%) and 686 girls (47.1%). The participants' mean age was 13.7 ± 2.4 years (range: 9.4–19.1 years).

Procedure

The survey was conducted in May 2002. Trained psychiatrists administered the School Sleep Habits Survey (a modified Korean version of the survey used in ref 4) to students in their homeroom classes during morning school hours when there were no scheduled examinations. All students attending school on the day of the survey were invited to participate. The school system in Korea consists of 6 years of elementary school (grades 1–6), 3 years of junior high school (grades 7–9), and 3 years of high school (grades 10–12). There is no accommodation for napping in school, and students are not allowed to leave school before dismissal time.

The School Sleep Habits Survey asks about usual sleep/wake patterns over the previous 2 weeks. The survey included the daytime-sleepiness scale, which rates sleepiness on a scale of 10 to 40, with increasing scores reflecting more sleepiness[6]; the sleep/wake-problems behaviors scale, which consists of 10 items regarding problems associated with sleep/wake behavior (eg, tardiness because of oversleeping, falling asleep in class, difficulty falling asleep, tiredness or sleepiness during the day, difficulty getting up in the morning) and is scored from 10 to 40, with higher scores reflecting more sleep-related problems[6]; the depressive-mood scale, scored from 6 to 18, with higher scores representing a more depressed mood[7]; and the morningness/eveningness scale, scored from 10 to 42, with higher scores representing greater morning preference.[8]

We calculated the following variables to compare sleep irregularity between school days and weekend days: "Bedtime shift" was defined as the difference between weekend and school-night bedtimes; "wake-time shift" was the difference between weekend and school-day wake times; and "weekend oversleep" was the difference between weekend and school-night total sleep time (TST).

Written informed consent was obtained from participants. In addition, consent was obtained from homeroom teachers and principals, because they represent students' parents at school in Korea. The study protocol was approved by the Ethics Committee of Dong-A Medical Center, Busan, Korea.

Statistics

The Students' t and χ^2 tests were used to examine group differences for continuous and discrete data, respectively. The paired t test was used to examine differences between school days and weekends. Analysis of variance was used to examine gender differences and grade effects on each of the sleep/wake variables. Tukey's tests were used to adjust for multiple comparisons. All data were analyzed by using SAS (SAS Institute, Cary, NC).

RESULTS

Data were grouped into 4 grade categories for analysis: 5th and 6th (mean: 11.2 ± 0.6 years; range: 9.4–13.3 years), 7th and 8th (mean: 13.3 ± 0.6 years; range: 10.7–14.3 years), 9th and 10th (mean: 15.0 ± 0.8 years; range: 12.8–17.6 years), and 11th and 12th (mean: 17.1 ± 0.6 years; range: 14.6–19.1 years). Data on sleep/wake variables by grade are presented in Table 1.

Sleep/Wake Patterns on School Days

Significant grade effects were found for bedtime, wake time, and TST on school days (Table 1). As grade level increased, students went to bed later, woke up earlier, and slept less. Average bedtimes were >130 minutes later ($P < .0001$), and average waking times were 60 minutes earlier ($P < .0001$) across the 4 grade groups. As a result, average TST decreased by >170 minutes ($P < .0001$). Whereas students' mean TST was >7 hours up to 9th grade, the TST dramatically shortened when students entered high school (10th-12th grades), with a mean of 6.02 hours for 10th-graders, 5.62 hours for 11th-graders, and only 4.86 hours for 12th-graders. Girls awoke significantly earlier than boys ($P < .001$). However, TST did not differ significantly between boys and girls. There was no difference in sleep latency during school days across grades, but girls reported a longer sleep latency than boys ($P = .02$).

Ideal sleep time, defined as how many hours of sleep a student felt he/she needed to be at his/her best, decreased by 135 minutes across grades ($P < .0001$), from 9.31 hours among 5th-graders to 7.05 hours among 12th-graders. The mean ideal sleep time (7.05 hours) for 12th grade is below the recommended sleep time of >8 hours for adolescents.[9,10] Even in the presence of decreasing ideal sleep time, the subjective "sleep debt" (ideal sleep time minus TST) on school days increased with higher grade level. The sleep debts were 0.9, 1.2, 2.1, and 2.0 hours for 5th- and 6th-graders, 7th- and 8th-graders, 9th- and 10th-graders, and 11th- and 12th-graders, respectively. This grade effect on sleep debt was highly significant ($P < .0001$), with no difference between boys and girls.

Sleep/Wake Patterns on Weekends

Significant grade effects were also found for bedtime, wake time, and TST on weekend nights (Table 1). Average bedtimes were 45 minutes later ($P < .01$), average waking times were 90 minutes later ($P < .0001$), and average TST was 36 minutes shorter ($P < .05$) across the 4 grade groups. This grade effect was relatively small compared with that found on school nights ($P < .0001$). Wake times on the weekend were significantly later among older students than among younger students ($P < .0001$), which was the opposite of what was found on school days. There was no significant difference between girls and boys on average weekend bedtime. However, girls, who awak-

TABLE 1. Sleep/Wake Patterns by Grade (Mean ± SD)

Variables	Grade				*F* Values		
	5–6 (A) (n = 525)	7–8 (B) (n = 343)	9–10 (C) (n = 251)	11–12 (D) (n = 338)	Gender	Grade	Posthoc
School-night bedtime	10:42 PM ± 1:18	11:12 PM ± 1:06	12:00 AM ± 1:06	12:54 AM ± 1:24			
Boys	10:42 PM ± 1:36	11:12 PM ± 1:12	12:06 AM ± 1:12	12:54 AM ± 1:36	0.01	202.69*	A < B < C < D
Girls	10:48 PM ± 1:00	11:12 PM ± 1:06	12:00 AM ± 1:00	12:54 AM ± 0:54		Grade × Gender (F = 0.01, P = .678)	
School-day wake time	7:18 AM ± 0:30	7:00 AM ± 0:30	6:48 AM ± 0:36	6:18 AM ± 0:24			
Boys	7:18 AM ± 0:30	7:00 AM ± 0:30	6:54 AM ± 0:36	6:18 AM ± 0:24	11.86*	272.50†	A > B > C > D
Girls	7:18 AM ± 0:30	7:00 AM ± 0:24	6:42 AM ± 0:30	6:12 AM ± 0:24		Grade × Gender (F = 2.62, P < .05)	
School-night sleep time	8:18 AM ± 1:12	7:36 AM ± 1:06	6:36 AM ± 1:24	5:24 AM ± 1:06			
Boys	8:12 AM ± 1:12	7:36 AM ± 1:00	6:36 AM ± 1:24	5:24 AM ± 1:42	0.00	337.15†	A > B > C > D
Girls	8:18 AM ± 1:12	7:36 AM ± 1:06	6:36 AM ± 1:12	5:24 AM ± 1:06		Grade × Gender (F = 0.15, P = .927)	
Weekend bedtime	11:00 PM ± 2:06	11:30 PM ± 2:30	11:36 PM ± 3:42	11:54 PM ± 3:00			
Boys	11:06 PM ± 2:18	11:12 PM ± 3:06	11:00 PM ± 4:48	12:24 AM ± 2:00	0.14	5.28‡	A < C, D
Girls	10:54 PM ± 1:42	11:42 PM ± 1:36	11:54 PM ± 2:48	11:06 PM ± 4:12		Grade × Gender (F = 9.06, P < .0001)	
Weekend wake time	8:06 AM ± 1:30	8:54 AM ± 2:06	9:30 AM ± 1:48	9:18 AM ± 1:36			
Boys	7:54 AM ± 1:36	8:24 AM ± 1:48	9:30 AM ± 1:48	9:12 AM ± 1:42	39.30*	43.82*	A < B < C = D
Girls	8:24 AM ± 1:24	9:24 AM ± 2:12	9:42 AM ± 1:42	9:24 PM ± 1:30		Grade × Gender (F = 3.27, P < .05)	
Weekend sleep time	9.0 ± 2.2	8.8 ± 2.6	9.0 ± 2.6	8.4 ± 2.2			
Boys	8.9 ± 2.5	8.1 ± 2.7	8.3 ± 2.8	8.2 ± 2.1	43.44†	3.19§	A, C > D
Girls	9.3 ± 2.0	9.5 ± 2.3	9.3 ± 2.4	8.8 ± 2.4		Grade × Gender (F = 3.24, P < .05)	
Self-estimated ideal sleep time	9.2 ± 2.4	8.8 ± 1.7	8.7 ± 2.0	7.4 ± 1.8			
Boys	9.0 ± 2.4	8.9 ± 1.8	8.6 ± 1.7	7.4 ± 1.9	0.03	52.31†	A > C, A, B, C > D
Girls	9.3 ± 2.3	8.7 ± 1.6	8.7 ± 2.1	7.4 ± 1.7		Grade × Gender (F = 1.37, P = .251)	

* P < .001.
† P < .0001.
‡ P < .01.
§ P < .05.

ened earlier than boys on school days had a significantly later wake time (P < .0001) and a longer TST (P < .0001) than boys did on the weekend. There was no difference in sleep-onset latency across grades or between genders.

The subjective sleep debt on weekends differed across grade levels. On average, 5th- and 6th-graders slept 8 minutes less than their ideal sleep time, and 7th- and 8th-graders slept as much as they needed. Older students displayed a negative sleep debt, meaning that they slept more than they needed: 18 minutes more for 7th- and 8th-graders and 1 hour more for 11th- and 12th-graders. This grade effect on sleep debt was highly significant (P < .0001).

Sleep Pattern Differences on School Days and Weekends

Sleep habits were substantially different between school nights and weekend nights (Table 2). There was a significant grade effect on bedtime shift (P < .0001). On weekends, compared with school nights, bedtime was delayed (shifted forward to a later time) by ~15 minutes for 5th- and 6th-graders and 7th- and 8th-graders (P = .001), whereas it was advanced

TABLE 2. Differences in Sleep/Wake Patterns Between School Days and Weekend by Grade (Mean ± SD)

Variables	Grade				*F* Values		
	5–6 (A) (n = 525)	7–8 (B) (n = 343)	9–10 (C) (n = 251)	11–12 (D) (n = 338)	Gender	Grade	Posthoc
Bedtime shift, min	16.1 ± 122.0	15.4 ± 144.0	−27.4 ± 210.6	−54.8 ± 181.1			
Boys	23.6 ± 166.2	5.2 ± 182.4	−63.2 ± 276.6	−29.4 ± 147.6	0.07	19.68*	A = B < C = D
Girls	8.3 ± 106.8	26.7 ± 83.4	−7.6 ± 160.8	−101.4 ± 246.0	Grade × Gender (F = 7.40, P < .0001)		
Wake-time shift, min	52.9 ± 62.9	110.5 ± 121.8	159.3 ± 106.2	179.8 ± 94.8			
Boys	41.5 ± 96.0	78.9 ± 103.2	128.0 ± 109.8	171.0 ± 99.6	54.02*	122.38*	A < B < C = D
Girls	66.4 ± 81.0	145.1 ± 131.4	177.5 ± 100.8	194.3 ± 84.0	Grade × Gender (F = 3.78, P = .0102)		
Weekend oversleep, min	44.0 ± 122.0	75.1 ± 124.0	142.6 ± 158.4	180.7 ± 122.8			
Boys	33.6 ± 151.8	32.4 ± 164.4	105.7 ± 173.4	166.3 ± 153.0	34.37*	61.64*	A < B < C < D
Girls	54.8 ± 126.6	118.4 ± 144.0	162.4 ± 147.0	205.4 ± 134.4	Grade × Gender (F = 3.07, P = .0269)		

"Bedtime shift" refers to the difference between weekend bedtime and school-day bedtime; "wake-time shift" is the difference between weekend wake time and school-day wake time; and "weekend oversleep" is the difference between weekend and school-day sleep time.
* P < .0001.

(shifted backward to an earlier time) by ~30 minutes for 9th- and 10th-graders ($P < .05$) and by nearly 1 hour for 11th- and 12th-graders ($P < .0001$).

Wake-time shift was also significantly influenced by grade ($P < .0001$). On weekends, wake time was delayed for all the grades. That is, compared with school days, students woke up later on the weekend (53 minutes later for 5th- and 6th-graders [$P < .0001$], 111 minutes later for 7th- and 8th-graders [$P < .0001$], 160 minutes later for 9th- and 10th-graders [$P < .0001$], and 180 minutes later for 11th- and 12th-graders [$P < .0001$]). On weekends, students from all grade levels slept more than they did on school nights, but the effect was more pronounced among older teenagers ($P < .0001$): 5th- and 6th-graders slept 44 minutes longer, 7th- and 8th-graders slept 75 minutes longer, 9th- and 10th-graders slept 143 minutes longer, and 11th- and 12th-graders slept 181 minutes longer. Although there was no significant difference in bedtime shift between the genders, girls reported a greater wake-time shift and a greater weekend oversleep than did boys ($P < .0001$).

Factors Affecting Adolescent Sleep/Wake Patterns

The most commonly reported reasons that students went to bed when they did on school nights were feeling sleepy (33.4%), completing homework (20.4%), finishing favorite television show (15.4%), getting home from night school (10.9%), finishing Internet use (8.4%), and parental control over bedtime (3.4%). Parental control over bedtime on school days decreased with grade group from 6.3% to 3.6%, 0.8%, and 0.6% ($P < .0001$), respectively.

The chief responses to the question of how students woke up on school days were "by parental control" (49.4%), "spontaneously" (30.0%), and "by alarm clock" (12.3%). Responses differed by grade. For example, parental control increased with grade, going from 41.1% to 48.1%, 54.9%, and 59.1% ($P < .0001$), respectively. On the other hand, awakening spontaneously decreased with increasing grade, going from 39.2% to 24.1%, 21.1%, and 18.1% ($P < .0001$), respectively. This reduction in spontaneous awakenings likely reflects the increasing sleep debt with higher grade.

On weekends, the rate of students waking up spontaneously more than doubled, from 30.0% to 65.1%, and being awakened by parents decreased from 49.4% to 9.7%. There were also grade effects in the same direction as on school days on both waking up spontaneously and being awoken by parents. The higher the grade, the less frequently teenagers woke up spontaneously ($P < .001$) and the more frequently they were awoken by their parents ($P < .001$).

Reported reasons for insufficient sleep on school days were early school start times (31.9%), entertainment such as Internet use and television (25.9%), homework (18.9%), and attending night school (14.9%). The most common explanations for insufficient sleep differed across grade levels: Academic demand and then entertainment were reported by 5th- and 6th-graders, entertainment and then academic demand by 7th-, 8th-, and 9th-graders, and early school start time and then academic demand by 10th-, 11th-, and 12th-graders ($P < .0001$). The frequency with which early school start time was indicated as the primary reason for insufficient sleep increased with grade level from 17.7% to 24.6%, 39.5%, and 53.4% ($P < .0001$), respectively. Only 0.2% of students indicated "doing part-time jobs" as their reason for sleep deprivation.

In higher grades, the average time of leaving home for school was earlier, going from 8:10 AM to 7:48 AM, 7:33 AM, and 6:55 AM ($P < .0001$). There was a tendency for girls to leave earlier than boys, although it failed to reach statistical significance ($P < .06$). Similarly, the higher the grade, the earlier the time of arrival at school, going from 8:24 to 8:06 AM, 7:54 AM, and 7:24 AM ($P < .0001$).

School start times varied by both grade level and school. On average, 5th to 6th grades started class at 8:30 to 8:40 AM, 7th to 9th grades at 8:10 to 8:30 AM, and 10th to 12th grades at 7:00 to 7:40 AM.

School dismissal times also varied by grade level and school. The 5th- and 6th-graders typically finished class at 2:40 to 2:50 PM, 7th-, 8th-, and 9th-graders at 3:10 to 3:30 PM, and 10th-, 11th-, and 12th-graders at 5:00 to 6:00 PM. Korean teenagers, especially 11th- and 12th-graders, typically stay at school for additional study (preparing for the college entrance examination) until 9:00 to 11:00 PM. Therefore, as grade level increased, the average time of arrival home grew later, going from 6:41 PM to 7:47 PM, 8:56 PM, and 11:11 PM ($P < .0001$).

Because of the extreme competition created by the college entrance examination, many students attend night schools or have tutoring in addition to regular school. The present study found that 71.1% of the students attended additional classes in the evening. More than one third of students attended night school until later than 10:00 PM and 14.3% until past midnight. The percentage of students who were in night school past midnight increased with grade, going from 0.5% to 0.9%, 14.9%, and 54.5% ($P < .0001$), respectively. Nearly half of the respondents reported that attending night school affected their sleep/wake patterns.

Sleep-Related Problems

Data on sleep/wake-problem behavior and morningness/eveningness preference scales by grade are presented in Table 3. As grade level increased, students reported increased sleep/wake-problem behavior and greater eveningness preference ($P < .0001$ for both).

Sixty-one percent of students reported that they had not woken up at night during the previous 2 weeks, and the frequency increased with grade from 51.3% to 56.3%, 63.0%, and 79.0% ($P < .0001$), respectively. As to whether they got enough sleep on school days, students responded with "always" (7.5%), "usually" (19.1%), "sometimes" (30.8%), "rarely" (31.8%), and "never" (10.8%). The percentage of responses of "rarely" or "never" increased with grade, going from 26.3% to 37.5%, 53.8%, and 64.6% ($P < .0001$), respectively. On the other hand, participants tended to feel that their TST on weekends was satisfactory, responding with "always"

TABLE 3. Daytime Sleepiness, Sleep Problem Behavior, Depressive Mood, and Morningness/Eveningness Scales by Grade (Mean ± SD)

Scales	Grade				*F* Values		
	5–6 (A) (N = 525)	7–8 (B) (N =343)	9–10 (C) (N = 251)	11–12 (D) (N = 338)	Gender	Grade	Post-hoc
Daytime sleepiness‖	14.2 ± 3.7	15.5 ± 3.8	18.4 ± 4.6	19.0 ± 4.2	10.75*	120.16†	A < B < C = D
Boys	14.0 ± 3.8	15.0 ± 3.9	17.7 ± 4.8	18.8 ± 4.3	Grade × Gender (F = 0.72, P = .5373)		
Girls	14.3 ± 3.6	16.0 ± 3.7	18.8 ± 4.4	19.2 ± 3.8			
Sleep-problems behavior ‖	17.6 ± 6.4	19.7 ± 6.3	23.4 ± 6.3	23.5 ± 5.5	4.04‡	81.72†	A < B < C = D
Boys	17.0 ± 6.5	19.7 ± 6.3	23.4 ± 6.3	23.6 ± 5.8	Grade × Gender (F = 1.11, P = .3435)		
Girls	18.1 ± 6.2	20.3 ± 6.2	23.7 ± 6.0	23.3 ± 5.1			
Depressive mood‖	8.1 ± 2.5	9.1 ± 2.7	10.2 ± 3.0	19.7 ± 2.7	29.15†	84.97†	A < B < C = D
Boys	7.9 ± 2.5	8.8 ± 2.8	9.8 ± 2.9	10.1 ± 2.6	Grade × Gender (F = 4.59, P = .0033)		
Girls	8.2 ± 2.4	9.5 ± 2.6	10.5 ± 3.1	11.8 ± 2.7			
Morningness/eveningness¶	29.1 ± 4.8	27.6 ± 4.3	24.8 ± 4.1	25.0 ± 4.1	11.82§	80.05†	A > B > C = D
Boys	29.4 ± 4.9	28.5 ± 4.6	25.4 ± 4.3	25.0 ± 4.1	Grade × Gender (F = 3.16, P = .0237)		
Girls	28.8 ± 4.7	26.6 ± 3.7	24.5 ± 3.9	25.0 ± 3.9			

* $P < .01$.
† $P < .0001$.
‡ $P < .05$.
§ $P < .001$.
¶ The higher the score, the more morning preference.
‖ The higher the score, the more the problems.

(25.2%), "usually" (39.9%), "sometimes" (24.0%), "rarely" (8.4%), or "never" (2.5%).

Eighteen percent of the respondents reported that they did not eat breakfast on most school days, with no significant differences across grades or between genders. The main reasons for missing breakfast were poor appetite (44.6%) and sleeping late (37.8%).

Daytime Sleepiness and Depressed Mood

Data on daytime sleepiness and depressed mood by grade are presented in Table 3. As grade level increased, adolescents reported increased daytime sleepiness and more depressed mood ($P < .0001$ for both).

A substantial number of students suffered from daytime sleepiness, which was perceived as either "a big problem" or "a very big problem" by 6.6% of respondents; the prevalence increased with grade from 2.1% to 3.2%, 10.7%, and 13.9% ($P < .0001$), respectively. Girls complained of daytime sleepiness more than did boys ($P < .001$).

Falling asleep during class and/or taking naps on weekends were reported frequently. Approximately 18% of students reported that they fell asleep ≥4 times per week in class, and the frequency of this problem increased with grade: 4.0%, 5.5%, 11.6%, and 24.9% ($P < .0001$), respectively. In addition, 35.0% of students reported that they took at least 1 nap on the weekend.

DISCUSSION

This study represents the first systematic analysis of sleep/wake patterns among Korean teenagers. Our findings demonstrate clear changes as these students make the transition from childhood to adolescence. Although sleep needs are, to a certain extent, determined individually, this survey demonstrates that Korean preadolescents and adolescents do not receive adequate sleep and that they have very irregular sleep/wake patterns. The most important contributors to insufficient sleep and irregular sleep/wake patterns among Korean students are academic pressure and early school start times. Students in higher grades reported increased daytime sleepiness, more sleep/wake-problem behavior, more depressed mood, and more eveningness preference.

The mean TST on school days decreased >3 hours across grades 5 to 12. When our results are compared with previous findings,[3,4,11,12] Korean students seem more severely sleep deprived than do adolescents in other countries. Our 11th- and 12th-graders' TST of 5.4 hours on school nights was >100 minutes shorter than that of their American peers (7–8 hours).[4,13] Korean adolescents' TST on school nights was also markedly shorter than reported results from Japan (6–7 hours)[14] and China (7.5 hours),[3] nations with cultures similar to that of Korea. Given research suggesting that adolescents need at least as much sleep as do prepubertal children[15] and that adolescents require at least 8.25 hours of sleep nightly to maintain optimal daytime alertness,[10] the magnitude of the sleep deprivation found in our cohort represents a major public health concern for Korea.

The mean weekend TST decreased from 9.1 to 8.5 hours across grades 5 to 12, which was a much smaller change than those in school-night TST across grades. Interestingly, and in sharp contrast to school-night sleep times, our results on weekend sleep time are almost identical to those of previous studies in the United States (TST for Korean 11th- and 12th-graders of 510 vs 518 minutes for their American counterparts).[4]

Although findings from Western countries suggest that sleep schedules on school and weekend nights are more consistent among school-aged children than among adolescents,[2,16] our preadolescents reported substantial differences in sleep patterns between school and weekend nights, which is likely a reflection of the more severe sleep deprivation of Korean children on school nights.

In comparison to preadolescents and younger adolescents (5th- to 8th-graders), older adolescents

(9th- to 12th-graders) woke up later on weekend mornings. We interpret this as a reflection of adolescents' (especially 11th- and 12th-graders') attempt to "make up" on weekends for chronic sleep debt that accumulated on school nights. This finding is consistent with previous reports.[4,17]

Mean self-estimated ideal TST decreased from 9.2 to 7.4 hours across grades 5 to 12. Because it is reported that adolescents require >8 hours of sleep nightly for ideal performance,[15] Korean teenagers (especially 11th- and 12th-graders) seem to underestimate their sleep needs. Korean students, while severely sleep deprived, may perceive that they need to shorten their sleep time even more to live up to societal pressure to study harder. As a result, our calculation that the sleep debt of Korean 11th- and 12th-graders is ~3 hours per night may actually be a gross underestimate.

Our data also demonstrate that weekend oversleep increases with grade. This discrepancy between weekend and school days increased markedly from 40 minutes among 5th- and 6th-graders to 3 hours among 11th- and 12th-graders. This oversleep represents the most salient aspect of Korean students' irregular sleep/wake patterns. Weekend oversleep is a common and consistent finding in studies of adolescent sleep patterns.[1,2,4,11,17] However, the magnitude of weekend oversleep found in this study (>3 hours in grades 11 and 12) was substantially greater than that in studies from other countries.[4,11,17] Interestingly, contrary to results from other countries,[4,11] Korean high school adolescents reported a backward (to an earlier time) shift of bedtime on weekends compared with that on school days. This finding suggests that their cumulative sleep debt across the school week and, thus, their homeostatic drive is significant enough to supersede circadian patterns and social needs.

The differences in sleep/wake patterns between boys and girls, on the whole, are consistent with previous reports.[2,4,11,18] Girls reported that they woke up earlier than boys on school mornings but later on weekend mornings. As previous researchers have speculated,[4,11,18] we also assume that these differences may result from differences in the time needed to prepare for school and/or family responsibilities such as morning house chores. Our findings that girls have a greater weekend wake-time shift and greater weekend oversleep suggest that girls may suffer more sleep deprivation on school days. Girls reported a significantly longer sleep latency on school nights than did boys. The reason for this is unclear, but others have reported similar findings.[19] Given their greater sleep debt on school nights, it perhaps is not surprising that girls also complained of more daytime sleepiness.

Several potential causes including physiologic development, shifting of circadian rhythms, and psychosocial, familial, or environmental factors can contribute to disturbed sleep during adolescence.[9,18,20] As in other cultures,[1,4] academic demand and earlier school start time are major externally imposed constraints on student sleep/wake patterns in Korea. Particularly among high school students, an early school start time was identified as the most important cause for insufficient sleep. Carskadon et al[1] suggested that early school start time is in direct conflict with the physiologic changes in circadian rhythm that occur during puberty. Despite a progressive delay in sleep onset through the teenage years, school start times become earlier in higher grades. Thus, Korean adolescents are literally burning the candle at both ends of their sleep time, resulting in profound sleep deprivation.

In addition to the factors mentioned above, the common Korean practice of attending night school or private tutoring in the evening and night for extra study, which is uncommon in Western nations, places an additional strain on the sleep/wake habits of Korean teenagers. It is interesting to note that the most-often cited reasons for insufficient sleep on school days were study-related activities such as early school start times, academic demand, and attending night school. In other cultures, part-time jobs have been found to have a strong influence on adolescent sleep/wake patterns.[9] Working teenagers report less sleep and more daytime sleepiness. However, part-time jobs were not an important determinant of sleep/wake patterns in our study, with only 0.2% of teenagers blaming part-time jobs as the primary reason for insufficient sleep. This finding reflects the general atmosphere of Korean society, which places a greater emphasis on education and much less importance on part-time jobs than in the West. Because Korean society demands that high school students be "study warriors," it is not surprising that educational demands play the largest role in limiting sleep time for Korean teenagers

An interesting finding of our study was that parental control over bedtime was relatively low (3.4%) compared with that in studies from Western countries.[9] Korean parents do not tend to impose sleep on their children if they are engaged in study-related activities. In fact, they often encourage their children to sacrifice sleep time for additional study until they are too sleepy to study. In Korea, there is even a widespread phrase advising 12th-graders that they will pass (the college entrance examination) with 4 hours of sleep but fail with 5 hours of sleep.

A substantial number of students reported that their sleep had not been satisfactory in the previous 2 weeks. The prevalence of not awakening during the night increased with grade, which suggests that sleep efficiency may improve with grade because of insufficient sleep. Our data also show that sleep/wake-problem behavior increases with grade. This implies that sleep disorders may increase with age, although we did not investigate the prevalence of sleep disorders such as insomnia in this survey. Many previous studies have indicated that insomnia symptoms are relatively common among adolescents,[11,13,21] and insomnia has been significantly correlated with behavioral problems.[3] The prevalence of sleep disorders and their relationship to sleep/wake patterns and behavioral or emotional problems among Korean adolescents need to be investigated further.

The most direct effect of insufficient sleep is day-

time sleepiness. Symptoms of daytime sleepiness among adolescents seem to be nearly universal.[4,11,22] A high proportion of Korean adolescents in our survey also reported excessive daytime sleepiness and falling asleep in the classroom, and these complaints increased with grade. It has been shown that functional impairment in neurobehavioral performance (such as cognition and motor coordination) is apparent with 5 hours of sleep per day, and the impairment is cumulative over time.[23] Therefore, it is very likely that our adolescents, especially the 11th- and 12th-graders, function at a level far below their optimum.

It is also reported that sleep deprivation and depressed mood are closely related, and insufficient sleep may result in mood lability.[20] Our results also showed that with higher grade, adolescents tended to be more sleep deprived, have more daytime sleepiness, and be more depressed. It seems imperative that clinicians and researchers concerned with adolescent behavior and mood pay close attention to sleep/wake patterns. Finally, our data indicate that substantial numbers of Korean students skip breakfast because of poor appetite and sleeping late. Assuming that a poor appetite may result from insufficient sleep, we believe that the sleep deprivation and erratic sleep/wake patterns of Korean adolescents have a major effect on teenage dietary behavior.

This study has several limitations. First, it was based only on student self-reports, which were retrospective and subjective, and not supported by more sophisticated measurements such as sleep diaries, actigraphy, or sleep laboratory recordings. However, other studies of adolescent sleep habits also relied on survey instruments similar to ours, and there is no reason to believe that Korean children have any difference in recall bias from that of children in other countries. As a result, the cross-cultural comparisons we have made should remain valid. A second limitation is the lack of data on sleep/wake habits among college students, who are under a completely different set of constraints in terms of study-related activities and school start times. Comparisons of the sleep/wake patterns of high school and college students may provide even more valuable insight into the factors affecting Korean adolescent sleep/wake patterns. Finally, because our survey was cross-sectional and based only on habits over the previous 2 weeks, it is difficult to draw conclusions about causal direction and long-term effects of insufficient sleep. Also, this was a large urban area and, as such, may not be representative of all Korean adolescents. We did not examine alertness-promoting behaviors such as caffeine and nicotine use or other domains of impact of insufficient sleep such as academic achievement; these clearly are areas for future study.

CONCLUSIONS

This work supports and extends the findings of previous studies on adolescent sleep habits.[1,2,4,11,16,22] The present study clearly demonstrates that most Korean students, even those as young as 10 years old, do not get an adequate amount of sleep on school nights. It also shows that there are significant discrepancies between weekday and weekend sleep/wake patterns and that the discrepancies increase with grade. Academic demand/stress and early school start times are the most important factors contributing to sleep deprivation among Korean teenagers. Chronic and profound sleep deprivation among adolescents may lead to detrimental effects on multiple aspects of their lives. Therefore, it seems imperative from a health standpoint to promote public awareness about the harmful effects of adolescent sleep deprivation and to invest more resources in devising ways to combat this problem in Korean society.

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