JOURNAL OF ADOLESCENT HEALTH 1993;14:401–406

INTERNATIONAL ARTICLE

Sleep Characteristics of Adolescents: A Longitudinal Study

MIRIAM M. M. ANDRADE, M.SC., ANA A. BENEDITO-SILVA, E.E., SORAHIA DOMENICE, M.D., IVO J. P. ARNHOLD, M.D., Ph.D., AND LUIZ MENNA-BARRETO, Ph.D.

The aim of the present research was to study sleep/wake cycle parameters of adolescents and to examine biologic and social influences on their changing sleep patterns. This was a longitudinal study of sleep characteristics of a group of 66 adolescents (mean age, 13 years and 6 months). The adolescents underwent a physical examination, had their pubertal development classified according to Tanner stages, and answered a sleep questionnaire on three timepoints at 6-month intervals. Sleep onset occurred about 1.0 hr later, wake-up time about 3.0 hr later, and sleep length was 1.0–1.5 hr longer on weekends when compared with weekdays. About 60% of the adolescents reported daytime sleepiness, mainly from 8:00 a.m. to 10:00 a.m. and from 2:00 p.m. to 4:00 p.m. on school days. Morning sleepiness on school days occurred at a time of the day that corresponded to sleep on non-school days. Additionally, there was a displacement toward later hours of the wake-up time and a sleep-length increase during weekends from the first to the third timepoint. Social factors such as home conditions and scheduling of school and non-school activities did not change throughout the period of pubertal development studied. Changes of sleep patterns detected may therefore represent an ontogenetic trend along puberty.

KEY WORDS:
Sleep
Adolescence
Pubertal development
Sleepiness
Nap

Certain traits of the human sleep pattern seem to be established during adolescence. Sleep-onset time tends to be delayed as adolescents grow older, and they report a decrease in sleep quality, insufficient sleep length, and increasing daytime sleepiness (1–5). According to the International Classification of Sleep Disorders (6), the prevalence of the delayed sleep phase syndrome (DSPS) in adolescents is about 7%. This sleep disorder is characterized by a delay in sleep-onset time compared to usual time but satisfactory sleep quality or duration if the person is free to sleep without interruption (6,7). It is assumed that daytime sleepiness can produce poor school performance and can lead to behavioral problems (7). Modifications of adolescents' sleep patterns have been related to greater social pressures, as well as normal ontogenetic trends. Nevertheless, there are only a few longitudinal studies in which the sleep/wake cycle of adolescents has been evaluated with reference to the subjects' physical development. The aim of the present research is to study sleep/wake cycle parameters of adolescents and to evaluate possible changes that might occur during pubertal development. It describes the demographic characteristics, sleep habits, and complaints of a group of adolescents during the period under study.

From the Grupo Multidisciplinar de Desenvolvimento e Ritmos Biológicos, Departamento de Fisiologia e Biofísica, ICB (M.M.M.A., A.A.B.-S., L.M.-B.), and the Departamento de Endocrinologia, Faculdade de Medicina (S.D., I.J.P.A), Universidade de São Paulo, São Paulo, Brazil.

Address reprint requests to: M. M. M. Andrade, Depto. Fisiologia e Biofísica, ICB/USP, Av. Lineu Prestes 1524, 05508-900, São Paulo, SP, Brazil.

Manuscript accepted December 28, 1992.

Published by Elsevier Science Publishing Co., Inc., 655 Avenue of the Americas, New York, NY 10010

1054-139X/93/$6.00

Table 1. Chronological Age in the First Semester

Age (year)	Female		Male		All	
	n	*f* (%)	*n*	*f* (%)	*n*	*f* (%)
12	12	37.5	11	32.4	23	34.8
13	14	43.8	14	41.2	28	42.4
14	2	6.2	6	17.6	8	12.1
15	4	12.5	1	2.9	5	7.6
16	–	—	2	5.9	2	3.1
Total	32	100.0	34	100.0	66	100.0

Methods

Subjects

Sixty-six healthy adolescents participated in the study performed over a period of approximately 1 year. The general purpose and conditions of the research were explained to the school's staff, students, and parents. Written consents were given by the school administration and by the parents. Thirty-two girls and 34 boys from 12 to 16 years old (77.2% from 12 to 13 years old at the beginning of the study) participated voluntarily in the survey (Table 1). These adolescents went to the same public school in the morning (7:20 a.m. to 12:30 p.m.) from Monday to Friday. They studied in two different grade classes of the middle school (according to the Brazilian educational system: 6th and 7th grade classes).

Measures Used

The adolescents underwent a physical examination, had their pubertal development classified according to Tanner stages (8,9), and answered a sleep questionnaire on three consecutive timepoints at about 6-month intervals (semesters): mid-September, beginning of April, mid-September. These months were selected in order to avoid the Daylight Saving Time and the effects of transition from holidays to the school semester (they represent a time-lag of about 1.5 months in the beginning of the school semester). The sleep questionnaire covered the following aspects: (a) demographic characteristics, such as age, sex, number of people living in the house, number of people sharing the bedroom, and illumination and sounds in the bedroom; (b) time spent in different daily activities, such as television watching, homework, sports, and "extra-school" classes (Arts, Music, foreign languages, etc.); (c) sleep/wake cycle parameters: sleep onset, wake up, nap onset, and nap wake-up time, awakenings at night, daytime sleepiness, sleep quality; and (d) medicine consumption related to sleep problems. Sleep schedules' answers were provided in multiple choice format, each choice representing an interval of 15 min: sleep-onset time alternatives ranging from 7:00 p.m. to 3:00 a.m., wake-up time ranging from 6:00 a.m. to 2:00 p.m., and nap onset and wake-up time ranging from 12:00 p.m. to 6:30 p.m. The daytime sleepiness question had the following format: "Do you usually feel sleepy during daytime, even without going late to bed at night?". There were 6 alternatives: "No," or "I feel sleepy from 8:00 a.m. to 10:00 a.m.", . . . , "I feel sleepy from 4:00 p.m. to 6:00 p.m." Sleep quality was measured by the following question: "Do you think that you sleep:" and the following possible answers: "very well, well, fair to well, fair to bad, bad, very bad."

Statistical Analyses

Test and retest reliability of the questionnaire was assessed during the first semester (10,11). κ coefficient was calculated and questions with $\kappa > 0.50$ were used for analysis; additionally two questions with κ coefficients near moderate level were also analyzed (daytime sleepiness, $\kappa = 0.48$; and sleep quality, $\kappa = 0.45$). School days and non-school days were analyzed separately. One-way analysis of variance (ANOVA) for repeated measures on the same elements was applied for the factors day of the week and semester to verify the influence of these factors in the means of sleep variables. When F ratio exceeded the critical value, tests on differences between pairs of means (Newman–Keuls method) were used (12). Sleep quality, daytime sleepiness, sleep disorders, home conditions, and extra-school activities were also investigated. Their stability over the study period was investigated by means of Cochran's Q test for related samples (13) in the case of binary variables, such as sound (silent or noisy room), illumination (dark or clear room), daytime sleepiness (sleepy or not sleepy), and nap (nap taken or no nap).

Results

General Health and Pubertal Status

Clinical evaluation showed that adolescents were in good health during the survey period. Their heights and weights were within the standard Brazilian patterns for their age (14). The first physical examination revealed that all the subjects had already reached at least Tanner stage 2 for at least one of

Table 2. Females' Pubertal Stages (n = 32)

		Tanner stages				
	Semester	T1	T2	T3	T4	T5
Breast	S1	–	9%	38%	38%	16%
	S2	–	3%	6%	63%	28%
	S3	–	3%	3%	47%	47%
Pubic hair	S1	–	–	31%	41%	28%
	S2	–	–	22%	25%	53%
	S3	–	–	12%	16%	72%

S1, S2, and S3 represent first, second, and third semesters.
T1, T2, T3, T4, and T5 represent Tanner stages 1, 2, 3, 4, and 5, respectively.

Table 4. Daytime Sleepiness

	S1		S2		S3	
Time of the day	n	f (%)	n	f (%)	n	f (%)
8:00 a.m.–10:00 a.m.	12	18	9	14	7	11
10:00 a.m.–12:00 p.m.	1	1	2	3	1	1
12:00 p.m.– 2:00 p.m.	5	8	5	8	4	6
2:00 p.m.– 4:00 p.m.	12	18	14	21	17	26
4:00 p.m.– 6:00 p.m.	2	3	2	3	–	–
More than 1 alternative	7	11	9	14	9	14
Not sleepy	27	41	25	38	28	42
Total	66	100	66	101	66	100

S1, S2, and S3 represent the first, second, and third semesters, respectively.

the characteristics investigated. Pubertal stages distribution and progression are shown in Tables 2 and 3.

Home Conditions

The majority of the families (95%) were comprised of 2 to 5 people. In the first semester, 91% of the students considered their bedroom silent and 88% considered it dark. Adolescents did not report changes in their bedrooms' illumination and sound over the three semesters. The students' home conditions remained very similar throughout the survey.

Non-School Activities

No one worked for pay. The students spent on average 3.5 hr per day watching television and a mean of 1.5 hr per day doing homework. One-way ANOVA for repeated measures showed no significant influence of the semester on the time spent on television watching and on the time spent doing homework, in other words, the amount of hours spent on these activities was the same for the three consecutive semesters analyzed. In the first semester 58% of the students practiced sports outside school and 63% went to extra-school classes. There was no observable change in the amount of time spent in these activities over the semesters.

Table 3. Males' Pubertal Stages (n = 34)

		Tanner stages				
	Semester	T1	T2	T3	T4	T5
Genitals	S1	–	21%	26%	41%	12%
	S2	–	18%	23%	47%	12%
	S3	–	9%	15%	53%	23%
Pubic hair	S1	3%	27%	23%	23%	23%
	S2	–	9%	27%	35%	29%
	S3	–	9%	18%	38%	35%

S1, S2, and S3 represent first, second, and third semesters.
T1, T2, T3, T4, and T5 represent Tanner stages 1, 2, 3, 4, and 5, respectively.

Sleep Quality, Sleepiness and Nap

No one reported being a poor sleeper. Sleep quality was considered very good by 32%, good by 54%, and fair to good by 14% of the adolescents in the first semester. The majority denied having sleep problems (85%) in an open-ended question. There was no report of medicine consumption related to difficulties in falling asleep or remaining awake. Habitual night awakenings were reported by 53% of the students: 6% woke up every night, 17% occasionally each week and 30% occasionally each month in the first semester. Daytime sleepiness (from 8:00 a.m. to 6:00 p.m.) was most frequent from 8:00 a.m. to 10:00 a.m. and from 2:00 p.m. to 4:00 p.m. (Table 4). The number of adolescents that reported daytime sleepiness remained stable for the three semesters analyzed (Q = 0.48, df = 2, $p > 0.05$). The early afternoon sleepiness episodes correspond to the most frequent nap time on weekdays. There were interindividual differences related to the frequency of naps on weekdays: some adolescents (20%) reported taking naps in the three semesters surveyed, 44% took naps in one or two semesters, but not in the other(s), and 36% never took naps during the study span. Nap frequency on school days and on non-school days did not change according to the semester. One-way ANOVA for repeated measures showed no significant effect of the semester on nap onset time, wake-up time, and nap length of those adolescents who reported taking naps in the three semesters (n = 13).

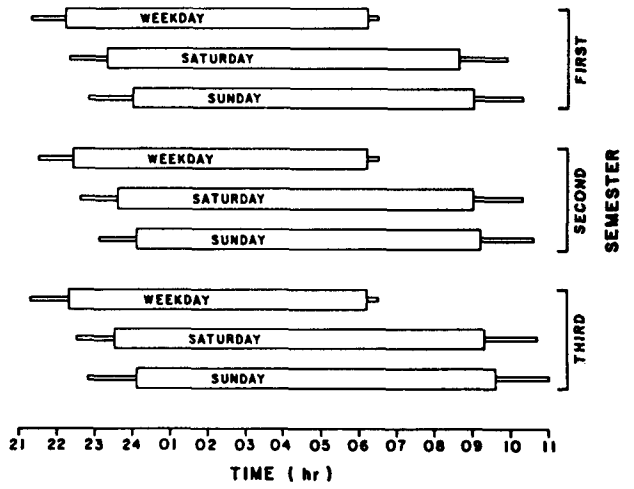

Figure 1. *Fluctuation of the sleep/wake cycle along the days of the week in the first, second, and third semesters. Bars represent the sleep period. Sleep-onset time (SOT) mean is plotted on the left side of the thick bar and wake-up time (WT) mean on the right side. Thin bars correspond to the standard deviation of SOT (left side) and of WT (right side).*

Day of the Week

A sleep schedule displacement toward later hours and a sleep-length increase were observed on weekends in comparison to weekdays (Figure 1). One-way ANOVA statistics for repeated measures evinced a significant effect of the day on the week on sleep-onset time (SOT) [$F(2, 130) = 124.24$ $p < 0.001$], Wake-up time (WT) [$F(2, 130) = 196.15$ $p < 0.001$], and nocturnal sleep length (NSL) [$F(2, 130) = 37.41$ $p < 0.001$]. SOT, WT, and NSL were statistically different between weekdays and weekends ($p < 0.01$) according to Newman–Keuls procedure. Friday/Saturday's Sleep WT was different from Saturday/Sunday's Sleep WT ($p < 0.05$), except for semester 2. Differences between Friday/Saturday's NSL and Saturday/Sunday's NSL were not significant.

Semester

Sleep characteristics averages calculated for each semester are shown in Table 5. The influence of the semester was significant on some of the sleep variables: Friday/Saturday's Sleep WT [$F(2, 130) = 11.47$ $p < 0.001$], Saturday/Sunday's Sleep WT [$F(2, 130) = 8.89$ $p < 0.001$] and Friday/Saturday's NSL [$F(2, 130) = 4.8$ $p < 0.02$].

Some significant differences between the three semesters were revealed by Newman–Keuls method. There was a WT displacement towards later hours comparing semester 1 to the other semesters: Friday/Saturday's Sleep WT happened 23 min later in semester 2 ($p < 0.01$) and 29 min later in semester 3 ($p < 0.001$), while Saturday/Sunday's Sleep WT occurred 13 min later in semester 2 (non-significant) and 34 min later in semester 3 ($p < 0.001$). As expected, owing to the school schedule, WT on weekdays remained almost the same (differences ranging from 2 to 4 min—not significant) along the three semesters. Friday/Saturday's NSL was longer in semester 3 comparing to semester 1 (difference between means was 27 min, $p < 0.025$).

Table 5. Noctural Sleep Schedules per Semester ($n = 66$)

Variable	S1 hr min (SD)	S2 hr min (SD)	S3 hr min (SD)
Sleep onset time			
Weekday	22 14	22 23	22 18
	(00 54)	(00 55)	(01 03)
Friday/Saturday	23 20	23 38	23 33
	(01 03)	(01 01)	(01 02)
Saturday/Sunday	23 57	24 07	24 10
	(01 14)	(01 04)	(01 19)
Wake-up time			
Weekday	06 15	06 11	06 13
	(00 19)	(00 17)	(00 21)
Friday/Saturday	08 39	09 02	9 18
	(01 17)	(01 17)	(01 23)
Saturday/Sunday	09 02	09 15	09 36
	(01 22)	(01 24)	(01 24)
Nocturnal sleep length			
Weekday	08 00	07 47	07 55
	(00 56)	(00 51)	(01 03)
Friday/Saturday	09 18	09 23	09 45
	(01 07)	(01 13)	(01 20)
Saturday/Sunday	09 04	09 08	09 25
	(01 16)	(01 14)	(01 11)

SD, standard deviation.
S1, S2, and S3 represent the first, second, and third semesters, respectively.

Discussion

The adolescents surveyed were healthy and normally developed for their age group. They all went to the same school on the same schedule and did not work. The majority did not report difficulty in falling asleep or maintaining sleep, although 60% reported daytime sleepiness. The number of individuals feeling sleepy varied along the course of the day. If this sleepiness were reflecting only fatigue

owing to school activities, we should expect equally frequent sleepiness during the school period or a linear increase. This was not, however, the case. The number of adolescents that felt sleepy was greater during the first two hours (from 8:00 a.m. to 10:00 a.m.) than in the following two hours (from 10:00 a.m. to 12:00 p.m.) of the morning. The early afternoon sleepiness episode (from 2:00 p.m. to 4:00 p.m.) corresponds to a well-known chronobiological phenomenon (the Post-Lunch Dip) (15). Our results are similar to those of Allen and Mirabile (16). The 17- to 18-year-old adolescents of their sample were least alert around 10:00 a.m. (64% at 8:00 a.m. and 9:00 a.m.) and most alert after 3:00 p.m.

We found a sleep schedule displacement toward later hours and an increase of nocturnal sleep on weekends compared with weekdays. There appears to be consensus that the adolescent's sleep schedule and length of sleep vary along the week, regardless of different population characteristics and type of study (1–3,5,17,18). The pattern of smaller amounts of sleep on weekdays and greater amounts on weekends (restriction-extension) has been related to adolescents' sleepiness. Our study supports this view, as morning sleepiness on school days occurred at a time of the day that corresponded to sleep on non-school days. Additionally, the adolescents surveyed did not complain of chronic sleep disturbances that could be responsible for sleepiness. These facts suggest that the wake-up hour is too early on school-days, which may account, at least in part, for morning sleepiness of this group.

While the student's home conditions, school schedule, and time spent in some non-school activities remained similar along the survey, some sleep characteristics changed. WT on weekends occurred later and NSL was longer in the third semester than in the first one. These modifications happened only during weekends suggesting that school schedules did not allow their manifestation during weekdays.

Sleep schedule displacement as adolescents grow older has been described by some authors while sleep length increase has not. Strauch and Meier (3) reported a continuous decline in sleep length on weekdays, on weekends and during vacations of a group of adolescents followed up for 10 years and surveyed every 2 years. The sleep-length decrease was less pronounced on weekends and during vacations than on weekdays. Comparing adolescents aged 10–13 years old, Anders et al. (17) observed a significant decline only on weekday sleep length. They also showed significant differences in sleep time between the youngest group and the oldest on either school or non-school nights. Levy et al. (2) verified a decline of sleep length per week and an increase of sleep need in a group of 12- to 18-year-old adolescents. Strauch and Meier (3) found that 54.3%–74.5% of their sample's adolescents would like to sleep more. This sleep need was neither related to difficulty in falling asleep nor to frequent awakenings at night. It is interesting that while these studies showed a decline in sleep length, they also showed that perhaps this decline did not correspond to the adolescent's sleep need.

As home conditions and the temporal organization of school and non-school activities remained similar throughout the survey, at a time when the adolescents were rapidly changing their maturity stage, we suggest that the observed sleep schedule displacement (later wake-up time) may be an ontogenetic trend corresponding to puberty. We also suggest that the sleep-length decrease found in others studies (but not in our present survey) may be related to social factors and/or long-term maturative processes. The verification of these sleep modifications suggests the need for further discussion about the organization of school schedules. In this age group, there seems to be a temporal conflict between an ontogenetic trend and the school schedule (the majority of schools in Brazil begin classes between 7:00 a.m. and 7:30 a.m.). This opposition between social obligations and sleep requirements tends to increase during development and may contribute to daytime sleepiness seen in adolescents. The consequences of this situation for the students' well-being and school performance should be carefully studied.

The authors wish to thank the participation and cooperation of the students, the teachers, the school personnel, and the Principal of Escola de Aplicação da Faculdade de Educação da Universidade de São Paulo, São Paulo, SP, Brazil.

We acknowledge the support of FAPESP and CNPq.

References

1. Rugg-Gunn AJ, Hackett AF, Appleton DR, et al. Bedtimes of 11 to 14-year-old children in north-east England. J Biosoc Sci 1984;16:291–7.
2. Levy D, Gray-Donald K, Leech J, et al. Sleep patterns and problems in adolescents. J Adolesc Health Care 1986;7: 386–9.
3. Strauch I, Meier B. Sleep need in adolescents: A longitudinal approach. Sleep 1988;11:378–86.
4. Carskadon MA, Harvey K, Duke P, et al. Pubertal changes in daytime sleepiness. Sleep 1980;2:453–60.
5. Bearpark HM. Sleep-wake disturbances in Sydney adolescents: A survey of prevalence and correlates. Thesis submitted to Macquarie University, Australia, June, 1986.

6. Diagnostic Classification Steering Committee, Thorpy MJ (chairman). International Classification of Sleep Disorders: Diagnostic and Coding Manual. Rochester, MN: American Sleep Disorders Association, 1990:128–33.
7. Thorpy MJ, Korman E, Spielman AJ, et al. Delayed sleep phase syndrome in adolescents. J Adolesc Health Care 1988;9:22–7.
8. Marshall WA, Tanner JM. Variations in the pattern of pubertal changes in girls. Arch Dis Child 1969;44:291–303.
9. Marshall WA, Tanner JM. Variations in the pattern of pubertal changes in boys. Arch Dis Child 1970;45:13–23.
10. Cohen J. A coefficient of agreement for nominal scales. Educ Psychol Meas 1960;20:37–46.
11. Spitzer RL, Fleiss JL. A re-analysis of the reliability of psychiatric diagnosis. Br J Psychiatry 1974;125:341–7.
12. Siegel S. Nonparametric Statistics for Behavioral Sciences. Tokyo, MacGraw-Hill. 1956.
13. Winner BJ. Statistical principles in experimental design. Tokyo, McGraw-Hill Kogakusha Ltd, 1971.
14. Marques RR, Marcondes E, Berquó E, et al. Crescimento e desenvolvimento pubertário em crianças e adolescentes brasileiros. II- altura e peso. São Paulo, Brasileira de Ciências, 1982.
15. Folkard S, Monk TH. Circadian performance rhythms. In: Folkard S, Monk TH, eds. Chichester, England: John Wiley & Sons. 1985:37–52.
16. Allen R, Mirabile J. Self-reported sleep-wake patterns for students during the school year from two different senior high schools. Sleep Res 1989;18:132.
17. Anders TF, Carskadon MA, Dement WC. Sleep habits of children and the identification of pathologically sleepy children. Child Psychol Hum Dev 1978;9:56–62.
18. Montagner H, Koch P, Soussignan R, et al. L'évolution temporelle du rythme veille-sommeil chez l'enfant et l'adolescent, de la section de CM1 de l'école élémentaire à la terminale du lycée, (mimeo:rapport sur l'étude réalisée au cours de l'année scolaire 1984–1985), Laboratoire de Psychophysiologie, Faculté des Sciences et des Techniques, Université de Franche Comté, Route de Gray, 25030, Besançon, France.