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FAST TRACK

Development of sleep patterns in early adolescence

L. LABERGE[1,2], D. PETIT[1], C. SIMARD[1], F. VITARO[2], R.E. TREMBLAY[2,3] and J. MONTPLAISIR[1,3]
[1]Centre d'étude du sommeil, Hôpital du Sacré-Coeur, Montréal, Québec, Canada, [2]Groupe de Recherche en Inadaptation Psychosociale chez l'enfant and [3]Département de Psychiatrie, Université de Montréal, Québec, Canada

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SUMMARY This study examines the developmental changes of sleep patterns as a function of gender and puberty and assesses the prevalence of sleep habits and sleep disturbances in early adolescence. It also investigates the relationship between sleep patterns, sleep habits and difficulty falling asleep and nocturnal awakenings. The present analyses are based on results available for 588 boys and 558 girls for whom mothers completed questions concerning demographics and sleep at annual intervals when their child was aged 10–13 years. The results indicated that nocturnal sleep times decreased, bedtimes were delayed and differences between weekend and school day sleep schedules progressively increased with age. Gender and puberty were both associated with the timing of sleep on weekends. Girls presented longer weekend time in bed (TIB) and later weekend wake time than boys. Similarly, subjects with higher pubertal status showed longer weekend TIB and later weekend wake time than subjects with lower pubertal status. Difficulty falling asleep was associated with later weekend wake time and with sleeping with a night light. In conclusion, the gender differences commonly reported in adolescents' sleep patterns are most likely explained by girls' higher pubertal status. This study emphasizes the link between puberty and a putative physiological need for more sleep, in presence of a general reduction of sleep times during adolescence. From age 10–13 years, the delay and lengthening of the sleep period on weekends in comparison to schooldays is associated with difficulty falling asleep.

KEYWORDS adolescence, gender, longitudinal study, puberty, sleep disturbances, sleep habits

INTRODUCTION

Sleep patterns of adolescents have been investigated by means of electrophysiological recordings (Feinberg 1974; Williams *et al.* 1974; Karacan *et al.* 1975; Carskadon 1982; Coble *et al.* 1984; Carskadon and Dement 1987) and questionnaire-based surveys, mainly using self-reports. Nearly all questionnaire-based surveys looked at adolescent sleep patterns from a cross-sectional perspective (Zepelin *et al.* 1977; Anders *et al.* 1978; White *et al.* 1980; Petta *et al.* 1984; Bearpark and Michie 1987; Henschel and Lack 1987; Wolfson and Carskadon 1998; Lee *et al.* 1999). The few longitudinal studies that evaluated the timing of sleep in adolescence have either reported figures for sleep length or bedtimes only (Klackenberg 1982; Rugg-Gunn *et al.* 1984; Strauch and Meier 1988) or have presented overall figures for a wide age range (Strauch and Meier 1988; Andrade *et al.* 1993). Hence, no longitudinal study has reported annual changes in the timing of sleep during adolescence.

During childhood, the sleep schedule on schooldays and weekends is generally constant, wake times in particular (Petta *et al.* 1984), leading to a stable circadian phase position for the sleep–wake cycle. When children enter adolescence, major changes in sleep patterns occur, characterized mainly by a delay of the sleep period: adolescents tend to stay up later at night and to sleep later in the morning than do prepubescent children (Dahl and Carskadon 1995). This circadian phase delay of the sleep period is more important on weekends than

Correspondence: Jacques Montplaisir, MD, PhD, CRCP(c), Centre d'étude du sommeil, 5400 boul. Gouin Ouest, Hôpital du Sacré-Coeur, Montréal, Québec, Canada H4J 1C5. Tel.: +1 514–338–2693; fax: +1 514–338–2531; e-mail: montjacq@crhsc.umontreal.ca

on schooldays (Wolfson 1996; Wolfson and Carskadon 1998). On schooldays, the timing of the sleep period is highly determined by early wake times mandated by the school schedule and by a greater parental control over bedtime than on weekends. In comparison with school-age children, for whom school day time in bed (TIB) and weekend TIB are quite similar, adolescents tend to sleep longer periods of time on weekend (Petta *et al.* 1984), possibly as a result of insufficient sleep on schooldays (Wolfson 1996). The adolescent sleep phase delay on weekend was traditionally attributed to psychosocial factors (Anders *et al.* 1978; Kirmil-Gray *et al.* 1984; Carskadon 1990a) but recent findings pointed to a phase delay of the biological clock itself. Indeed, age-related changes in the timing of sleep may be linked to age-related modifications in the phase of the circadian timing system (Brock 1991; Myers and Badia 1995). A progressive change in morningness–eveningness scores favoring greater numbers of evening types was reported in older students (Carskadon and Davis 1989) and found to be associated with higher puberty scores (Carskadon *et al.* 1993). More recently, the timing of melatonin secretion was significantly correlated with maturation, as assessed by the presence of secondary sexual characteristics, i.e. adolescents with higher puberty scores having later offset times of melatonin secretion (Carskadon *et al.* 1997).

In prepubertal children there is generally no gender difference in sleep patterns (Wolfson 1996). Conversely, numerous studies based on self-reports have noted significant gender differences in adolescent sleep patterns (Petta *et al.* 1984; Rugg-Gunn *et al.* 1984; Carskadon 1990b; Wolfson and Carskadon 1998; Lee *et al.* 1999). These differences may be associated with puberty: girls starting puberty earlier than boys (Petersen *et al.* 1988). However, none of these cross-sectional studies have controlled for pubertal status.

In comparison with preadolescents (Kahn *et al.* 1989; Blader *et al.* 1997; Paavonen *et al.* 2000), a significant number of adolescents report sleep disturbances (Zepelin *et al.* 1977; Price *et al.* 1978; Carskadon 1982; Kirmil-Gray *et al.* 1984; Bearpark and Michie 1987), as defined by difficulty falling asleep and nocturnal awakenings. The development of good sleep habits in adolescence is of prime importance as many adult insomniacs reported that their problem began in adolescence (Price *et al.* 1978; Bixler *et al.* 1979; Hauri *et al.* 1980). Based on mothers' report of childhood behavior, the aims of the present study were:

1 to document age-related changes and gender differences in sleep patterns in a large cohort of randomly selected normal early adolescents;

2 to examine at age 13 years the relationship between sleep patterns and puberty; and

3 to assess the prevalence and the relationships between sleep patterns, sleep habits and difficulty falling asleep and frequent nocturnal awakenings in the same children between 10 and 13 years of age.

METHODS

Subjects

Subjects were drawn from a longitudinal study of children aged from 6 to 16 years old (Vitaro *et al.* 1995; Zoccolillo *et al.* 1996; Pagani *et al.* 1997; Zoccolillo *et al.* 1999). This survey represents a randomly stratified, proportional sample of 2000 children selected from French-language school boards, as to be representative of all 11 administrative regions of Québec and of both urban and rural settings. The present analyses are based on results available for 1146 subjects (588 boys and 558 girls)[1] for whom their mothers had completed a questionnaire concerning sleep and pubertal status. This study was approved by the review board for human subjects of the Université de Montréal.

Instruments and procedures

Sleep habits and sleep disturbances

In the fifth year of the longitudinal study, the children were 10 years old. A sleep questionnaire was added to the annual questionnaire administered to mothers. At ages 10, 11, 12 and 13 years, mothers were asked about sleep patterns, sleep habits and sleep disturbances during the previous year. Questions about bedtimes and wake times were answered freely, without categories (open-ended questions). TIB represents the time elapsed from bedtime to wake up time in the morning. Weekend oversleep is defined as the difference between weekend TIB and school day TIB. Bedtime shift is the difference between weekend and school day bedtimes. Wake time shift is the difference between weekend and school day wake times. Questions regarding sleep habits were answered as 'yes/no'. The prevalence of difficulty falling asleep and of frequent nocturnal awakenings was estimated on a four-level scale (frequently, sometimes, seldom, or never). To avoid bias being introduced by the use of parental estimates of severity, we scored only whether or not an event occurred (never/seldom scored 0, and sometimes/frequently scored 1).

Pubertal status

At age 13 years, pubertal status was rated by the mother using the Pubertal Development Scale (Petersen *et al.* 1988). Mothers' ratings of growth spurt, body and facial hair development, and skin and voice changes were combined so as to yield one of a five-level categorical classification: (1) prepubertal; (2) early pubertal; (3) midpubertal; (4) late pubertal and (5) postpubertal. Petersen *et al.* (1988) measured the reliability and validity of this scale. Two measures per year were taken over a 3-year period; the alpha coefficient varied from 0.68 to 0.83, with a median of 0.77. The validity of the instrument was measured by comparing self-evaluation of subjects and that of an interviewer. The correlation coefficients varied from 0.41 to 0.79 with a median correlation of 0.70 (Petersen *et al.* 1988). In the present study, the Spearman correlation between our subjects' self-evaluations at age 13 years ($n = 607$) and their mothers' was 0.81.

Statistical analyses

To study change over time of sleep patterns, sleep habits and prevalence of sleep disturbances and their relationships, the analysis was limited to subjects for whom data for a given sleep variable were available at 10, 11, 12 and 13 years of age. A complete set of data was obtained for sleep patterns ($N > 741$), sleep habits ($N > 732$), and sleep disturbances ($N = 764$). To show age effect and gender differences, analyses of variance (ANOVAS) with repeated measures were performed for each sleep pattern variable in the four age groups (Table 1). Tukey HSD tests were used for posthoc comparisons. An effect size criterion (Cohen 1988) was used to take into account the possibility of finding several statistically significant results simply on the basis of the large sample size ($N > 500$). Only statistically significant F values for which effects for all groups differed by more than one-third of the sample standard deviation were interpreted as significant (corresponding to a mid-point between Cohen's small and medium effect size). For ages 10–13 inclusively, the Cochran Q-test was used to assess the variation in the prevalence of each sleep habit and sleep disturbance as a function of age; subsequently, a McNemar test was used for posthoc comparisons to specify at what age changes occurred, if any. Pearson χ^2 tests were used to evaluate gender differences for each sleep habit and sleep disturbance. Student's t-tests for independent samples were used to compare each sleep pattern variable with sleep disturbances, namely difficulty falling asleep and frequent nocturnal awakenings. Contingency coefficients were used to characterize the strength of the association between sleep habits and sleep disturbances. Bonferroni corrections were applied to the posthoc comparisons, the multiple χ^2 and the t-tests to take into account the number of comparisons ($N = 3$, $N = 4$ and $N = 36$, respectively).

Data for age 13 years from 1146 subjects (588 boys and 558 girls) were used to investigate the relationship between sleep patterns and puberty. One-way ANOVAS were performed on sleep pattern variables (Table 2). The analysis was limited

Table 1 Sleep patterns (means and standard deviations) based on parental reports by age

	Age				*F-values*		
Variables (N)	*10*	*11*	*12*	*13*	*Gender*	*Age*	*Post-Hoc*
School day bedtime							
Boys (349)	20 : 28 ± 28	20 : 46 ± 32	21 : 01 ± 32	21 : 28 ± 35	1.0	1363.2*	10 < 11 < 12 < 13
Girls (404)	20 : 29 ± 28	20 : 47 ± 29	21 : 04 ± 30	21 : 31 ± 34			
School day wake time							
Boys (361)	6 : 59 ± 23	6 : 59 ± 25	6 : 58 ± 26	6 : 56 ± 31	0.8	2.7	–
Girls (409)	6 : 59 ± 22	6 : 59 ± 22	6 : 58 ± 23	6 : 56 ± 31			
School day TIB							
Boys (349)	630 ± 29	613 ± 35	598 ± 34	568 ± 38	1.0	918.8*	10 > 11 > 12 > 13
Girls (402)	630 ± 32	612 ± 32	593 ± 34	566 ± 37			
Weekend bedtime							
Boys (348)	21 : 26 ± 38	21 : 46 ± 41	22 : 04 ± 41	22 : 34 ± 49	0.1	993.9*	10 < 11 < 12 < 13
Girls (402)	21 : 25 ± 37	21 : 45 ± 39	22 : 09 ± 40	22 : 34 ± 46			
Weekend wake time							
Boys (359)	7 : 43 ± 50	7 : 59 ± 52	8 : 08 ± 60	8 : 34 ± 67	29.1*	300.9*	10 < 11 < 12 < 13
Girls (402)	7 : 58 ± 51	8 : 16 ± 56	8 : 30 ± 63	8 : 57 ± 70			
Weekend TIB							
Boys (347)	616 ± 46	614 ± 52	604 ± 52	598 ± 58	40.1*	25.5*†	10, 11 > 12, 13
Girls (396)	634 ± 49	631 ± 53	621 ± 54	623 ± 62			
Bedtime shift							
Boys (348)	58 ± 32	59 ± 31	64 ± 32	66 ± 38	0.4	19.3*†	10, 11 < 12, 13
Girls (400)	56 ± 31	58 ± 33	65 ± 32	63 ± 34			
Wake time shift							
Boys (359)	44 ± 43	61 ± 46	71 ± 53	97 ± 62	37.3*	303.7*	10 < 11 < 12 < 13
Girls (402)	60 ± 48	77 ± 55	92 ± 60	121 ± 69			
Weekend oversleep							
Boys (347)	– 14 ± 44	1 ± 50	6 ± 53	30 ± 62	47.4*	171.2*	10 < 11 < 12 < 13
Girls (394)	4 ± 49	19 ± 56	27 ± 59	58 ± 67			

* $P < 0.000001$. †Does not meet effect size criterion values. Standard deviations = minutes.
TIB, time in bed.
TIB, weekend oversleep, bedtime shift and wake time shift are also presented in minutes.

Table 2 Sleep patterns (means and standard deviations) and pubertal status at age 13 years based on parental reports

	Pubertal Status				*F-values*	
Variables (N)	*Prepubertal*	*Early pubertal*	*Midpubertal*	*Late pubertal*	*Puberty*	*Post-Hoc*
School day bedtime (1132)	21 : 19 ± 28	21 : 23 ± 34	21 : 31 ± 35	21 : 31 ± 73	3.03	–
School day wake time (1145)	6 : 59 ± 31	6 : 58 ± 31	6 : 56 ± 31	6 : 58 ± 33	0.38	–
School day TIB (1131)	580 ± 32	574 ± 38	565 ± 39	566 ± 77	3.44	–
Weekend bedtime (1129)	22 : 25 ± 49	22 : 28 ± 53	22 : 37 ± 45	22 : 41 ± 84	3.35	–
Weekend wake time (1141)	8 : 15 ± 66	8 : 32 ± 62	8 : 42 ± 66	9 : 03 ± 72	21.00**	1 < 3 < 4; 2 < 4
Weekend TIB (1126)	590 ± 60	604 ± 60	606 ± 62	621 ± 64	6.57*	1, 2, 3 < 4
Bedtime shift (1128)	66 ± 42	65 ± 41	65 ± 35	71 ± 37	1.83	–
Wake time shift (1141)	77 ± 58	94 ± 56	106 ± 65	125 ± 68	23.37**	1 < 3 < 4; 2 < 4
Weekend oversleep (1125)	8 ± 58	31 ± 59	41 ± 65	54 ± 65	18.37**	1 < 2, 3 < 4

*$P < 0.01$; **$P < 0.00001$.
TIB, time in bed.

to pubertal categories for which there were a sufficient number of boys and girls to meet the ANOVAS' criterion. One-hundred-and-twenty-five boys and 5 girls were classified as prepubertal, 198 boys and 21 girls were classified as early pubertal, 212 boys and 182 girls were classified as midpubertal and 53 boys and 350 girls were classified as late pubertal. Thus, only pubertal status categories 1, 2, 3 and 4 were considered; of note is that all five categories are not expected to be represented at all ages for both boys and girls (Petersen *et al.* 1988). Bonferroni corrections were applied to take into account the number of sleep variables ($N = 9$) used in the ANOVAS. Tukey HSD tests were used for posthoc comparisons. Statistica for Windows (Statsoft Inc., Tulsa, OK, USA) was used for all statistical analyses. The alpha level was set at 0.05 for statistical significance.

RESULTS

Sleep patterns between ages 10 and 13 years

Table 1 presents means, standard deviations, and F values for sleep pattern variables from ages 10–13 years for boys and girls. ANOVAS revealed significant age effects ($P < 0.000001$) for school day and weekend bedtimes, school day TIB, weekend wake time, wake time shift and weekend oversleep. Principal gender effects were found for wake time on weekend, weekend TIB, weekend oversleep and wake time shift ($P < 0.000001$). No significant interaction was observed between age and gender for any of these sleep variables.

Between ages 10 and 13 years, the average bedtime on schooldays was delayed every year ($P < 0.00001$; Tukey HSD), to reach a total difference of approximately 61 min. The average wake time on schooldays remained very stable, and the average TIB on schooldays was shortened every year ($P < 0.00001$) to reach a total difference of 63 min. On weekends, the average bedtime was delayed every year ($P < 0.00001$), for a total difference over 3 years of approximately 69 min. The average wake time on weekend was also delayed every year ($P < 0.00001$), the total difference between ages 10 and 13 years was approximately 55 min. The average TIB on weekend slightly decreased every year; however, over a three year period the difference was only 14 min. Although the F value was statistically significant, age group differences for TIB on weekend were too small to meet the effect size criterion ($f = 0.21$).

Between ages 10 and 13 years, the average bedtime on weekend was delayed with respect to the average bedtime on schooldays by approximately one hour. Although the F value was statistically significant, age group differences were too small to meet the effect size criterion ($f = 0.11$). Between ages 10 and 13 years, the average difference between school day and weekend wake times increased every year ($P < 0.00001$), from about one hour at age 10 years to approximately two hours at age 13 years. From ages 10–13 years, the average weekend oversleep increased every year ($P < 0.05$). By age 13 years, the difference between weekend TIB and school day TIB was 45 min.

No gender difference was noted for ages 10–13 years for any school day sleep variable. On weekends, girls presented significantly later wake times and longer TIB than boys ($P < 0.000001$). Girls also presented a greater weekend oversleep and a greater weekend wake time shift than boys ($P < 0.000001$). No gender difference was found for bedtime on weekend or bedtime shift.

Sleep patterns according to pubertal status at age 13 years

Table 2 presents results of the one-way ANOVAS for the nine sleep variables presented on Table 1. Significant puberty effects were noted for weekend wake times, weekend TIB, wake time shift and weekend oversleep. Subjects with higher pubertal status woke up later on weekend mornings ($P < 0.00001$) and slept longer on weekends ($P < 0.01$) than subjects with lower pubertal status. Subjects with higher pubertal status also presented significantly larger variations between their school day and weekend wake times ($P < 0.00001$) and greater weekend oversleep ($P < 0.00001$) than subjects with lower pubertal status. No significant puberty effect was noted for any school day variable. The average weekend wake time and weekend TIB of subjects with the highest pubertal status was 48 min later and 31 min longer, respectively, than those of subjects with the lowest pubertal status.

Sleep habits

Table 3 indicates that 76.9% of the children slept in a separate room at age 10 years, compared to 80.6%, 84.3% and 88.3% at ages 11, 12 and 13 years, respectively. Table 3 also indicates that the proportion of children sleeping with a night light was 41.0% at age 10 years, and 23.1%, 18.5% and 10.6% at ages 11, 12 and 13 years, respectively. Approximately three percent of the children reported napping more than once per week at age 10 years. This prevalence was 0.9%, 1.7% and 1.9% for children aged 11, 12 and 13 years, respectively. No significant gender differences were found for the prevalence of sleeping alone, sleeping with a night light and napping more than once per week. Approximately 80% of the children frequently read and 65% frequently listened to music before sleeping. These bedtime habits occurred with greater frequency with advancing age and more in girls than in boys ($P < 0.00001$, Pearson chi-square) from ages 11–13 years.

Nearly 60% of the children had difficulty falling asleep at least sometimes from ages 10–13 years. Except for at age 11 years, girls were more likely to experience difficulty falling sleep ($P < 0.01$). Table 3 indicates that the proportion of children with difficulty falling asleep significantly diminished with age ($P < 0.0001$). Overall, 26% of the children were described by their mothers as having had frequent nocturnal awakenings at one point between ages 10 and 13 years. No gender difference with respect to nocturnal awakenings was observed. Approximately 15% of 10-year-olds frequently awoke at night as compared with 8.6%, 8.8% and 7.7% of children aged 11, 12 and 13, respectively. In this respect, 10-year-old children significantly differed from those aged 11, 12 and 13 years ($P < 0.0001$, McNemar test).

Student's *t*-tests were used to compare sleep patterns of subjects with or without difficulty falling asleep, and with or without frequent nocturnal awakenings, respectively. The only significant associations were for difficulty falling asleep and weekend wake time at ages 10, 11, 12 and 13 years ($t(751) = -3.3$, $P < 0.05$), wake time shift at age 11 years ($t(756) = -3.3$, $P < 0.05$) and weekend bedtime at age 12 years ($t(755) = -3.3$, $P < 0.05$). In comparison to subjects without difficulties falling asleep, subjects with difficulties woke up significantly later on weekends from ages 10–13 years, presented significantly larger differences between their school day and weekend wake times at age 11 years, and finally, had significantly later weekend bedtimes at age 12 years.

Contingency coefficients were calculated to assess associations between sleep habits and sleep disturbances listed in Table 3. The only significant association was for sleeping with a night light and difficulty falling asleep at ages 10 (0.12) and 11 years (0.14). Forty-seven and 48% percent of children sleeping with a night light had difficulty falling asleep at ages 10 and 11 years, respectively, compared to 35% and 31% for those who slept in a dark room.

DISCUSSION

The relationships between age, pubertal status, gender and sleep patterns

To our knowledge, this is the first longitudinal study of sleep patterns of a large representative sample of early adolescents.

Table 3 Sleep habits and sleep disturbances based on parental reports by age

Variables (N and percentage)	*Age*					
	10	*11*	*12*	*13*	*Q*	*Post-Hoc*
Sleeping alone						
Boys (345)	74.5	79.4	82.6	87.5	107.8*	All
Girls (387)	79.1	81.7	85.8	88.9		
Sleeping with a night light						
Boys (340)	40.9	20.9	18.2	10.0	282.1*	All
Girls (395)	41.0	25.1	18.7	11.1		
Napping more than once per week						
Boys (360)	2.8	0.8	1.1	1.7	11.8	–
Girls (410)	2.9	1.0	2.2	2.2		
Reading before sleeping						
Boys (345)	33.9	50.4	50.4	40.3	185.0*	10 < 11, 12 < 13
Girls (406)	39.7	67.2†	73.7†	71.2†		
Music before sleeping						
Boys (345)	14.2	20.0	30.1	38.0	268.0*	All
Girls (406)	17.0	30.5†	43.4†	56.2†		
Difficulty falling asleep						
Boys (358)	33.8	32.1	26.5	26.5	29.3*	10 > 11 > 12, 13
Girls (406)	45.1†	37.4	35.7†	36.2†		
Frequent nocturnal awakenings						
Boys (359)	17.3	8.9	9.5	8.1	34.1*	10 > 11, 12, 13
Girls (405)	12.1	8.4	8.2	7.4		

*$P < 0.00001$. McNemar's tests were used for posthoc comparisons. †$P < 0.05$, Pearson Chi-squares.

The present results based on parental reports confirm those of cross-sectional studies, i.e. (1) a reduction of nocturnal sleep length, (2) a delay of bedtimes and (3) increasing differences between school day and weekend sleep schedules (Anders *et al.* 1978; Carskadon *et al.* 1982; Petta *et al.* 1984; Szymczak *et al.* 1993; Wolfson and Carskadon 1998).

According to Klackenberg (1987), the parents are positively the most obvious and best source of information for their child's sleep behavior. Ferber (1995a) believes that until late childhood or adolescence, the complaints habitually come from the parents, not from the child. In Ferber's view (Ferber 1995b), it is the parents' perception of a sleep disorder that must be assessed. Many authors reported high consistency between parental answers and children's own answers on questions concerning sleep patterns and sleep habits (Saarenpää-Heikkilä *et al.* 1995; Epstein *et al.* 1998), and insomnia symptoms, such as difficulty falling asleep and nocturnal awakenings (Dixon *et al.* 1981; Fisher *et al.* 1994). In the present study, parent-reported data was not validated by children-reported data. Numerous factors may influence whether events or behaviors can be observed, considered significant and reliably reported by the parents (Weiss *et al.* 1973). For example children are more likely to cope with sleep difficulties on their own as they get older (Richman 1987). Reliability of early adolescent assessment could be augmented by obtaining information from multiple sources, including parent, child, teacher and examiner observation.

Of particular importance in this study is the marked decline in school day TIB from ages 10–13 years, due to progressively later bedtimes while wake time remained very stable. In contrast, weekend TIB was quite consistent. In this respect, Petta *et al.* (1984) have suggested that the steadiness of weekend TIB reflects the adolescents' sleep need, namely that their sleep need would be constant across this developmental stage. The sleep schedule displacement towards later hours on weekends is already manifest in school-age children (Gulliford *et al.* 1990). In adolescents, this change in the timing of sleep across the week may be more prominent due to a delay of the circadian phase (Carskadon *et al.* 1993; Carskadon *et al.* 1997). Progressively greater differences were observed between wake time on schooldays vs. weekends. This difference is 1 h at age 10 years and 2 h at age 13 years. The school schedule likely acts as a social synchronizer and may interfere with the physiological phase delay of the sleep period that occurs in adolescence. The 45 min weekend oversleep at age 13 years noted in the present study is comparable to that previously published from self-reported data (Anders *et al.* 1978; Petta *et al.* 1984; Bearpark and Michie 1987; Strauch and Meier 1988). Finally, the change in the relationship between school day TIB and weekend TIB occurred early in girls while it was more progressive in boys. As suggested by Petta *et al.* (1984), this gender difference is probably associated with earlier onset of puberty in girls than in boys.

The present study also clarifies the relationship between gender, pubertal status and the timing of sleep. At age 13 years, the difference in weekend wake time between early adolescents with a higher pubertal status and those with lower pubertal status suggests that the gender differences observed in Table 1 largely depend upon girls' higher pubertal status compared to boys. Of note is the significantly longer weekend TIB noted in our early adolescents with a higher pubertal status. That nocturnal sleep length augments with higher pubertal status on weekends supports Carskadon's view (Carskadon 1990a) that adolescents may have a physiological need for more sleep during puberty, not less, compared to prepubertal children. With respect to the timing of sleep on schooldays, neither gender nor puberty was associated with any school day sleep variable. Based on the observation that 4% of 13-year-olds were awakened by an alarm clock or by a parent on weekend mornings, in comparison with 70% for schooldays, Carskadon (1982) suggested that weekend sleep in young adolescents is less controlled by outside influences and therefore more naturalistic than on schooldays. The significant association between pubertal status and both weekend wake times and weekend TIB found in the present study further support this hypothesis, though the later weekend wake times possibly reflect, in part, a response to schooldays' sleep deprivation. In addition, sleep disturbances, as defined by difficulty falling asleep and frequent nocturnal awakenings, were not associated with school day sleep variables. On the other hand, subjects with difficulty falling asleep consistently woke up later on weekends from ages 10–13 years. This can be interpreted as a symptom of the considerable delay and lengthening of the sleep period on weekends in comparison to schooldays, with concomitantly later sleep onset and offset.

In all, the present results support the idea that puberty influences the timing of sleep patterns in early adolescents, particularly upon the weekend sleep schedule. Physiological concomitants of puberty may thus have an effect on the circadian phase delay of the sleep-wake cycle characteristic of adolescence. The similarity in the results obtained across studies, using different methodologies, suggests that the development of sleep patterns in early adolescence may be dependent on biological factors.

Sleep habits

Bedsharing or cosleeping, usually defined in the literature as sleeping in the parental bed, is consistently reported to decrease as the child's age increases. Klackenberg (1982) noted that the prevalence of bedsharing falls quite rapidly after age 9 years. In the present study, the number of children sleeping in a separate room significantly increased. As for bedsharing (Klackenberg 1982; Rath and Okum 1995), no gender difference was found in the proportion of boys and girls sleeping in a separate room or sharing their room. In preschool-aged children, cosleeping was related to sleep problems, including difficulty falling asleep and nocturnal awakenings (Schachter *et al.* 1989; Madansky and Edelbrock 1990; Latz *et al.* 1999). As in a previous study in preadolescents aged 8–10 years based on parental reports (Kahn *et al.* 1989), we found no association between sleep disturbances and the practice of sharing room with a sibling or parent in early adolescents.

In childhood, the use of a night light is considered as a presleep ritual and its request by children may come from fear of the dark and nightmares (Anders 1982; Ferber 1995a). Beltramini and Hertzig (1983) reported that 47% of children aged 1–5 years regularly insisted on sleeping with the light on. Our data indicate that a large percentage of children continue to sleep with a night light until 10 years of age. However, this sleep habit dramatically decreased after age 10 years. Kahn *et al*. (1989) reported that significantly more children aged 8–10 years old, with difficulty falling asleep and nocturnal awakenings, slept in rooms exposed to noise or light. Similarly, almost 50% of our early adolescents sleeping with a night light presented difficulty falling asleep at age 10 and 11 years. The presence of light in the nighttime environment may unfavorably influence sleep. Conversely, a recent study (Laberge *et al*. 2000) reported high anxiety scores in 11-year-olds suffering from parasomnias. It cannot be excluded that anxiety plays a role in the association between the use of a night light and sleep disturbances in early adolescence.

Preadolescents usually reported neither napping nor having no symptoms of excessive daytime sleepiness (Anders *et al*. 1978). According to Ferber (1990), excessive napping in preadolescents may indicate an inadequate sleep hygiene. In the present study, only a small percentage of early adolescents aged 10–13 years were reported to nap, a finding similar to that found in previous studies based on self-reports (Carskadon 1982; Simonds and Parraga 1982). In contrast, a significant percentage of older adolescents and college students reported excessive daytime sleepiness and regular naps (Anders *et al*. 1978; Carskadon 1982; Simonds and Parraga 1982; Andrade *et al*. 1993). Carskadon *et al* (1980) and Carskadon (1982) have shown in the sleep laboratory an increase in the propensity to fall asleep during the daytime for children at Tanner stages 3, 4 and 5 (mean ages were 13.4, 14.1 and 15 years, respectively) (Tanner 1962). Although daytime sleepiness was not specifically measured in the present study, the low percentage of napping in our subjects aged 10–13 years suggest that there is probably no increase of daytime sleepiness at that age. In those who actually nap, there was no association between sleep disturbances and napping. The same observation was made from self-reports of adolescents aged 13–17 years (Kirmil-Gray *et al*. 1984). These results suggest that napping in adolescents is not a consequence of sleep disturbances.

At age 13 years, 40.3% of boys and 71.2% of girls reported reading before bedtime. These percentages are similar to data obtained in adolescents aged 13–17 years where 75.3% reported reading to manage sleeping problems (defined by difficulties falling asleep and nocturnal awakenings) (Kirmil-Gray *et al*. 1984). In adults, lower percentages were found. In a survey of 1600 subjects aged 36–50 years, 23% of the women and 14% of the men considered reading and listening to music as the most important factor promoting sleep (Urponen *et al*. 1988). In this survey, as in the present one, significantly more women than men indicated reading and listening to music before bedtime. As pointed out by Ferber (1995b), some adolescents will inappropriately prolong their reading or music listening into the early morning. However, we found no association between reading or listening to music before sleeping and sleep disturbances in early adolescents. A similar finding was reported for adolescents aged 13–17 years (Kirmil-Gray *et al*. 1984).

The prevalence of difficulty falling asleep and of nocturnal awakenings reported here are similar to those reported by early adolescents in other populations (Klackenberg 1982; Bearpark and Michie 1987; Tynjälä *et al*. 1993). The higher prevalence of difficulty falling asleep among girls was also reported by older adolescents (Zepelin *et al*. 1977; Price *et al*. 1978; Welstein *et al*. 1983; Kirmil-Gray *et al*. 1984; Choquet *et al*. 1988; Cañellas *et al*. 1994; Vignau *et al*. 1997). However, we found no gender difference in the prevalence of nocturnal awakenings, as also noted in other studies (Klackenberg 1982; Bearpark and Michie 1987; Morrison *et al*. 1992). Classically, sleep disturbances are reported to be more frequent in older than in younger adolescents (Carskadon 1982). Surprisingly, the present study showed a decrease in the prevalence of difficulty falling asleep and of nocturnal awakenings from ages 10–13 years. There is a possibility that mothers have been inaccurate in reporting these sleep disturbances, assuming that their child was sleeping. The problem with most previous studies of sleep disturbances in adolescence comes from the fact that they looked at wide age ranges rather than at specific ages. In a study investigating sleep difficulties of children and adolescents from age 11–16 years from 11 European countries (Tynjälä *et al*. 1993), difficulties falling asleep were, as in the present study, more frequent in 11- and 12-year-olds, and this result was consistent across all countries. Another longitudinal survey of sleep problem during early adolescence also reported a decrease of nocturnal awakenings between ages 10 and 13 years (Klackenberg 1982). Zepelin *et al*. (1977) evoked the possibility of a transient, puberty-related increase of sleep disturbances at ages 11–12 years. Further studies of large populations of early adolescents recording sleep in the laboratory with concomitant measures of hormonal status will be needed to clarify this issue. Sleep diaries filled out over long periods of time and actigraphy may also contribute to elucidate this question.

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REFERENCES

Anders, T. F., Carskadon, M. A., Dement, W. C. and Harvey, K. Sleep habits of children and the identification of pathologically sleepy children. *Child Psychiatr. Hum. Dev.*, 1978, 9: 57–63.

Anders, T. F. Neurophysiological studies of sleep in infants and children. *J. Child Psychol. Psychiatry*, 1982, 23: 75–83.
Andrade, M. M. M., Benedito-Silva, A. A., Sorahia Domenice, E. E., Arnhold, I. J. and Menna-Barreto, L. Sleep characteristics of adolescents: a longitudinal study. *J. Adolesc. Health*, 1993, 14: 401–406.
Bearpark, H. M. and Michie, P. T. Prevalence of sleep/wake disturbances in Sydney adolescents. *Sleep Res.*, 1987, 16: 304.
Beltramini, A. U. and Hertzig, M. E. Sleep and bedtime behavior in preschool-aged children. *Pediatrics*, 1983, 71: 153–158.
Bixler, E. O., Kales, A., Soldatos, C. R., Kales, D. and Healey, S. Prevalence of sleep disorders in the Los Angeles Metropolitan area. *Am. J. Psychiatr.*, 1979, 136: 1257–1262.
Blader, J. C., Koplewicz, H. S., Abikoff, H. and Foley, C. Sleep problems of elementary school children. *Arch. Pediatr. Adolesc. Med.*, 1997, 151: 473–480.
Brock, M. A. Chronobiology and aging. *J. Am. Geriatr. Soc.*, 1991, 39: 74–91.
Cañellas, F., Palmer, A. and Calafat, A. Adolescents' sleep characteristics in Mallorca. *Sleep Res.*, 1994, 23: 240.
Carskadon, M. A., Acebo, C., Richardson, G. S., Tate, B. A. and Seifer, R. An approach to studying circadian rhythms of adolescent humans. *J. Biol. Rhythms*, 1997, 12: 278–289.
Carskadon, M. A. Patterns of sleep and sleepiness in adolescents. *Pediatrician*, 1990a, 17: 5–12.
Carskadon, M. A. Adolescent sleepiness: increased risk in a high-risk population. *Alcohol Drugs Driving*, 1990b, 5/6: 317–328.
Carskadon, M. A. and Davis, S. S. Sleep-wake patterns in the high-school-to-college transition: preliminary data. *Sleep Res.*, 1989, 18: 113.
Carskadon, M. A. and Dement, W. C. Sleepiness in the normal adolescent. In: C. Guilleminault (Ed.) *Sleep and its Disorders in Children*. Raven Press, New York, 1987: 53–65.
Carskadon, M. A., Harvey, K., Duke, P., Anders, T. F., Litt, I. F. and Dement, W. C. Pubertal changes in daytime sleepiness. *Sleep*, 1980, 2: 453–460.
Carskadon, M. A. The second decade. In: C. Guilleminault (Ed.) *Sleeping and Waking Disorders: Indications and Techniques*. Addison-Wesley, Menlo Park, 1982: 99–125.
Carskadon, M. A., Vieira, C. and Acebo, C. Association between puberty and delayed phase preference. *Sleep*, 1993, 16: 258–262.
Choquet, M., Tesson, F., Stevenot, A., Prévost, E. and Antheaume, M. Les adolescents et leur sommeil: approche épidémiologique. *Neuropsychiatrie Enfant Adolescent*, 1988, 36: 399–410.
Coble, P. A., Kupfer, D. J., Taska, L. S. and Kane, J. EEG sleep of normal healthy children. Part I. Findings using standard measurement methods. *Sleep*, 1984, 7: 289–303.
Cohen, J. *Statistical power analysis for the behavioral sciences* (2nd edn). Erlbaum, New Jersey, 1988.
Dahl, R. E. and Carskadon, M. A. Sleep and its disorders in adolescence. In: R., Ferber and M. Kryger (Eds.) *Principles and Practice of Sleep Medicine in the Child*. Saunders, Philadelphia, 1995: 19–27.
Dixon, K. N., Monroe, L. J. and Jakim, S. Insomniac children. *Sleep*, 1981, 4: 313–318.
Epstein, R., Chillag, N. and Lavie, P. Starting times of school: Effects on daytime functioning of fifth-grade children in Israel. *Sleep*, 1998, 21: 250–256.
Feinberg, I. Changes in sleep cycle patterns with age. *J. Psychiatr. Res.*, 1974, 10: 283–306.
Ferber, R. Childhood Insomnia. In: M. J. Thorpy (Ed.) *Handbook of Sleep Disorders*. Marcel Dekker, New York, 1990: 435–455.
Ferber, R. Sleeplessness in children. In: R. Ferber and M. Kryger (Eds) *Principles and Practice of Sleep Medicine in the Child*. Saunders, Philadelphia, 1995a: 79–89.
Ferber, R. Assessment of sleep disorders in the child. In: R. Ferber and M. Kryger (Eds) *Principles and Practice of Sleep Medicine in the Child*. Saunders, Philadelphia, 1995b: 45–53.
Ferber, R. Introduction: pediatric sleep disorders medicine. In: R. Ferber and M. Kryger (Eds) *Principles and Practice of Sleep Medicine in the Child*. Saunders, Philadelphia, 1995c: 1–5.
Fisher, B. E., Ross, K. and Wilson, A. Parents' and children's ratings of sleep behavior, excitement, and tiredness: a 10-week longitudinal study. *J. Gen. Psychol.*, 1994, 155: 191–199.
Gulliford, M. C., Price, C. E., Rona, R. J. and Chinn, S. Sleep habits and height at ages 5–11. *Arch. Dis. Child*, 1990, 65: 119–122.
Hauri, P., Percy, L., Olmstead, E. and Sateia, M. Childhood onset insomnia. *Sleep Res.*, 1980, 9: 201.
Henschel, A. and Lack, L. Do many adolescents sleep poorly or just too late? *Sleep Res.*, 1987, 16: 354.
Kahn, A., Van de Merckt, C., Rebuffat, E., Mozin, M. J., Sottiaux, M., Blum, D. and Hennart, P. Sleep problems in healthy preadolescents. *Pediatrics*, 1989, 84: 542–546.
Karacan, I., Anch, M., Thornby, J., Okawa, M. and Williams, R. Longitudinal sleep patterns during pubertal growth: four-year follow-up. *Pediatr. Res.*, 1975, 9: 842–846.
Kirmil-Gray, K., Eagleston, J. R., Gibson, E. and Thoresen, C. E. Sleep disturbance in adolescents: Sleep quality, sleep habits, beliefs about sleep, and daytime functioning. *J. Youth Adolesc.*, 1984, 13: 375–384.
Klackenberg, G. Incidence of parasomnias in children in a general population. In: C. Guilleminault (Ed.) *Sleep and its Disorders in Children*. Raven Press, New York, 1987: 99–113.
Klackenberg, G. Sleep behaviour studied longitudinally. *Acta Pediatr. Scand.*, 1982, 71: 501–506.
Laberge, L., Tremblay, R. E., Vitaro, F. and Montplaisir, J. Development of parasomnias from childhood to early adolescence. *Pediatrics*, 2000, 106: 67–74.
Latz, S., Wolf, A. W. and Lozoff, B. Cosleeping in context: sleep practices and problems in young children Japan and the United States. *Arch. Pediatr. Adolesc. Med.*, 1999, 153: 339–346.
Lee, K. A., McEnany, G. and Weekes, D. Gender differences in sleep patterns for early adolescents. *J. Adolesc. Health*, 1999, 24: 16–20.
Madansky, D. and Edelbrock, C. Cosleeping in a community sample of 2- and 3-year-old children. *Pediatrics*, 1990, 86: 197–203.
Morrison, D. N., McGee, R. and Stanton, W. R. Sleep problems in adolescence. *J. Am. Acad. Child Adolesc. Psychiatry*, 1992, 31: 94–99.
Myers, B. L. and Badia, P. Changes in circadian rhythms and sleep quality with aging: mechanisms and interventions. *Neurosci. Biobehav. Rev.*, 1995, 19: 553–571.
Paavonen, E. J., Aronen, E. T., Moilanen, I., Piha, J., Räsänen, E., Tamminen, T. and Almqvist, F. Sleep problems of school-aged children: a complementary view. *Acta Pædiatr.*, 2000, 89: 223–228.
Pagani, L., Boulerice, B. and Tremblay, R. E. The influence of poverty on children's classroom placement and behavior problems. In: J. Brooks-Gunn and G. Duncan (Eds) *Consequences of Growing Up Poor*. Russell-Sage, New York, 1997: 311–339.
Petersen, A. C., Crockett, L., Richards, M. and Boxer, A. A self-report measure of pubertal status: reliability, validity, and initial norms. *J. Youth Adolesc.*, 1988, 17: 117–133.
Petta, D., Carskadon, M. and Dement, W. Sleep habits in children aged 7–13 years. *Sleep Res.*, 1984, 13: 86.
Price, V. A., Coates, T. J., Thorensen, C. E. and Grinstead, O. A. Prevalence and correlates of poor sleep among adolescents. *Am. J. Dis. Child*, 1978, 132: 583–586.
Rath, F. H. and Okum, M. E. Parents and children sleeping together: cosleeping prevalence and concerns. *Am. J. Orthopsychiatry*, 1995, 65: 411–418.
Richman, N. Surveys of sleep disorders in children in a general population. In: C. Guilleminault (Ed.) *Sleep and its Disorders in Children*. Raven Press, New York, 1987: 115–127.
Rugg-Gunn, A. J., Hackett, A. F., Appleton, D. R. and Eastoe, J. E. Bedtimes of 11–14-yeard-old children in north-east England. *J. Biosoc. Sci.*, 1984, 16: 291–297.

Saarenpää-Heikkilä, O. A., Rintahaka, P. J., Laippala, P. J. and Koivikko, M. J. Sleep habits and disorders in Finnish schoolchildren. *J. Sleep Res.*, 1995, 4: 173–182.
Schachter, F. F., Fuchs, M. L., Bijur, P. E. and Stone, R. K. Cosleeping and sleep problems in Hispanic-American urban young children. *Pediatrics*, 1989, 84: 522–530.
Simonds, J. F. and Parraga, H. Prevalence of sleep disorders and sleep behaviors in children and adolescents. *J. Am. Acad. Child Adolesc. Psychiatry*, 1982, 21: 383–388.
Strauch, I. and Meier, B. Sleep need in adolescents: a longitudinal approach. *Sleep*, 1988, 11: 378–386.
Szymczak, J. T., Jasinska, M., Pawlak, E. and Zwierzykowska, M. Annual and weekly changes in the sleep-wake rhythm of school children. *Sleep*, 1993, 16: 433–435.
Tanner, J. M. *Growth at Adolescence*. Blackwell, Oxford., 1962.
Tynjälä, J., Kannas, L. and Välimaa, R. How young Europeans sleep. *Health Educ. Res.*, 1993, 8: 69–80.
Urponen, H., Vuori, I., Hasan, J. and Partinen, M. Self-evaluations of factors promoting and disturbing sleep: an epidemiological survey in Finland. *Soc. Sci. Med.*, 1988, 26: 443–450.
Vignau, J., Bailly, D., Duhamel, A., Vervaecke, P., Beuscart, R. and Collinet, C. Epidemiologic study of sleep quality and troubles in French secondary school adolescents. *J. Adolesc. Health Care*, 1997, 21: 343–350.
Vitaro, F., Tremblay, R. E. and Gagnon, C. Teacher ratings of children's behaviors and teachers' management styles: a research note. *J. Child Psychol. Psychiatry*, 1995, 36: 887–898.
Weiss, B. L., McPartland, R. J. and Kupfer, D. J. Once more: the inaccuracy of non-EEG estimations of sleep. *Am. J. Psychiatr.*, 1973, 130: 1282–1285.
Welstein, L., Dement, W. C., Redington, D., Guilleminault, C. and Mitler, M. M. Insomnia in the San Francisco bay area: a telephone survey. In: C., Guilleminault and E. Lugaresi (Eds) *Sleep/Wake Disorders: Natural History, Epidemiology, and Long-Term Evolution*. Raven Press, New York, 1983: 73–85.
White, L., Hahn, P. M. and Mitler, M. M. Sleep questionnaire in adolescents. *Sleep Res.*, 1980, 9: 108.
Williams, R., Karacan, I. and Hursch, C. *EEG of Human Sleep*. Wiley & Sons. New York., 1974.
Wolfson, A. R. and Carskadon, M. A. Sleep schedules and daytime functioning in adolescents. *Child Dev.*, 1998, 69: 875–887.
Wolfson, A. R. Sleeping patterns of children and adolescents. *Child Adolesc. Psychiatr. Clin. N. Am.*, 1996, 5: 549–568.
Zepelin, H., Hamilton, P. and Wanzie, F. J. Sleep disturbance in early adolescence. *Sleep Res.*, 1977, 6: 183.
Zoccolillo, M., Tremblay, R. E. and Vitaro, F. DSM-III-R and DSM-III criteria for conduct disorder in preadolescent girls: specific but insensitive. *J. Am. Acad. Child Adolesc. Psychiatry*, 1996, 35: 461–470.
Zoccolillo, M., Vitaro, F. and Tremblay, R. E. Problem drug and alcohol use in a community sample of adolescents. *J. Am. Acad. Child Adolesc. Psychiatry*, 1999, 38: 900–907.

[1] Comparisons were made between the group of 1146 subjects for which the information required (sleep characteristics and data for child's pubertal status) was available, and the group of 854 subjects for which the information required was not available. The comparisons were made for gender, parental characteristics (maternal education, paternal education, age of the mothers at the child's birth, age of the fathers at the child's birth, maternal occupational status and paternal occupational status) and geographical location of the school attended by the child. T-tests for independent samples did not show significant differences for gender, age of the fathers at the child's birth, paternal occupational status and geographical location of the school attended by the child. On the other hand, significant differences were found for maternal educational level (12.24 vs. 11.56, $t(1935) = -5.8$, $P < 0.001$), paternal educational level (12.48 vs. 11.68, $t(1767) = -4.8$, $P < 0.001$), age of the mothers at the child's birth (24.9 vs. 24.1, $t(1742) = -4.5$, $P < 0.001$) and maternal occupational status (45.3 vs. 42.1, $t(1745) = -5.2$, $P < 0.001$).