Effects of School Schedule Transition on Sleep-Wake Cycle of Brazilian Adolescents

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The objective of this paper is to evaluate the effects of school schedule transition (from afternoon to morning schedule) on sleep-wake cycle and diurnal sleepiness in adolescents. Subjects consisted of 28 school children (12 boys and 16 girls, mean age 12.1 ± 1.9 years) investigated on two occasions, during two consecutive weeks in October/1997 (fourth grade - afternoon schedule) and in May/1998 (fifth grade - morning schedule). Data were collected through actigraphs, sleep diaries, sleep habits questionnaires and visual analog scales. Results indicate that students are partially sleep deprived after the transition to the morning schedule although they are able - to some extent - to advance their sleep phase during school days and weekends. Diurnal sleepiness increases in the morning schedule, particularly at the beginning of the schooldays. Number of daytime naps increases and the number of spontaneous awakenings decreases after the transition. Since the primary focus of education is to improve learning conditions and maximize students' potentialities, school organization should take into account not only space and social aspects of school, but also temporal aspects of human biological organization, specially at this particular age. These temporal aspects seem to be particularly relevant when school schedule changes are envisaged. (Sleep and Hypnosis 2001;3(3):106-111)

Key words: sleep-wake cycle, diurnal sleepiness, sleep deprivation, adolescents, school schedule, sleep-wake cycle phase delay

INTRODUCTION

Researchers have long been concerned with students' sleep. In 1913, Terman and Hocking (1) had already raised a number of questions on the subject, namely: "What is the optimum amount of sleep for physicvels (measured by MSLT) in adolescents during a summer holiday camping. Golub has recently (2) found a delay in sleep-wake cycle (SWC) concurrent with the sexual development of Rhesus monkeys (Macaca mulata), and Tate & Richardson (3) have found the same association in a diurnal rodent (Octogon degu). Although these findings strongly suggest that the neuroendocrine system might act upon SWC regulation, the mechanisms involved in this process have not been well identified yet.

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Acknowledgments:
Fundação de Amparo à Pesquisa de São Paulo - FAPESP
Dept. of Psychobiology at Universidade Federal Paulista
Ivo Arnhold MD and his team of Hospital das Clínicas at Universidade de São Paulo

Accepted May 19, 2001

The Brazilian Context

The SWC phase delay in adolescents undergoing puberty, in conjunction with early school starting time, reduces sleep duration and increases sleepiness levels (4-6). In other countries where similar studies have been carried

out, students generally remain in school around seven hours a day; in Brazilian public schools the situation is different, since students, in general, attend classes in the morning or in the afternoon, remaining in school for about four hours.

We decided to study a group of adolescents who switched their school schedules, which is a common occurrence in Brazil: primary school students – from the first to the fourth grade (7 to 11 years old) have classes in the morning while those in the fifth to the eighth grade (beginning at 11 years of age and up) have afternoon classes. The shift from "afternoon to morning", which represents a phase advance, occurs in contrast with those who show a SWC phase delay. In other words, if on one side there is a SWC delay, the classes, in turn, start earlier. This situation may help us understand the possible conflict existing between social and biological factors acting upon adolescents SWC, and may contribute with chronobiologic reasoning to help improve school schedules.

METHODS

The purpose of this study was to evaluate some characteristics of adolescents' sleep-wake cycle in two different situations. In situation I, the adolescents went to school in the afternoon, from 1:00pm to 5:30pm. In situation II, the adolescents went to school in the morning, from 7:20am to 12:50am (except on Fridays, when they left school at 11:50am) (Table1).

Twenty-eight subjects, 12 boys and 16 girls (average age at the beginning of the study: 12.1±1.9 years) participated in the study. Data were obtained for both situations (stages I and II), with a six-month interval between the stages. Not all subjects participated in both stages. Due to this, in the case of some variables, the two groups (situations II and I) were compared by means of a cross sectional approach. Data relative to the same subjects in stages I and II obtained from questionnaires and actigraphs, on the other hand, were analyzed according to a longitudinal approach.

In each of the stages, the following instruments were used:

1) Questionnaires on sleeping habits, filled out by the students‘ parents in stages I and II (data relative to 24 subjects). Through a qui-square analysis, the number of occurrences regarding the following characteristics was compared:

-sleepiness (never, sometimes, always);

-how the students woke up (alarm clock, someone else, by himself/herself);

-occurrence of naps (never, sometimes, always);

2) Visual analog scales for subjective evaluation of sleepiness (7). The scales were filled out three times a day during the period of classes, throughout one entire consecutive week (from Monday to Friday) – 28 subjects during stage I and 24 subjects during stage II underwent this evaluation. Weekly averages were obtained based on data collected from all subjects for each time point. The comparison between the three time points of each stage was accomplished by using the Kruskall-Wallis non-parametric analysis.

3) Actigraphs: in both stages the same 11 subjects used actigraphs for two consecutive weeks. Rest/activity data were converted into sleep-wake data by using an algorithm previously validated (8).

4) Sleep diaries: simultaneously to the use of actigraphs, data were registered in sleep diaries. The students registered the starting time and the finish time of their sleep episodes, as well as the moments when they removed the actigraphs.

Based on data collected by means of actigraphs and those registered in the sleep diaries, sleep onset times and wake-up times were obtained for two consecutive weeks. Again based on these data, averages for school days

Table 1. Data collection

	Grade	School schedule	Data collection
I	fourth	From 1pm to 5:30pm	Two weeks in October/1997
II	fifth	From 7:20am to 12:50pm	Two weeks in May/1998

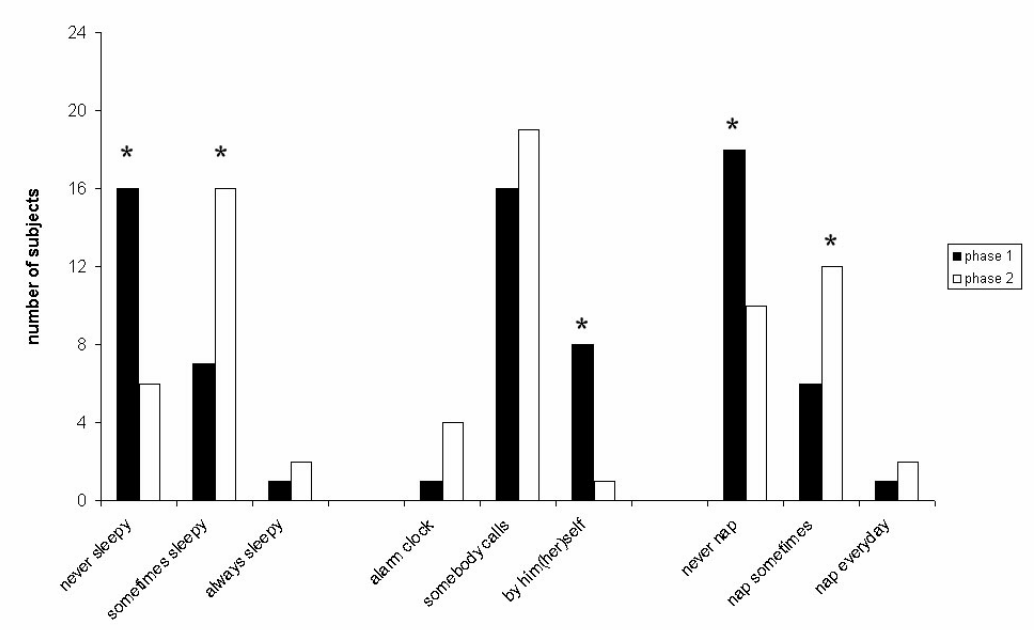

Figure 1. Histogram of absolute frequencies related to diurnal sleepiness, awakenings and napping. Data obtained from questionnaires filled out by parents (n=24). * Chi-square test, p<0.01.

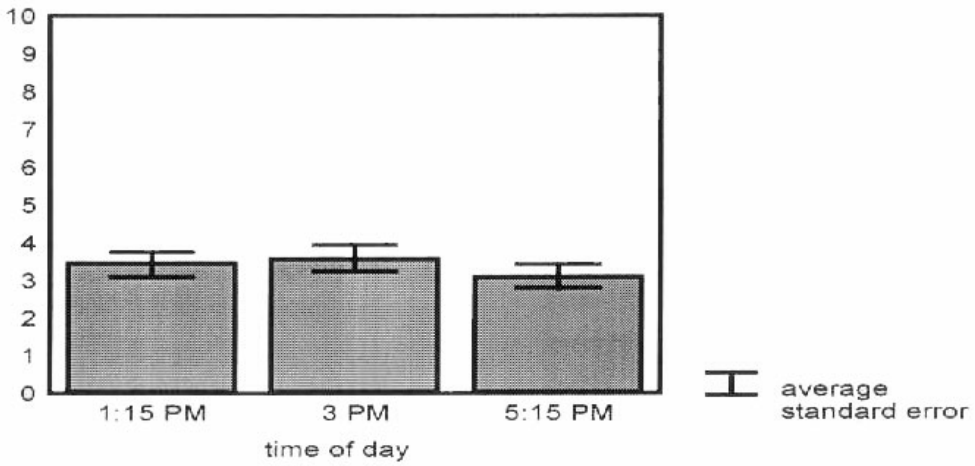

Figure 2: Diurnal sleepiness variation in phase I (afternoon schedule). There is no statistical difference (Kruskall-Wallis ANOVA) (n=28).

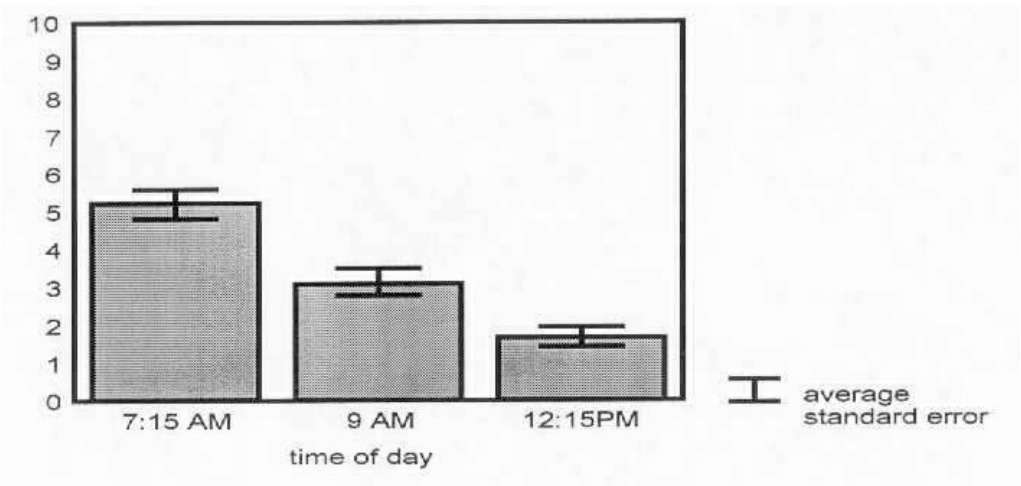

Figure 3: Diurnal sleepiness variation in phase II. Statistical difference was detected by Kruskall-Wallis ANOVA, p<0.001 (n=24)

and weekends were calculated. Comparisons between these averages were accomplished through a non-parametric test (the Kolmorogv-Smirnov test) for dependent samples.

In both stages the puberty phase was evaluated by endocrinology clinicians in accordance with Tanner stages (pubic hair both for girls and boys) (9). Twenty-four adolescents (16 girls and 8 boys) were submitted to this evaluation.

RESULTS

Sleep habits

The comparison between data relative to sleep habits obtained from the questionnaires filled out by the students' parents showed some differences between stages I and II, that is, after the shift of school starting times. As shown in Figure 1, the number of adolescents who sometimes "felt sleepy" increased in stage II. The number of spontaneous wake-ups showed a reduction from stage I to stage II. There was, in turn, an increase in the incidence of naps from stage I to stage II.

Diurnal sleepiness

The variation in sleepiness in the classroom is shown in Figures 2 and 3. For each schedule, an average corresponding to each day of the week (Monday to Friday) is shown. In stage I, when the students attended classes in the afternoon, no difference was detected between the three time points of evaluation. Otherwise, in stage II, significant differences were observed. The highest values were observed at the beginning of the schooldays.

Sleep-wake cycle

In Table 2 it can be observed that from stage I to stage II, that is, after the shift in school schedules, the adolescents started to wake up earlier, sleep earlier and have a shorter sleep duration in school days. In both stages there was a delay in sleep times and wake-up times on the weekends as compared to those on school days.

Tanner stages

Data in Table 3 show the results of the puberty phase. At the beginning of the study, five adolescents (4 boys and 1 girl) were going through phase I. In the second stage, 3 subjects (all of them boys) remained in phase I. It can be

Table 2. Mean values and standard deviaton (in parenthesis) of sleep onset, sleep offset and sleep duration on weekdays and weekends in both phases of the study.

n=11	Phase 1 (afternoon schedule)		Phase 2 (morning schedule)	
	weekdays	**weekends**	**Weekdays**	**Weekends**
Sleep Onset	11:02pm (47min)***	0:04am (62min)***	10:24pm (51min)**	11:08pm (86min)**
Sleep offset	8:02am (65min)*	8:59am (56min)*	6:05am (25min)***	8:15am (81min)***
Sleep duration	8h 38min (66min) n.s	8h 54min (67min) n.s.	7h 42min (51min)***	9h 38min (81min)***

Data were collected with actigraphs and edited based on sleep diaries. Statistical differences between weekdays and weekends detected by Kolmorogov-Smirnov Test for dependent samples. *** $p<0.01$; ** $p<0.05$; * $p<0.01$; n.s. non-significant.

Table 3. Tanner stages distribution among boys and girls in both phases of the study (n=16 for girls; n=8 for boys)

Tanner Stages	Girls		Boys	
	Phase I	**Phase II**	**Phase I**	**Phase II**
I	1	0	4	3
II	6	1	2	1
III	4	7	1	2
IV	5	6	1	2
V	0	2	0	0

assumed that at the beginning of the study most subjects were going through puberty development and were, therefore, subject to the changes in sleep-wake cycle typical of their age bracket (10,11).

DISCUSSION

The analysis of the results obtained shows that after the shift in school starting time – from afternoon to morning – there was a phase advance in the sleep-wake cycle. After moving to the morning shift, the adolescents went to bed one hour earlier and woke up two hours earlier on school days. Therefore, their sleep duration decreased one hour during school days and increased twenty-six minutes in the weekends.

A study by Carskadon et al. (12) that also assessed a shift in school schedules says that "along with strong psychological influences, changes in bioregulatory systems controlling sleep may limit teenager's capacities to make adequate adjustments to an early school schedule". Some comments should be made concerning the present study and the one carried out by Carskadon.

In our study, the magnitude of the schedule transition reached 5h 40min, whereas in Carskadon´s it amounted to 1h 05min. Moreover, the transition from the fourth to the fifth grade has a special meaning to the students. In the fourth grade, they are the oldest students in the afternoon period, while in the fifth they are the youngest ones in the morning period. Usually, the number of teachers increases from four to ten. For the purpose of minimizing the impact of such changes, the school pedagogical staff has developed a program of activities aimed at the student's adaptation.

This advance in sleep and wake-up times imposed by the school schedule occurred during a developmental moment characterized by a phase delay in biological rhythms. This might explain the fact that the advance in sleep time during school days has not shown the same magnitude as the advance in wake-up time in school days, thus generating a reduction in the total sleep time. In order to fully compensate for the early school starting time, the students bedtime would have to be around 9:30pm on school days, which did not occur. According to Carskadon (12), "imposition of an early school starting time may require unrealistic – if not unattainable – bedtimes to provide adequate timing for sleep".

Sleep deprivation and diurnal sleepiness

After the shift in school starting time, the students sleep duration was reduced and the irregularity of their sleep-wake cycle increased. Diurnal sleepiness values were higher at the beginning of the schooldays, when these students would be asleep in case they were allowed to.

Increased diurnal sleepiness is associated with decreased performance. There are, however, few studies correlating students' sleep with performance, probably due to the difficulties posed by the methodology used to assess students' performance. A lab study carried out by Randazzo et al. (13) has assessed students' cognitive performance after partial sleep deprivation, detecting a decrease in performance when compared to that of a group which had slept ad libitum. In the same study, the polysomnographic record of a night's sleep showed differences in sleep architecture. The last paradoxical sleep episode was reduced in the sleep-deprived group. Paradoxical sleep deprivation is related to memory deficits in humans and other animals (14-16). The meta-analysis performed by Pilcher and Huffcutt (17) has identified the effects of partial sleep deprivation upon cognition.

We understand that adaptation of school schedules to standard waking/sleeping cycle expression during adolescence can have a major impact on adolescents' academic, cognitive and social performance. If, on one hand, the relationship between puberty and SWC's phase delay has been satisfactorily demonstrated by both lab and field studies, on the other, the effect of sleep deprivation and SWC's irregularity upon cognitive functions have not been fully demonstrated yet, particularly by field studies

(real life situations). It would be worthwhile studying Brazilian school schedules, as well as those of other countries with similar regimen, since this could contribute to an understanding of such questions as well as others related to adolescents' health and school scheduling.

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