Sleep Parameters Recorded by Actiwatch_ in Elementary School Children and Junior High School Adolescents. Schooldays vs Weekends

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Over the last years, sleep habits evolution from childhood into adolescence has been identified as a preferential target for investigators. The present study examines the objective sleep patterns as recorded by Actiwatch in elementary–10.8 years children and junior high school–14.2 years adolescents. During schooldays and weekends elementary school children have constant sleep patterns. Significant differences were found in junior high school adolescents, first in comparison with elementary school subjects and second, between schooldays and weekends. During schooldays, adolescents get insufficient sleep, which they try to recompense during weekends. The majority of sleep parameters showed significant variation in weekends in contrast to schooldays. Present objective data revealed, that major changes in sleep patterns occur in adolescents. Adolescents, parents and health practitioners should realize the effects of chronic sleep insufficiency and develop new strategies in order to promote coherent sleep hygiene. **(Sleep and Hypnosis 2004;6(2):55-66)**

Key words: *sleep microstructure parameters, sleep quality, sleep schedule, circadian rhythm, sleep hours, actigraph*

INTRODUCTION

Sleep assessment is frequently evaluated in schoolchildren. Two generally accepted methods are employed as usual: first one is subjective–mainly consisting of daily logs together with self-report questionnaires and second one is objective represented by the most used approach–actigraphy. Previous reports (1-12), using primarily subjective sleep measurement, demonstrated that during transition into adolescence, sleep patterns are exposed to the increasing pressure of internal and external factors. Alteration in sleep and wake patterns are marked by biological and psychosocial conditions. When maturational process starts in children, their sleeping habits become more irregular, with an evident tendency to go to bed later and less regularly

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(1). Caraskadon (2) mentioned that adolescents need more sleep than prepubertally. Need to be remarked, there is an association between puberty and delay phase preference. The delay of sleep phase was linked with higher puberty scores (3-4). Puberty itself, parental involvement in children's bed and wake time, curfews and school schedule, part-time job, all together impose new model for sleep wake patterns (4). Children are active participants in social life, they interact constantly with environment, permanently being forced to adjust sleep model and functions to accommodate changing demands.

During childhood, the sleep schedule on schooldays and weekends is generally constant, wake time in particular, leading to a stable circadian phase position for the sleep-wake cycle (5). When children enter adolescence, major changes in sleep patterns occur, and the biggest change is characterized mainly by a delay of sleep period start; adolescents tends to stay up later in the night and to wake up later in the morning, than do prepubescent children (6). Need to be mentioned, this delay of circadian phase is much more important on weekends than on schooldays (7). On schooldays, the wake up time is determined mainly by the school schedule started time, and also, by a parental supervising activities, parental control over a get up in order to perform adequate school schedule.

All around the world is an ostensibly factor, as much as children increase in age, as much they receive less sleep (8). For example, in Japan (9), for elementary school sleep is around 8.9 for schooldays and 9.2 for weekends, for junior high school 7.6 for schooldays and 8.7 for weekends, in US 14.5 years old teenagers sleep 7.4 hours in schooldays and 9.7 hours in weekends (10). Unfortunately, daytime sleepiness is nearly universal manifestations. A linear rising trend for morning sleepiness was found in many countries (11).

Chronic sleep deficit and consequently negative health behavior for sleep patterns, already begins to occur in adolescence, at 12 years old, that cumulatively affects daytime functioning at a later age. Researchers found, that adolescents report sleep disturbances more often in comparison with preadolescents (12). Till now, the changes in sleep patterns during adolescence have been analyzed based mainly on subjective reports and only few using actigraphy (13,26). In the present study, we examined the sleep indicators particularities existing between schooldays and weekends, based on objective assessment, as recorded by Actiwatch in two different groups, elementary and middle high school children. Majority of publications, dedicated to sleep patterns in transitional period use general sleep indicators, e.g. total sleep time, sleep latency, time in bed. Our study, however display a full range of sleep microstructure parameters, during ordinary life circumstances as recorded by Actiwatch. Furthermore, weekly difference within and between groups was examined.

METHODS

Subjects

Participants were selected from the two junior high schools and one elementary school. Later, a letter of intentions was sent to the parents of 158 male children, 67 from elementary-4th -6th grade and 91-2nd grade from junior high schools in Toyama city, Japan. Of those, 66% from elementary school and 52% from junior high schools agreed to participate and gave written informed consents. Data from three elementary and three junior high school children were not successfully collected, due to subjective (forgot to wear Actiwatch) and objective (artifact during reading and recording). Also, two junior high school children complained of itching and we stopped measurement. The final group consisted of 41 elementary and 42 junior high school children, with a mean age of 10.8 (SD:0.8) for elementary school children and 14.2 years (SD:0.3) for junior high school children. At the

time of experiment, all children from both groups were in a good health condition, with no apparent manifestations of diseases (including sleeping problems) and did not take any medications during the period of measurement. School start time was 8.30 am from Monday to Friday. The survey was conducted between April and June 2002 for elementary school children and October and November 2002 for junior high school children.

Anthropometric measurement

In the first day of the experiment, children worn light cloths and we recorded the following anthropometric data: the heights of children were measured using a stadiometer, to the nearest 0.1 cm, the weights were measured using a balance scale, to the nearest 0.1 kg. Body mass index (BMI –the weight in kilograms divided by the squared height in meters) was calculated as an index of obesity. All anthropometric measurements were conducted two times and the mean was used in analysis.

Instruments and procedures

During experiment the sleeping habits were evaluated using questionnaire together with diaries and second objectively, using the Actiwatch-an actigraph that can estimate sleep-wake schedule by measurement of activity level (time-based activity data over extended period). In the present study, we focused our attention mainly on objective results, recorded by Actiwatch.

We used a kind of diary sleep questionnaire, concerned detailed sleep schedule, which children completed every day and included the records of bedtime, sleep latency time, sleep start time, wake up time and assumed sleep length. Participants were instructed to fill in the answers strictly after wake up. Sleep questionnaire data were expressed in hours and minutes. The means of the values from the 5 schooldays and 2 weekends were used in the analyses.

The Actiwatch has the capacity of true objective ambulatory monitoring over long periods. Actigraphy has been evolved into small, lightweight, watch liked device. Due to many factors, (user friendly, affordable, easy to use, suitable for long term use, require minimal supervision, large spectrum of sleep parameters), Actiwatch monitoring system - a non-intrusive method is most available for monitoring actual sleep parameters in children. In our experiment we used Actiwatch (Mini Mitter Company Inc., Bend, Oregon, USA). Till now Actiwatch has been used in a variety of populations (13) (including children) in order to discover sleep schedule and sleep disturbances (15). The American Academy of Sleep Medicine recognizes it as a useful adjunct in the clinical assessment of sleep disorders (14). Also, Actiwatch has been validated using polysomnography as a reference (15).

Internal memory and programming allows Actiwatch to record and keep data for long period of time. There is an omni-directional sensor inside, which integrate the degree and speed of motion and produces an electrical current that varies in magnitude according to activity's intensity. The high level of speed and motion produce increase in voltage. Children were instructed to keep Actiwatch attached for seven consecutive days, on non-writing wrist. All communication with Actiwatch was accomplished using an Actiwatch reader, connected to PC. An Actiwatch was programmed for each participant before the investigation began. The person's name, age, gender and epoch length (0.5-minute) was downloaded into each watch before positioning it on the non-dominant wrist of each participant. Also, we made setting of threshold automatic sensitivity (the algorithm automatically scores an epoch as sleep if the total activity value is equal to or less than the threshold sensitivity value calculated by mean score in active period multiplied by K (constant=0.888), and divided by epoch length). A watch position protocol was used to

insure that each watch was worn correctly.

After one week of recording, each watch was downloaded using a Mini-Mitter Actiware-Sleep software program. We collected the information, by entering the bedtime and wake up time manually for every day, and received automatically calculated results according to the algorithm. All sleep parameters, except Bed Time and Get up Time were calculated automatically, by Actiware-Sleep algorithm (16).

Definitions

Bed Time - the time at which the subject went to bed with intentions to sleep. Researchers must set this parameter manually, according to the sleep diary. In the Fig.1 is graphically represented by the blue line furthest to the left. Expressed in hours in minutes.

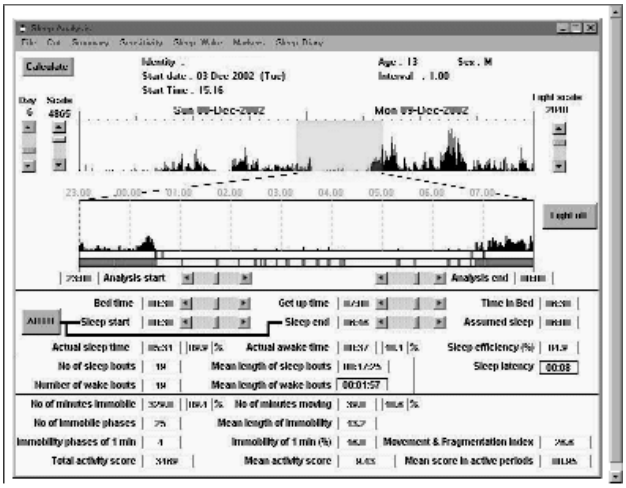

Figure 1. The black spikes represents the activity counts. The higher levels correspond to higher activity. The lover actogram is an expanded window from the upper one, corresponding to nighttime. The blue and pink lines in the left part represent the bedtime and sleep start time respectively. The same lines in the right part represent wake up and sleep end time.Bedtime and get up time were manually entered. The rest of sleep parameters were automatically calculated.

Get up Time - he time at which the subject left the bed, and graphically represented by the blue line furthest to the right. This parameter needs to be inputted manually, according to records from sleep diary. Expressed in hours and minutes.

Sleep Start - the time of sleep onset and is graphically represented by the pink line furthest to the right. Actiware-Sleep automatically will search for the first 10 min period in which no more than one epoch is scored as mobile.

Sleep End - the time of sleep termination, and is graphically represented by the pink line furthest to the right. Actiware-Sleep automatically will examine the 10 min period directly before the Get up time. The last epoch with no movement will be scored as the Sleep End time.

Assumed Sleep - the difference in time between the Sleep End and the Sleep Start times.

Actual Sleep Time - the amount of time, between Sleep Start and Sleep End that is scored as sleep according to the Actiware-Sleep algorithm. Determined by summing the number of epochs that do not exceed the sensitivity threshold and multiplying that value by the epoch length in minutes.

Actual Sleep Time Percentage - an index of the amount of the assumed sleep time that is actually sleep. Determined by dividing the Actual Sleep Time by the Assumed Sleep Time and multiplying by 100.

Actual Wake Time - the amount of time, between Sleep Start and Sleep End, which is scored as wake according to the Actiware-Sleep algorithm.

Actual Wake Time Percentage - the index of the amount of the assumed sleep time, which is actually wake. Determined by dividing the Awake time by Assumed Sleep Time and multiplying by 100.

Sleep Efficiency - the index of the amount of time in bed that is actually spent sleeping. Determined by dividing the Actual Sleep Time by the Time in Bed and multiplying by 100.

Sleep Latency - the period of time between Bed Time and the start of sleep.

Sleep Bouts - a count of the continuous blocks of epochs that represent sleep between the sleep start and sleep end. Actiware-Sleep counts the number of continuous blocks, one or more epochs in length, which is scored as sleep.

Wake Bouts - the count of the number of

awakenings between sleep start and sleep end times. Actiware-Sleep counts the number of continuous blocks, one or more epochs in length that are scored as wake.

Mean Length of Sleep Bouts - the average length of the sleep bouts calculated by the program: Actual Sleep Time divided by the Number of Wake Bouts.

Mean Length of Wake Bouts - the average length of the wake bouts calculated by the Actiware-Sleep program: the Actual Wake Time divided by the Number of Wake Bouts.

Number of Minutes immobile - summation of the time where the subject does not move. Calculated by summing the number of epochs that are scored as mobile and multiplying that value by the epoch length in minutes.

Number of Minutes Immobile Percentage - a relative value that compares the time spent moving to the assumed sleep period: the Number of Minutes Immobile divided by the Assumed Sleep Time and multiplying by 100.

Number of Minutes Moving - summation of the time the subject spent moving between Sleep Start and Sleep end. Calculated by summing the number of epochs that are scored as mobile and multiplying that value by the epoch length in minutes.

Number of Minutes Moving Percentage - amount of assumed sleep time spent moving. Calculated by dividing the Number of Minutes Moving by the Assumed Sleep Time and multiplying by 100.

Number of Immobile Phases - a count of the continuous blocks of immobility, calculated between Sleep Start and Sleep End. Determined by counting the number of continuous blocks, one or more epochs in length, those are scored as mobile.

Mean Length of Immobility - the average length of the blocks of inactivity: the Number of Minutes Immobile divided by the Number of Immobile Phases.

Immobility Phases of 1 Minute - the number of one-minute increments in which there is no motion, calculated between Sleep Start and Sleep End. Determined by counting the number of time intervals, only one minute on length, those are scored as immobile.

Immobility Phases of 1 Minute, Percentage - the one-minute immobility phases in relation to the total number of immobility phases. Determined by dividing the Immobility Phases of 1 Minute by the Number of Immobile Phases and multiplying by 100.

Total Activity Score - the summation of all activity counts between the Sleep Start and Sleep End Times.

Mean Activity Score - the magnitude of activity on a per-epoch-basis during sleep. Determined by dividing the Total Activity Score by the number of epochs during the Assumed Sleep period.

Mean Score in Active Periods - the magnitude of activity on a per-epoch-basis during sleep. Determined by dividing the Total Activity Score by the number of epochs during which activity counts were scored.

Fragmentation index - index of restlessness, calculated by summing the Number of Minutes Moving Percentage with the Immobility Phases of 1 Minute Percentage.

Statistical analysis

The subjective and objective sleep schedule parameters data were compared using paired and unpaired t-test. The number of sleep nights analyzed in both groups was five for schooldays and two for weekends. All statistical analyses were performed with SPSS (10.0 J). The statistical significance level was set at $p<0.05$.

RESULTS

Anthropometric measurement

Antrhropometric data for elementary school children: age 10.8 (0.8); weight 37.2 (10.4); height 141.6 (7.7); BMI 18.3 (3.5) and junior high school adolescents: age 14.2 (0.3); weight 56.4 (6.2); height 166.8 (5.7); BMI 20.3 (2.0).

Table 1. Sleep parameters in schooldays. Elementary school vs junior high school

	elementary school		junior high school		difference (95% CI)			
	mean	SD	mean	SD	difference	lower	upper	P value
BED_TIME	21:53	0:33	23:39	0:48	-1:45	-2:03	-1:27	<0.001
Get up time	6:45	0:24	6:58	0:25	-0:13	-0:24	-0:02	0.024
Time in bed	8:58	0:54	7:19	0:41	1:39	1:19	1:58	<0.001
Sleep start	22:05	0:34	23:46	0:52	-1:41	-2:01	-1:22	<0.001
Sleep end	6:00	0:34	6:42	0:26	-0:41	-0:56	-0:27	<0.001
Assumed sleep	7:55	0:36	6:55	0:45	1:00	0:40	1:18	<0.001
Actual sleep time	7:48	0:35	6:14	0:40	1:34	1:16	1:51	<0.001
Actual sleep (%)	98.43	1.89	90.13	3.30	8.31	7.07	9.55	<0.001
Actual wake time	0:07	0:09	0:41	0:15	-0:34	-0:40	-0:28	<0.001
Actual wake (%)	1.57	1.89	9.87	3.30	-8.31	-9.55	-7.07	<0.001
Sleep efficiency	87.97	4.63	85.15	3.92	2.82	0.67	4.97	0.011
Sleep latency	0:11	0:08	0:07	0:08	0:03:38	-0:00:08	0:07:25	0.059
Sleep bouts	4.98	2.35	22.73	6.42	-17.75	-19.84	-15.65	<0.001
Wake bouts	4.61	2.79	22.44	6.08	-17.83	-19.85	-15.81	<0.001
Mean sleep bout time	2:51	1:34	0:26	0:40	2:25	1:53	2:56	<0.001
Mean wake bout time	0:01:22	0:00:28	0:01:48	0:00:23	-0:00:26	-0:00:40	-0:00:13	<0.001
Immobile mins	404.60	35.54	368.21	38.68	36.39	19.33	53.44	<0.001
Immobile time (%)	85.11	3.87	88.68	2.99	-3.57	-5.19	-1.96	<0.001
Moving mins	71.44	20.56	47.58	15.08	23.86	15.46	32.27	<0.001
Moving time (%)	14.89	3.87	11.32	2.99	3.57	1.96	5.19	<0.001
No. immobile phases	43.15	7.89	34.00	8.70	9.15	5.25	13.05	<0.001
Mean length immobility	10.27	3.44	13.29	12.30	-3.02	-7.14	1.11	0.147
1 Minute immobility	6.79	2.92	4.23	3.08	2.56	1.13	3.99	0.001
1 Minute immobility (%)	14.91	4.31	11.26	5.44	3.65	1.34	5.97	0.003
Total activity score	9292.70	8655.01	4845.43	1752.90	4447.28	1644.39	7250.16	0.003
Mean activity score	19.21	16.38	11.51	3.94	7.70	2.31	13.10	0.006
Mean score in active	114.73	33.47	101.23	30.98	13.50	-3.43	30.43	0.115
Fragmentation index	29.80	7.70	22.58	8.03	7.23	3.53	10.92	<0.001

The mean differences between elementary and junior high school parameters are evaluated by unpaired t-test. The data are expressed in hours, minutes, percentage and numbers. Abbreviation: 95%CI: 95%confidence interval

Sleep parameters in schooldays

Table one represents results of all sleeping parameters in both groups during schooldays. We found statistically significant difference as follow: 1h 45 min later bedtime and 13 min later wake up time for adolescents examined in contrast with children. Also, adolescents showed decrease of time in bed, followed by late sleep start, and sleep end delay. Furthermore, we found an alarming increase in actual wake time percentage, 9.87% for adolescents in contrast with 1.57% in elementary school. Sleep efficiency showed a slightly decline. We also found, that middle high school adolescents spend more time in immobility, 88.68% versus 85.11%. Total activity score diminished and fragmentation index, or index of restlessness also, from 29.80 till 22.58 in adolescents.

Sleep parameters in weekends

Weekends schedule in elementary school children is characterized by stability in children and dispersion in adolescents, as shown in Table 2 statistically significant ($p<0.001$) differences were observed in majority of sleep parameters in junior high school adolescents in contrast to elementary school, as follows: bed time decreased by 2h, time in bed decreased by 36 min, get up time, same as sleep start became later by 1h 23 min, and 1h 57

Table 2. Sleep parameters in weekend. Elementary vs junior high school

	elementary school		junior high school		difference (95% CI)			
	mean	SD	mean	SD	difference	lower	upper	P value
BED_TIME	21:36	0:52	23:37	0:59	-2:00	-2:26	-1:35	<0.001
Get up time	6:40	0:36	8:03	0:52	-1:23	-1:43	-1:03	<0.001
Time in bed	9:03	0:48	8:27	0:58	0:36	0:13	0:59	0.003
Sleep start	21:48	0:53	23:46	1:02	-1:57	-2:23	-1:32	<0.001
Sleep end	5:54	0:46	7:47	0:55	-1:52	-2:13	-1:31	<0.001
Assumed sleep	8:03	1:03	8:01	0:56	0:02	-0:23	0:27	0.864
Actual sleep time	7:57	1:01	7:10	0:52	0:47	0:23	1:11	<0.001
Actual sleep (%)	98.89	1.11	89.62	4.10	9.28	7.95	10.60	<0.001
Actual wake time	0:05	0:05	0:50	0:20	-0:45	-0:51	-0:38	<0.001
Actual wake (%)	1.11	1.11	10.39	4.10	-9.28	-10:60	-7:95	<0.001
Sleep efficiency	87.80	7.36	85.06	5.89	2.73	-0.32	5.79	0.078
Sleep latency	0:14	0:12	0:08	0:10	0:06:07	0:00:28	0:11	0.034
Sleep bouts	4.25	2.63	26.46	8.69	-22.21	-24.85	-19.58	<0.001
Wake bouts	3.69	2.43	25.90	8.93	-22.21	-24.94	-19.47	<0.001
Mean sleep bout time	3:04	1:56	0:31	1:06	2:33	1:52	3:15	<0.001
Mean wake bout time	0:01:16	0:00:45	0:01:52	0:00:31	-0:00:36	-0:00:53	-0:00:19	<0.001
Immobile mins	411.53	56.26	423.57	49.12	-12.04	-34.27	10.18	0.280
Immobile time (%)	85.20	3.43	88.17	3.52	-2.97	-4.44	-1.50	<0.001
Moving mins	71.58	20.13	57.42	19.06	14.16	6.18	22.15	0.001
Moving time (%)	14.80	3.43	11.83	3.52	2.97	1.50	4.44	<0.001
No. immobile phases	45.10	9.71	40.50	11.76	4.60	0.06	9.14	0.047
Mean length immobility	9.68	2.66	16.41	35.81	-6.73	-17.95	4.48	0.232
1 Minute immobility	7.42	3.25	5.16	3.32	2.27	0.86	3.67	0.002
1 Minute immobility (%)	15.62	4.77	11.57	5.99	4.05	1.60	6.49	0.002
Total activity score	9010.29	4585.87	5910.86	2745.68	3099.43	1457.97	4740.89	<0.001
Mean activity score	18.28	7.71	12.18	5.73	6.10	3.13	9.07	<0.001
Mean score in active	128.61	83.30	99.11	30.77	29.50	2.27	56.74	0.034
Fragmentation index	30.42	7.46	23.41	8.96	7.01	3.39	10.64	<0.001

The mean differences between elementary and junior high school parameters are evaluated by unpaired t-test. The data are expressed in hours, minutes, percentage and numbers. Abbreviation: 95%CI: 95%confidence interval

min respectively. Actual sleep time percentage decreased by 9.28%, same as sleep efficiency. Sleep latency changed from 14 min in children to 8 min in adolescents. Interesting detection, we observed an increase in immobile time, from 85.20% in children to 88.17% in adolescents. Total activity score decline from 9010 in children till 5910 in adolescents and fragmentation index fell from 30 to 23.

Sleep differences between schooldays and weekends in elementary school group

During elementary school period, stability and plenty characterize sleep. As shown in Table 3, we found not significant changes in sleep parameters. Interestingly, children in elementary school even try to go to bed earlier in weekends, by 34 min on average (p=0.052). Respectively, sleep start starts early, by 48 min. Instead, get up time is the same during the schooldays 6:45 and weekend 6:40. Get up time, time in bed, sleep end and assumed sleep changed, but could not rich statistical significance. Only significant we found decrease in mean length immobility, from 10.27 to 9.68 (p=0.044).

Sleep differences between schooldays and weekends in junior high school group

A wide range of sleep patterns during

Table 3. Sleep parameters in elementary school. Schooldays vs weekends

	schooldays		weekends		difference (95% CI)			
	mean	SD	mean	SD	difference	lower	upper	P value
BED_TIME	21:53	0:33	21:19	1:54	0:34	-0:00:21	1:08	0.052
Get up time	6:45	0:24	6:40	0:36	0:05	-0:05:16	0:15	0.33
Time in bed	8:58	0:54	9:03	0:48	-0:05	-0:19	0:08	0.463
Sleep start	22:05	0:34	21:17	2:29	0:48	-0:00:27	1:36	0.052
Sleep end	6:00	0:34	5:54	0:46	0:06	-0:07	0:18	0.341
Assumed sleep	7:55	0:36	8:03	1:03	-0:08	-0:26	0:10	0.407
Actual sleep time	7:48	0:35	7:57	1:01	-0:09	-0:27	0:08	0.297
Actual sleep (%)	98.43	1.89	98.89	1.11	-0.46	-1.14	0.21	0.173
Actual wake time	0:07	0:09	0:05	0:05	0:02	-0:01	0:05	0.182
Actual wake (%)	1.57	1.89	1.11	1.11	0.46	-0.21	1.14	0.175
Sleep efficiency	87.97	4.63	87.80	7.36	0.18	-1.85	2.21	0.86
Sleep latency	0:11	0:08	0:15	0:12	-0:04	-0:08	0:00	0.068
Sleep bouts	4.98	2.35	4.25	2.63	0.73	-0.23	1.69	0.131
Wake bouts	4.64	2.81	3.69	2.43	0.95	-0.21	2.11	0.107
Mean sleep bout time	2:51	1:34	3:05	1:56	-0:14	-0:48	0:20	0.428
Mean wake bout time	0:01:22	0:00:28	0:01:16	0:00:45	0:00:06	-0:00:09	0:00:20	0.45
Immobile mins	404.60	35.54	411.53	56.26	-6.93	-22.70	8.84	0.38
Immobile time (%)	85.11	3.87	85.20	3.43	-0.09	-1.32	1.14	0.886
Moving mins	71.44	20.56	71.58	20.13	-0.14	-7.54	7.26	0.97
Moving time (%)	14.89	3.87	14.80	3.43	0.09	-1.14	1.32	0.886
No. immobile phases	43.15	7.89	45.10	9.71	-1.95	-4.22	0.33	0.091
Mean length immobility	10.27	3.44	9.68	2.66	0.60	0.02	1.18	0.044
1 Minute immobility	6.79	2.92	7.42	3.25	-0.63	-1.59	0.33	0.194
1 Minute immobility (%)	14.91	4.31	15.62	4.77	-0.71	-2.46	1.05	0.42
Total activity score	9292.70	8655.01	9010.29	4585.87	282.42	-2894.36	3459.19	0.858
Mean activity score	19.21	16.38	18.28	7.71	0.93	-4.91	6.78	0.748
Mean score in active	114.73	33.47	128.61	83.30	-13.89	-43.34	15.57	0.347
Fragmentation index	29.80	7.70	30.42	7.46	-0.62	-3.31	2.07	0.645

The mean differences between elementary and junior high school parameters are evaluated by paired t-test. The data are expressed in hours, minutes, percentage and numbers. Abbreviation: 95%CI: 95%confidence interval

weekends showed distinctness from schooldays as presented in Table 4. Surprisingly, we found some similar patterns, especially related to sleep initiation, as follow: bedtime and sleep start is almost the same during schooldays and weekends. Instead in the morning, because sleep is prolonged, major of changes occur. Get up time increase by 1h 04 min ($p<0.001$), time in bed extended by 1h 07 min ($p<0.001$), sleep end prolonged by 1h 05 min ($p<0.001$), assumed and actual sleep increased both ($p<0.001$). Actual sleep time percentage showed non-significant variation; instead actual wake percentage is higher during weekend. In weekend, sleep seems to be more agitated and we found an increase in the number of sleep-wake bouts, from 22 to 26 ($p=0.003$). Another argument for sleep disruption is the increased total activity score, from 4.845 to 5.910 ($p=0.018$).

Self-reported sleep parameters

As shown in Table 5, we found that self-reported sleepiness during schooldays increased from 26.2% in children to 66.6% in adolescents. Adolescents reported difficulties in falling in sleep 18.1% in contrast to only 2.4% in children. Sleep deepness decreased from 95.3% in children to 90.9% in adolescents. Morning feeling, described as good decreased form 47.7% in elementary school to 22.7% in junior high school, and described as bad increased from 14.3% to 38.6% in same groups. Complains regarding sleep

Table 4. Sleep parameters in junior high school. Schooldays vs weekends

	schooldays		weekends		difference (95% CI)			
	mean	SD	mean	SD	difference	lower	upper	P value
Bed time	23:39	0:48	23:37	0:59	0:02	-0:16	0:19	0.841
Get up time	6:58	0:25	8:03	0:52	-1:04	-1:21	-0:48	<0.001
Time in bed	7:19	0:41	8:27	0:58	-1:07	-1:26	-0:49	<0.001
Sleep start	23:46	0:52	23:46	1:02	0:00:23	-0:18	0:19	0.966
Sleep end	6:42	0:26	7:47	0:55	-1:05	-1:22	-0:48	<0.001
Assumed sleep	6:55	0:45	8:00	0:56	-1:05	-1:24	-0:46	<0.001
Actual sleep time	6:14	0:40	7:10	0:52	-0:56	-1:13	-0:40	<0.001
Actual sleep (%)	90.13	3.30	89.62	4.10	0.51	-0.57	1.59	0.347
Actual wake time	0:41	0:15	0:50	0:20	-0:09	-0:14	-0:03	0.004
Actual wake (%)	9.87	3.30	10.39	4.10	-0.51	-1.59	0.57	<0.001
Sleep efficiency	85.15	3.92	85.06	5.89	0.09	-1.47	1.66	0.906
Sleep latency	0:07	0:08	0:08	0:10	-0:01	-0:05:35	0:02:52	0.521
Sleep bouts	22.729	6.418	26.464	8.691	-3.74	-6.11	-1.36	0.003
Wake bouts	22.442	6.078	26.155	8.786	-3.71	-6.11	-1.32	0.003
Mean sleep bout time	0:26	0:40	0:31	1:06	-0:05	-0:12	12:00.0	0.547
Mean wake bout time	0:01:48	0:00:23	0:01:52	0:00:31	0:00:04	-0:00:13	0:00:05	0.395
Immobile mins	368.21	38.68	423.57	49.12	-55.36	-71.33	-39.4	<0.001
Immobile time (%)	88.68	2.99	88.17	3.52	0.52	-0.49	1.53	0.307
Moving mins	47.58	15.08	57.42	19.06	-9.84	-15.47	-4.22	0.001
Moving time (%)	11.32	2.99	11.83	3.52	-0.52	-1.53	0.49	0.307
No. immobile phases	34.00	8.70	40.50	11.76	-6.5	-9.84	-3.16	<0.001
Mean length immobility	13.29	12.30	16.41	35.81	-3.12	-14.97	8.73	0.598
1 Minute immobility	4.23	3.08	5.16	3.32	-0.92	-1.90	0.06	0.064
1 Minute immobility (%)	11.26	5.44	11.57	5.99	-0.31	-2.30	1.68	0.753
Total activity score	4845.43	1752.90	5910.86	2745.68	-1065.4	-1937.12	-193.73	0.018
Mean activity score	11.51	3.94	12.18	5.73	-0.67	-2.37	1.041	0.435
Mean score in active	101.23	30.98	99.11	30.77	2.12	-7.18	11.41	0.648
Fragmentation index	22.58	8.03	23.41	8.96	-0.83	-3.55	1.89	0.542

The mean differences between elementary and junior high school parameters are evaluated by paired t-test. The data are expressed in hours, minutes, percentage and numbers. Abbreviation: 95%CI: 95%confidence interval

Table 5. Self reported sleep parameters, %

		ES	JHS	P value
Sleepiness	yes	26.2	75	<0.001
	no	66.6	25	
Fall in sleep	easy	97.7	81.9	<0.001
	diff.	2.4	18.1	
Wake during night	no	54.8	56.8	NS
	1	35.7	38.6	
	2	4.8	2.3	
	3	2.4	2.3	
Sleep deepness	high	95.2	90.9	0.056
	low	4.8	9.1	
Morning feeling	good	47.7	22.7	<0.001
	satisf	35.7	38.6	
	bad	14.3	38.6	
Sleep plenitude	not suf.	38.1	56.8	0.025
	suffic	52.4	43.2	
	good	7.2	0	
Sleep in general	good	16.7	29.5	0.076
	norm	31	54.5	
	bad	52.4	15.9	

Descriptive statistics for self reported sleep parameters. Abbreviations: ES-elementary school, JHS-junior high school, diff.-difficult, satisf.-satisfactory, not suf.-not sufficient, suffic.-sufficient, norm.-normal.

insufficiency raised from 38.1% in children to 56.8% in adolescents; also, no one answered that sleep is enough, in contrast with 7.2% in children. If in elementary school children 45.3% reported as good self-impression about own sleep, in adolescence period only 29.5%.

DISCUSSION

As concerns regarding sleep and health status in schoolchildren grow, the accumulation of survey estimates of sleep-wake patterns structure becomes more important for many researchers. In order to achieve full imagine of sleep-wake habits, the most congruous approach is a combination of actigraphy and subjective questionnaire. Both complete each

other by increasing accuracy, reliability and continuity of survey data. The results of this study provide evidence that in transition from elementary to junior high school period sleep pursue serious changes in Japanese schoolchildren. If elementary school children have constant sleep patterns without noticeable difference during schooldays and weekends, middle high school subject's results showed a great variation, first in comparison with elementary school peers and second, between schooldays and weekends. Definitely, such changes in sleep-wake patterns appear during puberty (17). The present results are important, because we presented a full rage of the sleep microstructure parameters and especially such indices, (i.e. fragmentation index, sleep and wake bouts, immobile time, total activity score) which cannot be assessed during questionnaire-based survey. Our findings are in concordance with many reported data Park et al (18) suggested, the delay of sleep phase, reduction of sleep length, increased daytime napping, and transition to Evening type were remarkably represented around Grade 7.

According to reported studies (19,20), there are four areas of sleep regulation showing changes during adolescent maturation: decrease in non-REM and REM, more adult like pattern of REM sleep, increase in daytime sleepiness and shift in the circadian pattern toward a more owl-like tendency for later bedtimes and wake-up times.

One important moment: in adolescents, circadian system adapts slowly to changes in sleep-wake schedules. Circadian timing system adapts more easily to delays in the sleep-wake schedule, rather than to advance (20). When adolescents grow older, sleep onset time tends to be delayed, together with decrease in sleep quality, lack of sleep length, and excessive daytime sleepiness. Thorleifsdottir et al (21) mentioned, that the subjective self reported nocturnal sleep diminishes during adolescent period, causing sleep deprivation and increased daytime sleepiness. Similarly, our objective results are competent with above-mentioned subjective findings and we found that assumed sleep, actual sleep and sleep efficiency decreased significantly from elementary to middle school period

We found a sleep patterns schedule displacement for middle high school students, toward later hours followed by an increase of sleeping hours in weekends compared with weekdays. In our study adolescents showed assumed sleep time 7:19 in schooldays and 8:00 in weekends, and elementary school children 7:55 and 8:03 respectively. Regarding to this finding, there is a consensus in many studies, that the adolescents get insufficient sleep. For instance, Takaubu et al. (22) reported that schoolchildren have sufficient sleep 8h 54min in weekdays and 9h 11min in weekends, but high school students were apparently short of sleep, only 7h 38min in schooldays which they try to extend on weekends, up to 8h 39min. Fukuda and Ishihara (23) revealed that nighttime sleep length was shortest and several physical and mental conditions were worst at high school age. Our objective findings confirm Carskadon's suggestion that sleep on weekends is more naturalistic and is less controlled by outside influences that on schooldays.

Regarding the differences in sleep length we previously reported (24), that shorter sleep length was related with longer TV watching, PC and TV gambling, irregular eating habits and low level of physical activity.

Generally speaking, the biological tendency for sleep delay in adolescence, social influences toward sleep delay, access to a multiple stimulating activities, greater freedom to self-select bed times, and the increased stress and anxiety leading to difficulty falling asleep can all interact to produce significant disruption of sleep in many teenagers. As results, we can see chronic sleep deprivation, extreme emotional distress and great difficulties with attention and self-control (25).

According to Akerstedt (26), the index of sleep quality should include: sleep quality,

calmness of sleep, easiness of falling asleep, sleeping throughout the night and refreshness after sleep. They also concluded, that sleep quality is mainly a question of sleep continuity. In our study, we covered the main above criteria. Objective findings showed, that in adolescence, the main indices of sleep quality e.g. time in bed, sleep efficiency, actual sleep decreased significantly in comparison with elementary school period. The new findings, remarked in the present paper, are related with an impressive decrease in moving time, total activity score and fragmentation index and respectively increase immobility. It might be a hint of adolescent's sleep microstructure change in favor of immobility. Another new finding: there is a suggestive variation between schooldays and weekends: if in elementary school period weekly variations in sleep structures are ineloquent, in middle high school such variations are presented widely, due to the sleep schedule displacement toward later hours and increase in total sleep time during weekends. Above findings support recently reported by Wolfson et al (27) higher strengths of the association between actigraphy and sleep logs during school nights in comparison with weekend night period.

The present study also clarifies the subjective evaluation of sleep parameters in both groups. The most indicative findings, which have logical links with objective findings, are sleepiness increase in adolescents, (almost three times!), difficulties in falling asleep, low level of morning feeling, and complains about insufficiency of sleep (no one reported as sufficient sleep hours during schooldays). Surprisingly, the present study showed an increase in adolescent's self evaluation about own sleep as good and normal.

Some limitations of our study should be acknowledged. Both groups, Çóere confined only to the boys, due to school administration suggestion and measurement convenience. Also, the structure of present study imposed some limitations on our analyses and data interpretations. For example, we focused our attention on objective data, without many subjective interpretations of sleep parameters data. Elementary and middle school groups were homogeneous in terms of absence of sleep disturbances and high interest in own sleep. An additional limitation might be related with the time of experiment. According to some researchers (28), the sleep patterns suffer from seasonal modification, this factor could influence the results of the study.

Actigraphy is an efficient and useful method in disclose of the activity-rest patterns and circadian rhythms. Long term monitoring of sleep-wake patterns is required to detect and analyze in evolution modifications of sleep patterns from childhood to late adolescence. The present results are also useful step in establishing of general acceptable norms for actigraphy studies in children. The next investigations should elucidate the biological pathways of sleep changes and to elaborate the solutions in order to improve children's and adolescents sleep quality.

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