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The Association between Use of Mobile Phones after Lights Out and Sleep Disturbances among Japanese Adolescents: A Nationwide Cross-Sectional Survey

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Study Objective: The objective of this study was to examine the association between the use of mobile phones after lights out and sleep disturbances among Japanese adolescents.

Design and Setting: This study was designed as a cross-sectional survey. The targets were students attending junior and senior high schools throughout Japan. Sample schools were selected by cluster sampling. Self-reported anonymous questionnaires were sent to schools for all students to fill out.

Participants: A total of 95,680 adolescents responded. The overall response rate was 62.9%, and 94,777 questionnaires were subjected to analysis.

Intervention: N/A

Measurements and Results: Daily mobile phone use, even if only for a brief moment every day, was reported by 84.4%. Moreover, as for use of mobile phones after lights out, 8.3% reported using their mobile phone for calling every day and 17.6% reported using it for sending text messages every day. Multiple logistic regression analysis showed that mobile phone use for calling and for sending text messages after lights out was associated with sleep disturbances (short sleep duration, subjective poor sleep quality, excessive daytime sleepiness, and insomnia symptoms) independent of covariates and independent of each other.

Conclusion: This study showed that the use of mobile phones for calling and for sending text messages after lights out is associated with sleep disturbances among Japanese adolescents. However, there were some limitations, such as small effect sizes, in this study. More studies that examine the details of this association are necessary to establish strategies for sleep hygiene in the future.

Keywords: Sleep disturbance, mobile phone, epidemiology, adolescent, Japan

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INTRODUCTION

Sleep disturbances increase the risk of physical and mental problems.[1-3] Moreover, sleep disturbances are prevalent not only among adults, but also among adolescents.[4-6] It has been reported that sleep disturbances among adolescents are closely associated with various lifestyle habits such as drinking alcohol, smoking, eating breakfast, and participating in extracurricular activities.[7-9]

Among the lifestyle habits of adolescents that have been highlighted in recent years, the use of mobile phones is one of the most common means of communicating with others. According to the Ministry of Internal Affairs and Communications, the diffusion rate of mobile phones in Japan is 74.8% and 84.0% among the general and adolescent (age between 13-19 years) populations, respectively.[10] Mobile phone use has been reported to be associated with health problems and also with sleep patterns.[11-14] Loughran et al. reported the adverse effects of electromagnetic fields emitted by mobile phones on sleep electroencephalograms.[15] It has also been shown that exposure to mobile phone emissions at nighttime could have an effect on melatonin-onset time.[16] Furthermore, in a prospective cohort study of 1656 Belgian school-aged children, Van den Bulck reported that levels of tiredness after 1 year increased for respondents who used mobile phones more frequently after lights out.[17] Although this study did not demonstrate an association between mobile phone use and sleep disorders, it discussed the possibility of an increase in tiredness levels as a result of sleep disturbance caused by the use of mobile phones after lights out.

Several studies have shown that the use of electronic media, such as television, personal computers (Internet), and computer games, is associated with sleep disorders.[18-20] Nevertheless, many adolescents are not even aware of the adverse effects of using electronic media in bed and mistakenly believe that these media facilitate sleep.[21] Considering that more than 20% of the Belgian adolescents used mobile phones at least once a

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week after lights out,[17] the same observation may also apply to mobile phones and Japanese adolescents. Because mobile phones are frequently used after lights out despite their possible adverse effects on sleep, this lifestyle habit should be fully taken into consideration when formulating preventive strategies against sleep disturbances among adolescents. However, few studies, especially large-scale epidemiologic studies, have examined associations between mobile phone use after lights out and sleep disturbances both in Japan and globally. Therefore, in the present study, we conducted a nationwide survey of Japanese junior and senior high school-aged students to examine the association between the use of mobile phones after lights out and sleep disturbances.

This paper was based on the secondary analysis of data from a national survey. Hence, the association between mobile phone use and sleep disturbance was not the primary aim of this survey.

METHODS

Subjects and Sampling

We have previously conducted 4 cross-sectional nationwide surveys (1996, 2000, 2004, and 2007) of lifestyle habits, such as alcohol drinking, smoking, eating, and sleeping, among Japanese adolescents.[8,9,22,23] The present study was the fifth such survey.

For this study, of the 10,955 junior high schools and 5115 senior high schools registered in Japan in May 2008, 130 junior high schools (selection rate: 1.2%) and 110 senior high schools (selection rate: 2.2%) were sampled. We used a stratified, single-stage cluster-sampling method. Using this method, we divided Japan into regional blocks and randomly selected schools from each block. To avoid any sampling bias toward any regional blocks, stratified sampling was performed with regional blocks as the strata. All the students enrolled in the sampled schools were the subjects of this study. The sample size was determined by referring to the response rate and confidence intervals (CIs) based on the variance of the results obtained from the previous studies.[22,23]

In the Japanese education system, children enter primary school at the age of 6 years and leave after 6 years of study. They then enter junior high school for 3 years of study, followed by a further 3 years at senior high school. In this report, the first to third years of junior high school are called the 7th to 9th grades, and the first to third years of senior high school are called the 10th to 12th grades.

Survey Procedure

We sent a letter to the principal of each selected school asking for cooperation in our survey, along with the same number of questionnaires and envelopes as the number of students enrolled at the school. At each school that agreed to participate in our survey, each class teacher was instructed to protect the privacy of the respondents and to explain to the students that the completed questionnaires would not be seen by the teachers and that it was not necessary for the students to participate if they were not willing to do so. After the questionnaires had been filled in, they were placed in the envelopes provided, which were then sealed with an adhesive flap. Delivery and collection of the questionnaires were entrusted to the teachers, who were instructed to follow the guidelines for conducting the survey. The teachers collected and sent the sealed envelopes back to Nihon University School of Medicine without opening them. The survey period was from December 2008 to the end of January 2009. This survey was approved by the Ethics Committee of Nihon University School of Medicine.

Response Rates

Replies were obtained from 92 of the 130 junior high schools (school response rate 70.8%) and 80 of the 110 senior high schools (school response rate 72.7%; combined junior high and senior high school response rate 71.7%). A total of 95,680 envelopes were collected. The student response rate as a proportion of students enrolled at the sampled schools was 92.3% for the junior high schools, 83.8% for the senior high schools, and 87.2% as a whole. Accordingly, the overall response rate was 64.1% for the junior high schools, 62.1% for the senior high schools, and 62.9% as a whole. The response rates obtained in this study are similar to those obtained in previous studies using the same method.[8,9,22,23]

Of the collected questionnaires, 903 were excluded because the sex or grade was not specified or the answers were inconsistent. The data for the remaining 94,777 questionnaires were analyzed.

Measures

The major areas that were included in the questionnaire were (1) personal data, (2) lifestyle, (3) sleep status, (4) mental health status, and (5) use of mobile phones.

Personal data

The personal data included sex, school grade, and type of school (junior high school/senior high school).

Lifestyle

The questions related to lifestyle were whether the student ate breakfast (daily/occasionally/never) and whether he or she participated in extracurricular activities (participating/not participating). Moreover, the question, "How many days did you smoke during the previous month?" was included in the questionnaire. If the response to this question was "One day or more," then the student was defined as "smoking." Similarly, the question "How many days did you consume alcoholic beverages during the previous month?" was asked, and if the response was "One day or more," then the student was defined as "drinking alcohol."

Sleep Status

The sleep-status items included sleep duration, subjective sleep assessment, daytime sleepiness, and insomnia symptoms. Sleep disturbances were estimated on the basis of the sleep-status items. The question about sleep duration was "How many hours on average have you slept at night during the previous month? (less than 5 hours/5 hours or more but less than 6 hours/6 hours or more but less than 7 hours/7 hours or more but less than 8 hours/8 hours or more but less than 9 hours/9 hours or more). If the response to this question was "Less than 6 hours," then the student was defined as having "short sleep

duration." The question about subjective sleep assessment was "How do you assess the quality of your sleep during the previous month?" (very good/good/bad/very bad). If the response to this question was "bad or very bad," then the student was defined as having "subjective poor sleep quality." The question about daytime sleepiness was "Do you feel excessively sleepy during the daytime?" (never/seldom/sometimes/often/always). If the response to this question was "often or always," then the student was defined as having "excessive daytime sleepiness."

The following 3 questions about insomnia symptoms experienced during the previous month were embedded in the questionnaire: (1) "Do you have difficulty falling asleep at night?" (2) "Do you wake up during the night after you have gone to sleep?" (3) "Do you wake up too early in the morning and have difficulty getting back to sleep?"

Each question had 5 possible replies: "never," "seldom," "sometimes," "often," and "always." "Often" and "always" were taken as affirmative answers to the question. Insomnia symptoms were defined as being present when an affirmative answer was obtained for any of the 3 questions. These definitions were determined by referring to the previous studies.[2,9]

Mental health status

To evaluate the mental health statuses of the respondents, 2 independent factors ("depression/anxiety" and "decrease in positive feeling") included in the 12-item General Health Questionnaire (GHQ-12)[24,25] were used, and 1 item from each factor was selected for the total score. One of the items from the "depression/anxiety" factor (whether the respondent had felt an unusual amount of unhappiness and depression in the previous 30 days) was evaluated (not at all/no more than usual/more than usual/much more than usual). One of the items from the "decrease in positive feeling" factor (whether the respondent was able to enjoy normal activities more than usual in the previous month) was also evaluated (more so than usual/same as usual/less than usual/much less than usual). Each item described a symptom, and there were 4 possible answers: the 2 answers that indicated the absence of the symptom were assigned a rating of 0; the 2 answers that indicated the presence of the symptom were assigned a rating of 1. Thus, the overall score fell within the range of 0 to 2, and, accordingly, the higher the total score, the poorer the state of mental health was considered to be. In the present study, participants who had total scores of 1 or more were considered to have poor mental health. Previous studies have shown that evaluation of mental health status using depression symptoms with the GHQ-12 and with this cutoff point has a sensitivity of 87.0% and a specificity of 85.1%.[26]

Use of mobile phones

In this study, we used a questionnaire on mobile phone use that contained questions about the frequency of mobile phone use and questions about mobile phone use after lights out. Furthermore, the questions on mobile phone use after lights out included 2 separate questions, one on the use of a mobile phone for calling and the other on the use for sending text messages. The following 3 questions were asked about mobile phone use during the previous month: (1) "How many hours per day did you use your mobile phone (for calling, sending text messages, and Internet browsing)?" (not at all/less than 1 hour/1 hour or more but less than 2 hours/2 hours or more);

(2) "How often did you use your mobile phone (for calling) after lights out?" (not at all/1 to 3 times a month/once a week/a few times a week/every day); and (3) "How often did you use your mobile phone (for sending text messages) after lights out?"(not at all/1 to 3 times a month/once a week/a few times a week/every day).

Statistical Analyses

First, we tallied the responses to the 3 questions on mobile phone use. Next, we calculated the prevalence and 95% CIs for the 4 types of sleep disturbance: short sleep duration, subjective poor sleep quality, excessive daytime sleepiness, and insomnia symptoms. Finally, logistic-regression analyses were conducted to examine the association between the 2 types of mobile phone use (calling and sending text messages) after lights out and these sleep disturbances. Moreover, the following parameters were used as covariates: sex, grade, alcohol-drinking, smoking, eating breakfast, extracurricular activities, mental health, and the use of mobile phones. Our previous studies reported that the covariates, except the use of mobile phones, were associated with sleep disturbances.[8,9,22,23]

An odds ratio was calculated from both univariate logistic regression analysis and multiple logistic regression analysis with 95% CIs. We set the level of significance at $P < 0.01$. All analyses were performed using SPSS version 17.0 for Windows (SPSS, Inc., Chicago, IL).

RESULTS

Responses to the Questions About Use of Mobile Phones

The responses to the questions about duration of mobile phone use during 1 day is shown in Table 1. Daily mobile phone use, even if for only a brief moment every day, was reported by 84.4% (84.2%-84.6%) of the study population, 79.3% (78.9%-79.7%) of the boys, and 89.7% (89.4%-90.0%) of the girls. Moreover, 72.6% (72.2%-73.0%) of junior high school students and 92.9% (92.7%-93.1%) of senior high school students reported using their mobile phones every day. χ^2 TESTS revealed that the girls and senior high school students had more daily mobile phone use ($P < 0.01$).

The responses to the questions about frequency of mobile phone use for calling after lights out are shown in Table 2. In this study, 8.3% (8.1%-8.5%) of the study population, 7.6% (7.4%-7.8%) of the boys, 9.0% (8.8%-9.4%) of the girls, 4.9% (4.7%-5.1%) of junior high school students, and 10.7% (10.4%-11.0%) of senior high school students reported using their mobile phones every day for calling after lights out. χ^2 Tests revealed that the girls and senior high school students had more use of mobile phones for calling after lights out ($P < 0.01$).

The responses to the questions about frequency of mobile phone use for sending text messages after lights out are shown in Table 3. Daily use after lights out was reported by 17.6% (17.4%-17.8%) of the study population, 14% (13.7%-14.3%) of the boys, and 21.3% (20.9%-21.7%) of the girls. Daily use after lights out was also reported by 11.4% (11.1%-11.7%) of junior high school students and 22.1% (21.8%-22.4%) of senior high

school students. χ^2 Tests revealed that the girls and senior high school students had more use of mobile phones for sending text messages after lights out ($P < 0.01$).

Table 1—Duration of mobile phone use during 1 day, stratified by sex and grade

		Mobile Phone Use (%)				
	N	None	< 1 h	≥ 1 and 2 < h	≥ 2 h	Uncertain
Male						
Junior high school						
7th grade	6497	42.6	35.1	9.1	12.5	0.7
8th grade	6769	34.6	32.5	12.9	19.2	0.8
9th grade	6296	30.1	32.2	14.4	22.3	1.0
Senior high school						
10th grade	10154	8.7	35.8	20.4	34.1	0.8
11th grade	9599	8.4	34.2	21.5	35.0	0.9
12th grade	8762	9.3	37.5	18.6	33.5	1.1
Total	48077	19.8	34.8	16.9	27.6	0.9
Female						
Junior high school						
7th grade	6769	21.8	42.3	13.8	21.5	0.7
8th grade	6837	16.4	36.1	15.8	31.0	0.6
9th grade	6575	14.6	34.9	16.9	32.8	0.8
Senior high school						
10th grade	9964	3.9	27.9	22.0	45.5	0.6
11th grade	8662	2.9	28.6	21.9	45.8	0.8
12th grade	7893	3.5	34.5	19.8	41.4	0.8
Total	46700	9.6	33.5	18.8	37.5	0.7

Table 2—Frequency of mobile phones use for calling after lights out, stratified by sex and grade

		Mobile Phone Use For Calling (%)					
	N	None	1-3 times/ mo	Once/ wk	Several times/ wk	Every day	Uncertain
Male							
Junior high school							
7th grade	6497	86.1	3.9	2.3	3.5	2.4	1.8
8th grade	6769	81.6	4.5	3.1	4.9	4.4	1.5
9th grade	6296	79.9	4.1	3.5	5.6	5.2	1.7
Senior high school							
10th grade	10154	68.2	6.9	6.3	8.8	8.6	1.2
11th grade	9599	64.1	7.6	6.3	10.3	10.5	1.2
12th grade	8762	64.0	6.4	6.4	10.6	11.2	1.4
Total	48077	72.5	5.8	5.0	7.7	7.6	1.4
Female							
Junior high school							
7th grade	6769	80.6	5.6	3.0	5.5	4.1	1.3
8th grade	6837	77.0	6.1	3.5	6.2	6.0	1.2
9th grade	6575	74.8	6.5	3.7	6.4	7.3	1.3
Senior high school							
10th grade	9964	66.5	8.4	4.8	9.2	10.2	0.9
11th grade	8662	64.2	8.1	5.2	9.3	12.1	1.1
12th grade	7893	63.2	8.2	5.3	9.9	12.5	0.9
Total	46700	70.3	7.3	4.4	8.0	9.0	1.1

Prevalence of Sleep Disturbances

The prevalence of sleep disturbances with regard to sex and grade are shown in Table 4. The prevalence of short sleep duration was 32.0% (31.7%-32.3%), that of subjective poor sleep quality was 40.2% (39.9%-40.5%), that of excessive daytime sleepiness was 42.2% (41.9%-42.5%), and that of insomnia symptoms was 21.8% (21.5%-22.1%). χ^2 Tests revealed that the girls had more short sleep duration, subjective poor sleep quality, and excessive daytime sleepiness ($P < 0.01$), but there was no significant difference between sexes in regard to insomnia symptoms ($P < 0.13$). Moreover χ^2 tests revealed that senior high school students had more short sleep duration, subjective poor sleep quality, excessive daytime sleepiness, and insomnia symptoms ($P < 0.01$).

LOGISTIC-REGRESSION ANALYSES

Tables 5 and 6 show the results of the logistic-regression analyses that were used to estimate the association between 2 types of mobile phone use after lights out and sleep disturbances. Univariate logistic analyses revealed that mobile phone use after lights out, either for calling or for sending text messages, was significantly associated with all 4 types of sleep disturbance. Also, multiple logistic-regression analyses revealed that these 2 uses of mobile phones after lights out, each independent from the other factors and from each other, were significantly associated with all 4 types of sleep disturbance.

DISCUSSION

This study is the first large-scale epidemiologic study that examined the association between mobile phone use after lights out and sleep disorders, and the results of this study appear to be representative of the study population for 3 reasons: (1) the subject schools were selected randomly from among those nationwide, (2) the sample size was very large and the number of analyzed cased exceeded 90,000, and (3) the rate of response to the questionnaires was acceptably highThis study has clarified the actual situation of Japanese adolescents regarding the time spent using mobile phones. We found that the frequency of use of mobile phones was very high among Japanese adolescents and that 84.4% of the study population used mobile phones every day, even if only briefly. This rate closely matches the diffusion rate (84.0%) of mobile phones among Japanese adolescents reported by the Ministry of Internal Affairs and Communications.[10] This study also revealed that more than 30% of

Japanese adolescents used mobile phones for many hours (2 hours or more a day). These results indicate that a mobile phone is one of the electronic media that is closely related to the daily life of Japanese adolescents. The higher frequency of mobile phone use among senior, as compared with junior high school students, may be partly attributable to developmental factors in adolescents and to the expansion of social contacts as a result of advancement to higher education. However, we believe that this difference is primarily attributable to the rules related to the use of mobile phones in Japanese schools. Elementary and junior high schools in Japan generally prohibit students from bringing mobile phones to school, but senior high schools do not.[27] Thus, compared with junior high school students, senior high school students are in a more mobile phone-friendly environment.

As for the use of mobile phones after lights out, 8.3% of the study population reported using their mobile phone for making calls every day, and 17.6% reported using it for sending text messages every day. The frequency of use for sending text messages was especially high, with more than 40% of male and more than 50% of female senior high school students sending text messages at least once a week. Furthermore, 25% of female students reported using their mobile phones for sending text messages every day. The higher frequency of sending text messages, in comparison with calling, may be attributed to the convenience of sending text messages. Unlike calling, sending text messages does not require the sender and receiver to concurrently share communication time. Thus, the sender can communicate with multiple receivers in a short time regardless of the availability of the receiver. Because of these features, sending text

Table 3—Frequency of mobile phones use for sending text messages after lights out, stratified by sex and grade

		Mobile phone use for sending text messages (%)					
	N	None	1-3 times/mo	Once/wk	Several times/wk	Every day	Uncertain
Male							
Junior high school							
7th grade	6497	80.4	3.8	3.2	6.0	4.8	1.8
8th grade	6769	71.5	5.0	3.9	9.4	8.6	1.5
9th grade	6296	66.9	4.8	4.7	11.0	11.1	1.5
Senior high school							
10th grade	10154	49.4	7.0	7.4	17.6	17.4	1.1
11th grade	9599	49.1	6.2	7.4	17.3	18.9	1.1
12th grade	8762	51.7	5.8	6.9	16.7	17.7	1.3
Total	48077	59.3	5.7	5.9	13.8	14.0	1.3
Female							
Junior high school							
7th grade	6769	64.6	7.6	5.1	11.5	10.1	1.2
8th grade	6837	55.3	8.7	5.1	14.6	15.5	1.0
9th grade	6575	53.0	7.2	5.3	15.3	18.0	1.2
Senior high school							
10th grade	9964	38.5	7.8	7.0	20.2	25.8	0.7
11th grade	8662	36.8	7.6	7.5	19.4	27.8	0.8
12th grade	7893	39.9	6.1	6.9	20.2	26.1	0.9
Total	46700	46.7	7.5	6.3	17.3	21.3	0.9

Table 4—The prevalence of sleep disturbances among Japanese adolescents, stratified by sex and grade[a]

	Short Sleep Duration		Subjective Poor Sleep Quality		Excessive Daytime Sleepiness		Insomnia Symptom	
	%	95% CI	%	95% CI	%	95% CI	%	95% CI
Male								
Junior high school								
7th grade	12.8	12.0–13.6	27.9	26.8–29.0	25.2	24.1–26.3	19.5	18.5–20.5
8th grade	17.7	16.8–18.6	32.3	31.2–33.4	31.3	30.2–32.4	21.0	20.0–22.0
9th grade	26.9	25.8–28.0	37.9	36.7–39.1	33.6	32.4–34.8	23.8	22.7–24.9
Senior high school								
10th grade	33.2	32.3–34.1	44.7	43.7–45.7	46.0	45.0–47.0	21.5	20.7–22.3
11th grade	37.4	36.4–38.4	43.1	42.1–44.1	45.2	44.2–46.2	21.4	20.6–22.2
12th grade	42.9	41.9–43.9	44.2	43.2–45.2	44.7	43.7–45.7	24.2	23.3–25.1
Total	30.0	29.6–30.4	39.4	39.0–39.8	39.1	38.7–39.5	21.9	21.5–22.3
Female								
Junior high school								
7th grade	16.7	15.8–17.6	34.3	33.2–35.4	31.1	30.0–32.2	18.6	17.7–19.5
8th grade	22.7	21.7–23.7	37.0	35.9–38.1	38.7	37.5–39.9	21.6	20.6–22.6
9th grade	31.5	30.4–32.6	42.0	40.8–43.2	41.4	40.2–42.6	23.5	22.5–24.5
Senior high school								
10th grade	42.0	41.0–43.0	46.6	45.6–47.6	53.4	52.4–54.4	22.1	21.3–22.9
11th grade	43.4	42.4–44.4	44.8	43.8–45.8	52.7	51.6–53.8	22.9	22.0–23.8
12th grade	45.8	44.7–46.9	43.6	42.5–44.7	52.2	51.1–53.3	25.1	24.1–26.1
Total	35.0	34.6–35.4	41.9	41.5–42.3	46.0	45.5–46.5	22.4	22.0–22.8

CI, confidence interval. [a]Subjects with missing data were excluded from the analysis.

Table 5—The association between the use of mobile phones after lights out and sleep disturbances among Japanese adolescents[a,b]: short sleep duration and subjective poor sleep quality

Number of times mobile phones used after lights out, based on type of use	N	Short Sleep Duration						Subjective Poor Sleep Quality					
		Crude			Adjusted			Crude			Adjusted		
		OR	95% CI	P value	OR	95% CI	P value	OR	95% CI	P value	OR	95% CI	P value
For calling				< 0.01			< 0.01			< 0.01			< 0.01
0	67646	1.00			1.00			1.00			1.00		
1-3/mo	6229	1.41	1.33–1.48		1.12	1.05–1.19		1.40	1.33–1.48		1.06	1.00–1.13	
1/wk	4423	1.26	1.18–1.34		0.99	0.92–1.07		1.31	1.23–1.39		1.01	0.94–1.08	
Several/wk	7441	1.49	1.42–1.56		1.08	1.02–1.14		1.57	1.49–1.65		1.08	1.02–1.14	
Daily	7853	1.94	1.85–2.03		1.21	1.14–1.28		2.00	1.90–2.09		1.22	1.15–1.29	
For sending text messages				< 0.01			< 0.01			< 0.01			< 0.01
0	50349	1.00			1.00			1.00			1.00		
1-3/mo	6204	1.05	0.99–1.12		0.87	0.81–0.92		1.19	1.13–1.26		1.07	1.00–1.13	
1/wk	5767	1.15	1.09–1.22		0.88	0.83–0.94		1.25	1.18–1.32		1.05	0.98–1.11	
Several/wk	14698	1.37	1.32–1.42		0.97	0.93–1.01		1.49	1.43–1.54		1.16	1.11–1.21	
Daily	16696	1.89	1.82–1.96		1.15	1.09–1.20		1.95	1.88–2.02		1.27	1.21–1.33	

OR, odds ratio; CI, confidence interval. [a]Adjusted factors include sex, grade, drinking alcohol, smoking, eating breakfast, extracurricular activities, and mental health. [b]Subjects with missing date were excluded from the analysis.

Table 6—The association between use of mobile phones after lights out and sleep disturbances among Japanese adolescents: Excessive daytime sleepiness and insomnia symptoms

Number of times mobile phones used after lights out, based on type of use	N	Excessive Daytime Sleepiness						Insomnia Symptom					
		Crude			Adjusted			Crude			Adjusted		
		OR	95% CI	P value	OR	95% CI	P value	OR	95% CI	P value	OR	95% CI	P value
For calling				< 0.01			< 0.01			< 0.01			< 0.01
0	67646	1.00			1.00			1.00			1.00		
1-3/mo	6229	1.45	1.38–1.53		0.98	0.92–1.04		1.46	1.38–1.55		1.13	1.06–1.21	
1/wk	4423	1.30	1.22–1.38		0.91	0.85–0.98		1.50	1.40–1.61		1.19	1.10–1.29	
Several/wk	7441	1.58	1.50–1.65		0.98	0.93–1.04		1.79	1.70–1.89		1.26	1.18–1.34	
Daily	7853	2.12	2.02–2.22		1.17	1.10–1.24		2.47	2.35–2.60		1.44	1.35–1.53	
For sending text messages				< 0.01			< 0.01			< 0.01			< 0.01
0	50349	1.00			1.00			1.00			1.00		
1-3/mo	6204	1.40	1.32–1.47		1.24	1.17–1.31		1.15	1.08–1.23		1.07	0.99–1.15	
1/wk	5767	1.39	1.32–1.47		1.16	1.09–1.23		1.20	1.12–1.28		1.02	0.95–1.10	
Several/wk	14698	1.74	1.68–1.80		1.37	1.31–1.43		1.43	1.37–1.49		1.12	1.07–1.18	
Daily	16696	2.28	2.20–2.36		1.50	1.43–1.57		2.28	2.19–2.37		1.45	1.38–1.53	

OR, odds ratio; CI, confidence interval. [a]Adjusted factors include sex, grade, drinking alcohol, smoking, eating breakfast, extracurricular activities, and mental health. [b]Subjects with missing date were excluded from the analysis.

messages is regarded as a more accessible communication medium and tends to be preferred over calling, especially in circumstances in which the receiver is less likely to be available for communication. Therefore, it is understandable that, after lights out, the frequency of sending text messages is higher than that of calling.

In this study, to assess the association between mobile phone use after lights out and sleep disturbance, we conducted a multifaceted and comprehensive evaluation of sleep disturbance by focusing on 4 parameters; quantitative index (short sleep duration), qualitative index (subjective poor sleep quality), daytime consequences (excessive daytime sleepiness), and insomnia symptoms and, by using multiple logistic-regression analysis, adjusted for other confounding factors. We found that mobile phone use for calling and for sending text messages after lights out was associated with all sleep disturbances independent of the covariates and independent of each other.

Our finding that mobile phone use after lights out was associated with all forms of sleep disturbance, each different in nature, suggests that the use of mobile phones after lights out has various effects on sleep. Loughran et al.[15] reported that exposure to electromagnetic fields emitted by digital mobile-phone handsets prior to sleep decreased the rapid eye movement (REM) sleep latency and increased the electroencephalogram

spectral power in the 11.5- to 12.25-Hz frequency range during the initial part of sleep following exposure. Furthermore, Wood et al.[16] reported that, although subjects who were actively exposed to mobile-phone emissions showed no significant difference in total nighttime melatonin output relative to sham-exposed subjects, the pre-bedtime melatonin output was significantly lower in the former, indicating a delay in the onset time of melatonin secretion caused by mobile phone emission. These reports suggest that the use of mobile phones after lights out influences physiologic factors such as the sleep electroencephalogram and melatonin-secretion rhythm. Moreover, if communications made using a mobile phone after lights out are emotional, thoughtful, or considerable, they may induce emotional or cognitive arousal in the pre-sleep period that is considered to be a cause of insomnia symptoms.[28-31] Thus, mobile phone use after lights out may be presumed to also influence the psychological factors that disturb sleep. From the above, it is considered that various mechanisms—physiologic, psychological and others—are involved in the influence on sleep of mobile phone use after lights out. The results of this study showed that both calling and sending text messages were associated with sleep, each independently from the other. This may be because the mechanisms that influence sleep may differ according to type of mobile phone use. However, few studies have examined the association between mobile phone use after lights out and sleep, and the mechanisms underlying this association remain to be elucidated. Future studies should reveal more information about these mechanisms.

There were some limitations to our study. First, since this was a cross-sectional survey, a causal relationship could not be determined. For example, it could be that adolescents with sleep problems had difficulties falling asleep; they therefore used mobile phones. If so, treatment for sleep disturbances may decrease the use of mobile phones after lights out. Moreover, the proof of these mechanisms is not enough because there are few studies that have evaluated the influence of physiologic and psychological mechanisms derived from adolescents' use of mobile phones after lights out. When examining a causal relationship, a longitudinal study such as a cohort study and a biologic study are required, and such a study will be required in the future. Second, due to large sample size, the significant results may not necessarily endorse a true effect in this study. The results of this study showed significant associations between the use of mobile phones after lights out and sleep disturbances, but the odds ratios are small (less than 1.5). Then, the significance disappeared for some dummy variables, and some showed reverse associations after controlling the effects of covariates. Therefore, the effect sizes should be considered with the interpretation of the results of this study. Third, there may have been a degree of reporting bias because we used a self-reporting method. However, several previous reports have found that self-reported data on sleep status are consistent with physiologic data to a certain degree.[32,33] Fourth, the questions included in our questionnaire did not encompass all of the factors that might cause sleep disturbances. For example, noise levels at night, the person or persons with whom a subject sleeps, and commuting time to school are factors that could affect a subject's sleep. However, we were unable to include this line of inquiry in the questionnaire because of space limitations, and these items must be examined in the future. Finally, although the sample size was large, the approximate 37% nonresponse rate may have been a potential bias factor because we had no information about the nonresponders.

In conclusion, our results suggest that, among Japanese adolescents, the use of mobile phones for calling and for sending text messages after lights out is associated with various forms of sleep disturbance. However, there were some limitations, such as small effect sizes, in this study. Moreover, causal relationship could not be determined. More studies that examine details of this association are necessary. Because mobile phone use is one of the most familiar or intimate lifestyle factors for adolescents, it should be noted as a lifestyle habit that requires attention when attempting to establish strategies for appropriate sleep hygiene among adolescents. In the future, sleep hygiene education for adolescents should caution against the use of mobile phones after lights out; on the other hand, the rates of mobile phone use after lights out may decrease after treatment for a sleep disturbance.

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