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Associations between sleep disturbance and alcohol drinking: A large-scale epidemiological study of adolescents in Japan

Hisayoshi Morioka [a], Osamu Itani [a,*], Yoshitaka Kaneita [b], Maki Ikeda [a], Shuji Kondo [a], Ryuichiro Yamamoto [c], Yoneatsu Osaki [d], Hideyuki Kanda [e], Susumu Higuchi [f], Takashi Ohida [a]

[a] Division of Public Health, Department of Social Medicine, Nihon University School of Medicine, 30-1 Ohyaguchikami-machi, Itabashi-ku, Tokyo 173-8610, Japan
[b] Department of Public Health and Epidemiology, Faculty of Medicine, Oita University, Yufu-shi, Oita 879-5593, Japan
[c] Division of Clinical Psychology, Health Care and Special Support, Graduate School of Education, Joetsu University of Education, Joetsu-shi, Niigata 943-8512, Japan
[d] Division of Environmental and Preventive Medicine, Department of Social Medicine, Faculty of Medicine, Tottori University, Yonago-shi, Tottori 683-8503, Japan
[e] Department of Epidemiology and Public Health, Yokohama City University, Graduate School of Medicine, Yokohama-shi, Kanagawa 236-0004, Japan
[f] National Hospital Organization Kurihama Medical and Addiction Center, Yokosuka-shi, Kanagawa 239-0841, Japan

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ABSTRACT

In this study, we attempted to clarify the associations between various sleep disturbance symptoms and the frequency and amount of alcohol use among Japanese adolescents. This study was designed as a cross-sectional sampling survey. A self-administered questionnaire survey was administered to students enrolled in randomly selected junior and senior high schools throughout Japan. A total of 99,416 adolescents responded, and 98,867 questionnaires were subjected to analysis. The prevalence rates of sleep disturbance in the 30 days preceding the day of the survey were as follows: subjectively insufficient sleep (SIS) (boys: 37.6%, girls: 38.7%); short sleep duration (SSD) with less than 6 h of sleep (boys: 28.0%, girls: 33.0%); difficulty initiating sleep (DIS) (boys: 12.5%, girls: 14.1%); difficulty maintaining sleep (DMS) (boys: 10.1%, girls: 10.9%); and early morning awakening (EMA) (boys: 5.1%, girls: 5.0%). Adolescents reporting one or more symptoms of DIS, DMS, and EMA were classified as having insomnia, and its prevalence was 21.5%. The prevalence of each symptom of sleep disturbance increased significantly with the number of days on which alcohol was consumed in the previous 30 days and the amount of alcohol consumed per drinking session ($p < 0.01$). Multiple logistic regression analyses showed that the adjusted odds ratio (AOR) for each symptom of sleep disturbance, except SIS and EMA, tended to increase with the number of days on which alcohol was consumed and the amount of alcohol consumed per drinking session. The prevalence of sleep disturbance is particularly high among adolescents drinking alcohol. The risk of having each symptom of sleep disturbance, except SIS and EMA, increases with the number of days on which alcohol was consumed and the amount of alcohol consumed per drinking session. These findings reconfirm the need to eliminate underage drinking to ensure good sleep among adolescents.

Introduction

To date, many epidemiological studies have investigated insomnia and sleep disturbance (such as short sleep duration [SSD] or subjectively insufficient sleep [SIS]) among adolescents (Chung & Cheung, 2008; Johnson & Breslau, 2001; Johnson, Roth, Schultz, & Breslau, 2006; Kaneita et al., 2006; Liu, Uchiyama, Okawa, & Kurita, 2000; Mak, Lee, Ho, Lo, & Lam, 2012; Ohida et al., 2004; Ohayon, Roberts, Zulley, Smirne, & Priest, 2000; Roberts, Roberts, & Chan, 2006, 2008; Roberts, Roberts, & Chen, 2001; Tagaya et al., 2004; Yang, Kim, Patel, & Lee, 2005). In those studies, the prevalence of insomnia in adolescents varied from 4.0% to 23.5% because of differences in the survey methods and definitions of insomnia employed (Chung & Cheung, 2008; Johnson & Breslau, 2001; Johnson et al., 2006; Kaneita et al., 2006; Liu, Uchiyama, Okawa, et al, 2000; Mak et al., 2012; Ohayon et al., 2000; Ohida et al., 2004; Roberts et al., 2006, Roberts, Roberts, & Chan, 2008; Roberts et al., 2001; Yang et al., 2005). The average sleep duration

* Corresponding author. Tel.: +81 3 3972 8111x2272; fax: +81 3 3972 5878.
E-mail addresses: itani.osamu@nihon-u.ac.jp, nusmpublichealth@gmail.com, itaniosamu@gmail.com (O. Itani).

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of adolescents in Japan, Europe, and the US has been reported to be 6.3 h (Tagaya et al., 2004), approximately 8 h (Johnson et al., 2006), and 7.3 h (Wolfson & Carskadon, 1998), respectively. Adolescents of Chinese descent in Hong Kong have an average sleep duration of 7–8 h (Chung & Cheung, 2008; Liu, 2004; Liu, Uchiyama, Okawa, et al, 2000) while high school students in Korea have an average of 5–6 h (Yang et al., 2005). Sleep duration in Japan and Korea is particularly short; thus, sleep disturbance in adolescents is not rare, and represents a common health issue. As sleep disturbances in this age group are known to be associated with behavioral and emotional problems, such as depression, anxiety, attempted suicide, poor academic performance, and bad social attitudes (Chang, Ford, Mead, Cooper-Patrick, & Klag, 1997; Chung & Cheung, 2008; Johnson et al., 2006; Liu, 2004; Mak et al., 2012; Roberts et al., 2001; Roberts, Roberts, & Chen, 2002; Roberts, Roberts, & Duong, 2008; Wolfson & Carskadon, 1998), there is an urgent need to address and solve this issue. A number of epidemiological studies have examined the associations of insomnia/sleep disturbance in adolescents with physical, mental, and socioeconomic statuses, as well as lifestyle habits (Chung & Cheung, 2008; Johnson & Breslau, 2001; Johnson et al., 2006; Liu, Uchiyama, Okawa, et al, 2000; Roberts, Roberts, & Chan, 2008; Roberts et al., 2001; Roberts, Roberts, & Duong, 2008; Tagaya et al., 2004; Tynjälä, Kannas, & Levälahti, 1997; Vignau et al., 1997; Yang et al., 2005). With regard to lifestyle habits, some studies have reported associations between alcohol use and sleep disturbance in this age group (Chung & Cheung, 2008; Johnson & Breslau, 2001; Kaneita et al., 2006; Liu, Uchiyama, Okawa, et al, 2000; Ohida et al., 2004; Tynjälä, et al., 1997; Vignau et al., 1997). Most of those studies investigated associations between sleep disturbance and the presence or absence of alcohol use, and only a few studies investigated associations between the frequency of alcohol use and sleep problems or bad sleep habits (Johnson & Breslau, 2001; Tynjälä et al., 1997; Vignau et al., 1997). However, in those studies, no questions regarding insomnia symptoms, such as difficulty initiating sleep (DIS), difficulty maintaining sleep (DMS) early morning awakening (EMA), or sleep duration were posed (Tynjälä et al., 1997; Vignau et al., 1997). In addition, one study did not examine in detail the associations between insomnia symptoms and the number of days/amount of alcohol intake, although the researchers asked participants about their experiences with insomnia symptoms (Vignau et al., 1997).

Because alcohol is one of the important risk factors for non-communicable diseases (NCDs) and may lead to injury and violence, since 1979 the World Health Organization (WHO) has urged its member states to introduce legislation and take measures for promotion of intensive prevention programs and effective interventions against alcohol use. In addition, in 2011, it adopted a global strategy to reduce the harmful use of alcohol. For adolescents, in particular, alcohol is associated with behavioral problems (e.g., suicide) and social problems (e.g., accidents and crimes committed under the influence of alcohol), in addition to its influence on physical and mental development (Hingson, Heeren, Jamanka, & Howland, 2000). Minors may be susceptible to the effects of alcohol, as their alcohol metabolism is lower than that of adults (Kelly, Bonthius, & West, 1987). Furthermore, the age at onset of alcohol consumption is inversely related to the risk of developing alcohol dependence (Hingson, Hereen, & Winter, 2006). Therefore, more stringent measures for reducing the harmful use of alcohol are required for adolescents than for adults. Consequently, it is essential to collect additional evidence of the effects of alcohol intake in adolescents and to enhance the implementation of measures to prevent alcohol dependence on the basis of such evidence.

Although associations between the prevalence of sleep disturbance (SSD, SIS, etc.) or insomnia symptoms (DIS, EMA, and DMS) and lifestyle habits (especially alcohol-drinking) in adolescents have already been reported, to our knowledge, associations between the frequency/amount of alcohol use and SIS/SSD/individual insomnia symptom in adolescents have not been clarified. To fill this gap, we conducted a cross-sectional sampling survey of junior and senior high school students in Japan.

This study is one of a series of nationwide surveys on lifestyle habits, such as drinking alcohol, smoking, eating, and sleeping, in Japanese junior and senior high school students, and was preceded by four surveys conducted in 1996, 2000, 2004, and 2008 (Kaneita et al., 2006; Munezawa et al., 2011; Ohida et al., 2004; Suzuki, Minowa, & Osaki, 2000).

Materials and methods

Subjects and sampling

A single-stage cluster sampling method was employed. First, 10,785 junior high and 4991 senior high schools (15,776 in total) as of May 2009 in Japan were registered for this study. Among them, 131 junior high (selection rate: 1.2%) and 113 senior high schools (selection rate: 2.3%) were randomly selected. Probability-proportional-to-size sampling was employed so that the probability of selection was determined in proportion to the number of enrolled students. The sample size was determined by referring to the response rate of schools and the ranges of confidence intervals (CIs) based on the variance of the results of our last four nationwide surveys of alcohol drinking behavior. The determined sample size was almost the same as those of the previous surveys.

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 in senior high school. Primary and junior high school education is compulsory. 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 requesting cooperation in our survey to the principal of each selected school, along with the same number of questionnaires and envelopes as that of students enrolled at the corresponding school. At each school in which the principal had approved participation in our survey, home room teachers delivered the questionnaires to the students. To protect the privacy of the respondents and to obtain frank responses, we requested the teachers to comply with the following guidelines: 1) not to make any positive or negative remarks on alcohol use before the survey, 2) not to go around the classroom peering at the questionnaire sheets over the students' shoulders while the students were filling out the questionnaires, and 3) not to open the envelopes, thus protecting students' privacy. Teachers were also requested to inform the students that they would not open the students' envelopes. To ensure compliance with these guidelines, implementation guides for the survey were delivered to the teachers. In addition, it was stated in the questionnaire that the completed questionnaires would not be seen by the teachers. After filling out the questionnaire, each student was requested to place the completed questionnaire in a supplied envelope and then seal it with an adhesive flap. The teachers were requested to send back the sealed envelopes to the Nihon University School of Medicine without opening them, in accordance with the guide. The survey was conducted between October 2010 and March 2011. This study was approved by the Ethics Committee of the School of Medicine, Nihon University.

Table 1
Characteristics of the analyzed subjects.

	N	%
Sex		
Boys	48,794	49.3
Girls	50,073	50.6
Junior high school		
Grade 7	13,041	13.2
Grade 8	12,826	13.0
Grade 9	12,476	12.6
Senior high school		
Grade 10	21,444	21.7
Grade 11	20,168	20.4
Grade 12	18,466	18.7
Unknown	456	0.5
Intending to study at university		
Yes	39,291	39.7
No	46,422	47.0
Not yet decided	11,568	11.7
Unknown	1586	1.6
Having breakfast		
Every day	83,273	84.2
Sometimes	8759	8.9
Seldom	5522	5.6
Unknown	1313	1.3
Smoking (past 30 days)		
No	94,723	95.8
Yes	3934	4.0
Unknown	210	0.2
Drinking (past 30 days)		
No	84,038	85.0
Yes	14,127	14.3
Unknown	702	0.7
Participating in extracurricular activities		
Yes	68,396	69.2
No	28,529	28.9
Unknown	1942	2.0
Bedtimes		
Before or at midnight	51,805	52.4
After midnight	45,408	45.9
Unknown	1654	1.7
Mental health status		
Good	52,384	53.0
Poor	44,916	45.4
Unknown	1567	1.6

Response rates

The subjects of this study were 62,296 and 92,923 students enrolled in 131 and 113 randomly selected junior and senior high schools, respectively (total 155,219). Among the junior and senior high schools, 84 and 82 schools, respectively, returned responses (school cooperation rate: 64.1% and 72.6%, respectively). This means that a total of 166 out of 244 junior and senior high schools returned responses (overall school cooperation rate: 68.0%). Among 107,786 actual participants, 99,416 responded to the questionnaire (38,702 junior high school and 60,714 senior high school students). The percentages of students who responded to the questionnaire were 91.3% and 92.8% in junior and senior high schools, respectively, and 92.2% in total. The eventual response rates were 62.1% and 65.3% for junior and senior high schools, respectively, and 64.0% in total. These response rates were almost the same as those in a series of previous studies that we conducted in the same manner. From the collected questionnaires, 549 were excluded because sex or grade was not specified or the responses were inconsistent. Data from the remaining 98,867 questionnaires (38,552 and 60,315 from junior and senior high schools) were analyzed. The basic attributes of the 98,867 valid responders are shown in Table 1.

Measures

The questions were created with reference to the questionnaires used in the past four surveys (1996, 2000, 2004, and 2008) (Kaneita et al., 2006; Munezawa et al., 2011; Ohida et al., 2004; Suzuki et al., 2000). With regard to sleep status, the following two questions were added to the questionnaire to investigate whether the participants had experienced the corresponding symptoms of sleep disturbance in the previous 30 days:

1. "Do you always get sufficient sleep?"
   (Subjectively insufficient sleep: SIS)
2. "How many hours on average do you sleep at night?"
   (Short sleep duration: SSD)

For Question 1, the following four options were provided: very sufficient, sufficient, insufficient, and very insufficient. The answer options "insufficient" and "very insufficient" were taken as affirmative answers indicating the presence of the corresponding symptom.

For Question 2, the following six options were provided: <5 h, 5 h or more but <6 h, 6 h or more but <7 h, 7 h or more but <8 h, 8 h or more but <9 h, and ≥9 h. The first two were taken as affirmative answers indicating the presence of the corresponding symptom. SSD was determined to be less than 6 h of sleep (Liu, Uchiyama, & Kim, et al., 2000; Ohida et al., 2001, 2004).

The following three questions were included in the questionnaire to investigate whether the participants had experienced the corresponding insomnia symptoms in the previous 30 days:

3. "Do you have difficulty falling asleep at night?"
   (Difficulty initiating sleep: DIS)
4. "Do you wake up during the night after you have gone to sleep?"
   (Difficulty maintaining sleep: DMS)
5. "Do you wake up too early in the morning and have difficulty getting back to sleep?"
   (Early morning awakening: EMA)

For Questions 3–5, the following five answer options were provided: never, rarely, sometimes, often, and always. The options "often" and "always" were regarded as indicative of the corresponding symptoms. Almost all of the exposure and outcome measures were dichotomized for the analyses in this study. This was done because we used binomial logistic regression analysis, as in our previous series of studies (Kaneita et al., 2006; Munezawa et al., 2011; Ohida et al., 2004).

With regard to drinking alcohol, the following three questions were added to the questionnaire:

6. "How many days in total have you drank in the past 30 days?"
7. "How much alcohol do you drink per session?"

For Question 6, the following seven options were provided: none, 1 or 2 days, 3–5 days, 6–9 days, 10–19 days, 20–29 days, and every day. For statistical analyses, students who selected the options "1 or 2 days" and "3–5 days" were classified into the "1–5 days" group, those who selected "6–9 days" and "10–19 days" were classified into the "6–19 days" group, and those who selected "20–29 days" and "every day" were classified into the "over 20 days" group.

For Question 7, the following seven options were provided: I don't drink, less than a glass (a little amount), a glass, 2 glasses, 3–5 glasses, 6 or more glasses, and until I get dead drunk. The amount of alcohol consumption was reclassified into not drinking, less than

a glass (a small amount), 1 or 2 glasses, 3–5 glasses, and ≥6 glasses, after incorporating "until I get dead drunk" into ≥6 glasses.

The following personal data and lifestyle-related factors were used to investigate their potential role in the associations between sleep-related factors and frequency and amount of alcohol use: sex; school grade; intending to study at university or graduate school (yes/no); having breakfast (every day, sometimes, seldom); and participating in extracurricular activities (yes/no). The item "How many days have you smoked in the past 30 days?" was also included in the questionnaire and those who reported having smoked 1 day or more were classified as having smoked.

The Japanese version of the 12-item General Health Questionnaire (GHQ-12) was used to evaluate mental health status in the previous nationwide studies (Kaneita et al., 2006). The GHQ-12 is a self-administered questionnaire designed as a screening tool for mental diseases (D'Arcy & Siddique, 1984; Doi & Minowa, 2003). It consists of 2 factors – "depression and anxiety" and "decrease in positive feeling" – and a total of 12 items (6 items for each factor). Four answer options are provided for each item; selection of the two options representing absence of a corresponding symptom yields a score of 0 points, and selection of the other two options (representing having a corresponding symptom) yields a score of 1 point. The total possible score on this scale ranges from 0 to 12 points. Higher total scores indicate poorer mental health. The GHQ-12 was initially developed for adults, but was consequently verified for use in adolescents (Kaneita et al., 2009; Shimbo et al., 2005). Some studies set the cutoff value to 4 for the GHQ-12, and regarded a subject having 4 points or higher as having poor mental health (Kaneita et al., 2009; Ohida et al., 2001; Shimbo et al., 2005). Using the results of previous studies, one study reported that when one question each was extracted from each of the two factors and the sum of their scores was calculated, their sensitivity and specificity was high (87.0% and 85.1%, respectively) when a cutoff point of 1 was regarded as indicative of poor mental health (Suzuki et al., 2011). These methods and cutoff were employed in another large-scale epidemiological study (Munezawa et al., 2011). Based on the above facts and considering the simplicity of filling out a questionnaire, the following two questions were also included: "Have you felt more unhappy and depressed than usual in the past 30 days?" and "Have you been able to enjoy your normal daily activities more than usual?" A score of 0 was regarded as indicative of good mental health and 1 or higher was regarded as indicative of poor mental health.

Statistical analysis

First, the sex-based prevalence of SIS, SSD, DIS, DMS, and EMA was calculated. The sex-based prevalence of insomnia was also calculated, defining the presence of any one of the DIS, DMS, and EMA insomnia symptoms as indicating insomnia. We then examined associations between sex and SIS, SSD, DIS, DMS, EMA, and insomnia by using the χ^2-test. Second, the sex-based prevalence of SIS, SSD, DIS, DMS, EMA, and insomnia in response to the frequency (the number of days in which alcohol was consumed in the previous 30 days) and amount of alcohol consumption was calculated. We then examined associations between sex-based prevalence of SIS, SSD, DIS, DMS, EMA, and the frequency and amount of alcohol consumption by using the χ^2-test. Finally, multiple logistic regression analysis was performed to calculate the adjusted odds ratio (AOR) for each sleep disturbance symptom (SIS and SSD), insomnia symptom (DIS, DMS, and EMA), or insomnia in response to the frequency and amount of alcohol consumption and the corresponding 95% confidence intervals. In this analysis, each sleep disorder symptom, insomnia symptom, or insomnia was treated as a dependent variable, and alcohol consumption status (frequency and amount) and 8 demographic statistical factors (sex, grade of school, desire to go to university, mental health status, having breakfast, smoking, participation in extracurricular activities, and bedtime) were treated as explanatory variables. All analyses were performed using SPSS 16.0 for Windows.

Results

Prevalence of insomnia and sleep disturbance symptoms

Defining participants who reported having one or more of the 3 insomnia symptoms as those with insomnia, we calculated and indicated the sex-based prevalence of insomnia (Table 2). The sex-based prevalence of each of the 2 symptoms related to sleep disturbance and each of the 3 insomnia symptoms are also shown in Table 2.

The prevalence of insomnia was higher in girls (22.0%) than in boys (20.8%) ($p < 0.01$). Among the 3 insomnia symptoms, the prevalence of DIS and DMS was higher in girls than in boys ($p < 0.01$).

Among the symptoms related to sleep disturbance, the prevalence of SIS was 37.6% in boys and 38.7% in girls, and that of SSD was 28.0% in boys and 33.0% in girls. Many Japanese junior and senior high school students were not satisfied with their sleep quality and had less than 6 h of sleep per night.

Prevalence of alcohol use and sleep disturbance

The prevalence of the 2 sleep disturbance symptoms and 3 insomnia symptoms based on sex and frequency/amount of alcohol consumption is shown in Tables 3 and 4. The result of the χ^2-test

Table 2
Prevalence rates of insomnia, sleep disturbance symptoms and insomnia symptoms.

	Boys		Girls		*p* value[a]	Total	
	N	%	*N*	%		*N*	%
SIS							
No	29,691	62.4	30,234	61.3	<0.01	59,925	61.8
Yes	17,905	37.6	19,093	38.7		36,998	38.2
Total	47,596	100.0	49,327	100.0		96,923	100.0
SSD							
No	34,370	72.0	33,172	67.0	<0.01	67,542	69.4
Yes	13,388	28.0	16,342	33.0		29,730	30.6
Total	47,758	100.0	49,514	100.0		97,272	100.0
DIS							
No	41,732	87.5	42,516	85.9	<0.01	84,248	86.7
Yes	5968	12.5	6968	14.1		12,936	13.3
Total	47,700	100.0	49,484	100.0		97,184	100.0
DMS							
No	42,947	89.9	44,100	89.1	<0.01	87,047	89.5
Yes	4800	10.1	5416	10.9		10,216	10.5
Total	47,747	100.0	49,516	100.0		97,263	100.0
EMA							
No	45,348	94.9	47,075	95.0	0.45	92,423	94.9
Yes	2455	5.1	2493	5.0		4948	5.1
Total	47,803	100.0	49,568	100.0		97,371	100.0
Insomnia							
No	37,703	79.2	38,478	77.9	<0.01	76,181	78.5
Yes	9892	20.8	10,920	22.1		20,812	21.5
Total	47,595	100.0	49,398	100.0		96,993	100.0

Subjects for whom data were missing were excluded from the analysis.
Abbreviations: SIS, subjectively insufficient sleep; SSD, short sleep duration; DIS, difficulty initiating sleep; DMS, difficulty maintaining sleep; EMA, early morning awakening.
Insomnia: Subjects who had one or more symptoms of insomnia (DIS or DMS or EMA) were diagnosed as having insomnia.
[a] *p* value was calculated by χ^2-test, 2(SIS, SSD, DIS, DMS, EMA, Insomnia; No, Yes) × 2 (Sex; Boys, Girls).

Table 3
Prevalence rates in relation to sleep disturbances and the number of days in which alcohol was consumed in the previous 30 days.

	How many days in total did you drink in the past 30 days?								p value[a]
	None		1–5 days		6–19 days		Over 20 days		
	N	%	*N*	%	*N*	%	*N*	%	
Boys									
SIS									
No	25,949	64.1	2907	53.1	473	47.1	142	49.7	<0.01
Yes	14,546	35.9	2570	46.9	531	52.9	144	50.3	
Total	40,495	100.0	5477	100.0	1004	100.0	286	100.0	
SSD									
No	29,943	73.7	3473	63.2	542	53.8	143	49.8	<0.01
Yes	10,688	26.3	2022	36.8	465	46.2	144	50.2	
Total	40,631	100.0	5495	100.0	1007	100.0	287	100.0	
DIS									
No	35,930	88.5	4525	82.7	792	79.0	197	69.1	<0.01
Yes	4678	11.5	945	17.3	210	21.0	88	30.9	
Total	40,608	100.0	5470	100.0	1002	100.0	285	100.0	
DMS									
No	36,829	90.6	4779	87.2	832	82.9	211	73.3	<0.01
Yes	3811	9.4	701	12.8	172	17.1	77	26.7	
Total	40,640	100.0	5480	100.0	1004	100.0	288	100.0	
EMA									
No	38,840	95.4	5070	92.5	900	89.8	226	78.5	<0.01
Yes	1853	4.6	413	7.5	102	10.2	62	21.5	
Total	40,693	100.0	5483	100.0	1002	100.0	288	100.0	
Insomnia									
No	32,646	80.6	3969	72.7	671	67.0	168	58.5	<0.01
Yes	7871	19.4	1487	27.3	331	33.0	119	41.5	
Total	40,517	100.0	5456	100.0	1002	100.0	287	100.0	
Girls									
SIS									
No	26,491	63.1	3179	51.7	287	40.9	68	40.0	<0.01
Yes	15,480	36.9	2975	48.3	415	59.1	102	60.0	
Total	41,971	100.0	6154	100.0	702	100.0	170	100.0	
SSD									
No	29,060	69.0	3484	56.4	316	44.8	68	39.5	<0.01
Yes	13,072	31.0	2688	43.6	389	55.2	104	60.5	
Total	42,132	100.0	6172	100.0	705	100.0	172	100.0	
DIS									
No	36,754	87.3	4919	79.7	459	65.3	102	59.6	<0.01
Yes	5353	12.7	1251	20.3	244	34.7	69	40.4	
Total	42,107	100.0	6170	100.0	703	100.0	171	100.0	
DMS									
No	37,943	90.1	5218	84.5	529	75.2	121	69.9	<0.01
Yes	4188	9.9	959	15.5	174	24.8	52	30.1	
Total	42,131	100.0	6177	100.0	703	100.0	173	100.0	
EMA									
No	40,324	95.5	10,764	92.3	1505	77.9	359	94.9	<0.01
Yes	1855	4.5	898	7.7	200	22.1	25	5.1	
Total	42,179	100.0	11,662	100.0	1705	100.0	461	100.0	
Insomnia									
No	33,467	79.6	4286	69.5	384	54.6	86	50.0	<0.01
Yes	8557	20.4	1881	30.5	319	45.4	86	50.0	
Total	42,024	100.0	6167	100.0	703	100.0	172	100.0	

Subjects for whom data were missing were excluded from the analysis.
Abbreviations: SIS, subjectively insufficient sleep; SSD, short sleep duration; DIS, difficulty initiating sleep; DMS, difficulty maintaining sleep; EMA, early morning awakening.
Insomnia: Subjects who had one or more symptoms of insomnia (DIS or DMS or EMA) were diagnosed as having insomnia.
[a] p value was calculated by χ2-test, 2(SIS, SSD, DIS, DMS, EMA; No, Yes) × 4 (number of days in which alcohol was consumed in the previous 30 days; none, 1–5 days, 6–19 days, over 20 days).

showed a significant association between sleep disturbances and frequency/amount of alcohol consumption in both boys and girls ($p < 0.01$). The prevalence increased with the frequency (Table 3) and amount of alcohol use (Table 4) in both boys and girls ($p < 0.01$).

Multiple logistic regression analysis

Tables 5 and 6 show the results of multiple logistic regression analysis to determine associations between each sleep disturbance symptom (SIS and SSD), insomnia symptoms (DIS, DMS, and EMA), or insomnia and alcohol use (frequency and amount), after adjusting for 8 items (sex, grade, intending to study at university, having breakfast, smoking, participation in extracurricular activities, bedtime around midnight, and mental health status).

The AORs for SSD, DIS, DMS, EMA, and insomnia increased with the frequency of alcohol use (Table 5). In particular, the AOR of EMA was the highest for participants who consumed alcohol on 20 or more days in the 30 days preceding the survey (3.25, 95% CI: 2.54–4.17). As shown in Table 6, the AORs for SSD, DIS, DMS, EMA, and insomnia increased with the amount of alcohol consumption. In particular, the AOR of EMA for participants consuming 6 glasses of alcoholic beverages or more was the highest (1.99, 95% CI: 1.71–2.30).

Discussion

We believe that the present sample is representative of Japanese adolescents because 1) the participating schools were randomly selected from junior and senior high schools nationwide, and 2) approximately 100,000 responses were analyzed. To our knowledge, except for our previous nationwide surveys, only a few epidemiological studies have investigated sleep disturbance in adolescents on such a large scale (Gradisar, Gardner, & Dohnt, 2011).

Prevalence of insomnia

We classified students who reported having any one of the 3 insomnia symptoms (DIS, DMS, and EMA) as having insomnia. The prevalence of insomnia has previously varied across studies partly because of variations in its definition. Its prevalence also varies depending on which answer options in a questionnaire are considered to denote the presence of insomnia symptoms, and also on the survey method employed (e.g., self-administered questionnaire survey or interview survey). Furthermore, the prevalence of insomnia also varies depending on the period for which respondents are asked to report, in a questionnaire, whether the corresponding symptom is present. In the present study, each student was requested to select one answer option from among "never," "seldom," "sometimes," "often," and "always" to the questions regarding the presence of DIS, DMS, or EMA in the previous 30 days, and those who selected the options "often" and "always" were considered to have the corresponding symptom. We then classified those having any one of the 3 symptoms (DIS, DMS, or EMA) as persons with insomnia. The prevalence of insomnia obtained in this manner was 21.5%. Many studies that employed the same definition of insomnia reported a similar or slightly higher (up to 30%) prevalence than that in our study (Chung & Cheung, 2008; Kaneita et al., 2006; Liu, Uchiyama, Okawa, et al, 2000; Ohayon et al., 2000). It was reconfirmed that many adolescents had insomnia symptoms—an important health issue in this age group.

Differences in insomnia between sexes

The prevalence of insomnia was slightly higher in girls (22.1%) than in boys (20.8%) ($p < 0.01$). However, the AOR for insomnia in girls was significantly low ($p < 0.01$) (data not shown). The results of previous studies varied; some reported no sex differences in insomnia risk (Johnson et al., 2006; Liu, 2004; Liu, Uchiyama, Okawa, et al, 2000; Roberts et al., 2001), while others reported a higher risk in girls (Ohida et al., 2004; Roberts, Roberts, & Chan,

Table 4
Prevalence rates in relation to the amount of alcohol consumption and sleep disturbances.

	Amount of alcohol consumption										p value[a]
	Not drinking		Less than a glass		1 or 2 glasses		3–5 glasses		≥6 glasses		
	N	%	*N*	%	*N*	%	*N*	%	*N*	%	
Boys											
SIS											
No	19,075	66.3	5295	60.5	3216	54.2	1383	51.8	659	47.1	<0.01
Yes	9678	33.7	3451	39.5	2718	45.8	1289	48.2	740	52.9	
Total	28,753	100.0	8746	100.0	5394	100.0	2672	100.0	1399	100.0	
SSD											
No	21,711	75.3	6418	73.1	3798	63.8	1620	60.4	756	53.8	<0.01
Yes	7132	24.7	2365	26.9	2152	36.2	1061	39.6	648	46.2	
Total	28,843	100.0	8783	100.0	5950	100.0	2681	100.0	1404	100.0	
DIS											
No	25,734	89.2	7657	87.4	5033	84.8	2173	81.4	1060	76.0	<0.01
Yes	3105	10.8	1107	12.6	903	15.2	497	18.6	335	24.0	
Total	28,839	100.0	8764	100.0	5936	100.0	2670	100.0	1395	100.0	
DMS											
No	26,331	91.2	7883	89.8	5208	87.7	2287	85.6	1154	82.5	<0.01
Yes	2530	8.8	896	10.2	732	12.3	385	14.4	245	17.5	
Total	28,861	100.0	8779	100.0	5940	100.0	2672	100.0	1399	100.0	
EMA											
No	27,620	95.6	8354	95.0	5576	93.7	2467	92.2	1239	88.9	<0.01
Yes	1276	4.4	436	5.0	374	6.3	209	7.8	155	11.1	
Total	28,896	100.0	8790	100.0	5950	100.0	2676	100.0	1394	100.0	
Insomnia											
No	23,490	81.7	6898	78.9	4457	75.2	1876	70.3	914	65.6	<0.01
Yes	5275	18.3	1849	21.1	1470	24.8	791	29.7	479	34.4	
Total	28,765	100.0	8747	100.0	5927	100.0	2667	100.0	1393	100.0	
Girls											
SIS											
No	18,778	66.0	6418	59.3	3248	52.4	1320	49.3	395	38.3	<0.01
Yes	9690	34.0	4412	40.7	2945	47.6	1357	50.7	637	61.7	
Total	28,468	100.0	10,830	100.0	6193	100.0	2677	100.0	1032	100.0	
SSD											
No	20,475	71.6	7242	66.6	3524	56.7	1384	51.6	451	43.6	<0.01
Yes	8106	28.4	3626	33.4	2692	43.3	1300	48.4	583	56.4	
Total	28,581	100.0	10,868	100.0	6216	100.0	2684	100.0	1034	100.0	
DIS											
No	25,322	88.6	9306	85.7	5056	81.4	2052	76.5	673	65.6	<0.01
Yes	3253	11.4	1551	14.3	1159	18.6	629	23.5	353	34.4	
Total	28,575	100.0	10,857	100.0	6215	100.0	2681	100.0	1026	100.0	
DMS											
No	26,073	91.2	9693	89.1	5273	84.8	2194	81.9	761	73.9	<0.01
Yes	2514	8.8	1180	10.9	945	15.2	484	18.1	269	26.1	
Total	28,587	100.0	10,873	100.0	6218	100.0	2678	100.0	1030	100.0	
EMA											
No	27,512	95.9	10,362	95.2	5765	92.7	2460	91.8	856	82.9	<0.01
Yes	1111	4.1	517	4.8	457	7.3	221	8.2	177	17.1	
Total	28,623	100.0	10,879	100.0	6222	100.0	2681	100.0	1033	100.0	
Insomnia											
No	23,300	81.7	8394	77.4	4415	71.0	1736	64.8	544	52.8	<0.01
Yes	5204	18.3	2449	22.6	1800	29.0	941	35.2	487	47.2	
Total	28,504	100.0	10,843	100.0	6215	100.0	2677	100.0	1031	100.0	

Subjects for whom data were missing were excluded from the analysis.
Abbreviations: SIS, subjectively insufficient sleep; SSD, short sleep duration; DIS, difficulty initiating sleep; DMS, difficulty maintaining sleep; EMA, early morning awakening.
Insomnia: Subjects who had one or more symptoms of insomnia (DIS or DMS or EMA) were diagnosed as having insomnia.
[a] p value was calculated by χ2-test, 2(SIS, SSD, DIS, DMS, EMA; No, Yes) × 5 (amount of alcohol consumption; not drinking, less than a glass, 1 or 2 glasses, 3–5 glasses, ≥6 glasses).

2008; Tagaya et al., 2004), and yet another reported a higher risk in boys (Kaneita et al., 2006). One of the possible reasons for the higher prevalence of insomnia in girls is menstruation, a health factor unique to women (Johnson et al., 2006). Changes in the level of testosterone and estrogen have been reported to be associated with a higher risk of depression in girls, which in turn may contribute to insomnia (Angold, Costello, & Worthman, 1998). In fact, many cases of sleep disturbance in girls are attributed to depression (Wade, Cairney, & Pevalin, 2002). The odds ratio of insomnia adjusted for mental health status with other confounding factors was lower in girls ($p < 0.01$) than in boys in a previous study in Japan ($p < 0.01$) (Kaneita et al., 2006). In our study, in which we adjusted for mental health status along with other confounding factors, the AOR of insomnia in girls was slightly lower than that in boys (data not shown), corresponding to the above finding. Further research on the associations between different aspects of mental status or menstruation and insomnia are required in order to clarify sex differences in insomnia.

Table 5
Multiple logistic regression results in relation to sleep disturbances and the number of days in which alcohol was consumed in the previous 30 days.

	SIS			SSD			DIS			DMS			EMA			Insomnia		
	AOR	95% CI	*p* value	AOR	95% CI	*p* value	AOR	95% CI	*p* value	AOR	95% CI	*p* value	AOR	95% CI	*p* value	AOR	95% CI	*p* value
The number of days in which alcohol was consumed			<0.01			<0.01			<0.01			<0.01			<0.01			<0.01
None	1.00			1.00			1.00			1.00			1.00			1.00		
1–5 days	1.14	1.09–1.19		1.18	1.13–1.24		1.22	1.15–1.29		1.24	1.17–1.32		1.34	1.23–1.46		1.25	1.20–1.32	
6–19 days	1.33	1.19–1.49		1.59	1.42–1.77		1.56	1.38–1.76		1.63	1.43–1.86		1.75	1.48–2.06		1.60	1.43–1.78	
Over 20 days	1.15	0.92–1.43		2.05	1.65–2.54		2.00	1.60–2.49		2.23	1.78–2.78		3.25	2.54–4.17		1.88	1.53–2.31	

Abbreviations: SIS, subjectively insufficient sleep; SSD, short sleep duration; DIS, difficulty initiating sleep; DMS, difficulty maintaining sleep; EMA, early morning awakening; AOR, adjusted odds ratio; CI, confidence interval.
Insomnia: Subjects who had one or more symptoms of insomnia (DIS or DMS or EMA) were diagnosed as having insomnia.
Sex, Grade, Intending to study at university, Having breakfast, Smoking, Participating in extracurricular activities, Bedtimes, and Mental health status were used as covariance values.
Subjects with missing data were excluded from the analysis.

Short sleep duration

The prevalence of SSD (<6 h of sleep) in our study was 28.0% in boys and 33.0% in girls. These results were similar to those obtained in a nationwide study of Japanese adolescents conducted in 2000 (Ohida et al., 2004), and a little higher than those of two previous nationwide studies of Japanese adults (Liu, Uchiyama, & Kim, et al., 2000; Ohida et al., 2001). As the questionnaires used in those two previous studies and those used in the present study were almost the same, we can conclude that sleep duration of Japanese adolescents is shorter than that of Japanese adults. A study comparing the sleep duration of adolescents and young adults in Western countries indicated that young adults have a slightly shorter sleep duration (Ohayon et al., 2000), a finding opposite to the results obtained in Japan. Another study showed that the sleep duration of adolescents was not associated with their physical development but rather with environmental factors such as pressure from society, school, and peers (Carskadon et al., 1980). Environmental factors peculiar to Japan may be responsible for the relatively short sleep duration in Japanese adolescents.

To identify such factors, reference to the Korean situation is useful. Sleep duration of junior and senior high school students on school days in Korea has been shown to be shorter than that in Western countries (Yang et al., 2005). This was attributed to the pressure of entrance examinations and the early school start time in Korea (Yang et al., 2005). In the present study, the AOR of SSD for the participants who did not desire to go to university was lower than that for those who did desire a university education (data not shown). Like Koreans, the Japanese tend to attach much importance to academic background; therefore, the same factors may affect short sleep duration in both Korean and Japanese adolescents.

In the present study, the prevalence of SSD in girls was found to be higher than in boys ($p < 0.01$). The results of previous studies have varied; some reported a shorter sleep duration in girls than in boys (Ohida et al., 2004; Tagaya et al., 2004), whereas others reported no significant sex differences (Ohayon et al., 2000; Yang et al., 2005). Further data on bedtimes, wake-up times, and sleep duration in relation to sex and school days vs. holidays will be required in the future.

Associations between sleep disturbance and alcohol use

Many studies have investigated the associations between sleep disturbance and alcohol use in adolescents, but only a few studies have reported associations between the frequency of alcohol use and sleep problems or bad sleep habits (Johnson & Breslau, 2001; Tynjälä et al., 1997; Vignau et al., 1997). However, in those studies, no questions on sleep duration or insomnia symptoms, such as DIS, DMS, or EMA, were posed (Johnson & Breslau, 2001; Tynjälä et al., 1997). To our knowledge, the present study is the first to have investigated the associations between insomnia symptoms or sleep disturbances on the one hand and the frequency and amount of alcohol use on the other in adolescents.

We found that the prevalence of SIS, SSD, DIS, DMS, and EMA symptoms in adolescents increased significantly in both boys and girls with the frequency and amount of alcohol use ($p < 0.01$) (Tables 3 and 4). In particular, the prevalence of sleep disturbances was higher even in adolescents reporting less than 5 days of alcohol intake in the 30 days prior to the survey or less than a glass of alcohol per session than in those who never consumed alcohol. Therefore, alcohol consumption by adolescents must not be condoned, even if the amount of alcohol consumed is small.

Table 6
Multiple logistic regression results in relation to sleep disturbances and the amount of alcohol consumed per drinking session.

	SIS			SSD			DIS			DMS			EMA			Insomnia		
	AOR	95% CI	*p* value	AOR	95% CI	*p* value	AOR	95% CI	*p* value	AOR	95% CI	*p* value	AOR	95% CI	*p* value	AOR	95% CI	*p* value
Amount of alcohol consumed per drinking session			<0.01			<0.01			<0.01			<0.01			<0.01			<0.01
Not drinking	1.00			1.00			1.00			1.00			1.00			1.00		
Less than a glass	1.14	1.10–1.19		1.01	0.97–1.05		1.14	1.08–1.20		1.18	1.11–1.24		1.12	1.04–1.21		1.17	1.13–1.22	
1 or 2 glasses	1.23	1.17–1.28		1.21	1.15–1.26		1.26	1.19–1.33		1.42	1.34–1.52		1.40	1.28–1.53		1.34	1.28–1.41	
3–5 glasses	1.17	1.10–1.25		1.23	1.15–1.32		1.37	1.26–1.48		1.48	1.36–1.61		1.35	1.20–1.53		1.49	1.39–1.59	
≥6 glasses	1.40	1.26–1.54		1.52	1.38–1.68		1.68	1.51–1.88		1.76	1.56–1.98		1.99	1.71–2.30		1.73	1.57–1.91	

Abbreviations: SIS, subjectively insufficient sleep; SSD, short sleep duration; DIS, difficulty initiating sleep; DMS, difficulty maintaining sleep; EMA, early morning awakening; AOR, adjusted odds ratio; CI, confidence interval.
Insomnia: Subjects who had one or more symptoms of insomnia (DIS or DMS or EMA) were diagnosed as having insomnia.
Sex, Grade, Intending to study at university, Having breakfast, Smoking, Participating in extracurricular activities, Bedtimes, and Mental health status were used as covariance values.
Subjects with missing data were excluded from the analysis.

AORs for insomnia and sleep disturbance symptoms

Some physical and mental factors, socioeconomic factors, and lifestyle habits that affect insomnia symptoms (DIS, DMS, and EMA) in adolescents have been reported previously (Chung & Cheung, 2008; Johnson & Breslau, 2001; Kaneita et al., 2006; Liu, Uchiyama, Okawa, et al, 2000; Ohida et al., 2004; Roberts, Roberts, & Chan, 2008; Roberts, Roberts, & Duong, 2008). In a large-scale epidemiological study, Kaneita et al. (2000) reported that being male, being a junior high school student, having poor mental health, skipping breakfast, alcohol use, smoking, not participating in extracurricular activities, and late bedtimes increased the risk of insomnia. Other studies suggested that symptoms related to sleep disturbances, such as SSD, were also associated with similar factors (Chung & Cheung, 2008; Johnson & Breslau, 2001). In a large-scale epidemiological study, Ohida et al. (2004) reported that being female, being a high school student, mental stress, smoking, and alcohol use increased the risk of sleep disturbances such as SIS and SSD. To eliminate the effects of these confounding factors in the present study, we employed sex, grade, intending to study at university, having breakfast, smoking, participating in extracurricular activities, bedtimes, and mental health status as variables besides the frequency/amount of alcohol use. We performed multiple logistic regression analysis in order to investigate associations between the frequency/amount of alcohol use and each type of sleep disturbance (SIS, SSD, DIS, DMS, and EMA).

The results showed that the AOR for each sleep disturbance symptom, except SIS and EMA, increased as the number of days increased on which alcohol was consumed in the previous 30 days, or the amount of alcohol consumed per session increased (Tables 5 and 6). Several studies have reported that alcohol intake before bedtime suppresses rapid eye movement (REM) sleep during the first half of sleep in healthy adults (Feige et al., 2006; Lobo & Tufik, 1997; Williams, MacLean, & Cairns, 1983), and that a rebound effect leads to shallow sleep in the second half of sleep (Lobo & Tufik, 1997; Williams et al., 1983). Intake of a small amount of alcohol before bedtime has been reported to facilitate sleep initiation (Feige et al., 2006; Lobo & Tufik, 1997; Stone, 1980; Williams et al., 1983). Thus, although alcohol may be consumed to facilitate sleep initiation, alcohol intake may induce sleep disturbances (Wong & Brower, 2012). Because this was a cross-sectional study, we could not determine a causal relationship between alcohol consumption and sleep. However, for adolescents who are likely to have sleep disturbances due to alcohol intake, measures must be taken to reduce the frequency and amount of alcohol use as far as possible, to ensure sound sleep.

The effects of alcohol intake on REM sleep may increase with the amount of alcohol intake (Williams et al., 1983). The present epidemiological study of adolescents indicated that as the amount of alcohol consumed per drinking session increased, the AOR for SSD, DIS, DMS, and Insomnia increased, suggesting that the amount of alcohol intake affects various aspects of sleep, except SIS and EMA, in a dose-dependent manner.

As mentioned earlier, intake of a small amount of alcohol before bedtime has been reported to facilitate sleep initiation (Feige et al., 2006; Lobo & Tufik, 1997; Stone, 1980; Williams et al., 1983). However, we found that even a small intake of less than one glass of an alcoholic beverage significantly increased the AOR for DIS, a finding contradictory to previous results ($p < 0.01$). This discrepancy may have arisen because in previous papers, a small amount of alcohol was defined as 0.16 g/kg of alcohol. Considering the standard weight for junior and senior high school students, this amount may be equivalent to less than a half glass of alcoholic beverage. This may account for the discrepancy between the present and previous results.

In addition, because we did not ask about the time of alcohol use relative to initiation of sleep, we were unable to confirm whether alcohol was consumed immediately before bedtime. Nevertheless, even if the blood alcohol concentration becomes zero or nearly zero at bedtime after drinking several hours beforehand, such drinking could still affect sleep in a way similar to that of drinking before bedtime (Landolt, Roth, Dijk, & Borbély, 1996).

Limitations

The present study had some limitations. First, as it was cross-sectional in design, causal relationships could not be determined. Sleep disturbances may be attributable to alcohol intake, but the possibility that some of our participants consumed alcohol to resolve their sleep disturbances cannot be ruled out. Longitudinal research is required to clarify the effects of alcohol intake on sleep among adolescents.

Second, the use of a self-administered questionnaire leads to the possibility of bias. The data we obtained on the symptoms of sleep disturbances were less objective than those that would have been obtained using polysomnography. In addition, sleep duration might not have been recalled accurately, although recall-based reports on sleep are useful for large-scale epidemiological studies, and many such studies have used this method. Data on the frequency and amount of alcohol use in the previous 30 days might likewise be subject to recall bias. As underage drinking and smoking are illegal in Japan, and as the information on alcohol use and smoking were based on self-reported data, the respondents may have tended to underestimate their habits. Therefore, the impact of alcohol intake on sleep disturbance may have been underestimated to some extent.

Third, a non-response bias may have arisen, as certain schools and students did not participate. However, the relatively high rate of valid responses (64.0%) reduced the possible impact of a non-response bias. The possible factors that lowered the response rate are as follows: 1) the number of absentees on the day of the survey, including long-term absentees, was not excluded from the population, and 2) some schools refused to participate in the survey at the discretion of the school principals.

Fourth, this study examined associations of only 9 factors with sleep disturbance symptoms. The questionnaire did not include all the items that are considered to affect sleep, and which could be confounding factors, such as sharing of a bedroom, commuting time, academic performance, presence of siblings, sleep status of family members, family economic status, and physical fatigue.

Conclusion

As it is known that sleep disturbance in adolescents is associated with behavioral and emotional problems, it is very important to resolve sleep problems in adolescents. This study revealed that more than 20% of Japanese adolescents have insomnia symptoms and that the prevalence of sleep disturbance is higher in adolescents who drink alcohol than in those who do not. The risk of each symptom of sleep disturbance, except SIS and EMA, increased as the number of days on which alcohol was consumed in the previous 30 days and the amount of alcohol consumed per drinking session increased. As this was an epidemiological study with a large sample size, we believe that the present sample has provided data representative of Japanese adolescents. The results reconfirm the need to eliminate underage drinking in order to ensure good sleep among adolescents.

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Original Article

Disorders of arousal and sleep-related bruxism among Japanese adolescents: a nationwide representative survey

Osamu Itani [a], Yoshitaka Kaneita [b,*], Maki Ikeda [a], Shuji Kondo [a], Ryuichiro Yamamoto [c], Yoneatsu Osaki [d], Hideyuki Kanda [e], Kenji Suzuki [f], Susumu Higuchi [g], Takashi Ohida [a]

[a] Division of Public Health, Department of Social Medicine, Nihon University School of Medicine, Tokyo, Japan
[b] Department of Public Health and Epidemiology, Faculty of Medicine, Oita University, Oita, Japan
[c] Division of Clinical Psychology, Health Care and Special Support Graduate School of Education, Joetsu University of Education, Niigata, Japan
[d] Division of Environmental and Preventive Medicine, Department of Social Medicine, Faculty of Medicine, Tottori University, Tottori, Japan
[e] Department of Epidemiology and Public Health, Yokohama City University, Graduate school of Medicine, Kanagawa, Japan
[f] Suzuki Mental Clinic, Kanagawa, Japan
[g] National Hospital Organization Kurihama Medical and Addiction Center, Kanagawa, Japan

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ABSTRACT

Objective: The main objective of our study was to clarify the prevalence of disorders of arousal (confusional arousals, sleepwalking, sleep terrors) and sleep-related bruxism (teeth grinding) and their associated factors among Japanese adolescents.
Methods: Our study was designed as a cross-sectional sampling survey. The targets were students attending junior and senior high schools throughout Japan. The questionnaire asked for personal data and information on lifestyle, depressive state, and sleep status including the frequency of experiencing disorders of arousal and sleep-related bruxism.
Results: A total of 99,416 adolescents responded. The overall response rate was 63.7%, and 98,411 questionnaires were subjected to analysis. The prevalence of disorders of arousal was 7.1% (95% confidence interval [CI], 6.9–7.3%) among boys and 7.7% (95% CI, 7.5–7.9%) among girls. The prevalence of sleep-related bruxism was 2.3% (95% CI, 2.2–2.4%) among boys and 3.0% (95% CI, 2.8–3.2%) among girls. The factors associated with disorders of arousal were the grade in school, smoking habit, alcohol consumption, naptime (min), breakfast habit, participation in club activities, sleep duration, difficulty initiating sleep, nocturnal awakening, early morning awakening, subjective sleep assessment, snoring, decrease in positive feelings, and depression (all $p < .001$). The factors associated with sleep-related bruxism were gender, smoking habit, nocturnal awakening, snoring, early morning awakening, decrease in positive feelings, and depressive feelings (all $p < .001$).
Conclusions: If disorders of arousal or sleep-related bruxism are observed in an adolescent, his or her smoking habit, alcohol consumption, sleep status, and depressive state should be considered.

1. Introduction

Several studies have indicated that sleep disturbance might cause physical and mental concerns [1–4]. Sleep disturbance is observed not only among adults but also among adolescents, with a reported prevalence in adolescents of 10 to 40% [5–7]. According to the results of a large-scale survey on sleep status targeting approximately 106,300 junior high and high school students in Japan, 30.6% of the subjects reported getting less than 6 hours of sleep per night. In addition, 12.5% had excessive daytime sleepiness, and 40% had poor subjective sleep sufficiency [8]. Furthermore, 23.5% of Japanese adolescents experienced insomnia during the month before the survey [9]. To date previous epidemiologic studies of sleep disturbance among adolescents have focused on sleep deprivation and insomnia, and only a few epidemiologic studies have investigated other types of sleep disturbance worldwide.

The term *parasomnia* is a generic term used to describe abnormal behavior during sleep. According to the second edition of the International Classification of Sleep Disorders (ICSD-2), parasomnia is divided into three types as follows, disorders of arousal from nonrapid eye movement (NREM) sleep, parasomnias generally associated with rapid eye movement (REM) sleep, and other parasomnias [10]. Restless legs syndrome and sleep-related bruxism

* Corresponding author. Address: Department of Public Health and Epidemiology, Faculty of Medicine, Oita University, Hasama-machi, Yufu-shi, Oita 879-5593, Japan. Tel.: +81 97 586 5735; fax: +81 97 586 5739.
E-mail address: nusmpublichealth@gmail.com (Y. Kaneita).

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were previously included in the definition of parasomnia but were reclassified as sleep-related movement disorders in the ICSD-2 [10].

We previously studied and reported the prevalence of nightmare and sleep paralysis, which are classified as REM sleep parasomnias, and their associated factors in an epidemiologic study of parasomnia among Japanese adolescents [11]. In our study, we focused on disorders of arousal, which are classified as an NREM sleep parasomnias, and sleep-related bruxism, classified as a sleep-related movement disorder. The term *disorders of arousal* is a generic term for symptoms arising from incomplete arousal from sleep, and its Japanese term is *Neboke*. In addition, disorders of arousal are divided into three symptoms including, confusional arousal, sleepwalking, and sleep terrors [10]. Confusional arousals is a condition in which an individual awakens from sleep and remains in a sleep-fogged state for periods ranging from several minutes to sometimes several hours in contrast to only several seconds in healthy individuals.

Sleepwalking is a series of complex behaviors such as walking around while an individual is actually asleep. It may involve a wide range of behaviors including, sitting up, going up and downstairs, or going to another room to get a drink of water as if the individual intends to do so. Sleep terrors are characterized by abrupt arousals with screaming and shouting. Confusional arousals, sleepwalking, and sleep terrors have common characteristics and most of such episodes arise out of stage 3 and stage 4 NREM sleep [12–14]. These symptoms often are observed during the first one-third of nocturnal sleep when slow-wave sleep tends to occur. Some common genetic predispositions are suspected to be onset factors for disorders of arousal [15], and sleep deprivation is considered to induce disorders of arousal [15–17].

Sleep-related bruxism is defined by the ICSD-2 as an oral activity characterized by grinding (generating noise) or clenching (not generating noise) of the teeth during sleep and usually is associated with sleep arousal [10]. Factors that have conventionally been thought to contribute to sleep-related bruxism include mental (central nervous system) factors such as anxiety and stress [18,19]. Sleep-related bruxism, which is associated with microarousal (short arousals without recognition) [20] or with obstructive sleep apnea syndrome (OSAS) [21,22], has recently attracted increasing attention in relation to sleep dysfunction. In addition, from the aspect of dysfunction of the central nervous system, associations with an abnormality of neurotransmitter receptors in the brain have been reported [23].

It is important to collect epidemiologic findings on disorders of arousal and sleep-related bruxism to assess the actual status of sleep disturbance among adolescents. To date, however, few nationwide epidemiologic data are available on these disorders in the adolescent age group. Therefore, we conducted a nationwide survey of disorders of arousal and sleep-related bruxism among junior high and high school students in Japan. The primary purpose of our study was to clarify the prevalence of disorders of arousal and sleep-related bruxism among Japanese adolescents; the secondary purpose was to clarify the factors associated with disorders of arousal and sleep-related bruxism in this population.

2. Methods

2.1. Subjects and sampling

We previously conducted four cross-sectional nationwide surveys (1996, 2000, 2004, and 2008) of lifestyle habits such as alcohol consumption, smoking habit, eating, and sleeping among Japanese adolescents. Our study was the fifth survey of its kind. For our study, of the 10,785 junior high schools and 4991 senior high schools registered in Japan in September 2010, 131 junior high schools (selection rate, 1.2%) and 113 senior high schools (selection rate, 2.3%) were sampled. We used a stratified single-stage cluster sampling method in which we divided Japan into regional blocks and randomly selected schools from each block. To avoid sampling bias toward any regional blocks, stratified sampling was performed with regional blocks as the strata. All the students enrolled in the schools that were sampled were the subjects in our 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 our four previous studies.

In the Japanese education system, children enter primary school at the age of 6 years and leave after 6 years of study. Next they enter junior high school for 3 years of study, followed by a further 3 years at senior high school. Primary and junior high school education is compulsory. In our report, the first to third years of junior high school are referred to as the seventh to ninth grades, and the first to third years of senior high school as the 10 to 12th grades.

2.2. Survey procedure

In our study the following ethical considerations were taken into account, subjects' participation in the study was voluntary and their informed consent was required, subjects' willingness to cooperate was confirmed in writing, and permission to conduct the study was obtained from the ethics committee of the institution to which the authors belonged.

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. Additionally as stated on the questionnaire, the teachers also were required to explain to the students that the completed questionnaires would not be seen by the teachers and that it was not necessary for students to participate if they were unwilling. The questionnaire included 71 questions. The survey was conducted during the homeroom period at school, and the response time was approximately 50 minutes. 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 the Nihon University School of Medicine without opening them. The survey period was from October 2010 to the end of March 2011. This survey was approved by the ethics committee of the Nihon University School of Medicine.

2.3. Measures

The major areas that were included in the questionnaire were personal data and lifestyle, sleep status including disorders of arousal and sleep related bruxism, and depressive state.

2.4. Personal data and lifestyle

The personal data included gender, school grade, and type of school (junior high school or senior high school), as well as the desire of one to attend a university (yes or no). The questions related to lifestyle were if the student ate breakfast (daily, occasionally, or never) and if the student participated in club activities (actively participating, participating, though not actively, or not participating). For statistical analyses with regard to eating breakfast, the respondents who selected daily were classified into the yes category, and those who selected occasionally or never were classified

into the no category. Regarding subjects' participation in club activities, the respondents who selected actively participating or participating, though not actively, were classified into the yes category, and those who selected not participating were classified into the no category. Moreover, the question, "How many days did you smoke in the past 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 if the response was one day or more to the question, "How many days did you consume alcoholic beverages in the past month?" the student was defined as drinking alcohol.

2.5. Sleep status

The sleep status items included sleep duration, naptime, subjective sleep assessment, snoring, and insomnia symptoms. The question about sleep duration was, "How many hours on average have you slept at night during the previous month? (<5 h; ⩾5 h but <6 h; ⩾6 h but <7 h; ⩾7 h but <8 h; ⩾8 hours but <9 hours; or ⩾9 hours)." The question about naptime was, "How long was your naptime on average during the previous month?" (nothing; <15 min; ⩾15 min but <30 min; ⩾30 min but <1 h; ⩾1 h but <2 h; or ⩾2 h)". The question about subjective sleep assessment was, "How do you assess the quality of your sleep during the previous month? (very good, good, bad, or very bad)". The question about snoring was phrased as follows: "Have you been told by a family member or friend that you snored in the previous month?" (never, seldom, sometimes, often, or always)." The following three questions regarding 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 five possible replies including, never, seldom, sometimes, often, or 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 three questions.

The question on disorders of arousal focused on if the students had told their family members or friends they had disorders of arousal in the previous 30 days; the answer options were never, seldom, sometimes, often, or always. For statistical analyses, two definitions were prepared in relation to experience of disorders of arousal. (1) The respondents who selected never or seldom were classified into the no experience of disorders of arousal category, and those who selected sometimes, often, or always were classified into the with experience of disorders of arousal category. (2) The respondents who selected never, seldom, or sometimes were classified into the no experience of disorders of arousal category, and those who selected often or always were classified into the with experience of disorders of arousal category. The question on sleep-related bruxism focused on if the students had told their family members or friends that they had had bruxism while asleep in the previous 30 days; the answer options were never, seldom, sometimes, often, or always. For statistical analyses, two definitions also were prepared relating to experience of sleep-related bruxism. (1) The respondents who selected never or seldom were classified into the no experience of sleep-related bruxism category, and those who selected "sometimes, often, or always were classified into the category of with experience of sleep-related bruxism. (2) The respondents who selected never, seldom, or sometimes were classified into the no experience of sleep-related bruxism category, and those who selected often or always were classified into the category of with experience of sleep-related bruxism.

2.6. Depressive state

To evaluate the depressive state of the respondents, two independent factors (depression or anxiety and decrease in positive feeling) included in the 12-item general health questionnaire [24,25] were used. One of the items from the depression or anxiety factor (whether or not the respondent had felt an unusual amount of unhappiness and depression in the previous 30 days) was evaluated as not at all, no more than usual, more than usual, or much more than usual). One of the items from the decrease in positive feeling factor (whether or not the respondent was able to enjoy normal activities more than usual in the previous month) also was evaluated as more so than usual, same as usual, less than usual, or much less than usual. Previous studies have shown that evaluation of depressive state using depression symptoms with the 12-item general health questionnaire with this cutoff point had a sensitivity of 87.0% and a specificity of 85.1% [26].

2.7. Statistical analyses

We calculated the frequency of disorders of arousal based on the gender of the subject and the subjects' grade in school, and then we examined associations between the subjects' grade in school and disorders of arousal by gender using the χ^2 test. Associations between gender and disorders of arousal also were examined using the χ^2 test. Calculations and analyses of sleep-related bruxism were performed using the same approach. Then the percentages of individuals who had both disorders of arousal and sleep-related bruxism were calculated based on the frequency of which they experienced each symptom; associations were examined using the χ^2 test.

Next a multiple logistic regression analysis was performed to examine factors associated with disorders of arousal. Specifically definitions 1 and 2 with regard to disorders of arousal were used as the response variables, and the following factors were considered independent variables: gender, grade in school, with or without smoking habit, with or without alcohol-drinking habit, with or without eating breakfast, with or without participation in club activities, wishing or not wishing to attend a university, sleep duration, naptime, frequency of difficulty initiating sleep, frequency of difficulty maintaining sleep, frequency of early morning awakening, subjective sleep sufficiency assessment, snoring, assessment of positive feelings, and assessment of depressive feelings. Analyses of sleep-related bruxism also were performed using the same approach.

Besides the above-mentioned multiple logistic regression analysis, additional multiple logistic regression analyses were performed. One of the analyses used experience of disorders of arousal as a response variable and the frequency of experiencing bruxism as a predictor variable and the other used experience of bruxism as a response variable and the frequency of experiencing disorders of arousal as a predictor variable.

3. Results

3.1. Response rates

Replies were obtained from 89 of the 131 junior high schools (school response rate, 67.9%) and 81 of the 113 senior high schools (school response rate, 71.7%; combined junior high and senior high school response rates, 69.7%). A total of 99,416 envelopes were collected. Accordingly, the overall response rate was 61.9% for the junior high schools, 64.9% for the senior high schools, and 63.7% as a whole. The response rates obtained in our study are similar to those obtained in previous studies using the same method

[8,9,11]. In the calculation of this response rate, the denominator represented the number of all the students enrolled in the sampled schools; the number of students who were absent from the schools on the day of the survey was not subtracted from the total number of enrolled students but was treated as the number of invalid responses. This method may have potentially lowered the response rate. Of the collected questionnaires, 1005 were excluded because the gender or grade was not specified or the answers were inconsistent. The data for the remaining 98,411 questionnaires were analyzed. The number of respondents who answered the final question (No. 71) was 98,467 (63.1% of all respondents).

3.2. Prevalence of disorders of arousal and sleep-related bruxism

The results of responses regarding disorders of arousal based on gender and grade in school are shown in Table 1. A total of 47,981 boys participated in the study, and 4.4% and 2.7% responded often and always, respectively, to the question regarding the frequency of experiencing disorders of arousal. The results of the χ^2 test showed a significant association between grade in school and disorders of arousal in boys ($p < .001$). A total of 49,418 girls participated in the study, and 5.1% and 2.6% responded often and always, respectively, to the same question regarding the frequency of experiencing disorders of arousal. A significant association also was observed between grade in school and disorders of arousal in girls ($p < .001$). A significant difference was observed between boys and girls ($p < .001$); girls tended to have a higher frequency of disorders of arousal than boys. With regard to the entire study population, 24.5% (95% confidence interval [CI], 24.2–24.8%) of the respondents selected sometimes, often, or always when asked about the frequency of experiencing disorders of arousal, whereas 7.4% (95% CI, 7.2–7.6%) selected often or always.

The results of responses regarding sleep-related bruxism based on gender and grade in school are shown in Table 2. A total of 3.4%, 1.2%, and 1.1% of boys responded sometimes, often, and always, respectively, to the question regarding the frequency of experiencing sleep-related bruxism. The result of the χ^2 test showed a significant association between grade in school and sleep-related bruxism in boys ($p < .001$). A total of 4.2%, 1.6%, and 1.4% of girls responded sometimes, often, and always, respectively, to the same question regarding the frequency of experiencing sleep-related bruxism. The results of the χ^2 test showed no significant association between grade in school and sleep-related bruxism in girls ($p = .057$). A significant difference was observed between boys and girls ($p < .001$); girls tended to have a higher frequency of sleep-related bruxism than boys. With regard to the entire study population, 6.5% (95% CI, 6.3–6.7%) of the respondents selected sometimes, often, or always when asked of the frequency of experiencing sleep-related bruxism, whereas 2.7% (95% CI, 2.6–2.8%) selected often or always.

The percentages of individuals who had both disorders of arousal and sleep-related bruxism are shown in Table 3. The results of the χ^2 test showed a significant association between the frequency of experiencing disorders of arousal and that of sleep-related bruxism ($p < .001$).

3.3. Associations between disorders of arousal and personal, lifestyle, sleep status, and depressive state

The results of multiple logistic regression analysis of associations between disorders of arousal and personal data, lifestyle, sleep status, and depressive state are shown in Table 4. Significant associations were observed between disorders of arousal and each variable except gender and the desire to attend a university when either definition 1 or definition 2 was used. The factors with higher adjusted odds ratios (ORs) were as follows, with smoking habit (compared to without), with alcohol-drinking habit (compared to without), 60 minutes or longer naptime (compared to naptime of less than 15 min), often or always having early morning awakening (compared to never, seldom, or sometimes), bad or very bad subjective sleep assessment (compared to very good or good), always snoring (compared to never), and having depressive feelings much more than usual (compared to not at all). The adjusted ORs tended to decrease as the grade in school increased.

Table 1
Experiences of disorders of arousal among Japanese adolescents by grade in school.

	N	Disorders of arousal (%)					*P* value[a]	*P* value[b]
		Never	Seldom	Sometimes	Often	Always		
Boys							<.001	<.001
Junior high school								
Seventh grade	6343	66.5	13.3	13.9	4.1	2.2		
Eighth grade	6336	66.0	13.4	13.8	3.7	3.0		
Ninth grade	6131	63.8	13.5	15.5	4.0	3.2		
Senior high school								
10th grade	10,381	59.7	14.6	17.8	4.9	2.9		
11th grade	9842	61.6	14.6	16.6	4.7	2.6		
12th grade	8948	64.7	13.3	15.1	4.4	2.5		
Total	47,981	63.3	13.9	15.7	4.4	2.7		
Girls							<.001	
Junior high school								
Seventh Grade	6534	62.4	15.6	15.4	4.2	2.4		
Eighth Grade	6369	58.4	16.4	17.8	4.6	2.8		
Ninth Grade	6217	59.0	15.1	17.9	5.0	3.1		
Senior high school								
10th Grade	10,868	54.7	16.9	20.0	5.6	2.9		
11th Grade	10,108	55.8	16.3	19.9	5.4	2.5		
12th Grade	9322	59.6	14.9	18.2	5.1	2.3		
Total	49,418	57.9	15.9	18.5	5.1	2.6		

Subjects with missing data were excluded from the analysis.
[a] *P* value was calculated by χ^2 test, 5 (sleep drunkenness: never, seldom, sometimes, often, always) × 6 (grade: seventh, eighth, ninth, 10th, 11th, 12th).
[b] *P* value was calculated by χ^2 test, 5 (sleep drunkenness: never, seldom, sometimes, often, always) × 2 (gender: boys, girls).

Table 2
Experiences of sleep-related bruxism among Japanese adolescents by the grade in school.

	N	Sleep-related bruxism (%)					P value[a]	P value[b]
		Never	Seldom	Sometimes	Often	Always		
Boys							<.001	<.001
Junior high school								
Seventh grade	6343	90.6	4.0	3.2	1.2	1.1		
Eighth grade	6336	90.5	3.6	3.5	1.2	1.2		
Ninth grade	6131	90.4	3.7	3.3	1.4	1.3		
Senior high school								
10th grade	10,381	90.0	4.4	3.2	1.3	1.0		
11th grade	9842	89.1	5.2	3.4	1.3	1.0		
12th grade	8948	89.8	4.4	3.7	1.1	1.1		
Total	47,981	90.0	4.3	3.4	1.2	1.1		
Girls							0.057	
Junior high school								
Seventh Grade	6534	89.1	3.6	4.1	1.6	1.7		
Eighth Grade	6369	88.7	3.7	4.3	1.6	1.7		
Ninth Grade	6217	89.4	4.1	3.8	1.4	1.4		
Senior high school								
10th Grade	10,868	88.6	4.3	4.1	1.7	1.3		
11th Grade	10,108	88.7	4.1	4.3	1.4	1.6		
12th Grade	9322	88.7	3.9	4.3	1.9	1.2		
Total	49,418	88.8	4.0	4.2	1.6	1.4		

Subjects with missing data were excluded from the analysis.
[a] *P* value was calculated by χ^2 test, 5 (sleep bruxism: never, seldom, sometimes, often, always) × 6 (grade: seventh, eighth, ninth, 10th, 11th, 12th).
[b] *P* value was calculated by χ^2 test, 5 (sleep bruxism: never, seldom, sometimes, often, always) × 2 (sex: male, female).

Table 3
Experiences of both disorders of arousal and sleep bruxism.

			Sleep Bruxism (%)						P value[a]
		N	Never	Seldom	Sometimes	Often	Always	Total	
Disorders of arousal	Never	58,956	93.9	1.5	2.8	0.9	0.8	100.0	<.001
	Seldom	14,542	81.5	11.9	3.8	1.8	1.0	100.0	
	Sometimes	16,670	84.3	5.7	6.6	2.1	1.6	100.0	
	Often	4622	81.5	6.6	5.5	4.0	2.4	100.0	
	Always	2609	77.0	4.6	6.1	2.6	9.8	100.0	

Subjects with missing data were excluded from the analysis.
[a] *P* value was calculated by χ^2 test, 5 (disorders of arousal: never, seldom, sometimes, often, always) × 5 (sleep bruxism: never, seldom, sometimes, often, always).

3.4. Associations between sleep-related bruxism and personal, lifestyle, sleep status, and depressive state

The results of a multiple logistic regression analysis on associations between sleep-related bruxism and personal data, lifestyle, sleep status, and depressive state are shown in Table 5. The factors that indicated significant associations with sleep-related bruxism when either definition 1 or definition 2 was used were as follows, girls (compared to boys), with smoking habit (compared to without), with alcohol-drinking habit (compared to without), 60 minutes or longer naptime (compared to naptime of less than 15 min), with sleep disorders (i.e., difficulty in initiating sleep, difficulty in maintaining sleep, and early morning awakening) (compared to without), always snoring (compared to never), enjoyed normal activities much less than usual (compared to more so than usual), and having depressive feelings much more than usual (compared to not at all).

3.5. Associations between disorders of arousal and sleep-related bruxism

When we added experience of disorder of arousal as a response variable and the frequency of experiencing sleep-related bruxism as a predictor variable into the multiple logistic regression analysis model the results indicated that as the frequency of experiencing sleep-related bruxism increased, the adjusted OR for disorders of arousal increased. When we added experience of sleep-related bruxism as a response variable and the frequency of experiencing disorders of arousal as a predictor variable the results indicated that as the frequency of experiencing disorders of arousal increased, the adjusted OR for sleep-related bruxism increased (data not shown).

4. Discussion

Our study examined the prevalence of disorders of arousal and sleep-related bruxism and their associated factors among modern Japanese adolescents using representative samples. To date no epidemiologic study on disorders of arousal and sleep-related bruxism has included nearly 100,000 subjects, and to our knowledge our study is the first such study in the world.

4.1. Disorders of arousal

A previous epidemiologic study on disorders of arousal and similar symptoms was conducted and included 11,220 adults age 33 to 60 years [27]. According to the findings of that study, when asked of the frequency of sleepwalking in childhood and adulthood, 2.0%, 5.7%, and 17.9% of men and 2.8%, 5.7%, and 17.0% of women responded often, sometimes, and a few times, respectively. The results of a telephone survey showed that the prevalence of

Table 4
Factors associated with disorders of arousal among Japanese adolescents.

	N	Definition 1 for experience of disorders of arousal[a]				Definition 2 for experience of disorders of arousal[b]			
		AOR	95% CI		P value[c]	AOR	95% CI		P value[c]
Gender					<.001				.014
Boys	45,594	1.00				1.00			
Girls	47,398	1.17	1.13	1.21		1.07	1.01	1.13	
Grade					<.001				<.001
Seventh	12,038	1.00				1.00			
Eighth	12,080	0.98	0.92	1.04		0.95	0.86	1.06	
Ninth	11,620	0.95	0.89	1.01		0.93	0.84	1.04	
10th	20,405	0.94	0.89	1.00		0.86	0.77	0.94	
11th	19,212	0.83	0.78	0.88		0.75	0.67	0.83	
12th	17,425	0.74	0.69	0.79		0.68	0.61	0.76	
Smoking					<.001				<.001
No	89,210	1.00				1.00			
Yes	3570	1.34	1.24	1.46		1.39	1.24	1.55	
Drinking alcohol					<.001				<.001
No	81,286	1.00				1.00			
Yes	11,494	1.30	1.24	1.36		1.23	1.14	1.32	
Eating breakfast everyday					<.001				<.001
No	13,478	1.00				1.00			
Yes	79,302	0.85	0.82	0.89		0.87	0.81	0.93	
Participation in club activities					<.001				<.001
No	27,256	1.00				1.00			
Yes	65,524	1.11	1.07	1.16		1.13	1.07	1.20	
Wishing to go to university					<.001				.003
No	54,981	1.00				1.00			
Yes	37,799	1.11	1.07	1.15		1.09	1.03	1.16	
Sleep duration (h)					<.001				<.001
<6	28,436	1.00				1.00			
⩾6, <8	55,144	0.79	0.76	0.82		0.72	0.68	0.76	
8⩽	9200	0.83	0.78	0.90		0.82	0.74	0.91	
Naptime (min)					<.001				<.001
<15	34,222	1.00				1.00			
⩾15, <60	18,565	1.65	1.58	1.73		1.56	1.44	1.68	
60⩽	39,993	2.00	1.92	2.08		2.08	1.95	2.22	
Difficulty initiating sleep					<.001				<.001
Never/seldom/sometimes	80,463	1.00				1.00			
Often/always	12,317	1.16	1.11	1.22		1.44	1.34	1.54	
Nocturnal awakening					<.001				<.001
Never/seldom/sometimes	83,107	1.00				1.00			
Often/always	9673	1.12	1.07	1.18		1.47	1.37	1.58	
Early morning awakening					<.001				<.001
Never/seldom/sometimes	88,153	1.00				1.00			
Often/always	4627	1.43	1.33	1.53		1.54	1.40	1.69	
Subjective sleep assessment					<.001				<.001
Very good/good	57,409	1.00				1.00			
Bad/very bad	35,371	1.38	1.33	1.43		1.38	1.30	1.46	
Snoring					<.001				<.001
Never	73,066	1.00				1.00			
Seldom	7661	1.91	1.81	2.01		1.67	1.54	1.81	
Sometimes	7817	2.43	2.31	2.56		1.44	1.32	1.57	
Often	2384	2.85	2.61	3.11		3.89	3.50	4.32	
Always	1852	3.66	3.32	4.04		4.98	4.46	5.58	
Enjoyed normal activities					<.001				<.001
More so than usual	34,324	1.00				1.00			
Same as usual	48,191	0.83	0.80	0.86		0.81	0.76	0.86	
Less than usual	6762	0.91	0.86	0.97		0.88	0.80	0.97	
Much less than usual	3503	0.96	0.88	1.04		1.13	1.01	1.26	
Having depressive feelings					<.001				<.001
Not at all	22,589	1.00				1.00			
No more than usual	28,678	1.11	1.05	1.16		0.98	0.90	1.07	
More than usual	28,673	1.63	1.56	1.71		1.46	1.35	1.58	
Much more than usual	12,840	1.67	1.58	1.77		1.74	1.59	1.90	

Abbreviations: AOR, adjusted odds ratio; CI, confidence interval.

[a] Definition 1 for experience of disorders of arousal: the respondents who selected never or seldom as the frequency of being told of having disorders of arousal in the previous 30 days were classified into the no experience category, and those who selected often or always were classified into the with experience category.

[b] Definition 2 for experience of disorders of arousal: the respondents who selected never, seldom, or sometimes as the frequency of being told of having disorders of arousal in the previous 30 days were classified into the no experience category, and those who selected often or always were classified into the with experience category.

[c] *P* value was calculated by the multiple logistic regression analysis.

confusional arousals, sleepwalking, and sleep terrors among subjects ages 15 to 24 years was 8.9%, 4.9%, and 2.6%, respectively, in a study of 4972 general members of the population aged 15 years or older living in the United Kingdom [28]. In a study of 2463 students in the first to ninth grade, the prevalence of sleepwalking and sleep terrors was 4.6% and 6.5%, respectively [29]. The prevalence values reported in these studies and in our study might have varied due to the different questions that were used in each study. In par-

Table 5
Factors associated with sleep-related bruxism among Japanese adolescents.

	N	Definition 1 for experience of disorders of arousal[a]				Definition 2 for experience of disorders of arousal[b]			
		AOR	95% CI		P value[c]	AOR	95% CI		P value[c]
Gender					<.001				<.001
Boys	45,594	1.00				1.00			
Girls	47,398	1.45	1.37	1.53		1.50	1.37	1.63	
Grade					.007				<.001
Seventh	12,038	1.00				1.00			
Eighth	12,080	0.99	0.89	1.10		0.91	0.77	1.06	
Ninth	11,620	0.93	0.83	1.04		0.88	0.75	1.04	
10th	20,405	0.87	0.79	0.97		0.76	0.65	0.88	
11th	19,212	0.84	0.76	0.93		0.71	0.60	0.83	
12th	17,425	0.87	0.78	0.97		0.70	0.59	0.82	
Smoking					<.001				<.001
No	89,210	1.00				1.00			
Yes	3570	1.51	1.34	1.69		1.54	1.30	1.81	
Drinking alcohol					<.001				.001
No	81,286	1.00				1.00			
Yes	11,494	1.19	1.09	1.29		1.23	1.10	1.39	
Eating breakfast everyday					.005				.054
No	13,478	1.00				1.00			
Yes	79,302	0.90	0.84	0.97		0.90	0.81	1.00	
Participation in club activities					.105				.787
No	27,256	1.00				1.00			
Yes	65,524	1.05	0.99	1.12		0.99	0.90	1.09	
Wishing to go to university					.929				.083
No	54,981	1.00				1.00			
Yes	37,799	1.00	0.94	1.07		1.09	0.99	1.20	
Sleep duration (h)					.029				.019
<6	28,436	1.00				1.00			
⩾6, <8	55,144	1.02	0.95	1.09		0.99	0.90	1.09	
8⩽	9200	1.15	1.03	1.27		1.20	1.03	1.40	
Naptime (min)					<.001				.001
<15	34,222	1.00				1.00			
⩾15, <60	18,565	1.31	1.21	1.41		1.21	1.08	1.36	
60⩽	39,993	1.15	1.08	1.23		1.20	1.08	1.32	
Difficulty initiating sleep					.001				<.001
Never/seldom/sometimes	80,463	1.00				1.00			
Often/always	12,317	1.14	1.06	1.24		1.27	1.14	1.42	
Nocturnal awakening					<.001				<.001
Never/seldom/sometimes	83,107	1.00				1.00			
Often/always	9673	1.17	1.07	1.27		1.38	1.23	1.55	
Early morning awakening					<.001				<.001
Never/seldom/sometimes	88,153	1.00				1.00			
Often/always	4627	1.26	1.13	1.40		1.31	1.12	1.52	
Subjective sleep assessment					.169				.205
Very good/good	57,409	1.00				1.00			
Bad/very bad	35,371	1.05	0.98	1.11		1.06	0.97	1.17	
Snoring					<.001				<.001
Never	73,066	1.00				1.00			
Seldom	7661	2.26	2.07	2.47		2.25	1.97	2.57	
Sometimes	7817	4.55	4.24	4.88		2.70	2.38	3.06	
Often	2384	4.91	4.39	5.49		7.97	6.95	9.14	
Always	1852	7.66	6.85	8.57		12.58	11.01	14.39	
Enjoyed normal activities					<.001				<.001
More so than usual	34,324	1.00				1.00			
Same as usual	48,191	0.92	0.86	0.98		0.97	0.88	1.07	
Less than usual	6,762	1.09	0.98	1.21		1.14	0.97	1.33	
Much less than usual	3503	1.24	1.10	1.42		1.41	1.18	1.68	
Having depressive feelings					<.001				<.001
Not at all	22,589	1.00				1.00			
No more than usual	28,678	0.98	0.90	1.06		0.95	0.83	1.08	
More than usual	28,673	1.16	1.07	1.26		1.14	1.00	1.29	
Much more than usual	12,840	1.16	1.05	1.27		1.23	1.06	1.42	

Subjects with missing data were excluded from the analysis.
Abbreviations: AOR, adjusted odds ratio; CI, confidence interval.
[a] Definition 1 for experience of sleep-related bruxism: the respondents who selected never or seldom as the frequency of being told of having sleep-related bruxism in the previous 30 days were classified into the no experience category, and those who selected sometimes, often, or always were classified into the with experience category.
[b] Definition 2 for experience of sleep-related bruxism: the respondents who selected never, seldom, or sometimes as the frequency of being told of having sleep-related bruxism in the previous 30 days were classified into the no experience category, and those who selected often or always were classified into the with experience category.
[c] P value was calculated by the multiple logistic regression analysis.

ticular, the questions on and definitions of disorders of arousal differed from study to study and were not standardized. For example, with regard to disorders of arousal we did not ask separate questions on confusional arousals, sleepwalking, and sleep terrors. If we had, then the results may have been different. In addition, although the study by Ohayon et al. [28] used the Sleep-EVAL sys-

tem for the diagnosis and definition of disorders of arousal, we only posed a question of whether or not a participant had told his or her family members or friends that he or she had experienced disorders of arousal in the previous 30 days in our study, and the subjects subjectively selected an answer of never, seldom, sometimes, often, or always. For international development of future epidemiologic studies on disorders of arousal, standardization of the diagnosis, definition, and questioning methods must be considered.

We also analyzed factors associated with disorders of arousal and the results indicated that smoking habit, alcohol consumption, and depressive feelings were significantly associated with disorders of arousal. Several epidemiologic studies already have reported associations between smoking and sleep disturbance. In a study of 3056 adults, smoking was associated with difficulty initiating sleep and difficulty waking up [30]. In a study of 484 individuals ages 14 to 84 years, smoking was associated with reports of having trouble going to sleep and concerns of staying asleep [31]. In addition, the OR of confusional arousals among daily smokers was 1.7 [28]. A significant association was observed between smoking and disorders of arousal in our study, which concurs with the results of the previous studies. A possible physiologic mechanism by which smoking affects sleep is that nicotine stimulates the secretion of dopamine, norepinephrine, serotonin, and acetylcholine; thus, smoking is involved with the regulation of wakefulness [32].

With regard to the association between alcohol and sleep disturbance, it is known that alcohol intake raises the arousal threshold and thereby increases slow-wave sleep during the first half of nocturnal sleep when disorders of arousal can be most commonly observed [33]. The prevalence of alcohol intake at bedtime was high among individuals with disorders of arousal (confusional arousals, sleep terrors, and sleepwalking), and the OR of having sleep terrors in individuals who consumed alcohol at bedtime was 3.9 [28]. In our study a significant association also was observed between alcohol consumption and disorders of arousal. However, in a review of multiple studies, Pressman et al. [34] concluded that alcohol did not appear to play a role in triggering disorders of arousal. As such the effects of alcohol consumption on disorders of arousal have not yet been determined, and further accumulation of study findings is required.

With regard to associations between disorders of arousal and mental disorders, the prevalence of mental disorders including depression was higher among individuals with disorders of arousal than those without [28]. In addition a significant association was found between anxiety level and sleep terrors in a study of 1353 boys and girls ages 11 to 13 years [35]. In our study disorders of arousal were significantly associated with reduced positive feelings and increased depressive feelings. Involvement of serotonin is considered to be one of the physiologic mechanisms that link mental disorders and disorders of arousal. Serotonin is a neurotransmitter that greatly affects human emotions, and its deficiency is known to induce mental disorders such as depression [36]. Sleep-disordered breathing lowers the activities of the serotonergic system (5-hydroxytryptamine neurons), leading to sleepwalking [37]. There also is a report that the presence of sleepwalking was 4 to 9 times higher among patients with abnormalities of serotonin metabolism such as Tourette syndrome and migraine headaches [38–40]. Thus, serotonin may be involved in the onset of disorders of arousal including sleepwalking.

The results of our study also suggest that associations exist between disorders of arousal and snoring. Snoring is one of the typical symptoms of OSAS. A previous study has reported that the incidence of OSAS was distinctively high among patients with confusional arousal and night terrors [28]. Another study has reported that treatment of OSAS relieved symptoms of disorders of arousal [41]. Therefore, OSAS may be involved in the development of disorders of arousal.

4.2. Sleep-related bruxism

In a previous epidemiologic study of 2109 subjects in Canada on the prevalence of sleep-related bruxism, 13% of the subjects ages 18 to 29 years selected often or very often as responses to a question on the frequency of teeth grinding (between the upper and lower teeth, generating noise) during sleep [42]. In addition a study of 1119 patients in a dental office reported that the prevalence of teeth clenching (between the upper and lower teeth, without generating noise) during sleep was 9.6% and that of teeth grinding during sleep was 12.1% [43]. Meanwhile a study of 1040 patients in a dental office found that the prevalence of teeth grinding was 16.1% and that of teeth clenching was 34.2% [44]. In addition a study of 1052 students revealed that the prevalence of teeth grinding was 3.3%, that of teeth clenching was 13.4%, and that of both grinding and clenching was 4.5% [45]. Rugh et al [46] pointed out that there are two types of individuals with sleep-related bruxism, those who report the occurrence almost every night and those who temporarily exhibit it [46]. Individuals with temporary sleep-related bruxism may not be recognized as such by their families and friends. In addition, sleep-related bruxism without generating noise has been reported [47] and this type also may not be recognized by families or friends. The prevalence of sleep-related bruxism found in our study may be lower than the actual prevalence, as our results were merely based on responses to a questionnaire survey.

Several previous studies have reported factors associated with sleep-related bruxism. Ohayon et al. [18] conducted a study of 13,057 individuals ages 15 years or older in the United Kingdom, Germany, and Italy and found that the risk factors for sleep-related bruxism were OSAS, heavy alcohol consumption, caffeine consumption, smoking, and a highly stressful life. An association of smoking with sleep-related bruxism was reported in other studies [48,49]. Our study also recognized a significant association between sleep-related bruxism and smoking. However, to date the physiologic mechanism by which smoking affects sleep-related bruxism has not been clarified including how nicotine affects sleep-related bruxism as a neurochemically active substance [49].

In our study, a significant association was observed between alcohol consumption and sleep-related bruxism. The level of sleep-related bruxism usually is evaluated using the masticatory muscle activity level [50]. Rhythmic masticatory muscle activity, which is a movement of the lower jaw slower than a masticatory movement, often is observed during sleep and is found in 60% of healthy individuals [50]. The frequency of rhythmic masticatory muscle activity episodes and the amplitude of muscle activity were higher among subjects with sleep-related bruxism than among normal subjects. In a study by Hojo et al. [51] of 60 women ages 21 to 32 years, the authors found that the level of masticatory muscle activity increased with an increased alcohol intake [51], thus suggesting an association between alcohol consumption and sleep-related bruxism.

An association between depressive feelings and sleep-related bruxism was recognized in our study. An association between mental stress and sleep-related bruxism has been noted for quite some time. The level of masticatory muscle activity increased in response to stressful events [46], and in using the urinary catecholamine level as an indicator of the psychologic stress level the urinary catecholamine level was significantly higher in the group with high masseter muscle activity [52]. There also are studies that have refuted any significant associations between mental stress and sleep-related bruxism [53]; however, to date the evidence to support such associations is not strong [54]. Further studies to clarify the associations between psychologic stress and sleep-related bruxism are expected.

An association between sleep-related bruxism and snoring was suggested in our study. The results of previous studies have indicated that OSAS may be a risk factor for sleep-related bruxism

[18,55]. The physiologic mechanism for this relationship may include induction of masticatory muscle activity by the arousal response caused by apnea or hypopnea in patients with OSAS [21].

An association between sleep-related bruxism and disorders of arousal also was suggested in our study. A previous epidemiologic study has reported the co-occurrence of sleep talking with sleepwalking and sleep-related bruxism [56]. Physiologically it has been reported that more than 80% of episodes of sleep-related bruxism were observed during NREM sleep stages 1 and 2, most frequently in relatively unstable sleep states when a deep NREM sleep phase is shifting to an REM sleep phase [57]. During such periods microarousals that cannot be recognized by the sleeper often also are observed. Microarousals are a state during sleep in which part of the body reaches a state close to that during arousal; increased encephalogram arousal, autonomic nerve activity, and muscle activity is observed during microarousal [58]. It is known that bruxism immediately occurs after a microarousal event. Therefore, sleep-related bruxism also is considered to be a masticatory muscle activity secondary to increased central nerve activity itself caused by a microarousal event [58]. The results of our study support those of the previous studies.

4.3. Daily life guidance for adolescents with recognized disorders of arousal or sleep-related bruxism

Our study revealed associations between disorders of arousal or sleep-related bruxism and smoking habits, alcohol consumption, or depressive state in adolescents. From a public health viewpoint, if disorders of arousal or sleep-related bruxism are recognized in adolescents concerns of lifestyle habits such as smoking, consumption of alcohol, or concerns of depressive state which may harm their health in the future, may be an issue. If psychosocial factors related to such concerns can be elucidated and measures for modification of the family environment and school environment can be taken, then symptoms of disorders of arousal or sleep-related bruxism may effectively improve. The findings of our study should be used for resolution of these concerns and for daily life guidance and school education for adolescents.

4.4. Limitations

Our study had some limitations. First because the data were collected through a self-administered questionnaire and no physiologic measurements were used, it is possible that there were differences between the prevalence found in our study and the actual prevalence. Second the location where subjects slept might have affected whether or not symptoms could be easily recognized by their families. If a participant slept alone, the symptom may have remained undetected even if it were present. Third because the questionnaire response rate was 63.7%, a certain degree of nonresponse bias may have existed; however, this response rate is considered to be sufficient for this type of epidemiologic survey. Fourth because this was a cross-sectional study, no causal relationship could be determined. Future studies will be needed to resolve these previously mentioned limitations.

5. Conclusion

Our study revealed the prevalence of disorders of arousal and sleep-related bruxism and their associated factors in Japanese adolescents. In addition to smoking habit and alcohol consumption, depressive feelings were significantly associated with disorders of arousal and sleep-related bruxism. If disorders of arousal or sleep-related bruxism were observed in an adolescent, his or her smoking habit, alcohol consumption, and depressive state also should be considered.

Disclosure statement

This study was supported by a health science Research Grant from the Ministry of Health, Labor and Welfare of the Japanese Government. All of the authors have no potential conflict of interest, including specific financial interests and relationships and affiliations relevant to the subject matter or materials discussed in the manuscript. There was no off-label or investigational use in this study.

Conflict of interest

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: http://dx.doi.org/10.1016/j.sleep.2013.03.005.

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