A Nationwide Cohort Study of Parasomnias Among Adolescents

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ABSTRACT

Objective: To elucidate the incidence rates and predictive factors for parasomnias (disorders of arousal, nightmare, and sleep paralysis) in adolescents.

Methods: This was a prospective cohort study of high school students. In 2010, we conducted a baseline survey of first-year students enrolled in randomly selected Japanese schools (10 junior high schools and 14 senior high schools); 2 years later, a follow-up survey of the same participants was conducted. A self-administered questionnaire inquiring about parasomnias and lifestyles was provided to the students for both surveys. The incidence of new onset of each parasomnia was determined based on the longitudinal survey data obtained at 2 timepoints (ie, baseline and follow-up), separately for the junior and senior high-school students. Moreover, we performed multivariate analyses to identify the predictive factors for new onset of each parasomnia.

Results: 776 junior high school students and 2,697 senior high school students participated in both surveys (total response rate: 61.1%). The incidence rates of disorders of arousal, nightmares, and sleep paralysis during the observation period were 14.0%, 16.2%, and 3.3%, respectively, among junior high school students, and 15.1%, 27.8%, and 6.8%, respectively, among senior high school students. The predictive factors (adjusted odds ratio, *P* value) for new onset of disorders of arousal were female sex (1.38, .009) and sleep duration of less than 5 hours (1.95, .001). The predictive factors for onset of nightmares were female sex (1.82, < .001), enrollment in senior high school (vs junior high school) (2.14, < .001), poor subjective sleep quality (1.60, .010), and spending less than 2 hours studying after school hours (1.64, .027). The predictive factors for new onset of sleep paralysis were enrollment in senior high school (vs junior high school) (2.39, .002) and poor mental health status (1.98, < .001).

Conclusions: Our study results suggest that sleep status, lifestyle, and mental health are predictive factors for new onset of parasomnias in adolescents. These should be key areas of focus in school health services.

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Sleep is an important lifestyle habit for the maintenance of physical and mental health in adolescents.[1] Multiple studies have reported that sleep disorders during adolescence are risk factors for the development of physical diseases such as obesity, hypertension, and diabetes mellitus later in life.[2] Sleep disorders are also associated with cognitive impairment; difficulties with focus, memory, and attention; impaired decision-making; decreased reaction time; impaired/reduced academic performance; and decreased creativity.[3,4] Further, they are associated with alcohol and drug use, aggression, irritability, risky behaviors, anxiety, depression, suicidal thoughts and behaviors, poor impulse control and social skills, and low motivation, all of which are factors related to increased risk of psychiatric/psychological problems.[3–7] While sleep is important for adolescents, there is a high prevalence of sleep disorders among adolescents in developed countries, with studies reporting the prevalence of insomnia ranging from 9% to 13%.[8–11] A nationwide study of approximately 100,000 adolescents in Japan indicated that the prevalence of sleep duration under 6 hours was 30.6%,[12] whereas the prevalence of insomnia was 23.5%.[13]

Most epidemiologic studies of sleep disorders in adolescents focused on sleep duration and the presence or absence of insomnia symptoms; only a few addressed other types of sleep disorders. "Parasomnias" are a type of sleep disorder defined, according to the third edition of the International Classification of Sleep Disorders (ICSD-3),[14] as "undesirable physical events or experiences that occur during entry into sleep, within sleep, or during arousal from sleep." Disorders categorized under parasomnias include "disorders of arousal," "nightmares," and "sleep paralysis." Disorders of arousal are classified as non–rapid eye movement parasomnias and are divided into 3 categories: "confusional arousals," "sleepwalking," and "sleep terrors."[14] Although experiencing several seconds of confusion upon arousing from sleep occurs even in healthy persons, when the condition remains for several minutes, or even hours, is known as "confusional arousal." Sleepwalking is a condition in which an individual performs a series of complex activities during sleep, which may vary from simply sitting up to ascending and descending stairs or going into another room and drinking water. "Sleep terrors" are characterized by sudden arousal accompanied by loud screaming or crying.[14] "Nightmares" are characteristically highly unpleasant dreams that may recur; they are a disturbing psychological experience that typically occur during rapid eye movement (REM) sleep and often lead to awakening.[14] "Sleep paralysis" is an REM parasomnia characterized by loss of voluntary movement during the sleep onset period or while waking from sleep.[14] We previously conducted several nationwide epidemiologic studies of these parasomnias and reported on their prevalence and on the factors associated with them.[15,16] However, these studies had a severe limitation; they were cross-sectional studies in which all measurements were collected simultaneously. Cross-sectional studies are appropriate for assessing associations but not for assessing causality.[17]

Clinical Points

- Few longitudinal (cohort) epidemiologic studies have evaluated parasomnias in adolescents.
- We conducted a nationwide epidemiologic study with a cohort design to investigate parasomnias in adolescents to help fill this gap.
- Information about the predictive factors (eg, sleep duration, duration of study, or mental health) for the new onset of parasomnias may be useful in developing policies for preventing these conditions in adolescents.

To overcome these limitations, we conducted this new nationwide epidemiologic study to investigate the incidence rates and predictive factors for parasomnias in adolescents. The salient feature of this study is its cohort study design, which enabled us to assess the associations (including causality) between various factors and the incidence of parasomnias. Additionally, a cohort study has the advantage of enabling the calculation of incidence rates[18] by evaluating the new onset of parasomnias during the follow-up survey of participants who did not report parasomnias in the baseline survey.

METHODS

Study Design and Participants

This was a prospective cohort study of junior and senior high school students selected through random sampling of schools throughout Japan. In the Japanese educational system, students enter junior high school, which is compulsory, at age 12 and graduate after 3 years. Thereafter, they can choose to attend senior high school for 3 years. In 2008, our research group conducted an epidemiologic study of junior and senior high school students from 170 schools in Japan.[19] In January 2010, we contacted the principals of these 170 schools and requested that the schools participate in a new cohort study. We then surveyed all students who expressed willingness to participate. From October 2010 to November 2010, we conducted a baseline survey of students in their first year of either junior high school or senior high school. We conducted a follow-up survey from October 2012 to November 2012 when the students were in their third year of junior or senior high school.

Questionnaire

The surveys were conducted by distributing self-administered questionnaires to the participants, who completed them by themselves. The questionnaires included questions related to parasomnias and several other factors such as lifestyle.

Similar to our prior studies,[15,16] we prepared 3 questions related to parasomnias. The first was on disorders of arousal. While the ICSD-3 classifies 3 disorders—confusional arousals, sleepwalking, and sleep terrors—as disorders of arousal,[14] these disorders are collectively termed *neboke* in Japanese. Participants selected "never," "seldom," "sometimes," "often," or "always" in response to the question, "In the past month, have you experienced *neboke,* or has a family member suggested that you were in a state of *neboke*?" The second question was on nightmares; participants selected "never," "seldom," "sometimes," "often," or "always" in response to the question, "In the past month, have you awoken from a frightening dream?" The third question was on sleep paralysis, known as *kanashibari* in Japanese. Participants selected "no" or "yes" in response to the question, "Have you ever been unable to more your limbs or body while sleeping, trying to sleep, or awakening (*kanashibari*)?"

Regarding basic characteristics, participants were asked their sex and whether they were in junior or senior high school. Regarding lifestyle factors, we posed questions on (1) sleep: sleep duration, presence of insomnia symptoms (difficulty initiating sleep, difficulty maintaining sleep, and early morning awakening), and subjective sleep quality; (2) eating habits: eating breakfast every day, appetite, and coffee- or tea-drinking habits; (3) media use: hours spent watching television, playing video games, and using a mobile phone; and (4) school life and study: athletic activities during school, cultural extracurricular activities during school, period spent studying after school, victim of bullying (no/yes), bullying behavior toward other students (no/yes), and whether or not the participant had a confidant or sympathetic supporter. Mental health status was assessed using the Japanese version of the 12-item General Health Questionnaire (GHQ-12).[20,21] As in our previous studies, we set the cutoff score for the GHQ-12 at 4 points, with 4 points or higher indicating poor mental health status.

Ethical Considerations

The following ethical considerations were implemented: (1) participants were informed that participation was voluntary, and informed consent was obtained from each participant; (2) privacy was maintained by having each student personally complete and seal the questionnaire form in an unsigned envelope for submission; (3) the study was approved by the ethics committee of Nihon University School of Medicine.

Statistical Analysis

Only participants who participated in both the baseline and follow-up surveys were included in the statistical analysis. First, baseline prevalence was calculated for disorders of arousal, nightmares, and sleep paralysis. As in our previous study,[16] we calculated the prevalence of disorders of arousal, defining disorders of arousal as present in participants who responded "sometimes/often/always" to the question about disorders of arousal, and absent in participants who responded "never/seldom." As in our previous study,[15] we calculated the prevalence of nightmares, defining nightmares as present in participants who responded "seldom/sometimes/often/always" to the question about nightmares, and absent in participants who responded "never." We also calculated the prevalence of sleep

Table 1. Characteristics of the Analyzed Subjects (Junior/Senior High School Students) at Baseline Survey

Characteristic	Junior high school N	Junior high school %	Senior high school N	Senior high school %
Sex				
Boys	372	47.9	1,556	57.7
Girls	404	52.1	1,141	42.3
Sleep duration				
< 5 h/d	20	2.6	264	9.8
≥ 5 ~ < 6 h/d	45	5.8	433	16.1
≥ 6 ~ < 7 h/d	221	28.5	1,307	48.5
≥ 7 ~ < 8 h/d	266	34.3	454	16.8
≥ 8 ~ < 9 h/d	180	23.2	190	7.0
≥ 9 h/d	41	5.3	43	1.6
Unknown	3	0.4	6	0.2
Difficulty initiating sleep				
Never	355	45.7	1,142	42.3
Seldom	167	21.5	568	21.1
Sometimes	196	25.3	805	29.8
Often	32	4.1	129	4.8
Always	20	2.6	43	1.6
Unknown	6	0.8	10	0.4
Difficulty maintaining sleep				
Never	355	45.7	1,142	42.3
Seldom	167	21.5	568	21.1
Sometimes	196	25.3	805	29.8
Often	32	4.1	129	4.8
Always	20	2.6	43	1.6
Unknown	6	0.8	10	0.4
Early morning awakening				
Never	541	69.7	2,002	74.2
Seldom	116	14.9	351	13.0
Sometimes	101	13.0	259	9.6
Often	11	1.4	59	2.2
Always	6	0.8	23	0.9
Unknown	1	0.1	3	0.1
Subjective sleep quality				
Very good	227	29.3	419	15.5
Good	234	30.2	776	28.8
Normal	251	32.3	1,206	44.7
Poor	54	7.0	260	9.6
Very poor	7	0.9	34	1.3
Unknown	3	0.4	2	0.1
Eating breakfast every day				
Yes	727	93.7	2,325	86.2
No	44	5.7	367	13.6
Unknown	5	0.6	5	0.2
Appetite				
Good or moderate	751	96.8	2,597	96.3
Poor	20	2.6	93	3.4
Unknown	5	0.6	7	0.3
Coffee- or tea-drinking habits				
No	669	86.2	2,101	77.9
Yes	103	13.3	590	21.9
Unknown	4	0.5	6	0.2
Athletic activities during school hours				
No	167	21.5	1,164	43.2
Yes	576	74.2	1,472	54.6
Unknown	33	4.3	61	2.3
Cultural extracurricular activities during school hours				
No	491	63.3	1,778	65.9
Yes	188	24.2	708	26.3
Unknown	97	12.5	211	7.8
Period spent studying after school hours				
None	39	5.0	869	32.2
< 1 h/d	253	32.6	1,059	39.3
≥ 1 ~ < 2 h/d	300	38.7	603	22.4
≥ 2 h/d	172	22.2	153	5.7
Unknown	12	1.5	13	0.5
Hours spent watching television				
None	6	0.8	105	3.9
< 1 h/d	130	16.8	687	25.5
≥ 1 ~ < 2 h/d	307	39.6	1,010	37.4
≥ 2 h/d	329	42.4	880	32.6
Unknown	4	0.5	15	0.6
Hours spent playing video game				
None	222	28.6	1,058	39.2
< 1 h/d	280	36.1	783	29.0
≥ 1 ~ < 2 h/d	168	21.6	459	17.0
≥ 2 h/d	97	12.5	374	13.9
Unknown	9	1.2	23	0.9
Hours spent using mobile phone				
None	286	36.9	64	2.4
< 1 h/d	250	32.2	733	27.2
≥ 1 ~ < 2 h/d	124	16.0	723	26.8
≥ 2 h/d	106	13.7	1,165	43.2
Unknown	10	1.3	12	0.4
Victim of bullying				
No	653	84.1	2,516	93.3
Yes	117	15.1	158	5.9
Unknown	6	0.8	23	0.9
Bullying behavior toward other students				
No	687	88.5	2,558	94.8
Yes	85	11.0	123	4.5
Unknown	4	0.5	16	0.6
Confidant[a]				
No	128	16.5	466	17.3
Yes	644	83.0	2,207	81.8
Unknown	4	0.5	24	0.9
Sympathetic supporter				
No	99	12.8	407	15.1
Yes	672	86.6	2,250	83.4
Unknown	5	0.6	40	1.5
Mental health status				
Good (GHQ-12 ≤ 3 points)	543	70.0	1,588	58.1
Poor (GHQ-12 ≥ 4 points)	211	27.2	1,081	40.1
Unknown	22	2.8	48	1.8

(continued)

[a]Someone with whom the adolescent could consult about his or her problems.
Abbreviation: GHQ-12 = 12-item General Health Questionnaire.

paralysis, defining sleep paralysis as present in participants who responded "yes" to the question about sleep paralysis, and absent in those who answered "no."

Second, we calculated the incidence rate of each parasomnia, with new onset of the parasomnia considered to have occurred in students for whom the parasomnia was present at the follow-up survey but absent at the baseline survey. In addition, we used the χ^2 test to determine the association between type of school enrollment (junior or senior high school) and incidence rate of each parasomnia.

Third, we used multivariate analysis to identify the predictive factors associated with the incidence of each parasomnia. Including only students who were absent the condition at baseline, we conducted a logistic regression analysis using new onset of the condition at follow-up as the objective variable. Further, we included general lifestyle factors and factors previously reported to be significantly associated with parasomnias[15,16] as covariates in the model. These included basic attributes, lifestyle factors, and mental health status from the baseline survey. The backward

Table 2. Prevalences of Parasomnias at Baseline Survey (Junior/Senior High School)

		Survey response					
Parasomnia	N	Never	Seldom	Sometimes	Often	Always	Unknown
Disorders of arousal							
Junior high school	776	61.2%	16.0%	17.0%	3.2%	2.2%	0.4%
Senior high school	2,697	61.1%	15.7%	17.0%	4.0%	2.1%	0.1%
Nightmare							
Junior high school	776	70.0%	13.7%	12.6%	2.2%	1.2%	0.4%
Senior high school	2,697	67.1%	16.9%	12.9%	2.2%	0.8%	0.1%
Sleep paralysis		No	Yes	Unknown			
Junior high school	776	87.1%	12.5%	0.4%			
Senior high school	2,697	75.4%	24.4%	0.2%			

Table 3. Incidence Rates of Parasomnias Among Baseline to Follow-Up Survey (2 Years Interval)[a]

Parasomnia	N	%, Incidence rate	95% CI	*P*
Disorder of arousal (at follow-up survey)[b]				
Junior high school	598	14.0	11.3–16.8	.534[c]
Senior high school	2,070	15.1	13.5–16.6	
Nightmare (at follow-up survey)[d]				
Junior high school	543	16.2	13.1–19.3	<.001***,[e]
Senior high school	1,802	27.8	25.7–29.9	
Sleep paralysis (at follow-up survey)[f]				
Junior high school	668	3.3	1.9–4.6	.001**,[g]
Senior high school	2,207	6.8	5.7–7.8	

[a]Subjects with missing data were excluded from analysis.
[b]Only students whose response to the disorder of arousal question was "no (never/seldom)" at the time of the baseline survey were included in the analysis.
[c]*P* was calculated by χ^2 test 2(high school: junior, senior) × 2(disorders of arousal at follow-up: yes, no).
[d]Only students whose response to the nightmare question was "no (never)" at the time of the baseline survey were included in the analysis.
[e]*P* was calculated by χ^2 test 2(high school: junior, senior) × 2(nightmare at follow-up: yes, no).
[f]Only students whose response to the sleep paralysis question was "no" at the time of the baseline survey were included in the analysis.
[g]*P* was calculated by χ^2 test 2(high school: junior, senior) × 2(sleep paralysis at follow-up: yes, no).
**$P < .01$.
***$P < .001$.
Abbreviation: CI = confidence interval.

selection method (maximum likelihood method) was used as the variable selection method. Subjects with missing data were excluded from the analysis.

Fourth, we investigated the associations between after-school study time and sleep duration, and/or anxiety. Specifically, we calculated correlation coefficients (r_s) using the Spearman rank correlation coefficient method for 3 relationships using the baseline data: after-school study time versus sleep duration, after-school study time versus anxiety, and sleep duration versus anxiety. To evaluate anxiety, we asked the question, "Have you recently lost much sleep over worry?" which was one of the questions in the GHQ-12[20,21] utilized in this investigation. Subjects with missing data were excluded from the analysis.

Fifth, we investigated the relationship between shorter sleep duration and the new onset of nightmares in senior students. Specifically, we performed logistic regression analysis (forced entry method) using only the senior high school students' data: the new onset of nightmares at follow-up (2 years after baseline) was the objective variable, and sleep duration was the dependent variable. The adjusted factors were sex, insomnia symptoms, sleep quality, breakfast, appetite, coffee/tea, athletic activities, cultural extracurricular activities, time spent studying, television, video games, mobile phone usage, victim of bullying, bullying behavior toward other students, confidence, sympathy, and mental health. Subjects with missing data were excluded from the analysis.

The significance level was set at $P < .05$. Statistical analysis was performed using IBM SPSS Statistics V22.0 for Windows (IBM Corp, Armonk, NY).

RESULTS

Participant Numbers and Characteristics

Of the 170 schools we contacted, 10 junior high schools and 14 senior high schools agreed to participate; 5,687 students (1,304 junior high school students, 4,383 senior high school students) were surveyed. Of these, 3,473 students responded to both the baseline and the follow-up surveys (junior high school students = 776, senior high school students = 2,697). The overall response rate was 61.1% (junior high school students = 59.5%, senior high school students = 61.5%). The participants' baseline basic attributes and characteristics, grouped according to level of schooling, are shown in Table 1. Of the junior high students, 47.9% were boys and 52.1% were girls, and of the senior high students, 57.7% were boys and 42.3% were girls.

Prevalence of Parasomnias

The prevalence of each parasomnia among students at baseline is shown in Table 2. The prevalence of disorders of arousal was 22.4% (95% confidence interval: 19.5%–25.3%) for junior high school students and 23.1% (21.5%–24.7%) for senior high school students. For nightmares, the prevalence was 29.7% (26.5%–32.9%) for junior high school students and 32.8% (31.0%–34.6%) for senior high school students. The prevalence of sleep paralysis was 12.5% (10.2%–14.8%) for junior high school students and 24.4% (22.8%–26.0%) for senior high school students.

Incidence Rate of Parasomnias

The incidence rates of each parasomnia in the 2-year period between baseline and follow-up are shown in Table 3. For disorders of arousal, the incidence rate was 14.0% (11.3%–16.8%) for junior high school students and 15.1% (13.5%–16.6%) for senior high school students, which was not significantly different ($P = .534$). The incidence rate of nightmares was 16.2% (13.1%–19.3%) in junior high school students and 27.8% (25.7%–29.9%) in senior high school students; a significant

Table 4. Predictive Factors With Incidence of Parasomnias in Junior/Senior High School Students[a]

	Disorders of arousal[b]			Nightmare[c]			Sleep paralysis[d]		
	AOR	95% CI	*P*[e]	AOR	95% CI	*P*[e]	AOR	95% CI	*P*[e]
Sex			.009**			<.001***			
Boys	1.00			1.00					
Girls	1.38	1.09–1.76		1.82	1.47–2.24				
Junior/senior high						<.001***			.002**
Junior				1.00			1.00		
Senior				2.14	1.58–2.88		2.39	1.39–4.11	
Sleep duration			.001**						
<5 h/d	1.95	1.33–2.86							
≥5 h/d	1.00								
Subjective sleep quality						.010*			
Very good/good/normal				1.00					
Poor/very poor				1.60	1.12–2.29				
Cultural extracurricular activities during school hours			.090						
No	1.00								
Yes	1.25	0.97–1.62							
Period spent studying after school hours			.097			.027*			
<2 h/d	1.45	0.93–2.27		1.64	1.05–2.56				
≥2 h/d	1.00			1.00					
Victim of bullying									.053
No							1.00		
Yes							1.73	0.99–3.00	
Mental health status			.059			.059			<.001***
Good (GHQ-12 ≤ 3 points)	1.00			1.00			1.00		
Poor (GHQ-12 ≥ 4 points)	1.26	0.99–1.61		1.24	0.99–1.56		1.98	1.41–2.78	

[a]Subjects with missing data were excluded from analysis.
[b]Only students whose response to the disorder of arousal question was "no (never/seldom)" at the time of the baseline survey were included in the analysis.
[c]Only students whose response to the nightmare question was "no (never)" at the time of the baseline survey were included in the analysis.
[d]Only students whose response to the sleep paralysis question was "no" at the time of the baseline survey were included in the analysis.
[e]*P* was calculated by the multiple logistic regression analysis (backward elimination method).
*$P < .05$.
**$P < .01$.
***$P < .001$.
Abbreviations: AOR = adjusted odds ratio, CI = confidence interval, GHQ-12 = 12-item General Health Questionnaire.

Table 5. Correlation Coefficients Between After-School Study Time and Sleep Duration and Anxiety[a]

	After-school study time	Sleep duration	Anxiety
After-school study time	1.000	.053**	.019
Sleep duration	.053**	1.000	**–0.124*** **
Anxiety	.019	**–0.124*** **	1.000

[a]Data used were obtained at the baseline survey. Subjects with missing data were excluded from analysis. Correlation coefficients (r_s) were calculated by Spearman rank method.
**$P < .01$.
***$P < .001$.

Table 6. Relationship Between Sleep Duration at Baseline and New Onset of Nightmare in the Senior High School Students (Two Years)[a]

	New onset of nightmare		
	AOR	95% CI	*P*[b]
Sleep duration (at baseline)			.217
<5 h/d	1.00		
≥5 h/d	1.31	0.86–1.99	

[a]Subjects with missing data were excluded from analysis. Only senior high school students whose nightmare was "No (Never)" at the time of the baseline survey were included in the analysis. Adjusted factors: sex, difficulty initiating sleep, difficulty maintaining sleep, early morning awakening, sleep quality, breakfast, appetite, coffee/tea, athletic activities, cultural extracurricular activities, period spent studying, television, video game, mobile phone, victim of bullying, bullying behavior toward other students, confidant, sympathetic supporter, and mental health.
[b]*P* was calculated by the multiple logistic regression analysis (forced entry method).
Abbreviations: AOR = adjusted odds ratio, CI = confidence interval.

difference was observed between the two groups ($P < .001$). The incidence rate of sleep paralysis was 3.3% (1.9%–4.6%) for junior high school students and 6.8% (5.7%–7.8%) for senior high school students, which was significantly different ($P = .001$).

Predictive Factors of Parasomnias

Results of the logistic regression analysis of the incidences of each parasomnia are shown in Table 4. The significant predictive factors for the incidence of disorders of arousal were female sex ($P = .009$) and sleep duration of less than 5 hours ($P = .001$). The significant predictive factors for the incidence of nightmares were female sex ($P < .001$), senior high school enrollment (versus junior high school) ($P < .001$), poor subjective sleep quality ($P = .010$), and spending more than 2 hours studying after school ($P = .027$). The significant predictive factors for the incidence of sleep paralysis were being a senior high school student (versus junior high school) ($P = .002$) and having a poor mental health status ($P < .001$).

Associations Between After-School Study Time, Sleep Duration, and Anxiety

Table 5 shows the correlation coefficients (r_s) between after-school study time, sleep duration, and anxiety, calculated using the Spearman rank correlation coefficient method. The r_s of after-school study time versus sleep duration was 0.053. The r_s of after-school study time versus anxiety was 0.019. The r_s of sleep duration versus anxiety was –0.124.

Relationship Between Sleep Duration and New Onset of Nightmare in the Senior High School Students

Table 6 shows the results of the logistic regression analysis in senior high school students, where new-onset nightmares at follow-up was the objective variable and sleep duration was the dependent variable. With sleep duration < 5 h/d as the reference, the adjusted odds ratio for sleep duration ≥ 5 h/d was 1.31 (95% confidence interval: 0.86–1.99, $P = .217$), and no significant relationship was found between sleep duration at baseline and new onset of nightmares at follow-up.

DISCUSSION

We conducted this nationwide epidemiologic study to evaluate the incidence rates and predictive factors for parasomnias in adolescents, calculated according to age. To the best of our knowledge, this is the first study on incidence rates of parasomnias in adolescence, conducted using a highly representative random sample of a country's population.

Prevalence is one measure that expresses how a population is affected by a disease by determining the fraction of a total population that is affected by a condition at a specific point in time.[22] Several previous epidemiologic studies of parasomnias have reported on the prevalence of parasomnias, including several based on nationwide surveys of adolescents.[15,16,23,24] While prevalence represents a snapshot at a specific point in time, it does not allow for specification of date of onset or assessment of differences in risk based on date of onset[22]; to assess risk, "incidence rate" must be used. Incidence rate is defined as the rate at which new cases of a disease occur during a specified period in a population at risk for developing the disease.[22] Since incidence only includes new cases of a disease that arise within a specified period, incidence can be used to assess differences in risk of disease based on date of onset among specific groups (eg, age group). To date, very few epidemiologic studies have reported on the incidence rates of parasomnias. Data from the Quebec Longitudinal Study of Child Development were used for a study of parasomnias in childhood.[25] Following children from ages 1½ years to 13 years, the authors reported that the incidence rate of sleepwalking is lowest at 3½ years and gradually increases until age 12, while the incidence rate of sleep terrors is highest at age 2½ and tends to decrease until age 10.[25] Here, we assessed the risk of onset during adolescence according to age group by calculating the incidence rate of parasomnias within a 2-year period for both junior high school students (ages 13–15 years) and senior high school students (ages 16–18 years). Results indicated that the incidence rates of the parasomnias we assessed were higher among senior high school students than among junior high school students. The difference in incidence between the groups may suggest a difference in risk factors (etiology) between the groups,[26] which we did not assess here. Physiologically, changes in some sleep parameters that occur with age have been reported in previous research[27]; there may also be factors associated with the onset of parasomnias that change with age.

We also identified the predictive factors associated with the incidence of parasomnias in adolescents. Of the previous epidemiologic studies of factors associated with parasomnias,[15,16,23,28] all are cross-sectional, and none assessed causality. To fully establish causality, 4 conditions must be met: temporality, causal consistency, exchangeability, and no measurement error.[17] In the present study, we met the condition of temporality, by using a cohort study design, and exchangeability, by using multivariate analysis to adjust for confounders, thereby providing a higher level of evidence for causality.

We found that female sex was a significant predictive factor for new onset of disorders of arousal and nightmares. Several previous cross-sectional studies have also reported on the association between sex and disorders of arousal/nightmares[15,16,29]; however, the present study provided even stronger evidence of this association, including information on causality. Although it has been previously reported that adolescent females are at a significantly higher risk of having disorders of arousal,[16] a study examining the general population aged 15 years and older reported that risk does not differ according to sex.[28] Adolescents were the subjects of the present study, and the differences in age may have affected differences in risk according to sex. However, the reason for this is unknown; therefore, further research is needed. A previous meta-analysis reported that dream recall frequency is higher in females.[30] Greater frequency of night awakening[31] and greater interest in dreams[32] among females have also been suggested.

In the present study, short sleep duration (< 5 hours/day) was a significant predictive factor for new onset of disorders of arousal. Sleep deprivation is a known primer for the occurrence of arousal parasomnias.[14] Experimental sleep deprivation can be used to trigger episodes of sleepwalking in the laboratory. Indeed, 25–38 hours of sleep deprivation can significantly increase the number of sleepwalking events by a factor of 2.5–5 when compared to baseline values.[33–35]

In our study, poor subjective sleep quality was a significant predictive factor for new onset of nightmares. Previous epidemiologic studies have reported a marked association between subjective poor sleep quality and nightmares.[15,29,36] However, results of sleep laboratory studies did not show much difference between the objective sleep quality (obtained using polysomnography) of patients with nightmares and that of healthy controls, though subjective sleep quality estimates

were much lower.[37] Although it is possible that differences between the assessment methods for sleep quality (self-report questionnaires versus polysomnography) determine whether or not an association is found between sleep quality and nightmares, the mechanism for this remains unclear.

Spending a short period studying after school (< 2 hours/d) was also a predictive factor for new onset of nightmares. There have been no previous reports regarding an association between students' study hours and parasomnias; this is the first study to report on such an association. Others have reported an association between psychological stress and nightmares.[38] We had hypothesized that longer study hours would increase psychological stress and promote the incidence of nightmares. However, the results here were opposite to our hypothesis. The mechanism behind this finding is unclear. A previous study on children showed an association between decline in academic performance and nightmares.[39] However, we did not measure academic performance to be able to assess this. Further research is required to clarify the correlation between study hours and academic performance.

Poor mental health status was a significant predictive factor for the incidence of sleep paralysis. Several studies have documented the association between sleep paralysis and anxiety[40] or panic disorder.[41] Therefore, our cohort study presents a stronger evidence of the association, and causality, between poor metal health and sleep paralysis in adolescents.

Previous studies have suggested that short sleep duration and anxiety can trigger parasomnias.[14,42–48] Similarly, we hypothesized that short duration of time spent studying is an epiphenomenon of either short sleep duration or anxiety, and to test this hypothesis, we analyzed the relationship between each pair of the following variables: after-school study time, sleep duration, and anxiety. As a result, while we observed a moderately strong correlation between short sleep time and anxiety ($r_s = 0.124$), we did not find an obvious correlation between short study time and short sleep time ($r_s = 0.053$) or between short study time and anxiety ($r_s = 0.019$). Thus, we were unable to substantiate the existence of relationships between short after-school study time and total sleep time, and/or anxiety using our study data.

Even though a logistic regression analysis combining junior high school students and senior high school students did not reveal a significant association between sleep duration and new-onset nightmares, we hypothesized that a subgroup analysis limited to only senior high school students may show a significant relationship between sleep duration and new-onset nightmares. Therefore, we carried out a logistic regression analysis on senior high school students alone to test this hypothesis, in which new onset of nightmares at follow-up was the objective variable and sleep duration was the dependent variable. However, there was no significant relationship between shorter sleep duration and new onset of nightmares in the senior students. Thus, the idea of a relationship between shorter sleep duration and new onset of nightmares in senior students was not substantiated by the data obtained from the present study.

This study has some limitations. First, the definition of parasomnias that we used in the present study does not fully match the diagnostic criteria defined in the ICSD-3.[14] Second, due to ethical considerations and space limitations, we could not include questions about topics such as socioeconomic status (family budget, academic achievement), problematic behaviors (alcohol consumption, smoking), sleep environment (bedroom temperature and humidity), and reliability of medical history. It is possible that such factors influence the incidence of parasomnias and should be considered in future studies.

Through the present study, we have obtained epidemiologic knowledge about the predictive factors for the incidence of parasomnias in adolescents. These results provide suggestions for future planning of life and health strategies for adolescents and offer a scientific basis for developing policies to improve sleep in adolescence. Furthermore, the results could facilitate the development of future epidemiologic studies. The predictive factors for parasomnias identified here may be useful when selecting factors to manipulate as interventions in future interventional studies, which represent the next level of epidemiologic studies. The present study may also be a powerful source of evidence when performing meta-analyses of multiple, systematically collated, previous epidemiologic studies of parasomnias to yield higher-level evidence.

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