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ORIGINAL ARTICLE

Associations of sleep bruxism with age, sleep apnea, and daytime problematic behaviors in children

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OBJECTIVES: The aims of this study were to investigate the prevalence of sleep bruxism in children in Japan, and its relationships with sleep-related factors and daytime problematic behavior.
SUBJECTS AND METHODS: Guardians of 6023 children aged 2–12 years completed the Japanese Sleep Questionnaire. Multiple regression analysis and structural equation modeling were performed.
RESULTS: Sleep bruxism was reported in 21.0% children (n = 1263): the prevalence was highest in the age group of 5–7 years (27.4%). Multiple regression analysis showed that sleep bruxism had significant correlations with age 5–7 years (OR: 1.72; $P < 0.0001$), 'Moves a lot during sleep' (OR: 1.47; $P < 0.0001$), 'sleeps with mouth open' (OR: 1.56; $P < 0.0001$), and 'snores loudly' (OR: 1.80; $P < 0.0001$). In structural equation modeling, sleep bruxism had a significant but weak direct effect on daytime problematic behavior, while sleep bruxism significantly correlated with obstructive sleep apnea, which had a higher direct effect on daytime problematic behavior.
CONCLUSIONS: Sleep bruxism was reported in 21.0% of Japanese children and had independent relationships with age, movements during sleep, and snoring. A comorbidity of sleep-disordered breathing might be related to daytime problematic behavior in children with sleep bruxism.
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Keywords: tooth grinding; sleep-disordered breathing; development; co-sleeping; community samples

Introduction

Among sleep disorders recognized in children, sleep bruxism (SB) is one of the most commonly reported problems. Sleep bruxism is defined as repetitive jaw-muscle activity characterized by clenching or grinding of the teeth and/or bracing or thrusting of the mandible during sleep (American Academy of Sleep Medicine, 2014). Previous studies showed that the prevalence of SB decreased with age: from children (2–30%) (Laberge *et al*, 2000; Liu *et al*, 2005; Petit *et al*, 2007; Suwa *et al*, 2009; Serra-Negra *et al*, 2010; Simola *et al*, 2010; Lam *et al*, 2011; Insana *et al*, 2013) to adults (5–10%), and especially in the elderly population (2–4%) (Lavigne and Montplaisir, 1994; Ohayon *et al*, 2001; Kato *et al*, 2012). Interestingly, the prevalence of SB increases or decreases with age in preschoolers and school children (Reding *et al*, 1966; Laberge *et al*, 2000; Agargun *et al*, 2004; Liu *et al*, 2005; Shur-Fen Gau, 2006; Petit *et al*, 2007; Suwa *et al*, 2009; Simola *et al*, 2010; Renner *et al*, 2012). As most studies in children investigated the study population within limited age groups, age-related changes of the prevalence of SB in preschoolers and school children have not been clearly investigated (Manfredini *et al*, 2013).

Sleep-related problems are commonly reported in 25–40% of preschoolers and school children, for example, insomnia, obstructive sleep apnea (OSA), restless legs syndrome (RLS), somniloquy, enuresis, rhythmic movements, and disorders of arousal (Owens and Witmans, 2004). The prevalence of these sleep disorders was found to decrease or fluctuate in children. SB in children can be comorbid with various sleep disorders or associated with sleep-related symptoms and daily behavior. Interestingly, numerous studies have shown a significant correlation or comorbidity between SB and sleep problems and/or disorders in children (Laberge *et al*, 2000; Ng *et al*, 2002; Petit *et al*, 2007; Suwa *et al*, 2009; Carra *et al*, 2011; Insana *et al*, 2013; Shimizu *et al*, 2014). In addition, children with SB can have a high likelihood of showing daytime problematic behavior, which can also be frequently associated with sleep problems (Laberge *et al*, 2000; Ng *et al*,

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2002, 2005; Herrera *et al*, 2006; Petit *et al*, 2007; Ghanizadeh, 2008; Suwa *et al*, 2009; Carra *et al*, 2011; Lam *et al*, 2011; Insana *et al*, 2013; Serra-Negra *et al*, 2013). Currently, how the comorbidity with associated sleep-related symptoms influences daytime problematic behavior in the prevalence of SB in children remains little understood.

Therefore, the aims of this study were to assess age-dependent changes of the prevalence of SB and to investigate the relationships among sleep-related symptoms, daytime behavior, and SB in a large community sample of Japanese children. In this study, we used the Japanese Sleep Questionnaire (JSQ) that has been developed for Japanese children (Shimizu *et al*, 2014) as sleep environment and habits of Japanese (i.e., sleeping with parents and a use of a Japanese-style thin mattress placed on the floor) do not fit the standard questionnaires commonly used in other countries.

Methods

The study protocol and questionnaire were approved by the Human Research Ethics Committee of the Institutional Review Board at Osaka University Hospital.

Participants

Preschool participants were recruited from three community groups: a private kindergarten in Tokyo, 19 public nursery schools in Osaka, and recipients of government-regulated regular physical examinations at the age of 3 years in Osaka. Elementary school students were recruited from 17 public elementary schools in nine prefectures in Japan. Originally, guardians of 3100 preschoolers and 5525 elementary school students were enrolled in the study; however, after individuals with invalid answers or with incomplete answers were excluded, 2191 preschoolers (70.7%) and 3832 elementary school students (69.3%) were subject to analysis (Table 1). The total responder rate was 69.8% (6023/8625).

Measures

The JSQ-P consists of 39 items classified into 10 domains according to psychometric conditions, namely OSA, RLS-sensory, RLS motor, morning symptoms, sleep habits, parasomnias, insufficient sleep, daytime excessive sleepiness, daytime behavior, and insomnia or circadian rhythm disorders. The questions in the JSQ-E, consisting of 38 items, were modified to fit the lifestyle of elementary school children, taking into account frequently occurring sleep problems at this age. Guardians completed the JSQ-P and JSQ-E by rating on a 6-point intensity Likert scale, in which a score of 6 referred to strongly agree/true/applicable and 1 referred to strongly disagree/false/inapplicable. Higher scores indicated greater signs of sleep disorders or deleterious sleep habits with the exception of reverse items, which were rescored prior to analysis.

Both the JSQ-P and JSQ-E include a question about SB ‘Does he/she grind his/her teeth during sleep?’ by rating on a 6-point intensity Likert scale. In addition, there were 35 items common to the two modules, and they were used to analyze factors related to SB. All submitted surveys remained completely anonymous and did not include any personal information that might identify the respondent or their child.

Table 1 The number of children included in the analysis

JSQ-P				*JSQ-E*			
Age (years)	N	*Male*	*Female*	*Age (years)*	N	*Male*	*Female*
2	98	54	44	6	337	173	164
3	1055	575	480	7	642	312	330
4	576	308	268	8	633	305	328
5	229	129	100	9	615	274	341
6	233	123	110	10	664	324	340
Total	2191	1139	1002	11	643	308	335
				12	298	140	158
				Total	3832	1836	1996

JSQ-P, the Japanese Sleep Questionnaire for preschoolers; JSQ-E, the Japanese Sleep Questionnaire for elementary school students.

Statistics

Most statistical analyses were performed using JMP pro 10.02 (SAS Institute Inc., Cary, NC, USA). Children were classified into four age groups: 2–4, 5–7, 8–10, and 11–12. The 6-point Likert scale scores of tooth grinding, status of co-sleeping, and the common 35 items in the JSQ-P and JSQ-E were converted into dichotomous scores (1~3 in the original scores into 1; 4~6 in the original scores into 2) for logistic regression analysis. The crude and multivariate (adjusted) logistic regression analyses were performed using these 35 items, sex, age, and co-sleeping as independent variables, and the odds ratios (OR) and 95% confidential intervals (CIs) were calculated. The statistical significance was set to $P < 0.05$.

To clarify the relationship between SB and daytime problematic behavior, we also performed structural equation modeling (SEM). Data from 5215 children under 10 years of age were used in this analysis, since as shown in the results, the reported number of co-sleeping decreased in children over 10 years. First, exploratory factor analyses using the above 35 items were performed. The factorability of the data was confirmed by a Bartlett’s test of sphericity ($P < 0.0001$) and sampling adequacy by a Kaiser–Meyer–Olkin test above the minimum recommended value of 0.60 (0.866). A principal component analysis was used to extract the factors, followed by an oblique rotation using the direct oblimin method. After selecting factors to be retained by Kaiser’s criterion (eigenvalues above 1) and inspection of the scree plot, we chose a factor structure with a primary factor loading of 0.3 or above and no cross-loading of 0.3 or above. Using the obtained factors (i.e., ‘morning symptoms’, ‘excessive daytime sleepiness’, ‘problematic daytime behavior’, ‘sleep habit’, ‘restless legs syndrome’, ‘insomnia/parasomnia’ ‘circadian rhythm disorders’, and ‘OSA’) together with ‘Tooth Grinding’ score as observed valuables, a SEM was performed in the multivariate analysis to test the proposed pathways using SPSS Amos 22.0 (IBM, Tokyo, Japan). To empirically identify potentially important confounders, the following strategy was used: *a priori* conceptual models that focused on both direct and indirect pathways from ‘Tooth Grinding’ to ‘Daytime Problematic Behavior’ were proposed and statistically evaluated repeatedly until a good-fitting model was achieved. Overall model fit was mainly determined by the comparative fit index (CFI) and root mean square error of approximation (RMSEA).

Results

Prevalence of sleep bruxism in children

In total, 21.0% of parents reported tooth grinding during sleep in our study population. When children were classified into four age groups, the prevalence was highest (27.4%) in the age group from 5 to 7 years: the highest prevalence rate was 30.5% at the age of 6 (Figure 1). The association between 6-point original scores and the age was also shown in Table 2. No age-related decrease in prevalence was observed in ‘loud snoring’ although significant differences were noted among the four age groups by chi-square test ($P = 0.019$, Table 3). As reported previously, more than 95% of children younger than the age of seven co-slept with their caregivers (Shimizu *et al*, 2014), while the frequency gradually decreased to less than 80% in the 11–12 years age groups (Table 3). The association between the original scores of SB and snoring was also shown in Table 4. Chi-square test showed significant association between SB and snoring ($P < 0.001$) in our study population.

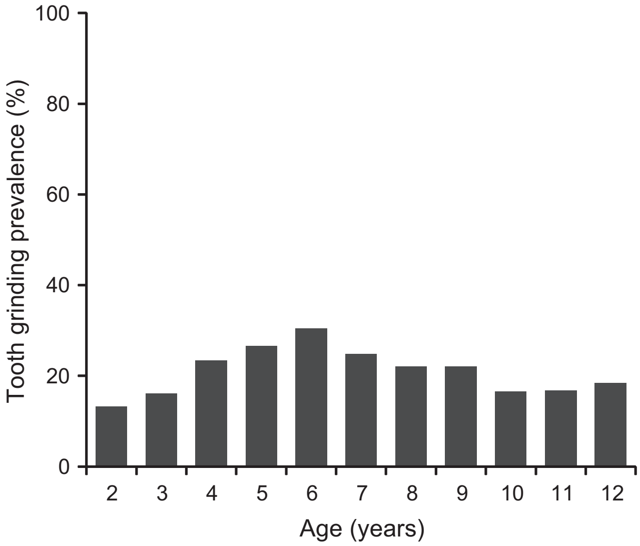

Figure 1 Age-dependent prevalence of parent-reported tooth grinding

Table 2 Frequency of tooth grinding in relation to age

	Frequency of tooth grinding (%)						
Age Groups (years)	*1*	*2*	*3*	*4*	*5*	*6*	P *value*
2–4	57.1	17.0	7.4	8.8	6.9	2.7	<0.0001*
5–7	44.1	17.6	10.5	13.9	9.5	4.0	
8–10	48.4	20.2	11.2	11.5	6.6	2.1	
11–12	53.0	20.6	9.0	9.8	5.4	2.1	

The scores of tooth grinding represent 1; never to 6; always.
**P* value in chi-square test, age groups (4) × tooth grinding (6).

Table 3 Age-related changes in prevalence of tooth grinding, loud snoring, and co-sleeping

	Age groups (years)				
	2–4	*5–7*	*8–10*	*11–12*	P *value**
Tooth grinding	319/1410 (18.5)	395/1046 (27.4)	386/1526 (20.2)	163/778 (17.3)	<0.0001*
Loud snoring	185/1544 (10.7)	176/1265 (12.2)	179/1733 (9.4)	118/823 (12.5)	0.019*
Co-sleeping	1724/5 (99.7)	1402/39 (97.3)	1741/171 (91.1)	737/204 (78.3)	<0.0001*

Data are shown as yes/no (% of yes).
**P* values in chi-square tests.

Factors associated with parent-reported tooth grinding

Table 5 shows the distribution of age, gender, co-sleeping, and variables from the JSQ between subjects with and without SB. A significantly higher odds ratio was recognized for male (OR = 1.15; $P = 0.024$). Children ranging from 5 to 7 years old had higher odds (OR = 1.80, $P < 0.0001$) of parent-reported SB compared with the age group 11–12 years. A significant correlation between SB and co-sleeping (OR = 0.76; $P = 0.032$) was also noted. Parent-reported SB was correlated with several items classified into 10 domains. In the domain for RLS (sensory), 'Says legs hurt at night' (OR = 1.46; $P = 0.049$) was correlated with parent-reported SB. SB had significant correlations with five items for OSA: 'Moves a lot during sleep' (OR = 1.78; $P < 0.0001$), 'Sleeps with mouth open' (OR = 2.00; $P < 0.001$), 'Sleeps with head arched back' (OR = 1.99; $P < 0.0001$), 'Snores loudly' (OR = 2.59; $P < 0.0001$), 'Stops breathing' (OR = 2.37; $P < 0.0001$), and 'Snorts and gasps' (OR = 2.14; $P < 0.0001$). Parent-reported SB was also correlated with the items related to morning symptoms such as 'Grumpy in the morning' (OR = 1.29; $P = 0.0002$), 'Needs much time to wake up' (OR = 1.25; $P = 0.0006$), 'Takes a long time to get out of bed' (OR = 1.21; $P = 0.0043$). Only one item in parasomnias domain ('Woken by scary dreams'; OR = 1.30; $P = 0.0052$) was significantly correlated with SB. SB was also correlated with a few items related to insomnia/circadian rhythm disorders such as 'Gets excited at night' (OR = 1.69; $P = 0.0006$), 'Has no pattern to sleep and wake-up times (OR = 1.30; $P = 0.018$), and 'Day–night reversal' (OR = 2.19; $P = 0.021$) as well as a sign of daytime excessive sleepiness 'Looks run down in the daytime' (OR = 1.38; $P = 0.011$). SB was found to be correlated with daytime problematic behavior: 'Restlessness in the daytime' (OR = 1.54; $P < 0.0001$) and 'Poor concentration in the daytime' (OR = 1.44; $P < 0.0001$). Correlations were also found with sleep habits ['Sleeps without being tucked in' (OR = 1.78; $P < 0.0001$)] and RLS (motor) ['Rubs feet at night' (OR = 1.48; $P = 0.044$) and 'Touches feet at night' (OR = 1.83; $P = 0.0018$)].

Multivariate logistic regression analysis showed that the probability of 'Moves a lot during sleep' (OR = 1.47; $P < 0.0001$), 'Sleeps with mouth open' (OR = 1.56; $P < 0.0001$), and 'Snores loudly' (OR = 1.80; $P < 0.0001$) remained significantly higher in children with SB compared with children without SB, as well as in age 5–7 compared with age 11–12 (OR = 1.80; $P < 0.0001$) (Table 5).

Relationship of sleep bruxism to daytime problematic behavior

As multivariate analysis failed to demonstrate the relationship between tooth grinding and daytime problematic behaviors, we next investigated how the relationship of tooth grinding to daytime behavior can explain concomitant sleep-related problems and/or the comorbidity of sleep disorders. By SEM, We got a good-fitting model with chi-square = 1.034, $P = 0.596$, CFI = 1.000, and RMSEA = 0.000 (Figure 2). This model suggests a significant but weak direct effect (0.04) of tooth grinding on daytime problematic behavior and morning symptoms. The weak correlation coefficient between 'Tooth grinding' and OSA was 0.26, while 'Tooth grinding' had only weak correlations with 'Circadian Rhythm Disorders' and 'RLS'.

Discussion

This study found that parent-reported SB was prevalent in a large number of Japanese preschoolers and school children aged between 2 and 12 years old. Overall, 21.0% of

Table 4 Relation between severity of tooth grinding and loud snoring

Loud snoring	*Total* N	*Tooth grinding (%)* 1	2	3	4	5	6	*Total*	P *value*
1	3601	47.7	20.7	15.0	9.3	6.1	1.2	100	<0.001*
2	1278	21.5	33.5	23.6	12.5	7.4	1.6	100	
3	486	19.5	20.8	30.5	13.4	11.1	4.7	100	
4	459	21.6	22.2	20.5	17.0	12.2	6.5	100	
5	148	18.2	23.6	22.3	12.2	13.5	10.1	100	
6	51	15.7	13.7	9.8	15.7	19.6	25.5	100	

The scores of tooth grinding represent 1; never to 6; always. The scores of 'Loud snoring' represent 1; quite false to 6; quite true.
**P* values in chi-Square test, loud snoring (6) × tooth grinding (6).

parents reported that their children showed tooth grinding during sleep. The result was within a range of prevalence of SB in different age ranges of preschoolers and/or school children, for example, five to more than 40%. The estimated prevalence of the present study was similar to that noted in Japan (24%) (Suwa *et al*, 2009), Taiwan (14.7–25.1%) (Shur-Fen Gau, 2006), and in Canada (9.3–19.2%) (Laberge *et al*, 2000) and in Finland (22.2%) (Simola *et al*, 2010). However, it was somewhat higher than that noted in China [Hong Kong: 5.9% (Lam *et al*, 2011); Beijing: 6.5%, (Liu *et al*, 2005)], Turkey (2–9%) (Agargun *et al*, 2004), and in USA (5–12%) (Reding *et al*, 1966). On the other hand, several studies have shown much higher prevalence of SB in Brazil (34–40%) (Serra-Negra *et al*, 2010; Renner *et al*, 2012) and in preschoolers in the USA (36.8%) (Insana *et al*, 2013). However, the difference in prevalence of SB in children between the above questionnaire-based studies cannot be concluded as the effects of geographical or racial differences as the questions and cut-off criteria for determining SB vary among studies. In addition, parent reports on witnessed tooth grinding during sleep would be more reliable when parents habitually co-sleep with children. Our result that 93% of Japanese parents reported co-sleeping with children supports the previous results on the higher frequency of co-sleeping in Japan compared to other countries (Latz *et al*, 1999; Iwata *et al*, 2013). Therefore, the current results on prevalence should be interpreted as epidemiological data that represent pediatric population in a co-sleeping culture.

Age-related prevalence

The present study showed that parent-reported SB increased from the youngest group [2–4 years of age (18.5%)] to the older [5–7 years of age (27.4%)] group and decreased at older than 8 years (20.2–17.3%), with a clear peak at 6 years old. Multivariate logistic regression analysis revealed that SB had a significant independent association with age. A few studies have also shown an increase of SB prevalence during the preschool period in Canada (Petit *et al*, 2007), Finland (Simola *et al*, 2010), and China (Liu *et al*, 2005). More studies have shown an age-related decrease in the prevalence of SB in school children in the USA (12.1–5.6%) (Reding *et al*, 1966), Brazil (39.1–35.7%) (Renner *et al*, 2012), Taiwan (25.1–14.7%) (Shur-Fen Gau, 2006), Japan (24.6–12.5%) (Suwa *et al*, 2009), Hong Kong (9–10% to 3–5%) (Lam *et al*, 2011), and China (6.7–3.7%) (Liu *et al*, 2005). Collectively, our results support previous findings of an independent curvilinear relationship between age and SB in preschoolers and school children.

The age-dependent change in prevalence in children is unique for SB when compared with other sleep disorders seen in children. In preschool children, 22.7% of SB started to occur at age 2.5 and until 6 years, 17–20% cases of SB emerged every year. However, only 4–6% disappeared from 3.5 to 5 years and 13.8% at 6 years. 71.5% of SB remained at 6 years (Petit *et al*, 2007) while only 33% of SB was persistent to age 13 years: the disappearance rate increased after 6 years (10–20%): (Laberge *et al*, 2000). Current knowledge on SB pathophysiology can propose the putative pathophysiological factors on the age-dependent change in relation to developmental status. Rhythmic masticatory muscle activity (RMMA), physiologically characterizing SB, was found to be correlated with arousal activities [i.e., micro-arousals and cyclic alternating pattern (CAP)] during sleep in children (Herrera *et al*, 2006) and in adults (Kato *et al*, 2001). Electroencephalographic (EEG) arousal does not change much with age in children (Scholle *et al*, 2012) while CAP phase A2 and A3, more related to RMMA, significantly decreased from preschoolers to school children (Bruni *et al*, 2002, 2005; Terzano *et al*, 2002). This suggests that arousal fluctuation in children in relation to development can be a physiological factor underlying curvilinear changes of SB prevalence.

Relationship to sleep breathing disorders

Parent-reported tooth grinding was independently correlated with several items categorized into the domain of OSA in the JSQ, as reported by the previous findings (Shimizu *et al*, 2014). Loud snoring and mouth opening during sleep were independently correlated with tooth grinding during sleep while witnessed respiratory pause was not. A significant correlation between SB and snoring has been supported by the previous studies in children (Ng *et al*, 2002; Ersu *et al*, 2004). Although studies have suggested the concomitant occurrence of tooth grinding in patients with OSA, a limited upper airway, rather than upper airway obstruction, could be a factor contributing to the relationship between snoring and SB in children and adolescents (Carra *et al*, 2012)

Table 5 Univariate and multivariate logistic regression analysis showing the crude and adjusted correlation between tooth grinding (TG) and 35 variables

	TG yes/no (%)	*Crude OR (95% CI)*	P *values*	*Adjusted OR (95% CI)*	P *values*
Sex					
Female	593/2405 (19.8)	1		1	–
Male	670/2355 (22.1)	1.15 (1.02–1.31)	0.024	1.09 (0.96–1.24)	0.2
Age					
2~4	319/1410 (18.5)	1.08 (0.87–1.33)	0.47	1.03 (0.81–1.31)	0.79
5~7	395/1046 (27.4)	1.80 (1.47–2.21)	<0.0001	1.72 (1.38–2.15)	<0.0001
8~10	386/1526 (20.2)	1.21 (0.99–1.48)	0.066	1.15 (0.93–1.43)	0.19
11~12	163/778 (17.3)	1	–	1	–
Sleeps alone					
No	1192/4412 (21.3)	1	–	1	–
Yes	71/348 (16.9)	0.76 (0.58–0.98)	0.032	0.86 (0.64–1.13)	0.28
I. Restless legs syndrome, sensory					
Says legs hurt at night					
No	1223/4656 (20.8)	1	–	1	–
Yes	40/104 (27.8)	1.46 (1.00–2.10)	0.049	1.13 (0.66–1.93)	0.66
Says legs feel hot at night					
No	1213/4621 (20.8)	1	–	1	–
Yes	50/139 (26.5)	1.37 (0.98–1.89)	0.067	1.08 (0.75–1.54)	0.66
Says legs feel strange at night					
No	1217/4634 (20.8)	1	–	1	–
Yes	46/126 (26.7)	1.39 (0.98–1.94)	0.067	0.89 (0.54–1.45)	0.65
II. Obstructive sleep apnea					
Moves a lot during sleep					
No	516/2628 (16.4)	1	–	1	–
Yes	747/2132 (25.9)	1.78 (1.57–2.02)	<0.0001	1.47 (1.29–1.68)	<0.0001
Sleeps with mouth open					
No	756/3566 (17.5)	1	–	1	–
Yes	507/1194 (29.8)	2.00 (1.76–2.28)	<0.0001	1.56 (1.35–1.81)	<0.0001
Sleeps with head arched back					
No	1124/4481 (20.1)	1	–	1	–
Yes	139/279 (33.3)	1.99 (1.60–2.45)	<0.0001	1.25 (0.99–1.59)	0.065
Snores loudly					
No	1015/4350 (18.9)	1	–	1	–
Yes	248/410 (37.7)	2.59 (2.18–3.08)	<0.0001	1.80 (1.47–2.20)	<0.0001
Stops breathing					
No	1215/4682 (20.6)	1	–	1	–
Yes	48/78 (38.1)	2.37 (1.64–3.40)	<0.0001	0.99 (0.65–1.51)	0.98
Snorts and gasps					
No	1187/4622 (20.4)	1	–	1	–
Yes	76/138 (35.5)	2.14 (1.60–2.85)	<0.0001	1.10 (0.78–1.53)	0.58
III. Morning symptoms					
Grumpy in the morning					
No	830/3387 (19.7)	1	–	1	–
Yes	433/1373 (24.0)	1.29 (1.13–1.47)	0.0002	1.17 (0.92–1.30)	0.3
Needs much time to wake up					
No	763/3123 (19.6)	1	–	1	–
Yes	500/1637 (23.4)	1.25 (1.10–1.42)	0.0006	1.03 (0.84–1.26)	0.79
Takes a long time to get out of bed					
No	834/3343 (20.0)	1	–	1	–
Yes	429/1417 (23.2)	1.21 (1.06–1.38)	0.0043	0.97 (0.79–1.19)	0.79
IV. Parasomnias					
Cries at night					
No	1219/4600 (20.9)	1	–	1	–
Yes	44/160 (21.6)	1.04 (0.73–1.44)	0.83	0.89 (0.59–1.32)	0.58
Wakes screaming and hard to be calmed down					
No	1235/4671 (20.9)	1	–	1	–
Yes	28/89 (23.9)	1.19 (0.76–1.80)	0.43	0.90 (0.54–1.47)	0.69
Woken by scary dreams					
No	1086/4231 (20.4)	1	–	1	–
Yes	177/529 (25.1)	1.30 (1.08–1.56)	0.0052	1.12 (0.91–1.37)	0.27
Wakes up at any little sound					
No	1215/4626 (20.8)	1	–	1	–
Yes	48/134 (26.4)	1.36 (0.97–1.89)	0.077	1.22 (0.84–1.75)	0.28
Awakes more than once during the night					
No	1226/4625 (21.0)	1	–	1	–
Yes	37/135 (21.5)	1.03 (0.71–1.48)	0.86	0.72 (0.47–1.07)	0.11

(continued)

Table 5 (continued)

	TG yes/no (%)	*Crude OR (95% CI)*	P *values*	*Adjusted OR (95% CI)*	P *values*
V. Insomnia/circadian rhythm disorders					
Late for (nursery) school due to waking up late					
No	1202/4567 (20.8)	1	–	1	–
Yes	61/193 (24.0)	1.20 (0.89–1.60)	0.23	0.93 (0.67–1.28)	0.66
Falls asleep during the daytime					
No	1209/4547 (21.0)	1	–	1	–
Yes	54/213 (20.2)	0.95 (0.70–1.30)	0.76	0.74 (0.53–1.02)	0.064
Snoozes at (nursery) school or kindergarten					
No	1248/4693 (21.0)	1	–	1	–
Yes	15/67 (18.3)	0.84 (0.46–1.44)	0.54	0.61 (0.32–1.09)	0.099
Goes to bed after 10 pm					
No	1051/3975 (20.9)	1	–	1	–
Yes	212/785 (21.3)	1.02 (0.86–1.20)	0.8	0.92 (0.75–1.12)	0.39
Gets excited at night					
No	1193/4600 (20.6)	1	–	1	–
Yes	70/160 (30.4)	1.69 (1.26–2.24)	0.0006	1.33 (0.95–1.84)	0.095
Gets grumpy at night					
No	1207/4577 (20.9)	1	–	1	–
Yes	56/183 (23.4)	1.16 (0.85–1.56)	0.35	0.87 (0.62–1.20)	0.4
Has no fixed pattern in sleep–wake cycle					
No	1136/4382 (20.6)	1	–	1	–
Yes	127/378 (25.1)	1.30 (1.05–1.60)	0.018	1.05(0.82–1.34)	0.67
Day–night reversal					
No	1248/4734 (20.9)	1	–	1	–
Yes	15/26 (36.6)	2.19 (1.13–4.09)	0.021	1.76 (0.85–3.54)	0.13
VI. Daytime excessive sleepiness					
Seems sleepy in the daytime					
No	1152/4399 (20.8)	1	–	1	–
Yes	111/361 (23.5)	1.17 (0.94–1.46)	0.16	0.86 (0.65–1.14)	0.3
Looks run down in the daytime					
No	1165/4486 (20.6)	1	–	1	–
Yes	98/274 (26.3)	1.38 (1.08–1.74)	0.011	1.13 (0.83–1.52)	0.44
VII. Daytime problematic behavior					
Restless in the daytime					
No	1037/4169 (19.9)	1	–	1	–
Yes	226/591 (27.7)	1.54 (1.30–1.82)	<0.0001	1.15 (0.92–1.44)	0.21
Poor concentration in the daytime					
No	1000/4027 (19.9)	1	–	1	–
Yes	263/733 (26.4)	1.44 (1.23–1.69)	<0.0001	1.06 (0.85–1.30)	0.62
VIII. Sleep habit					
Sleeps without being tucked in					
No	516/2628 (16.4)	1	–	1	–
Yes	747/2132 (25.9)	0.99 (0.87–1.13)	0.87	1.00 (0.84–1.19)	<0.0.99
Goes to bed by himself/herself					
No	553/2018 (21.5)	1	–	1	–
Yes	710/2742 (20.6)	0.95 (0.83–1.07)	0.38	0.95 (0.80–1.13)	0.56
IX. Insufficient sleep					
Stays up later than usual the day before a holiday					
No	694/2688 (20.5)	1	–	1	–
Yes	569/2072 (21.5)	1.06 (0.94–1.20)	0.33	0.93 (0.81–1.08)	0.35
Wakes up later on holidays					
No	635/2532 (20.1)	1	–	1	–
Yes	628/2228 (22.0)	1.12 (0.99–1.27)	0.065	1.10 (0.95–1.26)	0.23
X. Restless legs syndrome, motor					
Rubs feet at night					
No	1223/4657 (20.8)	1	–	1	–
Yes	40/103 (28.0)	1.48 (1.01–2.12)	0.044	0.90 (0.52–1.52)	0.69
Touches feet at night					
No	1219/4668 (20.7)	1	–	1	–
Yes	44/92 (32.4)	1.83 (1.26–2.62)	0.0018	1.42 (0.84–2.37)	0.19

and in adults (Dumais *et al*, 2015). Clearly, complex interactions between tooth grinding and factors related to airway flow limitation should be clarified in physiological studies.

In addition, SB was correlated with 'moves a lot during sleep'; this item was also incorporated into the domain of OSA in this questionnaire (Shimizu *et al*, 2014). Movements during sleep are often observed in pediatric OSA patients (Agargun *et al*, 2004; Coussens *et al*, 2014). Moreover, movements during sleep occur more frequently in children than in adolescents and adults (De Koninck *et al*, 1992). Although jaw motor activation in SB patients

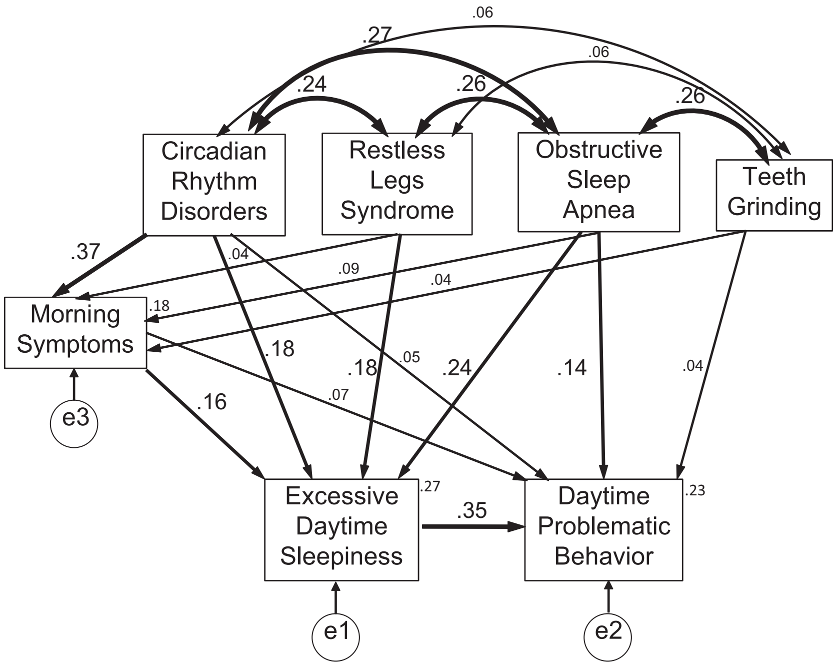

Figure 2 A proposed model showing standardized coefficients for daytime problematic behavior. All path coefficients are significant, $P < 0.01$. Chi-square = 1.034, $P = 0.596$, comparative fit index = 1.000, root mean square error of approximation = 0.000

is often correlated with motor signs of arousals such as leg jerking and body movements (Kato *et al*, 2013), whether or not a higher number of movement arousals are related to the occurrence of RMMA remain to be investigated in children.

Relationship to daytime problematic behavior

Recent studies showed that children with SB have a higher likelihood of hyperactivity (Herrera *et al*, 2006; Petit *et al*, 2007; Ghanizadeh, 2008) and low neurocognitive or academic performance (Lam *et al*, 2011; Insana *et al*, 2013; Serra-Negra *et al*, 2013). Similarly, crude analysis showed a significant correlation between SB and daytime problematic behaviors in this study. Nonetheless, this correlation was not found in the multiple logistic regression analysis. In addition, the SEM revealed a significant but very weak direct correlation between the two. Rather, daytime problematic behavior was more influenced by OSA (0.14) and excessive daytime symptoms related to various sleep problems (0.35). Generally, the results of the s.e.m. would support accumulated findings that compromised daytime problematic behavior is commonly observed among children with sleep problems related to sleep disorders such as parasomnias (Agargun *et al*, 2004; Shur-Fen Gau, 2006) and sleep apnea/snoring (Ng *et al*, 2005; Sogut *et al*, 2005; Shur-Fen Gau, 2006). Therefore, the relationship between SB and daytime problematic behavior may be influenced by the combinations among the comorbid sleep problems in the developmental processes of children.

Study limitations

Methodological limitations should be acknowledged for interpreting the data in this study. First, physiological evaluations would increase precision in identifying SB (Maluly *et al*, 2013). However, a questionnaire assessment was used in this study because it is a common strategy in a community epidemiological study, especially in children, to estimate the characteristic phenomena of SB such as tooth grinding. Although the JSQ has been previously validated (Shimizu *et al*, 2014), there is not yet a validated questionnaire to assess SB. It is possible for parents to misclassify tooth grinding noise during sleep depending on the parents' knowledge of tooth grinding or understanding of the questions. Another study limitation might be related to dental status in the study population, as the deciduous dental arch is completed at around age 2.5 years and tooth replacement starts around 5–6 years of age and continues until early adolescence. We did not evaluate how many teeth can engage in tooth contacts that can influence the generation of tooth grinding noise during the tooth replacement period in older school children. Finally, physical and health conditions related to SB and behavioral problems (Insana *et al*, 2013) were not included in the analysis.

In conclusion, parent-reported SB was reported in 21.0% of Japanese children from 2 to 12 years of age, who co-slept with guardians. Age was an independent factor affecting the prevalence of SB in children. Parent-reported SB was found to be correlated with clinical signs related to sleep-disordered breathing. The comorbidity of OSA may contribute to the relationship between daytime problematic behavior and SB. Further epidemiological and physiological investigations are needed to identify comorbid conditions that could explain the relationships among SB, age, and daytime problematic behavior.

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Author contributions

TK conceived the study. MT[1], KKN, IM collected data, and MT[1] and MT[2] analyzed data. MT[1], TK, SM, and MT[2] interpreted data, and MT[1], TK, and MT[2] wrote first draft. All authors contributed in writing final manuscript and have approved the final version.

Conflict of interest

None to declare.

References

Agargun MY, Cilli AS, Sener S *et al* (2004). The prevalence of parasomnias in preadolescent school-aged children: a Turkish sample. *Sleep* **27**: 701–705.

American Academy of Sleep Medicine (2014). *International classification of sleep disorders*, 3rd edn. American Academy of Sleep Medicine: Darien, IL.

Bruni O, Ferri R, Miano S *et al* (2002). Sleep cyclic alternating pattern in normal school-age children. *Clin Neurophysiol* **113**: 1806–1814.

Bruni O, Ferri R, Miano S *et al* (2005). Sleep cyclic alternating pattern in normal preschool-aged children. *Sleep* **28**: 220–230.

Carra MC, Huynh N, Morton P *et al* (2011). Prevalence and risk factors of sleep bruxism and wake-time tooth clenching in a 7- to 17-yr-old population. *Eur J Oral Sci* **119**: 386–394.

Carra MC, Bruni O, Huynh N (2012). Topical review: sleep bruxism, headaches, and sleep-disordered breathing in children and adolescents. *J Orofac Pain* **26**: 267–276.

Coussens S, Baumert M, Kohler M *et al* (2014). Movement distribution: a new measure of sleep fragmentation in children with upper airway obstruction. *Sleep* **37**: 2025–2034.

De Koninck J, Lorrain D, Gagnon P (1992). Sleep positions and position shifts in five age groups: an ontogenetic picture. *Sleep* **15**: 143–149.

Dumais IE, Lavigne GJ, Carra MC, Rompre PH, Huynh NT (2015). Could transient hypoxia be associated with rhythmic masticatory muscle activity in sleep bruxism in the absence of sleep-disordered breathing? A preliminary report. *J Oral Rehabil* **42**: 810–818.

Ersu R, Arman AR, Save D *et al* (2004). Prevalence of snoring and symptoms of sleep-disordered breathing in primary school children in istanbul. *Chest* **126**: 19–24.

Ghanizadeh A (2008). ADHD, bruxism and psychiatric disorders: does bruxism increase the chance of a comorbid psychiatric disorder in children with ADHD and their parents? *Sleep Breath* **12**: 375–380.

Herrera M, Valencia I, Grant M, Metroka D, Chialastri A, Kothare SV (2006). Bruxism in children: effect on sleep architecture and daytime cognitive performance and behavior. *Sleep* **29**: 1143–1148.

Insana SP, Gozal D, McNeil DW, Montgomery-Downs HE (2013). Community based study of sleep bruxism during early childhood. *Sleep Med* **14**: 183–188.

Iwata S, Iwata O, Matsuishi T (2013). Sleep patterns of Japanese preschool children and their parents: implications for co-sleeping. *Acta Paediatr* **102**: e257–e262.

Kato T, Rompre P, Montplaisir JY, Sessle BJ, Lavigne GJ (2001). Sleep bruxism: an oromotor activity secondary to micro-arousal. *J Dent Res* **80**: 1940–1944.

Kato T, Velly AM, Nakane T, Masuda Y, Maki S (2012). Age is associated with self-reported sleep bruxism, independently of tooth loss. *Sleep Breath* **16**: 1159–1165.

Kato T, Blanchet PJ, Huynh NT, Montplaisir JY, Lavigne GJ (2013). Sleep bruxism and other disorders with orofacial activity during sleep. In: Chokroverty S, Allen RP, Walters A, Montagna P, eds. *Sleep and movement disorders*. 2nd edn. Oxford University Press: New York, pp. 555–572.

Laberge L, Tremblay RE, Vitaro F, Montplaisir J (2000). Development of parasomnias from childhood to early adolescence. *Pediatrics* **106**: 67–74.

Lam MH, Zhang J, Li AM, Wing YK (2011). A community study of sleep bruxism in Hong Kong children: association with comorbid sleep disorders and neurobehavioral consequences. *Sleep Med* **12**: 641–645.

Latz S, Wolf AW, Lozoff B (1999). Cosleeping in context: sleep practices and problems in young children in Japan and the United States. *Arch Pediatr Adolesc Med* **153**: 339–346.

Lavigne GJ, Montplaisir JY (1994). Restless legs syndrome and sleep bruxism: prevalence and association among Canadians. *Sleep* **17**: 739–743.

Liu X, Ma Y, Wang Y *et al* (2005). Brief report: an epidemiologic survey of the prevalence of sleep disorders among children 2 to 12 years old in Beijing, China. *Pediatrics* **115**: 266–268.

Maluly M, Andersen ML, Dal-Fabbro C *et al* (2013). Polysomnographic study of the prevalence of sleep bruxism in a population sample. *J Dent Res* **92**: 97S–103S.

Manfredini D, Restrepo C, Diaz-Serrano K, Winocur E, Lobbezoo F (2013). Prevalence of sleep bruxism in children: a systematic review of the literature. *J Oral Rehabil* **40**: 631–642.

Ng DK, Kwok KL, Poon G, Chau KW (2002). Habitual snoring and sleep bruxism in a paediatric outpatient population in Hong Kong. *Singapore Med J* **43**: 554–556.

Ng DK, Kwok KL, Cheung JM *et al* (2005). Prevalence of sleep problems in Hong Kong primary school children: a community-based telephone survey. *Chest* **128**: 1315–1323.

Ohayon MM, Li KK, Guilleminault C (2001). Risk factors for sleep bruxism in the general population. *Chest* **119**: 53–61.

Owens JA, Witmans M (2004). Sleep problems. *Curr Probl Pediatr Adolesc Health Care* **34**: 154–179.

Petit D, Touchette E, Tremblay RE, Boivin M, Montplaisir J (2007). Dyssomnias and parasomnias in early childhood. *Pediatrics* **119**: e1016–e1025.

Reding GR, Rubright WC, Zimmerman SO (1966). Incidence of bruxism. *J Dent Res* **45**: 1198–1204.

Renner AC, da Silva AA, Rodriguez JD *et al* (2012). Are mental health problems and depression associated with bruxism in children? *Commun Dent Oral Epidemiol* **40**: 277–287.

Scholle S, Wiater A, Scholle HC (2012). Normative values of polysomnographic parameters in childhood and adolescence: arousal events. *Sleep Med* **13**: 243–251.

Serra-Negra JM, Paiva SM, Seabra AP, Dorella C, Lemos BF, Pordeus IA (2010). Prevalence of sleep bruxism in a group of Brazilian schoolchildren. *Eur Arch Paediatr Dent* **11**: 192–195.

Serra-Negra JM, Paiva SM, Abreu MH, Flores-Mendoza CE, Pordeus IA (2013). Relationship between tasks performed, personality traits, and sleep bruxism in Brazilian school children–a population-based cross-sectional study. *PLoS One* **8**: e80075.

Shimizu S, Kato-Nishimura K, Mohri I *et al* (2014). Psychometric properties and population-based score distributions of the Japanese Sleep Questionnaire for Preschoolers. *Sleep Med* **15**: 451–458.
Shur-Fen Gau S (2006). Prevalence of sleep problems and their association with inattention/hyperactivity among children aged 6-15 in Taiwan. *J Sleep Res* **15**: 403–414.
Simola P, Niskakangas M, Liukkonen K *et al* (2010). Sleep problems and daytime tiredness in Finnish preschool-aged children-a community survey. *Child Care Health Dev* **36**: 805–811.
Sogut A, Altin R, Uzun L *et al* (2005). Prevalence of obstructive sleep apnea syndrome and associated symptoms in 3–11-year-old Turkish children. *Pediatr Pulmonol* **39**: 251–256.
Suwa S, Takahara M, Shirakawa S *et al* (2009). Sleep bruxism and its relationship to sleep habits and lifestyle of elementary school children in Japan. *Sleep Biol Rhythms* **7**: 93–102.
Terzano MG, Parrino L, Rosa A, Palomba V, Smerieri A (2002). CAP and arousals in the structural development of sleep: an integrative perspective. *Sleep Med* **3**: 221–229.