Kobe J. Med. Sci., Vol. 68, No. 1 , pp. E23-E29, 2022

Increase in the Number and Duration of Sleep Episodes During Class After Reopening of Schools Following Closure due to COVID-19

SHIGEMI KIMURA[1,2,*], YUTAKA TAKAOKA [2,3], and AKI SUGANO [2,4]

[1]*Children's Rehabilitation, Sleep & Development Medical Center, Hyogo Prefectural Rehabilitation Central Hospital, Kobe, Japan;*

[2]*Division of Medical Law and Ethics, Department of Medical Systems, Kobe University Graduate School of Medicine, Kobe, Japan;*

[3]*Data Science Center for Medicine and Hospital Management, Toyama University Hospital, Toyama, Japan;*

[4]*Center for Clinical Research, Toyama University Hospital, Toyama, Japan*

**Corresponding author*

Received 30 August 2022/ Accepted 24 November 2022

Keywords: COVID-19 pandemic, School closure, Sleeping during class, Hypersomnolence disorders, School-aged population

Sleep is important for the well-being of school-aged children. Almost all schools in Hyogo prefecture in Japan were closed from April 7 to May 31, 2020, owing to the coronavirus disease 2019 pandemic. The pandemic restrictions resulted in the disruption of the sleep routines of children. The number of children who experienced sleepiness in class after school closure increased. The number of children who visited our hospital 1 year before and after the closure was 208 (11.73 ± 3.24 years of age) and 155 (11.45 ± 3.30 years), respectively. The number of chief complaints of sleep-related symptoms at the first visits showed no significant difference between the two time periods. The percentage of patients who slept during class increased (but not significantly) after the school closure. However, the mean number and duration of sleep episodes during class significantly increased from 0.31 ± 0.76 to 1.04 ± 1.14 episodes/day and from 15.8 ± 38.6 to 45.7 ± 46.9 min/day (each P < 0.001) before and after school closure, respectively. The total number of patients in our hospital with the primary central disorders of hypersomnolence, i.e., narcolepsy, idiopathic hypersomnia, and Kleine–Levin syndrome, and the number of patients with insufficient sleep syndrome after the school closure significantly increased compared with those before closure (P = 0.034 and 0.048, respectively). School closure was associated with an increased incidence of sleeping during class; therefore, maintaining a stable daily routine for children with sleep disorders could have an alleviating effect.

The outbreak of coronavirus disease 2019 (COVID-19) has affected the lives of children and adolescents worldwide. The Japanese government declared the first state of emergency in April 2020. Primary, junior high, and high schools, and universities in Hyogo prefecture, Japan, were closed from April 7 to May 31, 2020, leading to a perceived increase in the number of patients who visited our hospital with complaints of sleepiness in class after school reopening. It was reported that the Japanese elementary and junior high school students who stayed up late at night during the school closure, experienced greater difficulty in getting up in the morning and slept longer than those students who returned to school [1]. It was also reported that the COVID-19 pandemic resulted in significantly later bedtimes and longer internet use time after the school closure than before [2,3]. In addition, more than half of the participants in the study had later wake-up, breakfast, and lunch times after the school closure, which was associated with more unfavorable lifestyle changes and dietary intake [4]. Several studies worldwide also reported lower sleep quality and poor mental well-being because of the restrictions during lockdown [5,6]. However, to date, the impact of COVID-19 on children with sleep disorders has not been well documented.

In circadian rhythm disorders, an individual's internal sleep-wake rhythm and light-dark cycle are desynchronized [7]. Individuals with circadian rhythm disorders cannot sleep or wake up naturally as required for their work, school, or social obligations. In delayed sleep-wake phase disorder, a person remains asleep for several hours beyond the intended wake time, whereas advanced sleep-wake phase disorder shifts sleeping and waking times several hours earlier than the desired or customary time. Other types of circadian rhythm disorders include the following: irregular sleep-wake rhythm, wherein a person does not have a clear circadian rhythm; non-24-h sleep-wake rhythm, wherein a person's natural circadian rhythm does not align with the 24-h day; and

Phone: +81-078-927-2727 Fax: +81-078-925-9203 E-mail: 3658kimura1@gmail.com

circadian rhythm sleep disorder not otherwise specified, which is a disorder that is difficult to categorize into any of the aforementioned classifications [8].

Central disorders of hypersomnolence are characterized by severe daytime sleepiness despite normal quality and timing of nocturnal sleep and can be classified into eight subtypes according to the International Classification of Sleep Disorders, Third Edition (ICSD-3) [9]. This classification divides sleeping disorders into two categories: primary forms, i.e., occurring on their own because of an abnormality of hypocretin-1 or the immune system; and secondary forms, i.e., caused by an intimately related different condition. Primary forms, such as narcolepsy types 1 and 2 [10], idiopathic hypersomnia [11], and Kleine–Levin syndrome [12] are diagnosed based on symptoms and sleep testing results, whereas, in secondary forms, hypersomnia is caused by medical conditions, medication or substance use, psychiatric conditions, or insufficient sleep syndrome (ISS) [13].

Our study aimed to compare sleep pattern changes in school-aged children before and after school closure during the COVID-19 pandemic.

MATERIALS AND METHODS

Participants

The study was approved by our institutional ethics committee (permit number 2104) and conformed to the tenets of the Declaration of Helsinki. Informed consent was obtained from the parents or legal guardians of all participants.

Our Children's Rehabilitation, Sleep & Development Medical Center in Hyogo Prefectural Rehabilitation Central Hospital has two divisions: rehabilitation and sleep disorders. Almost all disabled children are seen by a pediatric orthopedic surgeon, and children with sleep disorders are seen by three pediatricians.

A total of 396 new patients visited the pediatric department of the hospital for treatment of sleep disorders between April 7, 2019, and April 6, 2020, before the 54-day school closure during the COVID-19 pandemic, and 261 new patients visited the department for the treatment of sleep disorders between June 1, 2020, and May 31, 2021, after the schools reopened. Preschool patients were excluded, and patients with diseases, such as cerebral palsy and muscular dystrophy, and chromosomal abnormalities were also excluded. We investigated the sleep patterns of school-aged children by collecting and comparing the chief complaints of 208 patients (boys, 112; girls, 96; mean age, 11.73 ± 3.24 years) one year before the school closure to those of 155 patients (boys, 87; girls, 68; mean age, 11.45 ± 3.30 years) one year after school reopening; the comparison of mean age between the groups revealed no significant differences (P = 0.42) (Figure 1).

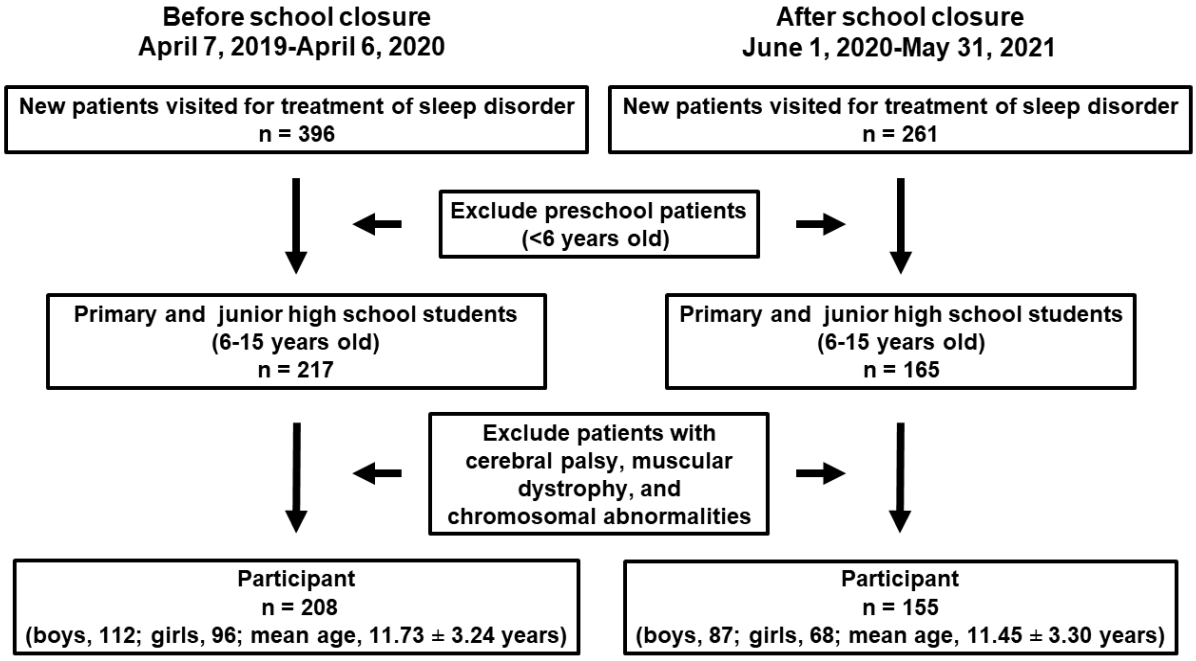

Figure 1. Data collection flow chart. The number of new patients depended on the number of available doctors qualified to manage these cases (three before school closure, two after school closure).

Study design

The sleep-related chief complaints of patients who visited our hospital were retrospectively compared before and after school closure due to the COVID-19 pandemic. Subsequently, we focused on the complaint that underwent the largest change (indicated by the smallest P-value) and analyzed the sleep logs and diagnoses of the patients with this complaint.

Analysis of sleep-related symptoms

This analysis included data obtained from the interview forms in the medical records of the participants' first visit, during which families were asked to select the appropriate chief complaints of sleep-related symptoms, namely, difficulty waking up, difficulty falling asleep, bad mood before sleeping, interrupted sleep, waking up very early in the morning, unrefreshing sleep, snoring, difficulty sleeping owing to a stuffy nose, talking during sleep, nightmares, night terrors, restless legs, itchiness during sleep, daytime drowsiness, sleeping during class, sleeping in the evening, absenteeism from school >2 days per week, and duration of use of electronic devices.

Analysis of sleep logs

The sleep logs were sent to the participants by mail before their first visit. The timing of sleep onset and awakening, total sleep duration, number and duration of episodes of awakening from sleep, and frequency and duration of sleeping during class were collected from the sleep logs. Sleeping during class was confirmed by sleep logs and information received from teachers and patients, according to the medical record. The daily means and standard deviations were calculated based on the data from the week before visiting our hospital.

Test of central disorders of hypersomnolence

Polysomnography (PSG) and the multiple sleep latency test (MSLT) (Pro-Tech Body position sensors, Phillips/Respironics Murrysville, PA, USA) were performed according to the standard protocols. Central disorders of hypersomnolence were diagnosed using sleep logs, PSG, MSLT, and medical records according to ICSD-3 [9]. Narcolepsy type 1 was diagnosed without measuring cerebrospinal fluid hypocretin-1 concentration because the affected patients clearly showed cataplexy. The diagnosis of ISS was confirmed by a reduction in sleeping during class and an extension of total sleep time to distinguish it from narcolepsy.

Statistical analysis

Statistical analyses were conducted using Microsoft Excel 2016 (Microsoft, Redmond, WA, USA). The chi-squared test was used to compare the data in the medical records obtained at the first visit before school closure with the corresponding values after school reopening for the number of sleep-related chief complaints, absence from school for >2 days per week, and duration of daily use of electronic devices, and presence of ISS.

Paired Student's t-test was used to compare normally distributed data (i.e., patients' age before and after school closure and total sleep duration). Nonparametric Mann–Whitney U test was used to compare non-normally distributed data (i.e., time of sleep onset and offset, number of episodes and average duration of awakenings from sleep, and number and average duration of sleeping during class). Differences in the incidence rates of the total number of patients with narcolepsy types 1 and 2, idiopathic hypersomnia, and Kleine–Levin syndrome between the 208 patients identified one year before school closure and 155 patients identified in the year after reopening were analyzed using the two-sided Fisher's exact test using R software v4.1.3 (R Foundation for Statistical Computing, Vienna, Austria) for a small number. Statistical significance was set at $P < 0.05$.

RESULTS

Changes in sleep-related symptoms and sleep logs

There were no significant differences in sleep disorder complaints, number of patients absent from school for >2 days per week, and duration of daily use of electronic devices before and after school closure (Table I). According to the PSG results, no patient had obstructive or central sleep apnea. In terms of sleep-related chief complaints, the smallest P-values (0.14) for the differences before and after school closure were obtained for nightmares and sleeping during class. The percentage of children with nightmares decreased from 12.5% (26/208) to 7.7% (12/155). The percentage of patients who slept during class was greater after reopening (31.6%, 49/155) than before closure (24.5%, 51/208). We decided to focus on sleeping during class because few children had nightmares.

Table I. Changes in sleep-related chief complaints, absenteeism from school, and duration of use of electronic devices by patients before and after school closure during the COVID-19 pandemic

	Before	**After**	**Ratio***	**P-value†**
	n = 208	**n = 155**	**After/Before**	
Boys/Girls (n)	**112/96**	**87/68**		
Age (mean ± SD, years)	**11.73 ± 3.24**	**11.45 ± 3.30**		
Difficulty in falling asleep	120 (57.7)	80 (51.6)	89.5	0.22
Bad mood before sleeping	15 (7.2)	13 (8.4)	116.3	0.69
Interrupted sleep	73 (35.1)	51 (32.9)	93.8	0.63
Waking up very early in the morning	21 (10.1)	21 (13.5)	134.2	0.32
Difficulty in waking up	155 (74.5)	106 (68.4)	91.8	0.17
Unrefreshing sleep	57 (27.4)	39 (25.2)	91.8	0.60
Snoring	29 (13.9)	20 (12.9)	92.6	0.75
Difficulty in sleeping owing to a stuffy nose	11 (5.29)	11 (7.1)	134.2	0.48
Talking during sleep	26 (12.5)	13 (8.4)	67.1	0.20
Nightmares	26 (12.5)	12 (7.7)	61.9	0.14
Night terrors	13 (6.3)	11 (7.1)	113.6	0.76
Restless legs	22 (10.6)	13 (8.4)	79.3	0.47
Itchiness during sleep	18 (8.7)	8 (5.2)	59.6	0.20
Daytime drowsiness	75 (36.1)	48 (31.0)	85.9	0.29
Sleeping during class	51 (24.5)	49 (31.6)	128.9	0.14
Sleeping in the evening	37 (17.8)	33 (21.3)	119.7	0.34
Absenteeism from school >2 days per week	92 (48.9)	66 (48.2)	98.6	0.82
	n = 186	n = 137		
Duration of using electronic devices	4.61 ± 3.84	4.63 ± 4.03	100.4	0.95‡
(mean ± SD: h/day)	n = 168	n = 121		

The before and after data are presented as frequencies (percentages).
SD, standard deviation; COVID-19, coronavirus disease 2019. "Electronic devices" include online gaming and watching television and YouTube using smartphones and computers.
*Ratio of the percentage after school closure to the percentage before school closure (expressed as a percentage).
†Chi-squared test
‡Mann–Whitney U test

Changes in the sleep logs of patients who slept during class

The increase in the number of patients sleeping during class was the principal focus of this study. The differences in the times of sleep onset and offset, mean total sleep duration, and mean number and duration of awakenings from sleep before and after closure were not significant. However, the mean number of episodes and duration of sleeping during class before and after closure significantly increased from 0.31 ± 0.77 to 1.04 ± 1.14 episodes/day ($P < 0.001$) and from 15.8 ± 38.6 to 45.7 ± 46.9 min/day ($P < 0.001$), respectively (Table II).

Table II. Changes in sleep pattern at night and the time and duration of sleeping during class before and after school closure in patients who selected "sleeping during class" on interview forms before their first visit

	Before school closure	**After school closure**	**P-value***
	(n = 51, mean ± SD)	**(n = 49, mean ± SD)**	
Boys/Girls(n)	**29/22**	**30/19**	
Age (mean ± SD)	**12.57 ± 2.07**	**12.02 ± 2.68**	
Sleep onset (time of day)	**23:38 ± 1:50**	**23:33 ± 1:38**	**0.65**
Sleep offset (time of day)	**8:09 ± 1:51**	**8:18 ± 1:54**	**0.70**
TST (h)	**8.57 ± 1.41**	**8.56 ± 1.95**	**0.96†**
Interrupted sleep (n)	**0.17 ± 0.74**	**0.12 ± 0.37**	**0.98**
Interrupted sleep (duration, min)	**9.1 ± 34.9**	**4.30 ± 12.6**	**0.81**
Sleeping during class (n)	**0.31 ± 0.77**	**1.04 ± 1.14**	**P < 0.001**
Sleeping during class (duration, min)	**15.8 ± 38.6**	**45.7 ± 46.9**	**P < 0.001**

SD, standard deviation; TST, total sleep time (hours); Interrupted sleep (n), number of awakenings from sleep (episodes/day); Interrupted sleep (duration), average duration of awakenings from sleep (min/day); sleeping during class (n), number of sleep episodes during class (episodes/day); sleeping during class (duration), average duration of sleeping during class (min/day)
*Mann–Whitney U test
†Student's t-test

Diagnosis of the patients who slept during class

・Circadian rhythm disorders

The number of patients with delayed sleep-wake phase disorder, advanced sleep-wake phase disorder, an irregular sleep-wake rhythm, a non-24-h sleep-wake rhythm, and circadian rhythm sleep disorder, not otherwise specified, were 29 (percentage of patients sleeping during class; 56.9%), 1 (2.0%), 3 (5.9%), 0, and 5 (9.8%), respectively, before school closure, and 16 (32.7%), 0, 2 (4.1%), 0, and 2 (4.1%), respectively, after school reopening. Their chief complaints included not only sleeping during class but also other sleep-related complaints.

・Incidence of central disorders of hypersomnolence

The present study was conducted considering the possibility of an increase in the incidence of central disorders of hypersomnolence. The number of cases of the primary forms, such as narcolepsy types 1 and 2, idiopathic hypersomnia, and Kleine–Levin syndrome increased after school closure from 1 to 2, 2 to 4, 0 to 2, and 0 to 1, respectively. Although there was no significant difference among the diseases owing to the small sample size, the number of cases of these primary forms of sleep disorders in the total patient cohorts (208 patients identified one year before school closure and 155 patients identified in the year after reopening) increased significantly from 3 (1.4%) before school closure to 9 (5.8%) after school reopening ($P = 0.034$). The chief complaint of all the patients with primary forms of central disorders of hypersomnolence was sleeping during class. Importantly, the study participants had not been vaccinated against COVID-19 and had not had COVID-19. Vaccination of teenagers had not started in Japan during the study period, and we confirmed that none of the participants had a history of COVID-19 based on a review of their medical records.

There was no patient with the secondary form of central disorders of hypersomnolence due to medical conditions, medication or substance use, or psychiatric condition because none of the patients had anxiety or mood disorders.

The number of patients with ISS among patients who complained of sleeping during class increased from 10 (19.6%) before school closure to 21 (42.9%) after school reopening. However, the number of patients with ISS significantly increased from 28 (ratio to the total number: 13.5%) to 33 (21.3%) ($P = 0.048$). The chief complaints of patients with ISS were not only sleeping during class but also daytime drowsiness.

DISCUSSION

Our results, obtained from the interview forms in the medical records of the participants' first visit, indicated no significant changes in sleep disorder complaints, number of patients absent from school for >2 days per week, or duration of daily use of electronic devices over the school closure period during the COVID-19 pandemic. According to the results of the interview forms, the percentage of new patients who complained of sleeping during class increased after the school closure, although this increase was not significant. Nakayama et al. revealed that children stayed up significantly later at night and had more difficulty getting up in the morning after the COVID-19 pandemic than before [2]. The participants in their study were students who did not visit the hospital. However, the participants in our study visited our hospital for therapy for sleep disorders. Hence, the differences in the results can be attributed to the difference in the type of participants. Furthermore, according to the sleep log data, the mean number and duration of sleep episodes during class increased significantly in our study.

The most common diagnosis among the patients who complained of sleeping during class was delayed sleep-wake phase disorder. The sleep logs revealed that the sleep onset and offset times before school closure were 23:38 ± 1:50 and 8:09 ± 1:51, respectively, and after school closure were 23:33 ± 1:38 and 8:18 ± 1:54, respectively. Thus, the sleep cycles were consistent with the diagnosis. Patients with circadian rhythm disorders may sleep during class [14].

The significant increase in the mean number of episodes and duration of sleeping during class after school closure indicated a significant increase in the central disorders of hypersomnolence. Furthermore, the number of patients with primary forms of central disorders of hypersomnolence, such as narcolepsy types 1 and 2, idiopathic hypersomnia, and Kleine–Levin syndrome, and the number of patients with ISS, significantly increased compared with those before school closure. All patients with primary forms of central disorders of hypersomnolence complained of sleeping during class in the interview form. In contrast, patients with ISS and circadian rhythm disorders mentioned not only sleeping during class but also daytime drowsiness or difficulty in waking up, which are characteristic of this disorder.

Additionally, the numbers of patients with primary forms of central disorders of hypersomnolence in 2015, 2016, 2017, 2018, 2019, and 2020 in our hospital were 2 (total patients; n = 526), 1 (n = 596), 0 (n = 449), 2 (n = 465), 3 (n = 369), and 9 (n = 261), respectively (unpublished data).

The prevalence of narcolepsy with cataplexy has been reported as 0.025% to 0.05% [15]. Globally, its prevalence is highest in Japan (0.16%) and lowest in Israel (0.0002%) [16]. Its age of onset in clinical populations appears to be bimodal, with the first peak at 15 years and the second at 35 years [17]. Kleine–Levin syndrome is a rare disorder with an estimated prevalence of 1–5/10^6 population when the ICSD-3 diagnostic criteria are applied [18]. Hence, the primary forms of central disorders of hypersomnolence are rare diseases. Further studies involving these disorders with larger sample sizes are needed.

A three-fold increase in narcolepsy onset was reported following the 2009 H1N1 winter influenza pandemic in China [19]. The autoimmune-mediated mechanism induced by influenza A virus H1N1 infection and vaccination was assumed to be a potential trigger for narcolepsy [20]. Alternatively, several environmental factors have been investigated as risk factors for narcolepsy. These factors, such as eating habits, obesity, migraines, and psychological stressors, could be the consequences rather than causes of narcolepsy [16].

The percentage of patients who reported daytime drowsiness decreased from 36.1% before school closure to 31.0% after school closure (after/before ratio, 85.9%). These results indicate that patients with narcolepsy types 1 and 2, idiopathic hypersomnia, Kleine–Levin syndrome, and ISS who originally complained of daytime drowsiness started sleeping in class after school closure during the COVID-19 pandemic.

These results showed that the mean number and duration of sleep episodes during class and the number of patients with primary forms of central disorders of hypersomnolence and ISS significantly increased after school closure during the COVID-19 pandemic. Further studies are needed on the central disorders of hypersomnolence with larger sample sizes. Our study findings concluded that school closure during the COVID-19 pandemic was associated with an increase in the mean number and duration of sleep episodes during class after school reopening.

ACKNOWLEDGEMENTS

We thank the staff at the Children's Rehabilitation, Sleep, and Development Medical Center, Hyogo Prefectural Rehabilitation Central Hospital, especially Dr. Makiko Toyoura, who provided sound advice for the care of the patients.

CONFLICT OF INTERESTS

The authors declare no conflicts of interest in association with the present study.

REFERENCES

1. Saito M, Kikuchi Y, Lefor AK, Hoshina M. Mental health in Japanese children during school closures due to the COVID-19. Pediatr Int. 2022;64(1):e14718.
2. Nakayama H, Matsuzaki T, Mihara S, Kitayuguchi T, Higuchi S. Change of Internet Use and Bedtime among Junior High School Students after Long-Term School Closure Due to the Coronavirus Disease 2019 Pandemic. Children (Basel). 2021; 8(6):480. doi: 10.3390/children8060480.
3. Ueno C, Yamamoto S. The relationship between behavioral problems and screen time in children during COVID-19 school closures in Japan. Scand J Child Adolesc Psychiatr Psychol. 2022;10:1-8.
4. Sugimoto M, Murakami K, Sasaki S. Temporal patterns of sleep and eating among children during school closure in Japan due to COVID-19 pandemic: associations with lifestyle behaviours and dietary intake. Public Health Nutr. 2022;16:1-15.
5. Illingworth G, Mansfield KL, Espie CA, Fazel M, Waite F. Sleep in the time of COVID-19: findings from 17000 school-aged children and adolescents in the UK during the first national lockdown. Sleep Adv. 2022;3(1):zpab021.
6. Micheletti MB, Cafiero P, Nápoli S, Lejarraga C, Bradichansky PP, Vitale MP, et al. Sleep problems in a sample of children with developmental disorders, before and during the COVID-19 pandemic. Arch Argent Pediatr. 2021;119(5):296-303.
7. Sateia MJ. International classification of sleep disorders-third edition: highlights and modifications. Chest. 2014;146(5):1387-94.
8. Zhu L, Zee PC. Circadian rhythm sleep disorders. Neurol Clin. 2012;30(4):1167-91.
9. American Academy of Sleep Medicine International Classification of Sleep Disorders. Illinois: American Academy of Sleep Medicine; 2014.
10. Nevsimalova S. Narcolepsy in childhood. Sleep Med Rev. 2009;13(2):169-80.
11. Trotti LM. Idiopathic hypersomnia. Sleep Med Clin. 2017;12(3):331-44.
12. Afolabi-Brown O, Mason TBA. Kleine–Levin syndrome. Paediatr Respir Rev. 2018;25:9-13.
13. Kohyama J, Anzai Y, Ono M, Kishino A, Tamanuki K, Takada K, et al. Insufficient sleep syndrome: an

unrecognized but important clinical entity. Pediatr Int. 2018;60(4):372-5.
14. Kimura S, Takaoka Y, Toyoura M, Kohira S, Ohta M. Core body temperature changes in school-age children with circadian rhythm sleep-wake disorder. Sleep Med. 2021;87:97-104.
15. Longstreth WT Jr, Koepsell TD, Ton TG, Hendrickson AF, van Belle G. The epidemiology of narcolepsy. Sleep. 2007;30(1):13-26.
16. Dauvilliers Y, Arnulf I, Mignot E. Narcolepsy with cataplexy. Lancet. 2007;369(9560):499-511.
17. Dauvilliers Y, Montplaisir J, Molinari N, Carlander B, Ondze B, Besset A, et al. Age at onset of narcolepsy in two large populations of patients in France and Quebec. Neurology. 2001;57(11):2029-33.
18. Gadoth N, Oksenberg A. Kleine-Levin syndrome; an update and mini-review. Brain Dev. 2017;39(8):665-71.
19. Han F, Lin L, Warby SC, Faraco J, Li J, Dong SX, et al. Narcolepsy onset is seasonal and increased following the 2009 H1N1 pandemic in China. Ann Neurol. 2011;70(3):410-7.
20. Partinen M, Kornum BR, Plazzi G, Jennum P, Julkunen I, Vaarala O. Narcolepsy as an autoimmune disease: the role of H1N1 infection and vaccination. Lancet Neurol. 2014;13(6):600-13.