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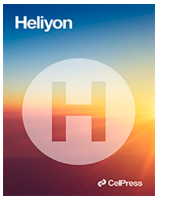

Research article

Delayed sleep-wake rhythm due to staying at home during the COVID-19 pandemic and sleep debt after returning to campus among Japanese nursing university students: A longitudinal study

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ABSTRACT

This study aimed to investigate sleep problems during staying at home due to the coronavirus disease 2019 (COVID-19) pandemic and after returning to campus among university nursing students. We analyzed data from self-reported sleep surveys conducted during a nursing course at a university in Tokyo between 2019 and 2021. During staying at home due to COVID-19, we observed delayed sleep-wake rhythm, prolonged sleep duration on weekdays, a decreased sleep debt, improved daytime sleepiness, and worsened insomnia, especially in terms of difficulty initiating sleep (Study 1; 18 paired data). After returning to campus, we found advanced wake-up time, shortened sleep duration, increased sleep debt, worsened insomnia, and increased daytime sleepiness (Study 2; 91 paired data). The association between advanced midpoint of sleep and commute time over an hour (aOR, 3.29; 95%CI: 1.24–8.72) was confirmed. Furthermore, sleep paralysis and nightmares were more prevalent among nursing students with an advanced midpoint of sleep, whereas nursing students whose midpoint of sleep was delayed had higher daytime sleepiness after returning to campus. To maintain regular sleep-wake rhythms and sufficient sleep duration, the educational environment surrounding nursing university students (e.g., curriculum, class schedule, style of class) should be established considering their age-dependent biological rhythm in addition to sleep hygiene education for students.

1. Introduction

In 2020, the coronavirus disease 2019 (COVID-19) pandemic drastically changed university-student life. Restriction of social activity as part of the public health measures (e.g., lockdown, stay-at-home order) resulted in a sudden transition to remote learning in university education [1]. In Japan, the government declared a state of emergency, forbidding non-essential outings from April 7, 2020, to May 25, 2020 [2]. Even after the cancellation of the declaration, online classes were executed in more than 80% of Japanese

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universities in June 2020 [3]. Then, offline classes were resumed with more than half of the classes were executed on-campus in almost all Japanese universities (98%) in October 2021 [4].

The impact of staying at home due to the COVID-19 pandemic on sleep among university students has been well discussed. Studies that surveyed university students reported that their sleep-wake rhythm (bedtime and wake-up time) was delayed during staying home due to the COVID-19 pandemic [5–9]. Originally, university students were likely to have activities and go to bed late at night because of their age-dependent delayed endogenous circadian clock [10]. A study reported that about 16% of university students were identified as the evening type, that is, more than half of them went to bed after 1:00 AM, supporting their delayed biological rhythm [11]. They are also forced to wake up early to fit the social clocks (e.g., early morning classes or early morning practice in club activities); therefore, delayed sleep-wake rhythm, subsequent insufficient sleep, and misalignment between circadian clock time and social time (i.e., social jetlag) are typical sleep problems in this age group. While staying at home due to the COVID-19 pandemic was associated with delayed sleep-wake rhythm, it increased the total sleep time in students who had sleep deficits. These findings were suggested by previous studies that reported an increase in the time-in-bed/sleep duration during the COVID-19 pandemic among university students [5–7,9]. The effects of the COVID-19 pandemic on subjective sleep quality, prolonged sleep latency, and worsened sleep quality were evaluated using the Pittsburgh Sleep Quality Index (PSQI), and insomnia symptoms, especially sleep initiation problems, were evaluated using the Insomnia Severity Index (ISI) [7,12] were reported. Another study reported that 18% of university students responded in the affirmative to the item “began to have insomnia” [13].

In contrast, positive effects of the COVID-19 pandemic on subjective sleep quality and mental health have been reported. A study found that the subjective impact on sleep was positive in students identified as evening type in contrast to negative in students identified as morning type [8]. Another study on sleep among high school students showed that sleep quality evaluated by the PSQI improved only among students with shorter sleep duration before the pandemic [14]. In sleep surveys among young people in Japan, daytime sleepiness, insomnia evaluated by the Athens Insomnia Scale (AIS), and health-related quality of life improved after the pandemic, accompanied by improvements in sleep duration and social jet lag degree [15]. In summary, staying at home worked positively on some young people with delayed sleep-wake rhythm, insufficient sleep, or social jetlag.

Nursing students have faced many difficulties during the COVID-19 pandemic, such as cancellation of clinical learning experiences, fear of being a nurse, financial problems [16], desire to quit nursing school due to fear of COVID-19 [17], and internet addiction (Internet Addiction Test, IAT >30) [18]. They had high perceived stress [17], high irritability, and poor sleep quality [19]. Among nursing students, the prevalence of sleep disturbance from a meta-analysis study was 27% during the COVID-19 pandemic [20]. In addition, worsened sleep quality assessed by the PSQI and decreased sleep efficiency, increased time-in-bed, and delayed sleep-wake rhythms have been found after the pandemic, among nursing students [21]. Other studies reported that the students’ sleep was associated with mental health including anxiety [22,23] and stress [24]. The result of their delayed sleep-wake rhythm after the pandemic was consistent with that of general university students [5–9], however, the impact of returning to campus on sleep has not been investigated either among nursing students or in general students.

Thus, this study aimed to investigate changes in sleep during staying at home due to the COVID-19 pandemic and after returning to campus among university nursing students.

2. Methods

2.1. Participants and data collection

We conducted questionnaire surveys during a nursing course at a university in Tokyo, Japan. We distributed paper-based questionnaires to sophomores between October and November 2019. We received 26 completed questionnaires (response rate: 20.2%) during the normal classes, not during the practical training period. In June 2020 and June–July 2021, we sent information about the web-based survey to all students via an in-school mail delivery system. The number of participants who accessed the question entry form and responded to the questionnaire was 307 in 2020 (response rate: 60.8%) and 224 in 2021 (response rate: 46.5%). While many students experienced on-demand remote classes in June 2020, they returned to on-campus classes from June–July 2021 at this university. Based on the questionnaire responses, we obtained the student IDs of all participants to link them as longitudinal data. To improve the response rate, we provided a gift voucher to those participants who completed all the questions in the web-based survey. The data used in the analyses were as follows:

First, 18 paired data of participants who answered “taking remote classes” in 2020 were used for analyses, to compare sleep before the pandemic with that while staying at home (Study 1). Second, we used 91 paired data sets from participants who responded that they were “taking remote classes” in 2020 and “taking on-campus classes” in 2021 for analyses to compare sleep while staying at home and returning to campus (Study 2).

2.2. Measures

We distributed the questionnaire written in Japanese, which consisted of the following items.

2.2.1. Characteristics of nursing students and lifestyle/social activities

We required the students to answer questions on age, sex, grade, whether they were living alone or not, commute time, starting time of class, engagement in a part-time job (yes/no), participation in a club activity (yes/no), Internet usage time on weekday/weekend, exercise habits per week ($\geq$4 days/2–3 days/$\leq$1 day/none), meal time, duration of each meal, frequency of skipping meals

(per week), body weight change (no change/loss/gain), and body mass index (BMI) calculated from self-reported height and weight. We used the Japanese version of the Internet Addiction Test (IAT) [25,26] to assess the level of Internet addiction.

2.2.2. Sleep pattern and sleep problems

Data on sleep patterns included information on sleep duration, bedtime, wake-up time on weekdays and weekends, and nap duration (none/less than 30 min/30–59 min/over 1 h). We defined sleep debt as the difference in sleep duration between weekdays and weekends. To express the tendency towards morningness or eveningness, we used the midpoint of sleep on free days with correction for oversleeping on free days (MSFsc) [27]. Social jetlag was calculated as the difference in the midpoint of sleep between weekdays and weekends [28]. We used the Japanese version of the Epworth Sleepiness Scale (ESS) [29–31] to assess daytime sleepiness. The total sum score ranges from 0 to 24, and ≥11 is regarded as excessive daytime sleepiness. We assessed sleep quality with the Japanese version of the AIS [32,33], which indicates possible insomnia when one has a score above five out of the total score. To assess sleep-related symptoms, the self-report questionnaire included questions on 'difficulty initiating sleep' (DIS), 'difficulty maintaining sleep' (DMS), 'early morning awakening' (EMA), 'difficulty in morning awakening' (DMA), 'nightmares, 'hypnagogic hallucinations' (HH), and 'sleep paralysis' (SP).

2.3. Statistical analyses

We showed representative values as mean ± standard deviation. We performed Wilcoxon signed-rank and chi-square tests, followed by residual analyses. To identify the factors related to advanced midpoint of sleep in 2021, we performed logistic regression analysis that included sex, grade, and commuting time. In the logistic regression analysis, the adjusted odds ratio (aOR) and 95% confidence interval (CI) represented the degree of association. There were no missing data in this analysis. We set the significance level at $p < 0.05$. We performed statistical analyses using IBM SPSS Statistics Version 25.0 (IBM Corporation, Armonk, NY, USA).

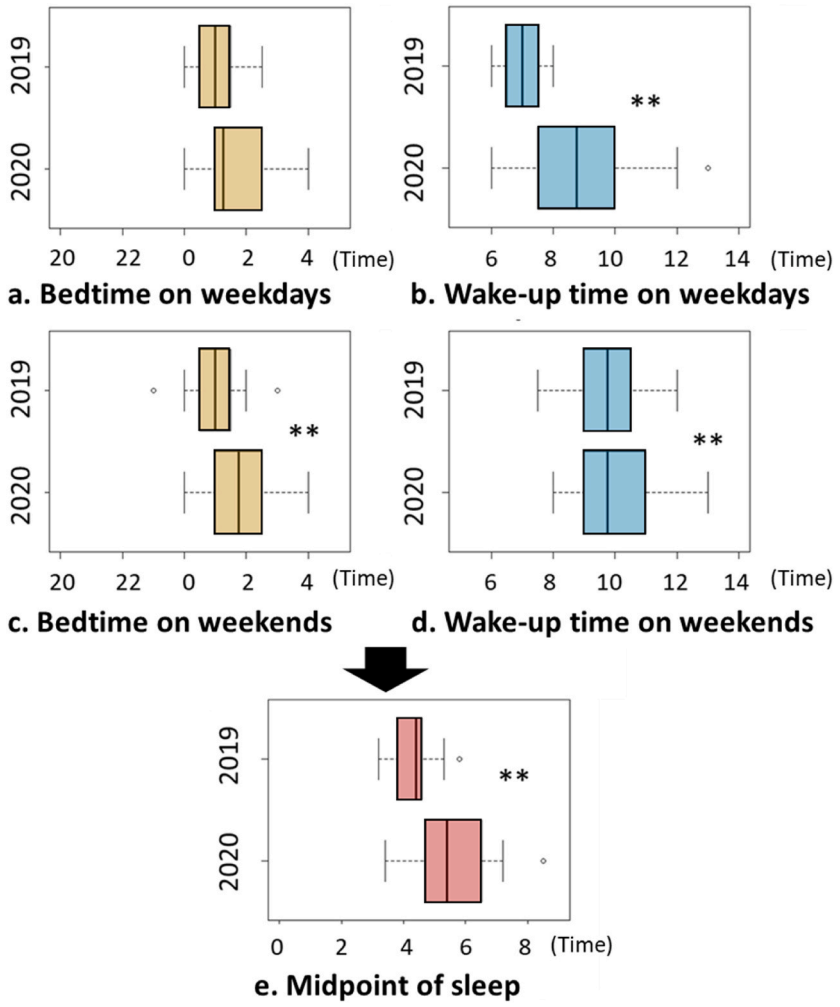

Fig. 1. Changes in sleep-wake rhythm after staying at home due to the COVID-19 pandemic. **$p < 0.05$.

2.4. Ethics

The Ethical Committee of the Institute of Neuropsychiatry (No.162) and Teikyo University (No.180-087-2) granted ethical approval for this survey. We assured the participants that their participation was voluntary, and that their participation/nonparticipation would have no educational disadvantage because the research collaborators (university lecturers) had no access to the participants' identities. We obtained informed consent from all the participants.

3. Results

3.1. Sleep, lifestyle, and social activities in 2019 and 2020 (study 1)

3.1.1. Characteristics of study participants

In Study 1, paired data of 18 students (17 females) aged 19–21 years in 2019 were used for analyses. Two of these students lived alone. The commute time was 68 ± 26 min.

3.1.2. Changes in sleep, lifestyle, and social activities after staying at home due to the COVID-19 pandemic

The changes in sleep after staying at home due to the COVID-19 pandemic are shown in Fig. 1 and Table 1. Bedtime on weekends, wake-up time on weekdays and weekends, and the midpoint of sleep were delayed. However, increased sleep duration on weekdays, decreased sleep debt and social jetlag, and improved daytime sleepiness as measured by the ESS were found. Insomnia evaluated by AIS worsened, while the number of students with DIS increased in 2020. There were no significant differences in nap duration or the presence of other insomnia or sleep-related symptoms.

Results show delayed class start time (9:17 to 10:53), delayed times for having breakfast (6:51 to 8:55) and lunch (12:02 to 12:57), increased internet usage time on weekdays (4.3 h–9.3 h), increased exercise (none:78%–33%, 2–3 days:0%–33%), while there were no significant differences in frequency of skipping meals, duration of each meal, BMI, body weight gain, part-time job, club activities, and internet addiction by IAT.

3.2. Sleep, lifestyle, and social activities in 2020 and 2021 (study 2)

3.2.1. Characteristics of study participants

In Study 2, paired data from 91 students (87 females, 48% freshmen, 42% sophomores, and 10% juniors) aged 18–21 years in 2020 were used for analyses. Sixteen (18%) students lived alone. The commute time was 59 ± 30 min.

Table 1
Changes in sleep while staying at home due to the COVID-19 pandemic n = 18.

		2019	2020	
Starting time of class	h:m	9:18 ± 0:51	10:52 ± 2:03	**
Bedtime on weekdays	h:m	1:04 ± 0:42	1:30 ± 1:11	
Bedtime on weekends	h:m	1:00 ± 0:57	1:42 ± 1:11	**
Wake-up time on weekdays	h:m	6:59 ± 0:39	8:55 ± 1:47	**
Wake-up time on weekends	h:m	9:41 ± 1:12	10:05 ± 1:33	**
Sleep duration on weekdays	h	5.8 ± 1.1	7.4 ± 1.2	**
Sleep duration on weekends	h	8.4 ± 1.5	8.3 ± 1.2	
MSFsc	h:m	4:20 ± 0:36	5:32 ± 1:18	**
Sleep debt	h	2.6 ± 1.7	1.0 ± 1.2	**
Social jetlag	h	1.3 ± 0.7	0.7 ± 0.9	**
Nap duration				
None	n (%)	5 (28)	4 (22)	
<30 min	n (%)	4 (22)	4 (22)	
30–59 min	n (%)	6 (33)	4 (22)	
>1 h	n (%)	3 (17)	6 (33)	
ESS score		12.7 ± 4.1	8.3 ± 4.2	**
AIS score		5.4 ± 2.5	8.7 ± 3.6	**
Presence of sleep-related symptoms				
DIS	n (%)	5 (28)	13 (72)	**
DMS	n (%)	2 (11)	3 (17)	
EMA	n (%)	1 (6)	3 (17)	
DMA	n (%)	6 (33)	10 (56)	
Nightmare	n (%)	10 (56)	12 (67)	
HH	n (%)	5 (28)	7 (39)	
SP	n (%)	4 (22)	2 (11)	

Mean Â ± standard deviation (SD) **p < 0.05. MSFsc: midpoint of sleep on free days with correction for oversleeping on free days; DIS: difficulty initiating sleep; DMS: difficulty maintaining sleep; EMA: early morning awakening; DMA: difficulty in morning awakening; HH: hypnagogic hallucinations; SP: sleep paralysis.

3.2.2. Changes in sleep, lifestyle, and social activities after returning to campus

The changes in sleep after returning to campus are shown in Fig. 2 and Table 2. The midpoint of sleep was predicted to be advanced in 2021. Sleep duration was shortened according to advanced waking time and unchanged bedtime. Sleep debt and social jetlag increased in 2021. Insomnia evaluated by AIS and daytime sleepiness measured by ESS worsened, although the presence of DIS decreased. There were no significant differences in nap duration or the presence of other insomnia or sleep-related symptoms.

Results showed advanced class start time (10:40 to 9:07), advanced times for breakfast (8:43 to 7:25) and lunch (12:44 to 12:31), shortened duration for breakfast (19 min–15 min) and lunch (19 min–14 min), decreased frequency of skipping lunch (1.2 days–0.6 days per week), increased number of students who engaged in part-time jobs (56%–81%), decreased Internet usage time on weekdays (8.5 h–8.0 h) and weekends (7.4 h–6.1 h), and decreased frequency of exercise (≥4 days:15%–4%, 2–3 days:30%–11%, none:32%–60%) after returning to campus. There were no significant differences in BMI, body weight gain, club activities, or Internet addiction according to the IAT.

3.2.3. Factors associated with advanced midpoint of sleep in 2021 compared to those in 2020

Of the 91 students, 34 (37%) showed an advanced midpoint of sleep for more than an hour. They were defined as an "advanced midpoint of sleep" group. Sleep variables are shown by group in Table 3. The advanced midpoint of sleep group showed earlier bedtime on weekends, longer sleep duration on weekends, higher prevalence of sleep paralysis and nightmare, lower daytime sleepiness measured by ESS, and lower frequency of skipping breakfast than the students without advanced sleep-wake rhythm.

Multiple logistic regression analysis adjusted for sex and grade showed that commute time over an hour (aOR:3.29, 95% CI:1.24–8.72) was associated with advanced midpoint of sleep (Table 4).

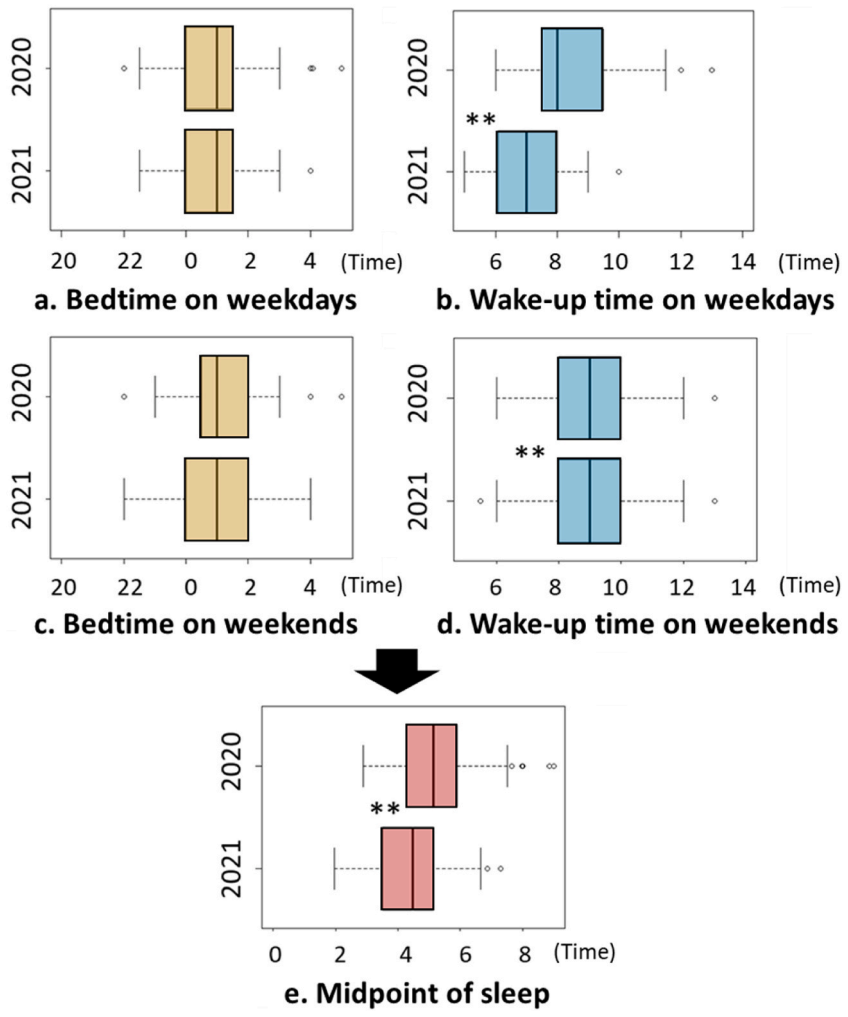

Fig. 2. Changes in sleep-wake rhythm after returning to campus during the COVID-19 pandemic. **p < 0.05.

Table 2
Changes in sleep after returning to campus n = 91.

		2020	2021	
Starting time of class	h:m	10:40 ± 4:43	9:07 ± 3:00	**
Bedtime on weekdays	h:m	0:59 ± 1:16	0:50 ± 0:47	
Bedtime on weekends	h:m	1:22 ± 1:18	1:03 ± 1:12	
Wake-up time on weekdays	h:m	8:32 ± 1:35	7:03 ± 1:02	**
Wake-up time on weekends	h:m	9:17 ± 1:36	8:49 ± 1:35	**
Sleep duration on weekdays	h	7.6 ± 1.2	6.2 ± 1.2	**
Sleep duration on weekends	h	7.9 ± 1.2	7.8 ± 1.4	
MSFsc	h:m	5:12 ± 1:21	4:23 ± 1:10	**
Sleep debt	h	0.4 ± 0.8	1.5 ± 1.6	**
Social jetlag	h	0.6 ± 0.8	1.0 ± 0.9	**
Nap duration				
None	n (%)	31 (34)	22 (24)	
<30 min	n (%)	21 (23)	22 (24)	
30–59 min	n (%)	23 (25)	27 (30)	
>1 h	n (%)	16 (18)	20 (22)	
ESS score		9.3 ± 4.5	12.3 ± 4.6	**
AIS score		7.1 ± 4.1	9.1 ± 3.6	**
Presence of sleep-related symptoms				
DIS	n (%)	62 (68)	46 (50)	**
DMS	n (%)	18 (20)	17 (19)	
EMA	n (%)	19 (21)	19 (21)	
DMA	n (%)	47 (52)	50 (55)	
Nightmare	n (%)	55 (60)	52 (57)	
HH	n (%)	28 (31)	31 (34)	
SP	n (%)	7 (8)	10 (11)	

Mean Â ± standard deviation (SD) **p < 0.05. MSFsc: midpoint of sleep on free days with correction for oversleeping on free days; DIS: difficulty initiating sleep; DMS: difficulty maintaining sleep; EMA: early morning awakening; DMA: difficulty in morning awakening; HH: hypnagogic hallucinations; SP: sleep paralysis.

Table 3
Sleep among students with/without advanced midpoint of sleep.

		Without advanced midpoint of sleep (n = 57)	With midpoint of sleep (n = 34)	
Sleep pattern in 2020				
Bedtime on weekdays	h:m	0:42 ± 0:56	1:27 ± 1:36	**
Bedtime on weekends	h:m	0:55 ± 0:58	1:07 ± 1:26	**
Wake-up time on weekdays	h:m	8:04 ± 1:05	9:23 ± 1:54	**
Wake-up time on weekends	h:m	8:47 ± 1:21	10:08 ± 1:38	**
Sleep duration on weekdays	h	7.3 ± 1.0	7.9 ± 1.4	
Sleep duration on weekends	h	7.9 ± 1.0	8.0 ± 1.6	
MSFsc	h:m	4:40 ± 1:00	6:06 ± 1:23	**
Social jetlag	h	0.5 ± 0.8	0.7 ± 0.8	
Sleep pattern in 2021				
Bedtime on weekdays	h:m	0:52 ± 0:58	0:46 ± 1:00	
Bedtime on weekends	h:m	1:18 ± 0:58	0:37 ± 1:19	**
Wake-up time on weekdays	h:m	7:08 ± 1:05	6:55 ± 0:56	
Wake-up time on weekends	h:m	8:52 ± 1:32	8:44 ± 1:42	
Sleep duration on weekdays	h	6.3 ± 1.2	6.2 ± 1.2	
Sleep duration on weekends	h	7.6 ± 1.2	8.1 ± 1.6	**
MSFsc	h	4:37 ± 1:07	3:58 ± 1:07	**
Social jetlag	h	1.1 ± 0.8	0.8 ± 1.1	
Other sleep variables in 2021				
ESS score		13.2 ± 4.6	10.8 ± 4.4	**
AIS score		8.8 ± 3.4	9.6 ± 3.9	
Presence of sleep-related symptoms				
DIS	n (%)	29 (51)	17 (50)	
DMS	n (%)	13 (23)	4 (12)	
EMA	n (%)	12 (21)	7 (20)	
DMA	n (%)	32 (56)	18 (53)	
Nightmare	n (%)	27 (47)	25 (74)	**
HH	n (%)	19 (33)	12 (35)	
SP	n (%)	1 (2)	9 (27)	**

Mean Â ± standard deviation (SD). **p < 0.05. MSFsc: midpoint of sleep on free days with correction for oversleeping on free days; DIS: difficulty initiating sleep; DMS: difficulty maintaining sleep; EMA: early morning awakening; DMA: difficulty in morning awakening; HH: hypnagogic hallucinations; SP: sleep paralysis.

Table 4
Factors related to advanced sleep-wake rhythms.

	aOR	95%CI	
Sex			
Male	1.0		
Female	0.15	0.01–1.66	
Grade			
Freshmen	1.0		
Sophomores	0.66	0.25–1.76	
Juniors	1.56	0.34–7.27	
Commute time			
<1 h	1.0		
≥1 h	3.29	1.24–8.72	**
Hosmer-Lemeshow test p = 0.992			

aOR, adjusted odds ratio; CI, confidence interval. **p < 0.05.

4. Discussion

During their staying at home due to COVID-19, delayed sleep-wake rhythm, prolonged sleep duration on weekdays, decreased sleep debt, and worsened insomnia, especially DIS, were observed among nursing students. These results are consistent with those of previous studies of general students [5–7,9]. As the on-demand remote classes were not assigned a fixed time, their class starting time and sleep-wake rhythm were delayed. Therefore, the sleep deficits were resolved, resulting in improved daytime sleepiness.

After returning to campus, advanced midpoint of sleep, shortened sleep duration on weekdays, and worsened daytime sleepiness were found among them, in contrast to the delayed sleep-wake rhythm during staying at home due to the COVID-19 pandemic. To the best of our knowledge, this study is the first to confirm that the students' midpoint of sleep advanced due to their return to campus. It also clarifies associated factors. A regular fixed starting time of class every morning after returning to campus might force them to wake up earlier than while staying at home. In terms of prevention of delayed sleep-wake rhythm, an earlier wake-up time seems to be effective; however, it shortens their sleep duration, resulting in sleep deficit.

Although the prevalence of DIS was lower in 2021 than in 2020, it was still higher even after returning to campus compared to the prevalence in 2019 or the previous study on nursing students before the COVID-19 pandemic [34]. As patients with delayed sleep-wake phase disorder have difficulty falling asleep at a conventional hour [35], nursing students with delayed sleep-wake rhythm were not able to adapt to advanced sleep-wake rhythm as per an earlier starting time of class even after returning to campus, owing to the misalignment of their internal clock. Additionally, psychological distress, including stress and anxiety due to the COVID-19 pandemic, may cause poor sleep quality [36]. The high prevalence of DIS should not be overlooked as an aspect of the risk factors for depression [37,38].

Notably, insomnia evaluated by AIS still worsened while sleep-wake rhythm and sleep duration were back to the former levels after returning to campus. According to a study that reported mental health among nursing students during the pandemic, 45% and 23% of them reported having post-traumatic stress disorder (PTSD) and insomnia, respectively [39]. Studies have noted that insomnia triggered by stressful life events continues for a long period [40]. Furthermore, another study suggested that COVID-19 fears induce suicidal ideation mediated by insomnia [41]. Thus, insomnia and insomnia-related symptoms should be followed up.

In this study, the wake-up time advanced, accompanied by changes in the starting time of the class after returning to campus. Furthermore, an advanced midpoint of sleep was associated with commute time. Some previous reports emphasized that class start time delay had favorable effects on health and academic performance of adolescents (junior/senior high school students) due to the subsequent adjustment of their internal clocks [42]. In contrast, other studies reported that later class times may have an adverse influence on university students who may freely engage in activities such as alcohol consumption and evening part-time jobs without parental supervision [43]. Thus, class start and commute times played key roles in the wake-up times in university students. This study also showed both positive and negative aspects of advanced midpoint of sleep after returning to campus. Sleep paralysis and nightmares were more prevalent among participants with an advanced midpoint of sleep than among those without. Sleep paralysis and nightmares are rapid eye movement (REM) parasomnias that are often caused by sleep deprivation, irregular sleep-wake schedules, and jet lag [44,45]. Since sleep duration and social jetlag did not differ between participants with and without advanced midpoint of sleep, it can be concluded that advanced midpoint of sleep might cause REM parasomnias. Moreover, they showed lower daytime sleepiness and less skipping breakfast than those without an advanced midpoint of sleep. In other words, participants whose midpoint of sleep was delayed had higher daytime sleepiness and skipped breakfast more frequently than those with advanced midpoint of sleep after returning to campus. In our previous study conducted before COVID-19, the evening type was associated with shorter sleep duration on weekdays, skipping meals, body weight gain, mental health-related quality of life, experiences of absence, tardiness, falling asleep during class, and interference with academic achievement among nursing university students [34]. Therefore, maintaining a delayed sleep-wake rhythm after returning to campus might lead to poor mental/physical health and academic performance, although this study did not evaluate these outcomes. In living with COVID-19, maintaining a regular sleep-wake rhythm is essential for nursing students even when preventive measures for the spread of COVID-19 (i.e., lockdown, staying at home order, and remote class) are taken. To maintain regular sleep-wake rhythms, the social environment surrounding nursing university students (e.g., curriculum, class schedule, style of class) should be established considering their age-dependent sleep-wake rhythm in addition to education for

students. For nursing university students whose study workload and academic pressure are high, approaches to the educational environment, such as student-selectable combinations of on-campus and online classes, may be effective. For students who have a long commute time, online classes allow them to extend their sleep time for more minutes/hours in the morning. However, it may result in worse sleep-wake rhythm disruption for students whose sleep-wake rhythm tends to be delayed.

This study has some limitations. In 2019, we conducted a paper-based sleep survey among sophomores. In 2020 and 2021, however, sleep surveys were conducted online among all nursing students of the collaborative university. The differences in the target population and sampling method might have led to sampling bias. Additionally, the representativeness of the study population was weak because of the small sample size of one university. However, it has significant implications in evaluating the change in sleep-wake rhythm within individuals between (i) before the COVID-19 pandemic and during staying at home due to the COVID-19 pandemic and (ii) during staying at home due to the COVID-19 pandemic and after returning to campus by using paired data, despite these limitations. Although the sample size was small ($n = 18$) in Study 1, the sleep-wake rhythm was delayed while staying at home due to COVID-19, which is consistent with the results of previous studies [5–9]. Study 2 revealed new findings on advanced midpoint of sleep and increased sleep debt after returning to campus, sleep-related symptoms among nursing students with advanced midpoint of sleep, and associated social factors (i.e., commute time). These novel findings of nursing students in a university located in Tokyo, which was the place most drastically influenced by the COVID-19 pandemic in Japan, would also be helpful for other populations maintaining their health during the COVID-19 pandemic. Further studies involving a plurality of nursing universities, including those in rural areas, where students' commuting time might differ from that in urban areas, are needed. Additionally, an effective approach for maintaining a healthy sleep-wake rhythm and sufficient sleep duration among nursing students should be investigated by revealing differences in class start times among universities and their influence on their sleep.

5. Conclusion

This study revealed that wake-up time advanced and sleep debt increased after students returned to campus, while it was delayed during staying at home due to the COVID-19 pandemic among nursing university students. Furthermore, REM parasomnias were more prevalent among nursing students with an advanced midpoint of sleep, whereas nursing students with delayed midpoint of sleep had higher daytime sleepiness after returning to campus. To maintain regular sleep-wake rhythms and sufficient sleep duration, the educational environment for nursing university students should be established considering their age-dependent sleep-wake rhythm in addition to sleep hygiene education for students.

Author contribution statement

Momoko Kayaba, Taeko Sasai-Sakuma: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper. Mami Ishitsuka, Miyako Ishidate, Kimiko Ueno, Yoko Kajihara: Performed the experiments; Contributed reagents, materials, analysis tools or data.

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Data availability statement

Data will be made available on request.

Declaration of interest's statement

The authors declare the following conflict of interests: Department of Somnology is an endowment department, supported with an unrestricted grant from Philips Japan Co., Ltd. and Koike Medical Co., Ltd.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.heliyon.2023.e14994.

References

[1] C.P. Camargo, P.Z. Tempski, et al., Online learning and COVID-19: a meta-synthesis analysis, Clinics 75 (2020) e2286.
[2] Prime Minister of Japan and His Cabinet. [COVID-19] Declaration of a State of Emergency in response to the Novel Coronavirus Disease. 2020 [cited 2022 2022/11/10]; Available from: https://japan.kantei.go.jp/ongoingtopics/_00018.html.
[3] Ministry of Education, Culture, Sports, Science and Technoligy Japan. The state of implementation of university class during COVID-19 in June 2020. 2020 [cited 2022 2022/11/10]; Available from: https://www.mext.go.jp/content/20200605-mxt_kouhou01-000004520_6.pdf.
[4] Ministry of Education, Culture, Sports, Science and Technoligy Japan. The state of implementation of university class during COVID-19 in October 2021. 2021 [cited 2022 2022/11/10]; Available from: https://www.mext.go.jp/content/20211118-mxt_kouhou01-000004520_1.pdf.
[5] G. Benham, Stress and sleep in college students prior to and during the COVID-19 pandemic, Stress Health 37 (3) (2021) 504–515.
[6] N. Cellini, N. Canale, et al., Changes in sleep pattern, sense of time and digital media use during COVID-19 lockdown in Italy, J. Sleep Res. 29 (4) (2020), e13074.
[7] S. Marelli, A. Castelnuovo, et al., Impact of COVID-19 lockdown on sleep quality in university students and administration staff, J. Neurol. 268 (1) (2021) 8–15.
[8] A.N. Smit, M. Juda, et al., Impact of COVID-19 social-distancing on sleep timing and duration during a university semester, PLoS One 16 (4) (2021) e0250793.
[9] K.P. Wright Jr., S.K. Linton, et al., Sleep in university students prior to and during COVID-19 Stay-at-Home orders, Curr. Biol. 30 (14) (2020) R797–R798.
[10] T. Roenneberg, T. Kuehnle, et al., A marker for the end of adolescence, Curr. Biol. 14 (24) (2004) R1038–R1039.
[11] M. Kayaba, T. Matsushita, et al., Impact of sleep problems on daytime function in school life: a cross-sectional study involving Japanese university students, BMC Publ. Health 20 (1) (2020) 371.
[12] L. Viselli, F. Salfi, et al., Sleep quality, insomnia symptoms, and depressive symptomatology among Italian university students before and during the Covid-19 lockdown, Int. J. Environ. Res. Publ. Health 18 (24) (2021).
[13] T. Cerqueira, S.G. Batista, et al., Impact of the COVID-19 pandemic on stress, sleep, and oral health in university students, Front. Pain Res. 2 (2021), 744264.
[14] F.D. Genta, G.B. Rodrigues Neto, et al., COVID-19 pandemic impact on sleep habits, chronotype, and health-related quality of life among high school students: a longitudinal study, J. Clin. Sleep Med. 17 (7) (2021) 1371–1377.
[15] K. Tanioka, M. Kayaba, et al., Changes in sleep behavior, sleep problems, and psychological distress/health-related quality of life of young Japanese individuals before and during the COVID-19 pandemic, Chronobiol. Int. 39 (6) (2022) 781–791.
[16] C.M. Heilferty, L.J. Phillips, et al., Letters from the pandemic: nursing student narratives of change, challenges and thriving at the outset of COVID-19, J. Adv. Nurs. 77 (8) (2021) 3436–3445.
[17] C. Laranjeira, A. Querido, et al., COVID-19 pandemic and its psychological impact among healthy Portuguese and Spanish nursing students, Health Psychol. Res. 9 (1) (2021), 24508.
[18] M.J. Tahir, N.I. Malik, et al., Internet addiction and sleep quality among medical students during the COVID-19 pandemic: a multinational cross-sectional survey, PLoS One 16 (11) (2021) e0259594.
[19] J.A.A. De Los Santos, L.J. Labrague, et al., Fear of COVID-19, poor quality of sleep, irritability, and intention to quit school among nursing students: a cross-sectional study, Psychiatr. Care 58 (1) (2022) 71–78.
[20] M. Mulyadi, S.I. Tonapa, et al., Prevalence of mental health problems and sleep disturbances in nursing students during the COVID-19 pandemic: a systematic review and meta-analysis, Nurse Educ. Pract. 57 (2021), 103228.
[21] C. Romero-Blanco, J. Rodriguez-Almagro, et al., Sleep pattern changes in nursing students during the COVID-19 lockdown, Int. J. Environ. Res. Publ. Health 17 (14) (2020).
[22] E. Kaplan Serin, R. Dogan, The relationship between anxiety and hopelessness levels among nursing students during the COVID-19 pandemic and related factors, Omega (2021), 302228211029144.
[23] B. Kokturk Dalcali, H. Durgun, et al., Anxiety levels and sleep quality in nursing students during the COVID-19 pandemic, Psychiatr. Care 57 (4) (2021) 1999–2005.
[24] I. Bodys-Cupak, K. Czubek, et al., Stress and sleep disorders in polish nursing students during the SARS-CoV-2 pandemic-cross sectional study, Front. Psychol. 12 (2021), 814176.
[25] National Hospital Organization Kurihama Medical and Addicition Center. Japanese version of Internet Addiction Test. [cited 2022 2022/11/10]; Available from: https://kurihama.hosp.go.jp/hospital/screening/dq.html.
[26] K.S. Young, Internet addiction: the emergence of a new clinical disorder, Cyberpsychol. Behav. 1 (3) (1998) 237–244.
[27] T. Roenneberg, K.V. Allebrandt, et al., Social jetlag and obesity, Curr. Biol. 22 (10) (2012) 939–943.
[28] M. Wittmann, J. Dinich, et al., Social jetlag: misalignment of biological and social time, Chronobiol. Int. 23 (1–2) (2006) 497–509.
[29] M.W. Johns, A new method for measuring daytime sleepiness: the Epworth sleepiness scale, Sleep 14 (6) (1991) 540–545.
[30] M.W. Johns, Reliability and factor analysis of the Epworth sleepiness scale, Sleep 15 (4) (1992) 376–381.
[31] M. Takegami, Y. Suzukamo, et al., Development of a Japanese version of the Epworth Sleepiness Scale (JESS) based on item response theory, Sleep Med. 10 (5) (2009) 556–565.
[32] I. Okajima, S. Nakajima, et al., Development and validation of the Japanese version of the Athens insomnia scale, Psychiatr. Clin. Neurosci. 67 (6) (2013) 420–425.
[33] C.R. Soldatos, D.G. Dikeos, et al., Athens Insomnia Scale: validation of an instrument based on ICD-10 criteria, J. Psychosom. Res. 48 (6) (2000) 555–560.
[34] M. Kayaba, T. Matsushita, et al., Sleep-wake rhythm and its association with lifestyle, health-related quality of life and academic performance among Japanese nursing students: a cross-sectional study, BMC Nurs. 20 (1) (2021) 225.
[35] L.C. Lack, H.R. Wright, Clinical management of delayed sleep phase disorder, Behav. Sleep Med. 5 (1) (2007) 57–76.
[36] P. Simor, B. Polner, et al., Home confinement during the COVID-19: day-to-day associations of sleep quality with rumination, psychotic-like experiences, and somatic symptoms, Sleep 44 (7) (2021).
[37] T.F. Blanken, D. Borsboom, et al., Network outcome analysis identifies difficulty initiating sleep as a primary target for prevention of depression: a 6-year prospective study, Sleep 43 (5) (2020).
[38] G.T.P. Santiago, A.C. de Menezes Galvao, et al., Changes in cortisol but not in brain-derived neurotrophic factor modulate the association between sleep disturbances and major depression, Front. Behav. Neurosci. 14 (2020) 44.
[39] J. Gao, F. Wang, et al., Mental health of nursing students amid coronavirus disease 2019 pandemic, Front. Psychol. 12 (2021), 699558.
[40] P. Lavie, Sleep disturbances in the wake of traumatic events, N. Engl. J. Med. 345 (25) (2001) 1825–1832.
[41] W.D.S. Killgore, S.A. Cloonan, et al., Suicidal ideation during the COVID-19 pandemic: the role of insomnia, Psychiatr. Res. 290 (2020), 113134.
[42] A.G. Wheaton, D.P. Chapman, et al., School start times, sleep, behavioral, health, and academic outcomes: a review of the literature, J. Sch. Health 86 (5) (2016) 363–381.
[43] S.V. Onyper, P.V. Thacher, et al., Class start times, sleep, and academic performance in college: a path analysis, Chronobiol. Int. 29 (3) (2012) 318–335.
[44] A. Stefani, B. Hogl, Nightmare disorder and isolated sleep paralysis, Neurotherapeutics 18 (1) (2021) 100–106.
[45] S. Scarpelli, M.R. Nadorff, et al., Nightmares in people with COVID-19: did coronavirus infect our dreams? Nat. Sci. Sleep 14 (2022) 93–108.