Causes of Excessive Daytime Sleepiness in Japanese Medical Students : A Cross-sectional Study

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Background : Most surveys regarding excessive daytime sleepiness (EDS) in university students have used only questionnaires. The present study was performed to clarify the causes of EDS and the characteristics of students with EDS using a sleep diary, polysomnography (PSG), and multiple sleep latency testing (MSLT) in addition to questionnaires.

Methods : Medical students with and without EDS were recruited using a poster. EDS was defined as Japanese Epworth Sleepiness Scale score ≥ 11, and all participants underwent PSG and MSLT. They were also asked to record a sleep diary for 1 month and to complete the Japanese version of the Pittsburgh Sleep Quality Index, the Sleep Hygiene Index, and lifestyle questionnaires. Sleep disorders were diagnosed based on the International Classification of Sleep Disorders, and the characteristics were compared between students with and without EDS.

Results : Among the 59 students who participated in the study, 33 were classified as having EDS and the remaining 26 did not have EDS. In the EDS group, 16 students were diagnosed with insufficient sleep syndrome (ISS), six had narcolepsy, five had insomnia, three had idiopathic hypersomnia, one had delayed sleep-wake phase disorder, one had obstructive sleep apnea, and one had periodic limb movement disorder. The questionnaires revealed that the most important factor for EDS was poor sleep hygiene due to their lifestyle.

Conclusion : The survey including PSG and MSLT revealed that approximately half of the medical students with EDS showed ISS followed by narcolepsy, insomnia, and other sleep disorders, and the main characteristic of the students with EDS was poor sleep hygiene. *Shinshu Med J 71 : 43—52, 2023*

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Key words : polysomnography, multiple sleep latency test, Epworth sleepiness scale, sleep hygiene

I Introduction

Medical students have been reported to show poor quality of sleep and low academic performance due to excessive daytime sleepiness (EDS)[1)]. Questionnaire surveys have also shown that 51 % of medical students in Malaysia[2)] and 25 % of those in the USA[3)] had a short sleeping time of less than 7 h per night, which may be related to insufficient sleep syndrome (ISS), and 36 % of medical students in Morocco complained of EDS[1)]. In a questionnaire survey, 43 % of Japanese university students reported dozing off more than once per day during lectures, and 42.3 % and 37.8 % slept for only 6-7 hours or < 6 hours, respectively[4)]. In addition, a questionnaire survey using SLEEP-50 demonstrated that 12.0 % of university students in the southeastern USA had insomnia, 16.0 % had narcolepsy, 8.0 % had restless legs syndrome (RLS) or periodic limb movement disorder (PLMD), 7.0 % had circadian rhythm disorder, and 4.0 % had other hypersomnia and obstructive sleep

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apnea (OSA)[5]. However, most previous studies regarding EDS in university students were based only on questionnaire surveys and did not include objective examination of the causes of EDS using both polysomnography (PSG) and multiple sleep latency test (MSLT). Both PSG and MSLT in addition to a sleep diary are necessary to make accurate diagnoses of sleep disorders causing EDS, such as OSA, ISS, narcolepsy, idiopathic hypersomnia (IH), delayed sleep-wake phase disorder (DSWPD), PLMD, etc. OSA is characterized by frequent periodic sleep apnea due to upper airway obstruction during sleep, which causes periodic hypoxemia, sleep fragmentation, and lack of deep sleep, resulting in EDS. After exclusion of other apparent sleep disorders, a diagnosis of ISS is based on a shorter time in bed than expected for age on most days for at least 3 months leading to inability to have the necessary sleep time, resulting in EDS, and the disappearance of EDS when longer sleep times can be obtained. Narcolepsy is diagnosed by the presence of EDS for at least 3 months and mean sleep latency < 8 min with evidence of two or more sleep-onset REM periods (SOREMPs) on MSLT with (Type 1) or without clear cataplexy (Type 2). IH is diagnosed by the presence of EDS for at least 3 months and mean sleep latency < 8 min with evidence of less than two SOREMPs on MSLT and absence of cataplexy and hypocretin deficiency (if measured), and no other identifiable causes, such as narcolepsy, OSA, etc. DSWPD is characterized by habitually delayed sleep-wake timing, usually greater than 2 h, relative to conventional or socially acceptable timing and difficulty falling asleep at a time required to obtain sufficient sleep duration on a school or work night and arising at the required times. PLMD is characterized by frequent involuntary limb movement during sleep accompanied by sleep disturbance or other functional impairment. Students with diagnoses such as narcolepsy, SAS, PLMD, and idiopathic hypersomnia require specific therapies for these sleep disorders. The present study was performed to clarify the causes of EDS and the characteristics of Japanese medical students with EDS using a sleep diary, PSG, and MSLT in addition to questionnaires.

Ⅱ Materials and Methods

A Subjects

This cross-sectional study was conducted in a population of medical students at Shinshu University School of Medicine and Health Sciences from July 2017 to December 2020. Posters about the study were displayed on the campus to call for the participation of two groups of medical students with and without EDS. All subjects were given an adequate explanation of the study and provided written informed consent to participation. Students who had already been diagnosed with any sleep disorders and were undergoing treatment with medications, such as hypnotic agents, antihistamines, psychotropic agents, and antianxiety medications, were excluded.

B Protocol

The students were divided using the Japanese version of the Epworth Sleepiness Scale (JESS)[6] into the EDS group (JESS score ≥ 11) and non-EDS group (JESS score < 11). All subjects answered the Pittsburgh Sleep Quality Index (PSQI)[7] and Japanese version of the Sleep Hygiene Index (J-SHI)[8], recorded a sleep diary for 1 month, and then underwent PSG and MSLT. They were also asked about their lifestyle (exercise habits, alcohol drinking, smoking, frequency of skipping breakfast, frequency of part-time jobs, and club activities) using a questionnaire. Finally, sleep disorders were diagnosed based on the International Classification of Sleep Disorders - Third Edition (ICSD-3)[9] by the corresponding author who is a member of the Japanese Society of Sleep Research. This study was conducted in accordance with the International Conference on Harmonization-Good Clinical Practice and the Declaration of Helsinki (2008) and was approved by the institutional research ethics committee of Shinshu University School of Medicine (No. 3736, July 5, 2017).

C Evaluation methods

1 Japanese version of the Epworth Sleepiness Scale (JESS)

JESS is a self-rated questionnaire to measure the degree of sleepiness based on a score of 0-3 points

for each of eight situations. A total score ≥ 11 is taken to indicate EDS[6].

2 Pittsburgh Sleep Quality Index (PSQI) and lifestyle questionnaire

PSQI is a self-rated questionnaire that assesses sleep quality and disturbances over a 1-month period. Nineteen individual items generate seven component scores : subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbance, use of sleeping medication, and daytime dysfunction. A total score for these seven components ≥ 6 points is taken to indicate poor quality of sleep[7].

The lifestyle questionnaire is a self-rated questionnaire to assess lifestyle habits. The questionnaire elicited responses regarding the number of times per week the participant exercised, drank alcohol, skipped breakfast, and engaged in activities at night and whether they were a current smoker or not.

3 Japanese version of Sleep Hygiene Index (J-SHI)

The Sleep Hygiene Index (SHI) is a self-reported index developed by Mastin et al.[10] to assess sleep hygiene behaviors. SHI translated into Japanese (Japanese version of SHI : SHPS-J)[8] was used in this study. The 13 questions were scored on a scale ranging from 0 to 4 defined as follows : 0, never ; 1, rarely ; 2, sometimes ; 3, frequent ; and 4, always. In this study, the responses "frequently (3 points)" and "always (4 points)" in each item were defined as indicating poor sleep hygiene.

4 Polysomnography

Standard overnight attended PSG was performed starting at 20 : 00, and the data were collected from 21 : 00 to 06 : 00 the next morning. PSG was recorded with a digital polygraph (EEG-9200 ; Teijin Pharma Co. Ltd., Tokyo, Japan) according to the guidelines of the American Academy of Sleep Medicine (AASM) Manual for Scoring of Sleep and Associated Events version 2.1[11]. First, one ground channel, F_3-M_2, F_4-M_1, C_3-M_2, C_4-M_1, O_1-M_2, and O_2-M_1 channels were chosen for EEG, and monitoring was applied in accordance with the instructions of the 10-20 International Placement System. Electrooculography was recorded from right and left corners of the eyes, and electromyography was recorded from the submental muscle and right and left tibialis anterior muscles. Other channels were nasal pressure, oronasal airflow, thoracoabdominal inductance plethysmogram, percutaneous oxygen saturation (SpO_2), neck microphone, body position sensors, and a modified lead II ECG. PSG data were analyzed using POLYSMITH ver. 7.0 (Nihon Kohden, Tokyo, Japan), and the analyses were carried out both automatically and manually in accordance with the recommendations of the AASM[12].

5 Multiple sleep latency test

MSLT was conducted according to the guidelines of the Japanese Society of Sleep Research[13] on the day after PSG examination. Monitoring was repeated five times at 08 : 00, 10 : 00, 12 : 00, 14 : 00, and 16 : 00. In this test, we measured sleep latency and REM sleep latency in each nap. The test was finished if no sleep occurred within 20 minutes after turning off the lights or was continued for 15 minutes after onset of sleep.

D Statistical analysis

Values in the text, tables, and figures are shown as the means ± standard deviation (SD). Fisher's exact test was used for statistical analysis of the ratio of smokers and the subjects who showed shorter sleep latency defined as mean sleep latency in 5 naps < 8 min on MSLT. Welch's t test was used for other analyses. In all analyses, $P < 0.05$ was taken to indicate statistical significance.

Ⅲ Results

A Causes of EDS in medical students

Among the total of about 1320 medical students on the campus, 59 students (23 men) with a mean age of 21.6 ± 1.6 years participated in this study. These students were divided into the EDS group ($n = 33$) and non-EDS group ($n = 26$) based on their JESS scores. In the EDS group, ISS was the most common cause of EDS ($n = 16$) **(Table 1)**. Six students were diagnosed with narcolepsy (type 1 (NT1), $n = 3$; type 2 (NT2), $n = 3$) ; five had insomnia (IN), all of whom showed hypnagogic disorder ; and one also woke in the middle of the night. Three students were diagnosed with idiopathic hypersomnia (IH), one with delayed sleep-wake phase disorder (DSWPD), one

Table 1 Causes of excessive daytime sleepiness (EDS) in medical students, that were diagnosed in accordance with the International Classification of Sleep Disorders – Third Edition (ICSD-3)

	EDS	non-EDS	total
Number	33	26	59
Normal	0 (0.0)	25 (96.2)	25
ISS	16 (48.5)	0	16
IN	5 (15.2)	0	5
Narcolepsy Type 1	3 (9.1)	0	3
Narcolepsy Type 2	3 (9.1)	0	3
IH	3 (9.1)	0	3
OSA	1 (3.0)	1 (3.8)	2
DSWPD	1 (3.0)	0	1
PLMD	1 (3.0)	0	1

Values are number and ( ) is %. EDS was identified based on Japanese Epworth Sleepiness Scale (JESS) score ≥ 11.
Abbreviations : DSWPD, delayed sleep-wake phase disorder ; IH, idiopathic hypersomnia ; IN, insomnia ; ISS, insufficient sleep syndrome ; OSA, obstructive sleep apnea ; PLMD, periodic limb movement disorder.

Table 2 Results of PSG and MSLT in the EDS group

	ISS	NA	IN	IH	DSWPD	OSA	PLMD
Number, n (%)	16 (48.5)	6 (18.2)	5 (15.2)	3 (9.1)	1 (3.0)	1 (3.0)	1 (3.0)
PSG							
SL, min	12.9 ± 11.9	8.5 ± 4.5	23.7 ± 23.7	9.3 ± 7.6	4.0	20.5	4.0
REM latency, min	93.5 ± 34.5	61.2 ± 25.0	149.9 ± 56.2	109.3 ± 36.5	90.4	91.5	97.0
Sleep efficiency, %	95.5 ± 3.6	95.2 ± 2.6	86.9 ± 12.8	93.7 ± 1.6	93.5	93.5	95.0
Sleep architecture							
Stage W, %	4.5 ± 3.6	4.8 ± 2.6	13.1 ± 12.7	6.3 ± 1.6	6.5	6.5	5.0
Stage N1, %	8.8 ± 4.4	8.4 ± 2.2	10.6 ± 4.3	12.9 ± 5.7	8.0	9.3	6.5
Stage N2, %	46.8 ± 6.9	47.2 ± 6.8	39.9 ± 7.1	52.2 ± 6.5	49.1	52.3	51.9
Stage N3, %	22.4 ± 6.4	20.7 ± 5.7	21.1 ± 5.9	12.9 ± 3.1	17.1	11.7	17.1
Stage REM, %	17.4 ± 4.4	18.9 ± 4.4	15.3 ± 4.4	15.7 ± 3.2	19.4	20.2	19.6
AI, events/h	10.6 ± 4.3	10.5 ± 3.6	12.7 ± 5.7	11.4 ± 1.1	15.4	9.9	14.9
AHI, events/h	2.5 ± 1.9	2.1 ± 1.7	3.7 ± 2.7	1.8 ± 1.1	1.4	7.8	0.1
PLMI, events/h	2.1 ± 3.2	4.6 ± 6.2	2.7 ± 3.4	3.0 ± 1.9	5.6	12.8	26.3
MSLT							
SL, min	5.8 ± 3.7	3.5 ± 0.6	8.0 ± 3.6	2.5 ± 0.9	4.3	9.6	1.3
Number of REM, *n*	1.1 ± 1.3	3.5 ± 1.1	0.6 ± 0.8	0.7 ± 0.5	2.0	0.0	0.0

Values are mean ± standard deviation (SD). EDS was identified by the scores of the Japanese Epworth Sleepiness Scale (JESS) ≥ 11.
Abbreviations : AHI, apnea hypopnea index ; AI, arousal index ; DSWPD, delayed sleep-wake phase disorder ; EDS, excessive daytime sleepiness ; IH, idiopathic hypersomnia ; IN, insomnia ; ISS, insufficient sleep syndrome ; MSLT, multiple sleep latency test ; NA, narcolepsy ; OSA, obstructive sleep apnea ; PLMD, periodic limb movement disorder ; PLMI, periodic limb movement index ; PSG, polysomnography ; SL, sleep latency.

with OSA, and one with PLMD. In the non-EDS group, only one student was diagnosed with OSA (apnea hypopnea index [AHI] = 15.4 events/h). **Table 2** shows the results of PSG and MSLT in each sleep disorder in the EDS group. The students with ISS showed no abnormalities on PSG. Furthermore, some

Table 3 Comparison of the results of PSG and MSLT between the EDS and non-EDS groups

	EDS	non-EDS	*P*-value
Number	33	26	
PSG			
SL, min	13.1 ± 13.7	13.1 ± 9.9	0.761
REM latency, min	97.5 ± 43.8	117.1 ± 39.3	0.097
Sleep efficiency, %	93.8 ± 6.4	89.3 ± 6.8	0.020
Sleep architecture			
Stage W, %	6.2 ± 6.4	10.7 ± 6.8	0.019
Stage N1, %	9.3 ± 4.2	12.5 ± 5.4	0.022
Stage N2, %	46.7 ± 7.0	51.4 ± 11.1	0.059
Stage N3, %	20.4 ± 6.4	15.2 ± 7.8	0.008
Stage REM, %	17.4 ± 4.2	12.0 ± 3.2	< 0.001
AI, events/h	11.2 ± 4.2	12.0 ± 4.9	0.559
MSLT			
Mean SL, min	5.7 ± 3.7	8.2 ± 3.4	0.010
SL < 8 min in 5 naps, *n*	22	4	< 0.001
Number of REM, *n*	1.3 ± 1.4	0.5 ± 0.8	0.016

Values are means ± SD. EDS was identified based on Japanese Epworth Sleepiness Scale (JESS) score ≥ 11.

Abbreviations : AI, arousal index ; EDS, excessive daytime sleepiness ; MSLT, multiple sleep latency test ; PSG, polysomnography ; REM, rapid-eye movement ; SL, sleep latency.

students showed SOREMPs once or twice during MSLT. All students with narcolepsy showed normal PSG, and short sleep latency (< 8 min), and at least two had SOREMP with a mean of 3.5 SOREMP during MSLT. The sleep latency was > 20.0 minutes in two of five students with insomnia (mean sleep latency : 23.7 ± 23.7 min on PSG). One student with AHI of 7.8 events/h was diagnosed with OSA by PSG. In one student with PLMD, periodic limb movement index (PLMI) was 26.3 events/h and PLMI with arousal was 8.2 events/h on PSG, so PLMD was diagnosed as the cause of EDS. **Table 3** shows a comparison of the results of PSG and MSLT between the EDS and non-EDS groups. The percentages of sleep efficiency, stage N3, and stage REM on PSG were significantly increased, while the percentages of stage wake and stage N1 on PSG were significantly decreased in the EDS group compared to the non-EDS group. The mean sleep latency in MSLT was shorter and the frequency of SOREMP was higher (both $P < 0.01$) in the EDS group than the non-EDS group.

B Results of circadian rhythm, PSQI, lifestyle questionnaire, and J-SHI

Table 4 shows the mean ± SD daily bedtime, wake-up time, and total sleep time for 1 month in each individual subject. The mean bedtime was significantly later in the EDS group than that in the non-EDS group. However, there were no significant differences in wake-up time or total sleep time between the two groups. The SDs of bedtime, wake-up time, and total sleep time were significantly greater in the EDS group than the non-EDS group. **Table 5** shows the PSQI score and lifestyle questionnaire results in the two groups. The PSQI scores were higher in the EDS group than the non-EDS group, and 20 students in the EDS group had scores > 6 points compared to only two students in the non-EDS group. There were no significant differences in the lifestyle questionnaire results between the two groups. **Table 6** shows the results of J-SHI. The total scores and scores of item numbers 1, 2, 3, 6, 7, 8, 12, and 13 were significantly higher in the EDS group than the non-EDS group. The items of questions 1, 2, and 3 suggested that the students in the EDS group had poor sleep habits, while the others suggested poor sleep environments.

Table 4 Comparison of sleep diaries between EDS and non-EDS groups

	EDS	non-EDS	*P*-value
Number	33	26	
Bedtime (O'clock)	0 : 58 ± 1 : 03	0 : 28 ± 0 : 34	＜0.05
SD for bedtime, minute	91 ± 35	40 ± 16	＜0.01
Wake-up time (O'clock)	7 : 56 ± 0 : 52	7 : 42 ± 0 : 53	0.827
SD for wake-up time, minute	93 ± 38	55 ± 19	＜0.01
Total sleep time (hours)	6.98 ± 0.92	7.23 ± 0 : 85	0.298
SD for total sleep time, minute	97 ± 31	51 ± 22	＜0.01

Values are means ± standard deviation (SD). EDS was identified based on Japanese Epworth Sleepiness Scale (JESS) score ≥ 11 ; SD for bedtime, wake-up time, and total sleep time, mean values of standard deviation (SD) of bedtime, wake-up time, and total sleep time for 1 month in each individual subject.

Table 5 Comparison of PSQI score and Interviewed lifestyle questionnaire between EDS and non-EDS groups

	EDS	non-EDS	*P*-value
Number	33	26	
PSQI score	6.4 ± 2.0	2.8 ± 1.7	＜ 0.001
Interviewed Lifestyle questionnaire			
Exercise habit/week, times	1.5 ± 1.3	0.9 ± 1.2	0.730
Drinking alcohol, times/week	0.5 ± 0.6	0.6 ± 1.5	0.790
Current smoker, *n*	3	0	0.248
Skipping breakfast, times/week	1.1 ± 2.2	1.7 ± 2.9	0.409
Activities at night, times/week	2.5 ± 2.0	1.5 ± 1.4	0.174

Values are means ± SD. Poor quality of sleep was identified based on PSQI score ≥ 6.
Abbreviations : EDS, excessive daytime sleepiness ; PSQI, Pittsburgh Sleep Quality Index.

Ⅳ Discussion

Medical students have been reported to show poor sleep quality, EDS, and reduced academic performance[1)-3)14)15)]. However, most surveys performed to date were based only on questionnaires, and PSG and MSLT have not been used to evaluate sleep quality and sleep disorders. The goal of this study was not to determine the prevalence of EDS among medical students. As participants with and without EDS were recruited using posters, the EDS group was larger due to a higher level of concern about sleep quality in these subjects. However, by using both PSG and MSLT in addition to questionnaires, the precise causes of EDS in Japanese medical students who complained of EDS were elucidated. In the present study, the most common sleep disorder responsible for EDS was ISS, which was seen in 48.5 % of participants **(Table 1)**, followed by narcolepsy in 18.2 %, insomnia in 15.2 %, IH in 9.1 %, OSA in 3.0 %, and PLMD in 3.0 %. On the other hand, the only sleeping disorder found in the non-EDS group was mild to moderate OSA, which was seen in one student. Both narcolepsy with cataplexy (type 1) and narcolepsy without cataplexy had prevalence rates of 0.22 % among the about 1340 medical students included in this study in contrast to the prevalence rates of 0.16 % (type 1) and 1 %-3 % (type 2) in the general Japanese population (https://jssr.jp/files/guideline/narcolepsy.pdf). Diagnosis of some sleep disorders requires PSG and MSLT, and we were able to clarify the accurate causes of EDS, including SAS, narcolepsy, etc. A cross-sectional survey using the SLEEP-50 questionnaire in a population of medical students in Jordan demonstrated that 30.7 % of the students were short sleepers and 66.2 % had at least one sleep disorder[15)]. The most common sleep disorders were hypersomnia (23.1 %) and insomnia (18.3) fol-

Table 6 Results of J-SHI

	EDS	non-EDS	*P*-values
Number	33	26	
1. I take daytime naps lasting two or more hours.	2.2 ± 1.0	1.0 ± 0.8	< 0.001
2. I go to bed at different times from day to day.	2.6 ± 0.9	1.4 ± 0.8	< 0.001
3. I get out of bed at different times from day to day.	2.5 ± 0.9	1.4 ± 0.9	< 0.001
4. I exercise to the point of sweating within 1 h of going to bed.	0.4 ± 0.6	0.3 ± 0.6	0.563
5. I stay in bed longer than I should two or three times a week.	1.9 ± 1.3	1.5 ± 1.2	0.269
6. I use alcohol, tobacco, or caffeine within 4 h of going to bed or after going to bed.	1.4 ± 1.2	0.6 ± 0.7	0.002
7. I do something that may wake me up before bedtime (e.g., play video games, use the internet, or clean)	3.3 ± 0.9	2.3 ± 1.2	0.002
8. I go to bed feeling stressed, angry, upset, or nervous.	1.3 ± 1.0	0.6 ± 0.7	0.005
9. I use my bed for things other than sleeping or sex (e.g., watch television, read, eat, or study).	2.1 ± 1.2	1.7 ± 1.4	0.382
10. I sleep on an uncomfortable bed (e.g., poor mattress or pillow, too many or not enough blankets).	0.3 ± 0.5	0.3 ± 0.4	0.794
11. I sleep in an uncomfortable bedroom (e.g., too bright, too stuffy, too hot, too cold, or too noisy).	1.1 ± 1.2	0.8 ± 0.9	0.362
12. I do important work before bedtime (e.g., pay bills, schedule, or study).	2.3 ± 1.0	1.2 ± 0.9	< 0.001
13. I think, plan, or worry when I am in bed.	2.1 ± 1.2	1.2 ± 0.9	0.003
Total score	23.3 ± 5.2	14.4 ± 5.8	<0.001

Values are means ± SD.

Abbreviations : EDS, excessive daytime sleepiness ; J-SHI, Japanese version of Sleep Hygiene Index.

lowed by circadian rhythm disorder (13.3 %), OSA (12.1 %), RLS/PLMD (10.4 %), and narcolepsy (7.9 %). In the present study, narcolepsy and insomnia were also important causes of EDS with prevalence rates of approximately one third that of ISS. In contrast to the study in Jordan, OSA and RLS/PLMD were only seen in one student each in the present study. There may be ethnic differences in the frequency of sleep disorders[5)15)16)]. The purpose of the present study was not to determine the prevalence of sleep disorders among medical students. Therefore, the prevalence of causes of EDS could not be compared with other population-based questionnaire surveys and also the method used here was different from a questionnaire survey. Accurate diagnosis of the causes of EDS cannot be obtained only by a questionnaire survey. Most studies concerning population-based surveys of sleep disorders used the SLEEP-50 questionnaire[17)]. It was demonstrated that the agreement between all clinical diagnoses and SLEEP-50-classifications was substantial ($\kappa = 0.77$), and the SLEEP-50 seems able to detect a variety of sleep disorders and can aid in screening for common sleep disorders in the general population. In the present study, the causes of EDS could not be clarified without PSG and MSLT in more than 30 % of cases. Therefore, PSG and MSLT are needed to make an accurate diagnosis.

The sleep efficiency and the periods of stage N3 and REM sleep on PSG were significantly increased and the mean sleep latency in MSLT was shorter in

the EDS group than the non-EDS group **(Table 3)**. The largest proportion of participants in the EDS group without sleep disturbance during sleep and showing greater desire to sleep had ISS (48.5 %) followed by narcolepsy (18.2 %) and IH (9.1 %) **(Table 2)**. Therefore, the EDS group showed higher sleep efficiency and shorter sleep latency than the non-EDS group. In addition, the reasons for the longer N3 and REM periods were as shown in **Table 3**. A previous study showed that when sleep episodes were curtailed to 4 h for 4 nights, slow-wave sleep in non-REM sleep was increased by approximately 20 % in the first night[18]. Therefore, many students with EDS, especially ISS and insomnia, did not have sufficient sleep periods in daily life, and so they had an increased percentage of slow-wave sleep in the present study **(Table 2)**. Moreover, the period of REM sleep was longer in the EDS group, especially among those with ISS and NA, compared to the non-EDS group. It has been demonstrated that the percentage of REM sleep is significantly decreased during the early period of sleep deprivation, but rebounds in the two recovery nights, especially in the first recovery night, compared with baseline levels[19].

In this study, PSQI scores were higher in the EDS group **(Table 5)**, and 20 students had scores $>$ 6 points compared to only two in the non-EDS group, suggesting that 60.6 % of participants in the EDS group showed poor quality of sleep (data not shown). Medical students must get up early to attend classes in the morning, and 52.0 % of students sleep for less than 7 h per night[20] **(Table 4)**. In the present study, the mean bedtime was significantly later in the EDS group and the total sleep time was shorter although the differences were not significant. However, the SDs of bedtime, wake-up time, and total sleep time were significantly greater in the EDS group, suggesting irregularity of sleep habits, and poor sleep hygiene corresponding to the results of J-SHI (**Table 6**, Item No. 2, 3). Some of the students diagnosed with narcolepsy, SAS, PLMD, insomnia, and IH showed poor sleep hygiene, which may cause further exaggeration of EDS. Preišegolavičiūtė et al.[21] suggested that medical students have poorer quality of sleep and show a worse impact of poor sleep on the quality of life compared to students of law and economics. A systematic review of EDS in medical students suggested that the relationship between sleep duration and sleep quality may predict EDS[22]. The times at which classes start and of bedside learning vary from day to day, which may cause irregular sleeping habits. In the present study, J-SHI showed higher scores in usage of alcohol, tobacco, or caffeine within 4 h of going to bed or after going to bed, and feelings of stress, anger, upset, or nervousness when going to bed, which may contribute to the impairment of sleep quality **(Table 6)**. J-SHI also revealed that playing video games and use of social networks in bed or before going to bed caused sleep deprivation and delayed bedtime in the EDS group. The results of the present study suggested the need for further longitudinal studies of the benefits of using a sleep diary for students complaining of EDS to guide improvement of their lifestyle and sleep hygiene. In cases in which EDS does not improve, PSG and MSLT should be performed.

The present study had two limitations. First, some students, especially those with ISS, showed SOREMP once or twice during MSLT. NT2 was diagnosed by more than two SOREMPs and shorter sleep latency $<$ 8 minutes on MSLT. There are difficulties in distinguishing NT2 without cataplexy from ISS and IH[23]. MSLT must be repeated at regular intervals to confirm stable hypersomnia and allow accurate diagnosis of NT2 and IH[24]. In the present study, most students who showed EDS had inadequate sleep hygiene. MSLT should be performed after a sufficient time to correct inadequate sleep hygiene and should be repeated. Three students in the EDS group who slept over 7 h almost every night, who showed no problems on PSG, and had less than two SOREMPs were diagnosed with IH. However, if they slept more and their EDS recovered, they would not have been diagnosed with IH but with ISS. In addition, we did not measure orexin in cerebrospinal fluid. Second, the study was cross-sectional rather than longitudinal in design, and so it was not possible to clarify changes in diagnosis over time. However, in the

students who complained of EDS, not only a questionnaire survey but also PSG and MSLT are required to obtain an accurate diagnosis. In the present study, over 30 % of the medical students had sleep disorders that could be diagnosed by PSG and MSLT.

Ⅴ Conclusion

This survey including PSG and MSLT among medical students revealed that the most common cause of EDS was ISS, affecting half of the participants, followed by narcolepsy, IN, IH, OSA, DSWPD, and PLMD, and the major characteristic of the students with EDS was poor sleep hygiene.

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