ORIGINAL ARTICLE

A school-based sleep hygiene education program for adolescents in Japan: a large-scale comparative intervention study

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Abstract
Sleep hygiene education involves promoting good sleep habits in all aspects of lifestyle and behavior. In this study, we evaluated the effects of a sleep hygiene education program for Japanese high school students who did not have insomnia symptoms. Tenth-grade students ($N = 2815$; intervention, $n = 1347$; control, $n = 1468$) from 16 high schools in a provincial city in Japan participated in this cluster-controlled trial. In this program, teachers conducted a 5-min class based on various catchphrases once per week using teaching materials developed for this study ("Healthy Living Sleep Guidelines for High School Students"). Twelve classes were conducted. The baseline and follow-up surveys were performed. The difference between the groups was examined using an intention-to-treat principle with the full analysis set. We selected the generalized estimating equation for this analysis. The intention-to-treat analysis revealed that the intervention group presented significantly greater prevention of insomnia symptoms and short sleep duration (< 6 h) compared to the control group (adjusted odds ratio: 0.72 [95% confidence interval: 0.54–0.96], adjusted odds ratio 0.79 [95% CI 0.67–0.94]). However, there were no significant differences in odds ratios between the two groups for poor subjective sleep quality, excessive daytime sleepiness, and late bedtime.This sleep hygiene education program may be useful as a low-cost, highly valid, and accessible primary prevention method for insomnia symptoms. However, the applicability of this program for children of other ages and regions needs to be verified.

Introduction

Sleep problems are common among adolescents, with a prevalence of 11–30% worldwide [1, 2]. In Japan, 28.7% of male and 32.6% of female high school students sleep less than 6 h per day [3]. Sleep problems in adolescence are associated with mental health [4–6]; they can not only affect current mental health but also may increase the risk of later onset of depression [7]. Sleep problems during adolescence can also negatively impact physical health, leading to cardiovascular disease, obesity, and insulin resistance [8–10]. Reduced sleep duration is related to excessive daytime sleepiness [3, 11], a known trigger of deficits in attention and performance during key daily tasks, leading to worsened academic performance [12].

Particularly, insomnia is the most prevalent sleep disorder in adolescents. Kaneita et al. reported that 23.4% of the Japanese adolescents in 2004 had one or more of the following insomnia symptoms: difficulty initiating sleep (DIS), difficulty maintaining sleep (DMS), early morning awakening (EMA), or nonrestorative sleep [13]. Factors associated with insomnia among adolescents in Japan are male sex, poor mental health, and lifestyle behaviors such as skipping breakfast, drinking alcohol, smoking, and not participating in extracurricular activities [13]. Insomnia is also a well-known risk factor for depression [14, 15]. In fact, insomnia and depression may have a bidirectional relationship, with insomnia inducing and being induced by depression [4]. Therefore, insomnia symptoms are more morbid than other sleep problems, such as short sleep duration and poor sleep quality, and it is a more important target for sleep therapy.

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The impact of insomnia symptoms among adolescents highlights the need for appropriate intervention.

The incidence rate of insomnia among Japanese adolescents has been reported to be 9.2% among high school students [16]. Previous studies in various countries have shown that 14.0–16.0% of adolescents have new-onset insomnia [17, 18]. Insomnia is a complex disease, and genetic, biological, environmental, and social factors contribute to its development. A recent review reported that factors of new-onset insomnia among adolescents include gender, school stress, electronic media use, and high caffeine intake [19]. Factors associated with new-onset insomnia among adolescents in Japan include "being woken by a nightmare", "poor mental health status", "longer duration of extracurricular learning", and "longer duration of mobile phone use" [16].

Adolescent sleep problems are best addressed within a public health framework rather than on an individual basis [20]. Sleep hygiene education aims to promote good sleep habits including the aspects of lifestyle and behavior. Such programs rely on comprehensive lifestyle management such as limiting caffeine, tobacco, and alcohol use; promoting exercise; decreasing stress; and managing the timing of sleep and daytime naps [21]. Previous reports suggest that not getting enough sleep is often the result of poor sleep hygiene [22]. Sleep hygiene education can help gain a better understanding of sleep hygiene and increase sleep duration and quality [23–27]. A recent review reported that sleep improvement programs may improve awareness that education can change sleep behavior/routines and extend sleep durations, and later may have downstream positive effects on youth metabolic function and weight [28]. Therefore, it is particularly important to understand the effectiveness of school-based sleep education programs on high school students, as sleep education at this developmental stage could be particularly beneficial.

The Japanese Ministry of Health, Labour, and Welfare released the "Sleep Guidelines 2014 for Health Promotion", which provide information on good sleep hygiene according to the latest scientific evidence. Good sleep hygiene requires appropriate knowledge about sleep and its health effects and arranging one's lifestyle and environment in a way that ensures quality sleep. However, it remains unclear which specific aspects of sleep education are truly beneficial. For instance, Gruber found mixed results regarding the impact of 15 sleep hygiene programs on sleep behavior, knowledge, and health outcomes [29]. One possible reason is that transforming knowledge to action is exceedingly slow.

While making changes regarding sleep hygiene is often recommended as the first line of intervention for addressing sleep problems, few studies have investigated sleep hygiene education programs in Japan. We, therefore, evaluated the effect of a sleep hygiene education program on preventing the incidence of insomnia symptoms in adolescents as the

main goal of our study. As a secondary goal, we examined changes in other sleep problems after this program. According to the ICD-10, poor sleep quality, short sleep duration, and daytime sleepiness are the main determinants of insomnia [30]. Thus, we focused on insomnia symptoms and hypothesized that the sleep problems (especially insomnia symptoms) of intervention group participants would improve after the program compared to the baseline, whereas these problems would worsen among control group participants over the same period.

Methods and materials

Study design, sample size, and participants

The design of this study is an open-label, non-randomized parallel group, school-based trial and followed the Consolidated Standards of Reporting Trials (CONSORT) guidelines for the design. This study was approved by the local ethics committee and was registered at ClinicalTrials.gov (identifier no. UMIN000027587).

Figure 1 shows the flowchart of the participant progress through the study. Tenth-grade students ($N = 4300$) from all 21 high schools located within a medium-sized city in Japan (population = 420,725 in 2016) were included as potential participants. Sixteen schools with 3227 tenth-grade students in the 2015 academic year agreed to participate. Prior to the baseline survey, we allocated these schools (and students) to the intervention and control groups (eight schools each) based on three factors: (1) university advancement rate, (2) school type (public or private), and (3) school specialty (specialized or regular). The effect size was estimated from previous sleep hygiene programs [31, 32]. Considering a type I error of 0.05, a power of 0.80, 200 students per cluster (assuming the same sample size for each cluster), and an intraclass correlation coefficient of 0.05, the target sample size for the present study was 1950 (at least 975 in each group). Assuming that 90% participation rate, the planned sample was a minimum of 2408 students. In accordance with school nurses' request, the intervention was conducted during the class hours as a curriculum of each school. As some school principals refused to cooperate with a randomized controlled trial (RCT) protocol, we did not conduct an RCT to ensure the required sample size. The teacher for each class distributed the questionnaires to the students.

In the baseline survey, 28 students in the intervention group and 34 students in the control group refused to participate in the survey. After the baseline survey, we excluded the students who were already exhibiting insomnia symptoms. After excluding 180 students in the intervention group and 170 students in the control group, 1347 students in the intervention group and 1468 were students in the control
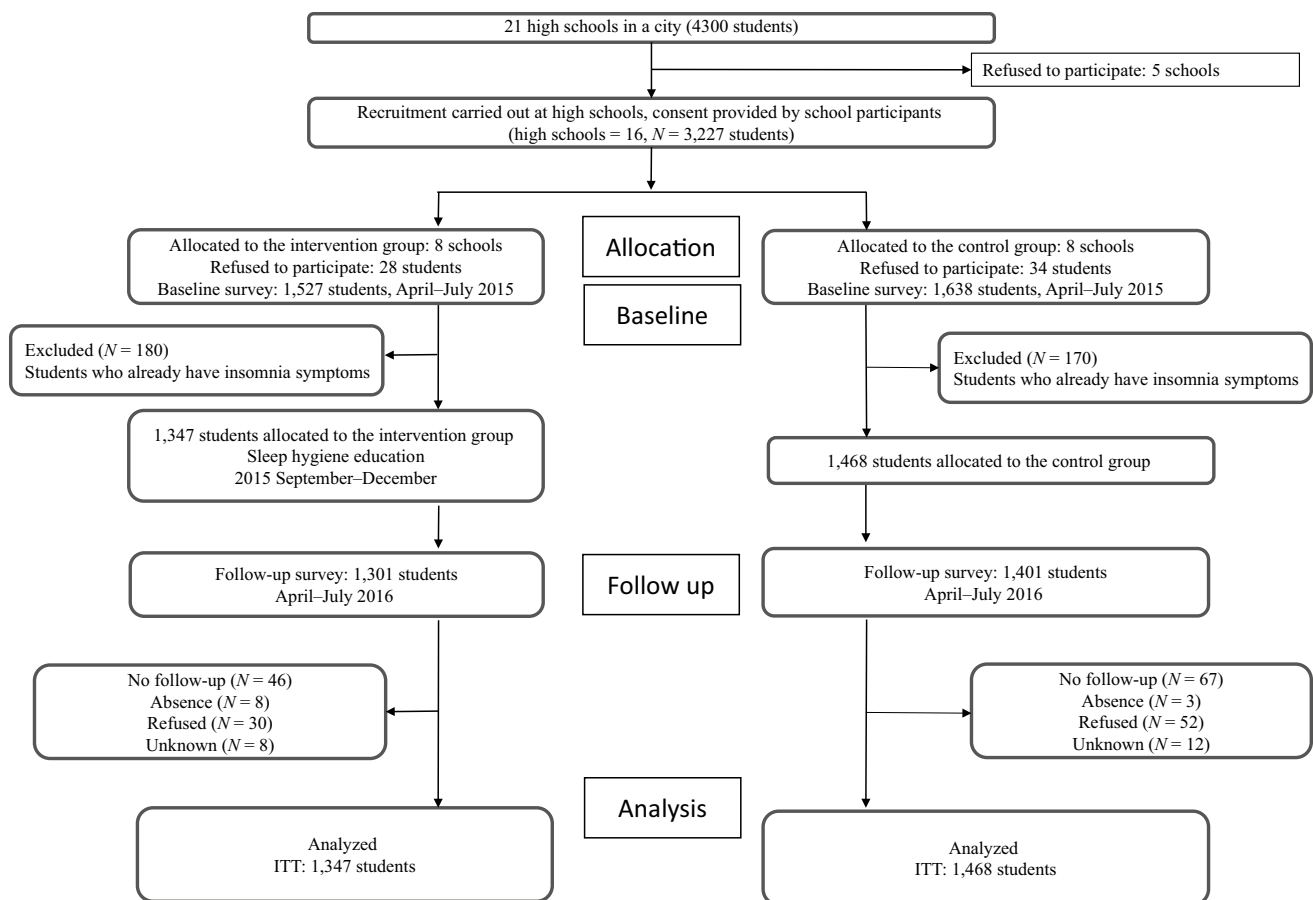
Fig. 1 Flowchart of the school and subject recruitment process

group were included. Between the two surveys, 30 students refused to participate in the intervention or complete the questionnaires, eight declined for unknown reasons, and eight were absent from follow-up in the intervention group. The remaining 1301 students completed the intervention. The participation rate was 96.6% in the intervention group. All participants were 15–16 years old at baseline.

Participants' confidentiality was assured in accordance with the Declaration of Helsinki. The school nurses and teachers verbally explained the sleep hygiene education program and questionnaires to the students, and those who agreed to participate signed a written consent form. Thus, all survey participants provided written informed consent to participate. To protect students' privacy, the questionnaire clearly stated that completed surveys would not be seen by teachers. After completing the questionnaires, students placed them in sealed envelopes. Figure 1 shows the study procedure. The study period was from April 2015 to July 2016: (baseline survey: April–July 2015; follow-up survey: April–July 2016). The sleep hygiene education program was conducted from September to December 2015. The control group did not receive any intervention during the

study period. However, after the completion of the study, the control group received educational materials related to sleep hygiene. None of the participants was provided any incentives during the study period.

Intervention

To ensure that students acquired proper sleep knowledge, teaching materials entitled "Healthy Living Sleep Guidelines for High School Students: 12 Sleeping Catchphrases for High School Students" were developed. We developed our own because Japan's "Sleep Guidelines 2014 for Health Promotion" [33] includes articles on drinking and smoking, which are illegal for those aged younger than 20 years. We modified the government's guidelines by deleting articles related to drinking alcohol and smoking and simplifying expressions to ensure that most high school students could understand the material (Table 1). In this process, we listened to the opinions of the school teachers and the developers of the sleep guidelines 2014. Prior to the study, we asked ten high school students whether they could understand the contents of the guidelines. Similar to previous education

Table 1 Sleep hygiene education program catchphrases

Catchphrase 1: Good sleep makes both the body and the mind healthy
Catchphrase 2: Add a healthy rhythm to your sleeping and waking times through adequate exercise and a proper breakfast
Catchphrase 3: Good sleep leads to the prevention of lifestyle-related illnesses
Catchphrase 4: The feeling of good rest from sleep is important for mental health
Catchphrase 5: Get enough sleep according to your age and the season so that you do not feel too sleepy during the day
Catchphrase 6: For good sleep, it is important to prepare an appropriate sleeping environment
Catchphrase 7: Young people should avoid staying up late and maintain the pattern of their circadian rhythm
Catchphrase 8: Get sufficient sleep every day in order to recover from tiredness and improve performance
Catchphrase 9: Use your age to determine how many hours of sleep you need
Catchphrase 10: When it is difficult to fall asleep, relax in your own way
Catchphrase 11: Pay attention to differences in your sleep patterns
Catchphrase 12: If you are having trouble due to not being able to sleep, do not keep it a secret and consult a specialist

programs, this program focused on educating participants on the importance of sleep, sleep physiology, sleep duration appropriate to age, the negative effects of sleep interruption and lack of sleep, and the effects of caffeine and alcohol on sleep [23–27].

The intervention consisted of approximately 5-min classes for each catchphrase held once per week over 12 weeks by the students' regular teachers using the teaching materials. The study materials were divided between students and teachers. The materials for teachers included reading materials and answers to questions, and teachers were only required to read the script during the lectures. This ensured that the teaching method and the quality of the lectures remained the same. We used quizzes or checklists of lifestyle factors such as eating breakfast, exercising, and consuming caffeine before bedtime in the classes to hold students' interest: students were initially given the multiple-choice quiz, followed by the answers and an explanation of those answers. For example, participants were told, "Depending on your age, the suitable sleeping time varies. Which is longer—sleeping time in your 20 s or that in your 60 s?" After the quiz, teachers gave explanatory lectures on each phrase.

Questionnaire

The primary areas covered by the questionnaire were (1) demographic variables (e.g., gender, school), (2) sleep status, (3) lifestyle, (4) mental health status, and (5) Internet usage.

Sleep status Sleep status was assessed in terms of sleep duration, subjective sleep quality, bedtime, insomnia symptoms, excessive daytime sleepiness, and nightmares. These questions have been used in several national surveys of Japanese adolescents [13, 34, 35]. Sleep duration was assessed with the question, "How many hours on average do you sleep at night?" If students' response was less than 6 h, they were defined as having a short sleep duration [34, 36]. Subjective sleep quality was assessed with "How would you assess the quality of your sleep?" ("very good," "good," "bad," or "very bad"); participants who responded with bad or very bad were considered to have poor subjective sleep quality [37]. Bedtime was assessed with "What time do you go to bed?" Individuals who answered 1 a.m. or later were defined as having a late bedtime [38]. Insomnia symptoms in the previous month were assessed with three questions: (1) "Do you have difficulty initiating sleep?" (2) "Do you have difficulty maintaining sleep?" and (3) "Do you have early morning awakening?" Each item had five response options: "never", "seldom", "sometimes", "often", and "always". "Often" and "always" were considered affirmative answers, and insomnia symptoms were considered present when an affirmative answer was obtained for any question; this definition was determined using previous nationwide studies [13, 34, 35]. To assess excessive daytime sleepiness, we used the Japanese version of the Epworth Sleepiness Scale (JESS) [39]. Each question was graded from 0 to 3, and excessive daytime sleepiness was determined using a total JESS score of 11 or higher. The presence of nightmares was assessed with the question, "Have you ever been wakened by a nightmare?" The response options were "never", "seldom", "sometimes", "often", and "always". Responses of "often" and "always" were considered affirmative answers [40].

Lifestyle The questions related to lifestyle included whether the student ate breakfast or consumed caffeine (daily/occasionally/never) and whether the student participated in club activities (participating/not participating). Smoking was assessed with the question "How many days did you smoke during the previous month?" If the response to this question was 1 day or more, then the student was defined as smoking [38]. Similarly, alcohol consumption was assessed with the question "How many days did you consume alcoholic beverages during the previous month?" If the response was 1 day or more, then the student was

defined as drinking alcohol [38]. Regarding cellular phone use after lights out, students could choose from "not at all", "one to three times a month", "once a week", "a few times a week", or "every day". If the response was one day or more, then the student was defined as using a cellular phone after lights out [34].

Mental health The Japanese version of the 12-item General Health Questionnaire (GHQ12-J) was used to evaluate mental health status [41, 42]. Participants whose total GHQ12-J score was ≥ 4 were considered to have poor mental health; this cutoff was deemed valid in past studies [13, 43].

Internet usage We used the Japanese version of the diagnostic questionnaire developed by Young to assess problematic Internet use [44]. We followed Young's dichotomous distinction of problematic Internet use using a cutoff of 5 [44].

Statistical analyses

First, descriptive statistics for all participants at baseline was calculated and compared using the χ^2 test. Second, McNemar's test was used to measure changes in the incidence of sleep problems in both groups over time [45]. The unadjusted generalized estimating equation (GEE) was also used to compare the groups. Third, we calculated the incidence of new onset sleep problems between baseline and follow-up in both groups. The cumulative incidence rates for both groups were compared using the χ^2 test. Fourth, we examined the relationship between education program completion and incidence of sleep problems [46]. The primary outcome is the incidence of insomnia symptoms. The secondary outcome is the incidence of other sleep problems. The difference between the groups was examined using an intention-to-treat (ITT) principle with the full analysis set. We selected the GEE for this analysis, as it is useful for analyzing repeated measurements of health results. These repeated measurements included individuals as a subject variable and days as an intra-subject variable. GEEs were conducted using presence or absence of each sleeping problem (i.e., insomnia symptoms, poor sleep quality, excessive daytime sleepiness, short sleep duration, and late bed time during follow-up) as the dependent variable. We adjusted for sex, academic achievement, school type, school specialty, breakfast consumption, cultural club activities, and cellular phone use after lights out. The last three variables were different from baseline for both groups. Adjusted odds ratios (AORs) and 95% confidence intervals (CIs) were calculated. We set the level of significance at $p < 0.05$. All analyses were performed using SPSS Statistics 22.0 for Windows (IBM Corp., Armonk, NY).

Results

Table 2 shows participants' basic characteristics. Although no significant differences between the groups were found regarding sleep problems at baseline, significant differences were found for cultural club activities, eating breakfast every day, and cellular phone use after lights out.

Table 3 shows the change over time in the prevalence of sleep problems in the groups. In the control group, aside from poor sleep quality, the prevalence of all sleep problems

Table 2 Demographics and Baseline Characteristics of the Participants

Variable	Intervention group ($N=1347$)			Control group ($N=1468$)			Chi-square score	*p* value
	N	%	95% CI	N	%	95% CI		
Sex (female)	675	50.1	47.4–52.8	778	53.0	50.4–55.6	2.34	0.126
Poor subjective sleep quality	132	9.8	8.2–11.4	153	10.4	8.8–12.0	0.27	0.605
Excessive daytime sleepiness	579	43.0	40.3–45.7	658	44.8	42.2–47.3	0.89	0.346
Short sleep duration (<6 h)	327	24.3	22.0–26.6	368	25.1	22.9–27.3	0.22	0.643
Late bedtime (after 1:00 a.m.)	185	13.7	11.9–15.6	207	14.1	12.3–15.9	0.05	0.722
Eating breakfast every day	1202	89.2	87.6–90.9	1345	91.6	90.2–93.1	4.72	0.030
Consuming caffeine every day	238	17.7	15.6–19.7	244	16.6	14.7–18.5	0.54	0.461
Sports club activities	869	64.5	61.9–67.0	954	65.0	62.5–67.4	0.08	0.777
Cultural club activities	416	30.9	28.5–33.4	531	36.2	33.7–38.7	8.63	0.003
Poor mental health status	497	36.9	36.3–41.2	568	38.7	36.3–41.2	1.07	0.301
Problematic Internet use	74	5.5	4.3–6.8	98	6.7	5.3–8.0	1.44	0.230
Cellular phone use after lights out	253	18.8	16.7–20.9	208	14.2	12.4–16.0	11.07	0.001
Frequent nightmares	22	1.6	0.9–2.2	35	2.4	1.6–3.1	2.41	0.171

Data are presented as percentages

p values were calculated using the Chi-squared test

CI confidence interval

Table 3 The Change over Time in the Prevalence of Sleep Problems in the Two Groups

Time period	Intervention group											Control group											I vs C		
	Baseline (N=1347)		Follow-up (N=1301)		McNemar's Chi-squared	Cramer's v	p value						Baseline (N=1468)		Follow-up (N=1401)		McNemar's Chi-squared	Cramer's v	p value					β	95% CI		p value
	N	(%)	N	(%)									N	(%)	N	(%)											
Poor subjective sleep quality	132	9.8	128	9.8	0.01	0.001	0.942						153	10.4	150	10.7	0.05	0.006	0.758					−0.10	−0.35	0.15	0.419
Excessive daytime sleepiness	579	43.0	591	45.4	3.46	0.037	0.063						658	44.8	675	48.2	9.31	0.058	0.003					0.14	−0.01	0.29	0.074
Short sleep duration (<6 h)	327	24.3	334	25.7	0.69	0.017	0.382						368	25.1	430	30.7	11.56	0.065	0.001					−0.25	−0.42	−0.08	0.004
Late bedtime (after 1:00 a.m.)	185	13.7	225	17.3	6.68	0.052	0.008						207	14.1	266	19.0	13.47	0.070	<0.001					−0.10	−0.30	0.09	0.304

p values were calculated using McNemar's test for intra-group comparison and unadjusted GEE's test for inter-group comparison

Baseline: grade 10 baseline survey

Follow-up: grade 11 baseline survey

I intervention group (sleep hygiene education), C control group

Table 4 The Cumulative Incidence Rates in Both Groups

Group	N	Cumulative incidence rate (%)	Chi-squared score	Cramer's v	p value
Primary outcome					
Insomnia					
Intervention	96	7.4	4.44	0.04	0.035
Control	135	9.6			
Secondary outcomes					
Poor subjective sleep quality					
Intervention	83	7.1	0.47	0.01	0.493
Control	98	7.8			
Excessive daytime sleepiness					
Intervention	67	11.5	0.30	0.02	0.581
Control	61	10.5			
Short sleep duration (<6 h)					
Intervention	183	18.6	3.16	0.04	0.075
Control	229	21.8			
Late bedtime (after 1:00 a.m.)					
Intervention	146	13.1	0.13	0.01	0.723
Control	163	13.6			

Cumulative incidence: There were no symptoms at the baseline survey, but there were symptoms at the follow-up survey

In each section, missing data have been excluded from the statistical analyses

p values were calculated with the Chi-squared test

increased significantly after 1 year. Conversely, in the intervention group, we observed no significant changes in the prevalence of short sleep duration and poor subjective sleep quality. Furthermore, when comparing the intervention and control groups, we saw significant differences in short sleep duration ($\beta = -0.25$; 95% CI (-0.42, -0.08), $p = 0.04$).

Table 4 shows the cumulative incidence in both groups. The cumulative incidence of insomnia was significantly lower in the intervention group (7.4%) than in the control group (9.6%) ($\chi^2 (2) = 4.44$ $p = 0.035$). Conversely, for poor sleep quality, short sleep duration, and late bedtime, the cumulative incidence rate in the intervention group tended to be lower than in the control group, although there were no significant group differences. Regarding excessive daytime sleepiness, the cumulative incidence rate tended to be higher in the intervention group than in the control group, although there were no significant group differences.

Table 5 displays the GEE results examining the relationship of the intervention and the incidence of sleep problems and poor mental health. The ITT analysis revealed that the odds ratio for insomnia symptoms and short sleep duration

Table 5 Effects of the Sleep Hygiene Education Program on Incidence of New Sleep Problems

Dependent variable	Primary outcome	Secondary outcomes			
	Insomnia symptoms	Poor subjective sleep quality	Excessive daytime sleepiness	Short sleep duration (< 6 h)	Late bedtime (after 1:00 a.m.)
ITT analysis					
AOR	0.72*	0.91*	1.02*	0.79*	0.97*
95% CI	0.55–0.95	0.71–1.18	0.81–1.23	0.67–0.94	0.76–1.08
p value	0.022	0.487	0.864	0.008	0.787

Insomnia symptoms were defined as answering affirmatively for difficulty initiating sleep, difficulty maintaining sleep, or early morning awakening

AOR adjusted odds ratio, *CI* confidence interval, *ITT* intention-to-treat

*Adjusted for academic achievement of the school, school type, school specialty, sex, breakfast consumption, cultural club activity, and cellular phone use after lights out by generalized estimating equation

were significantly lower in the intervention group (AOR 0.72; 95% CI 0.54–0.96, AOR 0.79; 95% CI 0.67–0.94) than in the control group. In addition, there were no significant differences in the odds ratios for poor subjective sleep quality, excessive daytime sleepiness, and late bedtime between the two groups.

Discussion

We examined the relationship between completion of a sleep hygiene education program for high school students and various sleep problems. Our main findings suggest that this sleep hygiene education program will be useful for primary prevention of insomnia symptoms for those who do not already have insomnia symptoms and short sleep duration. The teaching materials used in our program were manualized, allowing the program to be easily implemented within normal health classes without specialized teaching staff. Compared to previous research results, this study had a large sample size and a high retention rate. Given the lack of epidemiological studies examining the impact of sleep hygiene education programs for adolescents in Japan, our results may be critical for future research on this topic.

The intervention group had a significantly lower incidence of insomnia symptoms than the control group; other sleep problems exhibited no statistical difference. The reasons for these differences could be due to the following. First, we excluded the students who showed insomnia symptoms at the baseline because we hypothesized that there would be no intervention effect for students with insomnia. Sleep hygiene is conventionally regarded as having dubious efficacy for the treatment of insomnia, in contrast to cognitive-behavioral therapy for insomnia (CBT-I) [47]. However, sleep hygiene appears useful only for primary prevention—that is, for those who do not already have sleep problems. Treatments such as CBT-I might be more useful for those

who already have sleep problems. Second, many Japanese high school students prefer staying up late [48]. This might explain why they do not mind the short sleeping durations. However, participants who were concerned about future insomnia symptoms and their present short sleep duration might have adopted the sleep hygiene practices taught in this program as a preventative measure, which resulted in less insomnia symptoms and short sleep duration.

Data from normal sleepers show that sleep quality and quantity are adversely affected when certain sleep behaviors are practiced. Evidence suggests that poor sleep hygiene can worsen sleep [49]. In this study, the incidence of sleep problems except for excessive daytime sleepiness in the intervention group tended to reduce compared to the control group, although it was not significantly different. To date, previous studies have shown the positive effects of sleep education on sleep duration [27, 50]. Previous studies have reported that sleep education programs resulted in significantly longer weekday and weekend total sleep time [50]. However, our study did not examine differences between weekday and weekend total sleep time. Cross-sectional evidence suggests that adolescents tend to increase their weekend sleep duration to compensate for short weekday sleep duration [51]. Future sleep intervention programs may need to emphasize the importance of focusing on cycle of sleep rhythm. Studies have also shown that Japanese adolescents typically sleep for a shorter duration (about 6 h) compared to other Asian and western adolescents [48, 52, 53]. Thus, educating Japanese high school students on the importance of sleep is considered to be a useful measure to maintain their physical and mental health.

This study has several strengths. First, this study utilized a large sample size and had a high retention rate among students and a high participation among schools. The number of participants in previous studies varied widely, ranging from approximately 30 [27, 54] to 2800 [55]. Furthermore, most of these studies were limited to including only one or

a few schools [27, 54]. Second, the period from program completion to the final evaluation was longer in the present study compared in other studies. In previous studies of sleep hygiene education, the study period was typically 6 weeks [23, 24, 47]; shorter programs lasted about 4 weeks [25, 56], and longer programs lasted up to 12 weeks [26, 27]. The length of the period between program commencement and evaluation does have an impact on the results. Generally, over shorter periods, the relationship between the education program and the outcome will be more strongly reflected in the results; as the period lengthens, the relationships becomes less clear. Third, the present program was run by teachers who oversaw regular health classes, none of whom were experts or had received special training on sleep. The teachers followed full scripts for each lecture, which limited the burden placed on them while maintaining uniformity of lecture content. The materials for students included detailed commentary on each phrase, which allowed students to review them. The teachers gave a 5-min lesson for each theme over the course of 12 weeks. Such "microteaching" is reported to be an effective training strategy since it has similar outcomes as conventional teaching methods [57]. In many previous programs, four 50-min lectures were given over a 4- or 5-week period by sleep research experts [23, 24, 27]. Compared to these studies, the lectures in our program were far shorter and did not require expert administration; therefore, this program can be easily incorporated into the normal curriculum, and it does not present many barriers for use in schools.

This study has several limitations. First, the design was non-randomized, which could have led to unknown confounding factors influencing the results despite adjusting for different factors at baseline. However, a non-randomized controlled design is a widely accepted quasi-experimental design for evaluating public health interventions [58]. A future cluster randomized controlled study is needed; to do so, we would need to work not only with the school but also with the Board of Education. Second, this study used tenth-grade students in 2015 from a single provincial city in Japan. As such, caution is required when generalizing the results. In the future, we would like to investigate whether similar relationships are observed among students from other grades and districts. We also want to investigate the implementation status of the guideline items. Third, we used self-administered questionnaires, and there are few validated measures for assessing sleep duration, quality, and insomnia symptoms. Measurements using objective indices to examine sleep, such as polysomnography and actigraphy, might provide stronger evidence in support of our results. Fourth, our results might be affected by non-response or recall bias. Although sufficient prior explanation and measures to ensure privacy were implemented, we cannot deny that some bias remains. Fifth, the intervention was not effective to promote earlier bedtime or prevent short sleep duration. To address these problems, it is recommended that students correct their behavior by maintaining a sleep diary. Finally, although we wanted to include all schools in this city, only about third-fourth of them participated. Thus, the possibility of a selection bias cannot be denied.

Conclusion

We conducted a non-randomized controlled study involving high school students to examine the effects of short-term sleep hygiene education. This sleep hygiene education program might be useful for primary prevention of insomnia and short sleep duration. Despite the study's limitations, this study is a useful population approach model for adolescents and could be used by future studies to continue sleep-related research.

Compliance with ethical standards

Conflict of interest All authors declare that they have no conflicts of interest.

Ethical approval All procedures performed in this study were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This study was approved by the Ethics Committee of Oita University School of Medicine.

Informed consent Informed consent was obtained from all study participants.

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