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ORIGINAL ARTICLE

Sleep-related factors associated with industrial accidents among factory workers and sleep hygiene education intervention

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Abstract

This study was conducted to investigate the association between industrial accidents and sleep-related parameters in factory workers, and to examine the effectiveness of sleep education intervention for improvement of sleep status. 714 factory workers were included in the study. A baseline survey was conducted using a self-administered questionnaire in December 2013. The questionnaire included items for the evaluation of sleep status (containing PSQI and ESS), sleep-related lifestyle habits, and experience of industrial accidents. In January 2014, workers were selected for a sleep education program that included attendance at a lecture and a take-home leaflet containing information on how to improve their sleep habits. All of the workers then participated in a follow-up survey in March 2014 to investigate the effectiveness of the education program. We first analyzed the association between industrial accidents and sleep status at the time of the baseline survey. Then, using data from the follow-up survey, we examined the effectiveness of sleep education by analyzing the differences in the improvement of sleep disorders and sleep habits between the groups who did and did not receive sleep education. We detected a significant association between the occurrence of industrial accidents and PSQI scores from the baseline survey. With regard to the effectiveness of the sleep hygiene education intervention, the percentage of early risers increased significantly in the intervention group among the participants less than 40 years of age. Among the participants aged 40 years or older, the percentage of those who did not drink an alcoholic beverage before going to sleep increased significantly in the intervention group.

Keywords Non-randomized controlled trials · Good sleep habits · Insomnia · Circadian rhythm · Occupational injuries · Epidemiology

Introduction

The diversification of labor and the expansion of the 24-h society in recent years have been increasingly leading to sleep problems [1]. In an epidemiological study of the Japanese general population, 12.2% of adult men and 14.6% of women reported symptoms of insomnia (difficulty initiating sleep, difficulty maintaining sleep with difficulty resuming sleep, and early morning awakening with difficulty resuming sleep), and 3.2% of men and 4.2% of women also suffered from daytime disorders [2]. A further study also found that a higher proportion of workers complained of insomnia compared with the general adult population [3].

Sleep disorders may constitute a risk factor for the lifestyle-related conditions of obesity [4, 5], hypertension [4, 6], glucose intolerance [4, 7], cardiovascular disease [4, 8], and depression [9, 10]. Insomnia not only causes distress during

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the night, but also leads to impaired daytime functioning, with accumulation of fatigue and diminished memory and attention, potentially resulting in a diminished quality of life [11, 12]. Insomnia in workers, in particular, reduces working efficiency and job satisfaction and increases the incidence of work-related injuries and problems such as absenteeism, presenteeism, and early retirement, which incur both direct and indirect financial losses [13]. Many studies have reported a relationship between sleep problems and work injuries. Evidence from these studies recently underwent a systematic review [14]. This review abstracted 27 observational studies and featured a meta-analysis of 54 relative risk estimates from among those studies. The findings of the meta-analysis suggested that workers with sleep problems had a 1.62 times higher risk of being injured than workers without sleep problems. The Pittsburgh Sleep Quality Index (PSQI), developed at University of Pittsburgh School of Medicine, is a questionnaire used worldwide to assess of sleep quality [15]. It consists of 10 questions that assess different aspects of sleep quality. This questionnaire is advantageous because of its widespread use in a variety of settings and translation into many languages, including Japanese [16]. A previous study assessed a healthy (control subjects) and psychiatric disordered group (insomnia, depression, anxiety disorder, and schizophrenia) with the use of the Japanese version of PSQI and reported α reliability coefficient of 0.77, the sensitivity of 80.0–85.7%, and the specificity of 86.6% [17]. Therefore, the Japanese version of the PSQI is convenient and easy-to-use and has sufficient discrimination power.

Sleep disorders cause serious health and lifestyle-related problems, and in particular, excessive daytime sleepiness (EDS) due to a sleep disorder is often a serious problem for workers. According to a previous research, in a survey of the general population in Japan, 2.8% of males and 2.5% of females were aware of EDS [18]. In a survey of the Finnish population, it was reported that 11% of males and 7% of females were aware of daytime sleepiness almost every day [19]. In a similar research conducted in the US population, the Epworth Sleepiness Scale (ESS) [20], which is a questionnaire based on self-awareness for the assessment of EDS, was used [21]. The ESS has been validated clinically in populations of sleep disorder patients, showing 74% sensitivity and 50% specificity relative to the Multiple Sleep Latency Test (MSLT), which is an objective physiological test [22]. Therefore, the ESS has high sensitivity and specificity for the assessment of EDS. In the research that used ESS for the assessment of EDS in the US population, it was reported that 25% of individuals had ESS scores higher than 11 [21]. A reason that EDS is an important problem for workers is that EDS lowers behavioral functioning [23–26] and makes them take poor decisions [27]. Therefore, it has been reported that EDS is a cause of various traffic and occupational accidents [28–31].

Under these circumstances, investigation of measures to improve sleep in workers is an urgent issue. One means of alleviating insomnia is the use of sleeping pills and other drug therapies. Although drug therapy may be effective, it also causes problems such as drug dependency and carry-over effects, and is, therefore, problematic for workers.

Another, non-drug treatment for insomnia is sleep hygiene education directed at the population as a whole using talks and pamphlets. In a previous study, Kakinuma et al. [32] reported the effectiveness of sleep hygiene education intervention among workers. A total of 391 day-shift workers in the Japanese information technology (IT) industry were randomly allocated to either an intervention group or a control group, and the intervention group received 60 min of sleep hygiene education. However, this intervention did not generate a significant improvement in sleep quality (Pittsburgh Sleep Quality Index). There has been a paucity of epidemiological interventional studies on the effects of sleep hygiene education alone on sleep quality. Therefore, we designed a new epidemiological interventional study of sleep hygiene education to overcome the limitations of the study by Kakinuma et al. The present study was characterized by (1) a sufficient sample size to ensure high statistical reliability, (2) the preparation of new sleep hygiene education materials containing information based on evidence incorporating the latest conclusions of sleep science research, and (3) a sufficiently long follow-up period allowing the effect of the intervention to become apparent. In this study, we investigated the effect of intervention by means of sleep hygiene education and the association between sleep quality and experience of occupational accidents in the same group of subjects.

Materials and methods

Study participants and procedures

The study subjects were employees working rotating shifts in a factory in Kagoshima Prefecture, Japan, manufacturing vehicle engine parts on a 24-h basis. The sleep status and lifestyle habits of all the employees working at the factory at that point were surveyed in December 2013 (baseline survey). Study participation was completely voluntary.

The following method was employed in survey: an administrator of this company delivered (1) the instructions, (2) a self-administered questionnaire, and (3) an envelope to each worker. The workers were requested to complete the questionnaire on their own. After completing the questionnaire, each worker put it in the envelope and sealed it. The sealed envelopes were collected and then opened for the first time at the investigating institution.

The following six common items were included in the questionnaires used in this surveys. (1) Basic attributes: the participants were required to enter their employee number, sex, employment status (regular/non-regular), job category (management/non-management), and departments in which the employees worked. (2) Working conditions: working hours per day, overtime (hours) per month, number of days off per month, and Midnight shift work (22:00–5:00). (3) Sleep status indexes: Japanese version of PSQI [15, 16] and ESS [20, 33]. (4) Practice of 12 lifestyle habits associated with sleep (yes/no): (1) eating snacks after dinner, (2) exercising, (3) taking a bath or a shower, (4) Attempting to read a book, (5) attempting to listen to music, (6) attempting to maintain a healthy lifestyle, (7) attempting to avoid coffee and tea, (8) decreasing the duration and number of times of daytime napping, (9) attempting to go to bed when feeling sleepy, (10) attempting to get up early in the morning, (11) attempting not to have an alcoholic beverage before going to sleep, (12) attempting to get early morning sunlight exposure (5) smoking habit. (6) Occupational accidents or near-miss experience per month (experienced neither event/experienced near-miss experiences only/experienced occupational accidents). Employees were asked if they had ever experienced each of the following accidents: (1) falling from a height, (2) stumbling, (3) collision, (4) being struck by a falling/airborne object, (5) being trapped under/hit by a collapsing structure, (6) being caught or entangled, (7) cuts/abrasions (cut by a box cutter, etc.), (8) directly touching a very hot or cold object (burns, etc.), (9) electric shock/fire, (10) directly touching hazardous material, (11) traffic accident, (12) rebound from bodily movement/excessive bodily movement.

In January 2014, following a baseline survey, specific employees attended a lecture on sleep hygiene education. Attendance was voluntary and limited to employees who were at work on the date of the lecture.

A follow-up survey of all the employees registered as factory workers was conducted in May 2014. In addition to the items covered in the baseline survey, the follow-up survey also included a question (yes/no format) asking (7) whether the respondent had attended the sleep hygiene education lecture in January 2014.

Intervention by sleep hygiene education

In 2013, the Japanese Ministry of Health, Labour and Welfare established a Working Group on Sleep Guidelines Revision, gathering the latest evidence from sleep science research, and published "Sleep Guidelines 2014 for Health Promotion" [34]. The document is written in simple language, aimed at the general public, and includes "12 basic sleep guidelines" designed for use in lifestyle coaching to promote health as part of sleep hygiene education. These 12 sleep guidelines are as follows: (1) good sleep leads to a healthy body and mind, (2) regular meals and routine exercise are important, (3) lack of sleep correlates strongly with lifestyle-related diseases, (4) mental health can be maintained by rest while asleep, (5) it is important to obtain an appropriate amount of sleep for an individual's age and for the time of year, (6) creating an environment conducive to sleep is important, (7) young people should avoid staying up late at night, (8) for working-age people, good sleep allows recovery from fatigue and improves productivity, (9) it is important for older people to make arrangements so that they sleep soundly, (10) go to bed when feeling sleepy, and do not wake up too late, (11) pay attention to any unusual physical changes while sleeping, and (12) consult a specialist if insomnia does not improve. The sleep hygiene education implemented in this study used a four-page leaflet describing the content of these 12 sleep guidelines in accessible, simple language. This was distributed to the audience during a lecture, comprising an hour-long talk explaining the content of the leaflet and the 12 sleep-related lifestyle habits, and providing guidance on how to improve lifestyle habits and put the guidelines into practice.

Statistical analysis

Respondents who reported attending the sleep hygiene education lecture in the follow-up survey were defined as the Intervention Group. Respondents who had not attended the lecture or did not answer that specific question were defined as the Control Group. Data from the baseline survey were then used to calculate the composition of the Intervention and Control Groups according to the following parameters: "basic attributes", "working conditions", "sleep status indices", "lifestyle habits associated with sleep", "smoking", and "occupational accidents or near-miss experiences per month". The two groups were compared using the chi-squared test.

Next, multivariate analysis was used to investigate the association between sleep quality status, level of daytime drowsiness, and experience of occupational accidents, using study group data from the baseline survey. We examined the relationship between two indicators of sleep status and occupational accidents using two different models. In one model, we used the Pittsburgh Sleep Quality Index (PSQI) [15, 16] score as an indicator of insomnia. n the other model, we used the Epworth Sleepiness Scale (ESS) [20, 33] score as an indicator of daytime disorders. This allowed us to separately examine the relationship between daytime drowsiness (daytime disorders) and occupational accidents and the relationship between insomnia (the primary sleep disorder that causes daytime drowsiness) and occupational accidents.

Logistic regression analysis was performed using the forced entry method, with the experience of an occupational accident or near-miss experience in the previous month as the objective variable (respondents who answered "experienced near-miss experiences only" or "experienced occupational accidents" were classified as having had an occupational accident or a near-miss experience, and those who answered "experienced neither event" were classified as not having had one) and PSQI score as the dependent variable (Model 1). Age, sex, employment status, job category, departments in which the employees worked, working hours per day, overtime per month, number of days off per month, midnight shift work, smoking habits, and exercise habits were inputted to the model as adjustment factors. The forced entry method was used because there was no advanced hypothesis regarding the order of importance of the dependent (adjustment) variables. The same analysis was also performed using the ESS score as the dependent variable (Model 2).

We then investigated the effectiveness of sleep hygiene education on sleep-related lifestyle habits. We calculated the proportion of people in the Intervention and Control Groups who were putting the 12 sleep-related lifestyle habits into practice at the time of the baseline survey and of the follow-up survey. We also used McNemar's test [35, 36] to compare the changes between the baseline and follow-up surveys in the Intervention and Control Groups (comparison within group), and used a two-sample McNemar's test [37, 38] to compare the Intervention and Control Groups with each other (comparison between groups). We then performed a sub-group analysis by testing according to age class to examine the difference in effect of sleep hygiene education for each age group. According to a previous study in the field of learning science, comparison of fluid intelligence and crystallized intelligence is a method for characterizing the changes in cognitive and learning functions with age [39, 40]. Fluid intelligence refers to intelligence that reflects items such as calculation ability, concentration, and intelligence quotient, and fluid intelligence decreases after the age of 20 years, and in particular, decreases quickly after the age of 40 years. Crystallized intelligence reflects intelligence that is accumulated with experience, such as empirical knowledge and decision-making, and this type of intelligence improves with age. Based on these previous studies in the field of learning science, we performed our analysis by stratifying participants into two groups, using the age of 40 as the boundary.

Finally, we investigated the effectiveness of sleep hygiene education for improving sleep quality and daytime drowsiness. The proportions of respondents with a PSQI score of ≥ 6 in the baseline and follow-up surveys were calculated separately for the Intervention and Control Groups, and McNemar's test was used to investigate the difference between the scores in the baseline survey and follow-up survey (comparison within group). We also used a two-sample McNemar's test to compare the Intervention and Control Groups with each other (comparison between groups). The same analysis was performed for an ESS score of ≥ 11 or occupational accidents/near-miss experience per month.

We set the level of significance at $P < 0.05$. All analyses were performed using SPSS 22 for Windows (IBM Corp, Armonk, NY, USA).

Informed consent and ethical considerations

The following instructions were provided to the workers: (1) this survey is part of a medical study. What is written in the questionnaire will not be subject to evaluation related to participants' working performance or punishment; (2) subjects' participation in the survey must be voluntary, and subjects who do not participate will not suffer any loss; (3) the completed questionnaires will not be seen by other workers; (4) subjects' privacy will be strictly protected. In this survey, permission to conduct the survey was obtained from the Ethics Committee of Nihon University school of Medicine and the Ethics Committee of Oita University faculty of Medicine.

Results

An overall flow diagram of this survey is shown in Fig. 1. In the baseline survey, responses were received from 798 out of a total of 800 registered employees (response rate 99.8%). The sleep hygiene education program was attended by 287 employees. In the follow-up survey, responses were received from 783 registered employees. The analysis set comprised data from 714 individuals, including participants who had completed both the baseline and follow-up surveys (complete follow-up rate 89.3%). The following individuals ($n = 69$) were excluded due to missing answers, lack of consent to participate in the study, inability to consolidate data (according to lack of employee number), or lack of basic data on sex and/or age. Overall, in the follow-up survey, 104 individuals answered that they had attended the sleep hygiene education lecture (Intervention Group). The Control Group included 217 individuals who answered no participation of the sleep hygiene education lecture, and 393 individuals who did not answered whether or not they had attended the sleep hygiene education lecture.

Table 1 shows the profiles of employees at the time of the baseline survey (Control and Intervention Groups). The analysis set included 596 men (83.5%) and 118 women (16.5%) with an age range of 18–62 years (mean age 38.4 ± 11.6 years). Out of the total, 62.9% were engaged in midnight shift work. The PSQI score was ≥ 6 in 38.0% of the participants, and the ESS score was ≥ 11 in

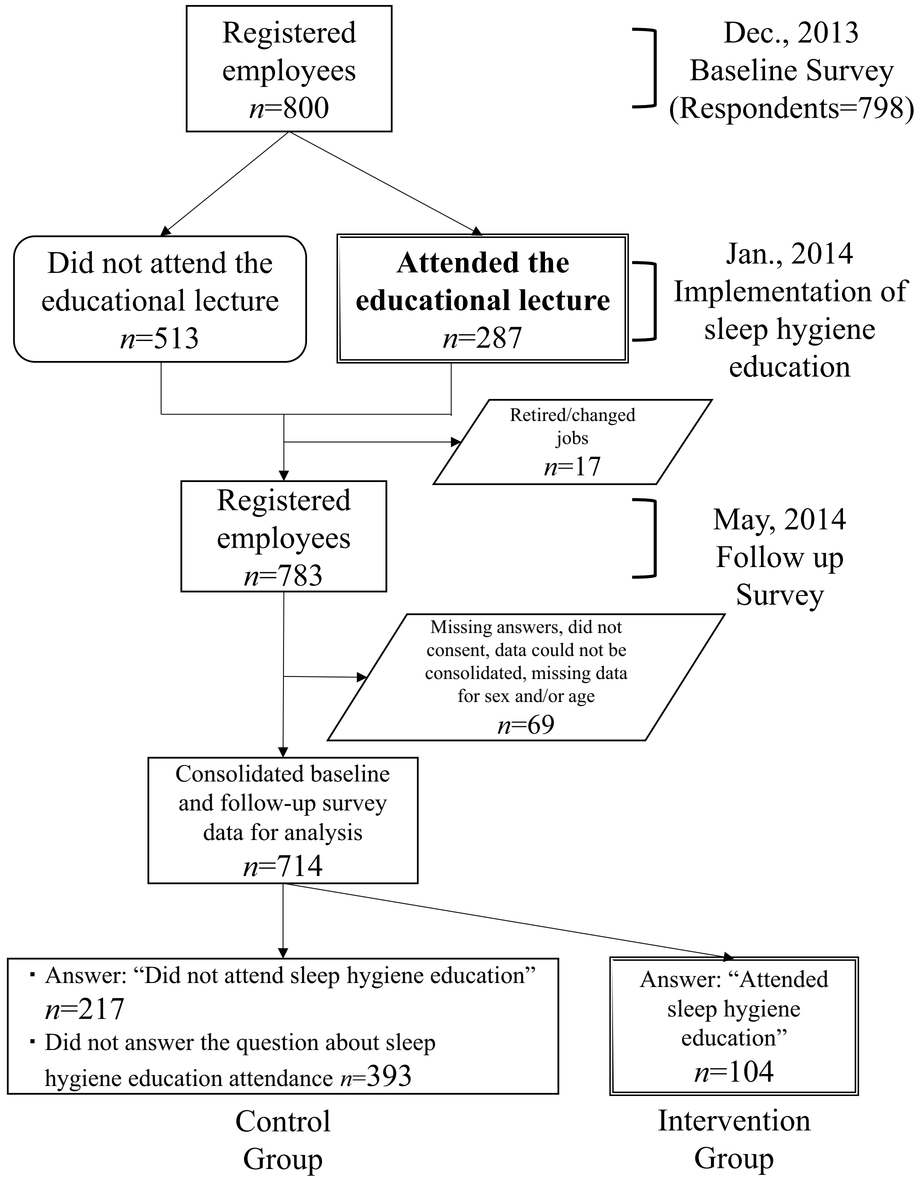

Fig. 1 Overall-flow diagram of this study: baseline and follow-up survey, and sleep hygiene education intervention

26.9%. Comparisons between the Control and Intervention Groups for each parameter using chi-squared test found no significant differences.

Table 2 shows the associations between the occurrence of occupational accidents/near-miss experiences and PSQI/ESS scores found in the baseline cross-sectional study. In Model 1, with the PSQI score input as a dependent variable, the occurrence of occupational accidents/near-miss experiences was significantly associated with exercise habits ($P = 0.034$) or PSQI score ($P = 0.009$). There was no significant association with any other dependent variable. In Model 2, with the ESS score input as a dependent variable, the occurrence of occupational accidents/near-miss experiences was significantly associated with age group ($P = 0.012$) and exercise habits ($P = 0.011$). There was no significant association with any other dependent variable, including the ESS score ($P = 0.204$).

In a comparison of chronological changes in sleep-related lifestyle habits in the Intervention and Control Groups, an investigation of the entire population found no significant difference in lifestyle habits in intragroup (baseline vs. follow-up) or intergroup (Control Group vs. Intervention Group) comparisons. We then performed a sub-group analysis stratified by age group, and found that among employees aged < 40 years (Table 3) in the Intervention Group, significantly more employees were attempting to wake up early in the morning in the follow-up survey compared with the proportion at the baseline ($P = 0.031$). This difference was not observed in the Control Group ($P = 0.162$). There was also a significant

Table 1 Profile of Employees at baseline survey (control and intervention group)

	Control group ($n=610$)	Intervention group (%) ($n=104$)	*P*
Sex			0.422
Male	83.9	80.8	
Female	16.1	19.2	
Age class			0.068
<30 years	26.9	33.7	
30–39 years	22.8	11.5	
40–49 years	26.9	28.8	
≥50 years	23.4	26.0	
Employment status			0.770
Regular	92.5	92.3	
Non-regular	1.8	1.0	
Unknown	5.7	6.7	
Job category			0.739
Management	3.0	1.9	
Non-management	86.9	89.4	
Unknown	10.2	8.7	
Working hours per day			0.502
<8 h/day	26.4	24.0	
≥8 h/day or < 10 h/day	67.5	69.2	
≥10 h/day	4.9	3.8	
Unknown	1.1	2.9	
Overtime per month			0.677
<20 h/month	53.8	48.1	
≥20 h/month or < 45 h/month	34.6	39.4	
≥45 h/month or < 80 h/month	1.1	1.0	
≥80 h/month	0.8	0.0	
Unknown	9.7	11.5	
Number of days off per month			0.352
≤4 days	23.1	22.1	
5–8 days	57.7	62.5	
9–12 days	17.0	11.5	
≥13 days	0.2	1.0	
Unknown	2.0	2.9	
Midnight shift work (22:00–5:00)			0.172
No	63.6	58.7	
Yes	32.6	33.7	
Unknown	3.8	7.7	
Sleep duration			0.334
<5 h/day	5.6	7.7	
≥5 h/day or < 7 h/day	56.7	46.2	
≥7 h/day or < 9 h/day	35.4	42.3	
≥9 h/day	1.0	1.9	
Unknown	1.3	1.9	
PSQI score			0.330
≤5 points	53.1	58.7	
≥6 points	38.2	36.5	
Unknown	8.7	4.8	
ESS score			0.821
≤10 points	71.0	71.2	
≥11 points	27.0	26.0	

Table 1 (continued)

	Control group ($n=610$)	Intervention group (%) ($n=104$)	*P*
Unknown	2.0	2.9	
Nightcap habit			0.813
None	73.9	75.0	
Less than once a week	6.7	5.8	
1–2 times per week	5.1	2.9	
3 or more times per week	13.1	14.4	
Unknown	1.1	1.9	
Smoking habit			0.818
None	53.0	50.0	
Not having smoked for ≥ 1 month	3.3	1.9	
Sometimes	1.6	1.0	
Everyday	39.2	43.3	
Unknown	3.0	3.8	
Exercise Habit			0.907
Very often	4.9	2.9	
Sometimes	24.8	26.0	
Seldom	34.9	33.7	
Rarely	31.1	32.7	
Unknown	4.3	4.8	
Occupational accidents or Near-miss experience per month			0.930
Experienced neither event	64.6	65.4	
Experienced near-miss experiences only	23.9	24.0	
Experienced occupational accidents	8.4	6.7	
Unknown	3.1	3.8	

We have combined all the participants in the baseline study ($n=714$)

PSQI Pittsburgh Sleep Quality Index, *ESS* Epworth sleepiness Scale

P was calculated by χ^2 test

difference between the two groups (Control vs. Intervention) ($P=0.005$). Furthermore, among employees aged ≥ 40 years (Table 4) in the Intervention Group, significantly more employees reported attempts not to consume alcohol before going to sleep in the follow-up survey compared with the proportion at the baseline ($P=0.002$). This difference was not observed in the Control group ($P=.883$). There was also a significant difference between the two groups (Control vs. Intervention) ($P=0.005$).

Table 5 shows a comparison of chronological changes in PSQI, ESS scores, and Occupational accidents/Near-miss experience per month in the Intervention and Control groups. No significant difference was evident in the PSQI, ESS scores, or Occupational accidents/Near-miss experience in all intragroup (baseline vs. follow-up) or intergroup (Control vs. Intervention) comparisons.

Discussion

In this study, we investigated whether or not the experience of accidents in the workplace was related to sleep disorder index scores (PSQI or ESS) and whether intervention by means of sleep hygiene education was effective for improving sleep-related lifestyle habits and sleep disorder index scores in employees engaged in rotational shift work. The larger sample size and longer follow-up period for evaluating the effectiveness of intervention, as well as the high response and follow-up rates, make this study more reliable than previous studies.

In this study, we found a significant association between a high PSQI score, indicating low sleep quality, and the experience of accidents. A number of previous studies have also reported that sleep disorders are associated with

Table 2 Associations between the occurrence of occupational accidents/near-miss experiences and PSQI/ESS scores found in the baseline cross-sectional study

	AOR	95% CI	P
Model 1			
Age class			0.067
<30 years	1.00		
30–39 years	0.82	0.47–1.44	
40–49 years	0.51	0.28–0.91	
≥50 years	0.48	0.25–0.95	
Exercise Habit			0.034
Very often	1.00		
Sometimes	6.88	1.45–32.69	
Seldom	8.36	1.79–39.15	
Rarely	9.72	2.05–46.17	
PSQI score			0.009
≤5 points	1.00		
≥6 points	1.76	1.15–2.68	
Model 2			
Age class			0.012
<30 years	1.00		
30–39 years	0.77	0.46–1.29	
40–49 years	0.47	0.27–0.80	
≥50 years	0.42	0.22–0.78	
Exercise habit			0.011
Very often	1.00		
Sometimes	4.84	1.32–17.81	
Seldom	6.55	1.80–23.75	
Rarely	7.79	2.13–28.56	
ESS score			0.204
≤10 points	1.00		
≥11 points	1.31	0.87–1.98	

Data at the time of the baseline survey were used

P was calculated by logistic regression analysis (Forced Entry Method)

Missing data were excluded from the statistical analyses (Model 1: $n=490$, Model 2: $n=567$)

PSQI Pittsburgh Sleep Quality Index, *ESS* Epworth sleepiness Scale, *AOR* Adjusted Odds Ratio, *CI* Confidential Interval, *Objective variable* occupational accidents or near-miss experience per month, *Adjusted factors* sex, employment status, job category, departments in which the employees worked, working hours per day, overtime per month, number of days off per month, midnight shift work, smoking habit

accidents. A study of public transport drivers found that the incidence of traffic accidents increased proportionally to the level of subjective drowsiness [41]. Individuals sleeping for < 6 h have been found to fall asleep at the wheel more frequently than those sleeping for a minimum of 7 h [42]. It has also been shown that among drivers causing accidents, those with < 6 h of sleep were more likely to have been involved in a rear-end collision with another vehicle or involved in a single-vehicle accident [43]. Insomnia is associated not only with sleep problems at night, but also physical and mental problems such as fatigue, reduced concentration, drowsiness, and reduced motivation, during the day. A study in the United States found that insomnia accompanied by these daytime symptoms increases the risk of injury [44]. Our results were also consistent with these findings. The logistic regression analysis in this study considered two models. Although the PSQI and ESS are separate indicators that assess insomnia and daytime disorders, respectively, the PSQI includes daytime disorders as one of its assessment indicators, and thus duplicates the primary object of assessment of the ESS. Therefore, entering both indicators as dependent variables in the same model could lead to strong multicollinearity and inappropriate analysis results. We calculated Spearman's rank correlation coefficient to examine the relationship between PSQI and ESS scores, Spearman's rank correlation coefficient between the PSQI and ESS scores was $r=0.261$, $P<0.001$, thus demonstrating a significant correlation between them. Consequently, strong multi-collinearity would be expected when entering both the PSQI score and ESS score as explanatory variables in the same model. Therefore, we deemed it appropriate to enter them into separate models.

In the present study, we did not find a significant correlation between the ESS score (the indicator of daytime disorders) and experience of occupational accidents. Several previous studies had reported a relationship between daytime sleepiness and work injury [45–47]. However, in a systematic review of sleep problems and accidents, Uehli et al. reported that the association between "daytime sleepiness" and work injuries was weak [14] They discussed whether this could be explained by sleepy people being aware of their limitations at the time of risk and adopting coping strategies. A similar reason could also explain the results of the present study. As the ESS is a self-administered questionnaire, it is also possible that the person may not have an accurate grasp of their sleepiness. Going forward, more research needs to be conducted.

In the present study, we found that when sleep hygiene education was provided in the form of a lecture, this resulted in improvements in some lifestyle habits in specific age groups; however, there was no significant improvement in the PSQI or ESS scores, which are indicators of overall sleep status. Previous studies also found no significant improvement in sleep quality resulting from intervention in the form of sleep hygiene education alone [32]. One possible reason for the absence of any effect may have been the education method used. In our study, we used a simple lecture format as the main method of sleep hygiene education. Although the lecture format has the advantage of transmitting knowledge to a large number of people at the same time, in the field of

Table 3 Comparison of chronological changes in sleep-related lifestyle habits in the Control and Intervention groups (among those aged less than 40 years)

	Group	*n*	Baseline (%)	Follow-up (%)	Change from baseline (%)	[a]*P* (within group)	[b]*P* (Control vs. Intervention)
1. Eating snacks after dinner	Control	294	25.5	28.6	3.1	0.306	0.464
	Intervention	45	24.4	22.2	− 2.2	1.000	
2. Exercising	Control	295	16.9	22.0	5.1	0.050	0.832
	Intervention	45	17.8	24.4	6.7	0.581	
3. Taking a bath or a shower	Control	294	34.0	33.3	− 0.7	0.912	0.355
	Intervention	45	20.0	26.7	6.7	0.549	
4. Attempting to read a book	Control	294	13.9	13.3	− 0.7	0.885	0.298
	Intervention	45	4.4	8.9	4.4	0.625	
5. Attempting to listen to music	Control	294	28.6	26.5	− 2.0	0.519	0.688
	Intervention	45	17.8	13.3	− 4.4	0.727	
6. Attempting to maintain a healthy lifestyle	Control	294	33.3	31.0	− 2.4	0.470	0.785
	Intervention	45	26.7	26.7	0.0	1.000	
7. Attempting to avoid coffee and tea	Control	294	18.0	20.1	2.0	0.496	0.848
	Intervention	45	11.1	13.3	2.2	1.000	
8. Decreasing the duration and number of times of daytime napping	Control	293	19.5	14.7	− 4.8	0.066	0.725
	Intervention	45	11.1	8.9	− 2.2	1.000	
9. Attempting to go to bed when feeling sleepy	Control	294	43.2	41.5	− 1.7	0.668	0.378
	Intervention	45	31.1	37.8	6.7	0.629	
10. Attempting to get up early in the morning	Control	294	21.8	17.7	− 4.1	0.162	0.005
	Intervention	45	6.7	20.0	13.3	0.031	
11. Attempting not to have an alcoholic beverage before going to sleep	Control	292	23.3	21.6	− 1.7	0.653	0.514
	Intervention	45	22.2	15.6	− 6.7	0.549	
12. Attempting to get early morning sunlight exposure	Control	294	11.9	12.6	0.7	0.868	0.070
	Intervention	45	4.4	13.3	8.9	0.125	

Missing data were excluded from the statistical analyses

[a]*P* was calculated by McNemar's test

[b]*P* was calculated by two-sample McNemar's test

school education it has long been known that educational effectiveness drops dramatically when students are listening to content delivered unilaterally by a lecturer [48, 49]. Recently, school education has started to incorporate problem-based learning and other forms of learning that involve active participation by students in educational activities, to improve educational effectiveness. These strategies have been found to be effective [50, 51]. Future studies to investigate the effectiveness of sleep hygiene education incorporating active learning are required. A second possible reason for these findings may be problems with the type of subject group for which the interventional approach was used. We utilized the so-called "population approach" [52], involving the entire group in our sleep hygiene education intervention. However, it is possible to adopt a "high-risk approach" [53], where education is focused intensively on the group with the most severe condition, and this strategy may be more effective. Future studies are also required to investigate the effect of different approaches in the field of sleep hygiene education. A third issue is the number and content of educational opportunities. The sleep hygiene education consisted of a single lecture delivered to the study group. It is possible that there were variations in the relative importance of the content to the individuals in the study group at the time the lecture was delivered. It is important for individuals to adopt and persist with healthy lifestyle behavior to prevent and treat lifestyle-related diseases and many other chronic conditions. They must also modify behaviors that have a negative effect on health, and must maintain these modifications. Maintaining both types of behavioral changes would lead to improved health. Health behavior is defined as "any behavior undertaken with the aim of maintaining or promoting health or recovering from illness" [54]. Health behavior can be divided into the following five stages: (1) precontemplation stage, (2) contemplation stage, (3) preparation stage, (4) action stage, and (5) maintenance stage [55]. These five stages are not a one-way progression from (1) to (5); if an individual is unsuccessful halfway through the process, they

Table 4 Comparison of chronological changes in sleep-related lifestyle habits in the Control and Intervention groups (among those aged 40 years or more)

	Group	*n*	Baseline (%)	Follow-up (%)	Change from baseline (%)	*P* (within group)[a]	*P* (Control vs. Intervention)[b]
1. Eating snacks after dinner	Control	282	22.0	19.9	− 2.1	0.504	0.056
	Intervention	55	14.5	25.5	10.9	0.146	
2. Exercising	Control	282	13.8	13.8	0.0	1.000	0.339
	Intervention	55	14.5	10.9	− 3.6	0.625	
3. Taking a bath or a shower	Control	283	30.7	27.6	− 3.2	0.349	0.495
	Intervention	55	25.5	18.2	− 7.3	0.388	
4. Attempting to read a book	Control	281	12.8	13.2	0.4	1.000	0.373
	Intervention	55	16.4	20.0	3.6	0.625	
5. Attempting to listen to music	Control	281	10.3	14.2	3.9	0.109	0.297
	Intervention	55	14.5	12.7	− 1.8	1.000	
6. Attempting to maintain a healthy lifestyle	Control	280	26.8	31.4	4.6	0.118	0.118
	Intervention	54	24.1	18.5	− 5.6	0.508	
7. Attempting to avoid coffee and tea	Control	282	16.7	14.5	− 2.1	0.451	0.474
	Intervention	55	10.9	12.7	1.8	1.000	
8. Decreasing the duration and number of times of daytime napping	Control	277	10.1	11.9	1.8	0.499	0.745
	Intervention	55	16.4	16.4	0.0	1.000	
9. Attempting to go to bed when feeling sleepy	Control	283	43.8	41.7	− 2.1	0.571	1.000
	Intervention	54	46.3	44.4	− 1.9	1.000	
10. Attempting to get up early in the morning	Control	279	20.8	21.5	0.7	0.890	0.929
	Intervention	54	24.1	24.1	0.0	1.000	
11. Attempting not to have an alcoholic beverage before going to sleep	Control	276	15.9	16.7	0.7	0.883	0.005
	Intervention	55	7.3	25.5	18.2	0.002	
12. Attempting to get early morning sunlight exposure	Control	280	12.5	16.8	4.3	0.067	1.000
	Intervention	55	10.9	16.4	5.5	0.508	

Missing data were excluded from the statistical analyses

[a]*P* was calculated by McNemar's test

[b]*P* was calculated by two – sample McNemar's test

Table 5 Comparison of chronological changes in PSQI/ESS scores and experienced occupational accidents or Near-miss in the Control and Intervention groups

	Group	*n*	Baseline (%)	Follow-up (%)	Change from baseline (%)	*P* (within group)[a]	*P* (Control vs. Intervention)[b]
PSQI score ≥ 6 points	Control	544	41.5	39.2	− 2.4	0.259	0.218
	Intervention	96	37.5	39.6	2.1	0.839	
ESS score ≥ 11 points	Control	583	27.8	26.9	− 0.9	0.718	0.376
	Intervention	101	26.7	31.7	5.0	0.359	
Occupational accidents or near-miss experience per month	Control	579	33.2	31.8	− 1.4	0.562	0.669
	Intervention	100	32.0	28.0	− 4.0	0.571	

Missing data were excluded from the statistical analyses

PSQI Pittsburgh Sleep Quality Index, *ESS* Epworth sleepiness Scale

[a]*P* was calculated by McNemar's test

[b]*P* was calculated by two-sample McNemar's test

will revert to the earlier stages. However, continued effective health coaching is believed to result in progress. As the behavior, knowledge, and mindset required at each stage differ, a suitable approach for each stage is needed. Future studies of sleep hygiene education must also address the diverse approaches required for individuals at each different stage.

In the present research, we studied the changes in lifestyles related to sleep that resulted from sleep hygiene education for each age group, and we showed a significant improvement in different lifestyles for the under 40 and the 40-and-over year age groups. There are some previous studies that assess aging influence on sleep-related lifestyles. Changes were noted in the required amount of sleep and aging. Ohayon et al. performed a meta-analysis of 3577 individuals in 65 papers investigating night sleep with the use of polysomnographic data. They reported a decrease in total sleep time (approximately 7 h at 25 years of age compared with < 6 h after 65 years); increase in the frequency of wake after sleep onset; decrease in sleep efficiency, which was particularly significant at > 40 years of age; and decrease in slow wave sleep with age [56]. A previous study assessed the relationship between insomnia and age. Lichstein et al. [57] reviewed 20 studies and reported that the prevalence and severity of insomnia were associated with age in 60% of studies. These authors found strong evidence for increased "Difficulty Maintaining Sleep" with age, but modest evidence for increased "Difficulty Initiating Sleep" and "Early Morning Awakening" with age. These authors found strong evidence for increased "Difficulty Maintaining Sleep" with age, but modest evidence for increased "Difficulty Initiating Sleep" and "Early Morning Awakening" with age. These changes may be related to the age-related differences in the effect of sleep hygiene education.

Several aspects of our findings limit generalization and, therefore, warrant mention. First, in this study, we were unable to perform a completely random allocation when dividing subjects into the Intervention and Control Groups, as only those individuals who were at work on the day of the lecture and who wished to attend were allocated to the Intervention Group. Therefore, in the process of group allocation, there may have been some bias in terms of factors such as willingness to learn, as this would have depended on whether or not individuals wanted to attend the lecture. Second, as self-administered questionnaires were used, some data obtained would have been subjective. For example, information on working hours or number of days off per month was based on self-reported data, and there may have been some discrepancies between the reported data and the actual status of individuals. Third, we did not screen for sleep problems, such as sleep apnea syndrome, when recruiting participants of this study. Therefore, our study groups may include individuals who were suffering from sleep problems. Fourth, the relationship between sleep-related lifestyles (or sleep hygiene education) and frequency of accidents could not be verified in this study. Of the conceivable causative factors, there might have been an insufficient period of assessment or inadequate assessment to judge whether lifestyle has improved. A future study that includes the above-mentioned parameters will need to be conducted to verify the present study.

Our results suggested that the sleep quality is associated with the frequency of workplace accidents, and that sleep hygiene education may improve some lifestyle habits. In the present study, results of the sub-group analysis of lifestyle changes associated with sleep hygiene education differed by age group. This suggests that sleep hygiene education may yield different changes in lifestyle habits in different age groups. Further studies are required to increase the effectiveness of interventions by addressing the content and methods of sleep hygiene education and the selection of subjects. Further study is also needed to determine factors that would increase motivation to participate in sleep hygiene education.

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Compliance with ethical standards

Research involving human participants and/or animals None.

Conflict of interest The authors have no conflict of interest to declare.

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