Original research article
Title page

The impact of rotating work schedules, chronotype, and restless legs syndrome/Willis-Ekbom disease on sleep quality among female hospital nurses and midwives: A cross-sectional survey

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The impact of rotating work schedules, chronotype, and restless legs syndrome/Willis-Ekbom disease on sleep quality among female hospital nurses and midwives: A cross-sectional survey

Abstract

Background: Decreases in **s**ubjective sleep quality are prevalent among nurses and midwives engaged in rotating shift work.

Objectives: The present study aimed to examine the relationship between differences in work schedules and subjective sleep quality among female nursing staff.

Design: A cross-sectional survey design was used for descriptive and logistic regression analyses. Data collection was conducted from December 2016 to September 2017.

Settings; Participants were recruited from five regional core hospitals in Japan.

Participants: A total of 1,253 nurses and midwives were included in the final analysis.

Methods: Subjective sleep quality was assessed using the Japanese version of the Pittsburgh Sleep Quality Index. Chronotype and social jet lag were calculated for both work day and work-free day. Symptoms related to restless legs syndrome/Willis-Ekbom disease were assessed using the Japanese version of the Cambridge-Hopkins questionnaire short form 13. Participants with the urge to move their legs, though not fulfilling the restless legs syndrome/Willis-Ekbom disease criteria, were classified as having leg motor restlessness. Logistic regression analyses for poor sleep were adjusted for age, body mass index, smoking, drinking, menstruation status, the presence of premenstrual syndrome, and the presence of a spouse.

Results: Rates of poor sleep (Pittsburgh Sleep Quality Index score ≥6) among those working, day shifts, rotating 12.5-hour night shifts, rotating 16-hour night shifts, and three-shift rotations were 41.2%, 51.1%, 44.5%, and 60.4%, respectively. Approximately 40% of three-shift rotation workers experienced difficulty initiating sleep. Shift workers tended to exhibit evening chronotype, delayed sleep phase, and high social jet lag. The prevalence of restless legs syndrome/Willis-Ekbom disease was 2.5%. Leg motor restlessness was observed in. 15.5% of participants. The adjusted odds ratios (95% confidence interval) of three-shift work (*vs.* day shift), evening chronotype (*vs.* morning chronotype), and the presence of leg motor restlessness (*vs.* no leg motor restlessness) for those with poor sleep were 2.20 (1.47–3.30), 1.95 (1.29–2.94), and 1.66 (1.15-2.39), respectively.

Conclusions: Regardless of the working schedules, rates of poor sleep were high among female hospital nurses and midwives. Our findings suggest that poor sleep quality is influenced by three-shift rotation, the evening chronotype, and leg motor restlessness.

Keywords: Midwifery; Nurses; Work schedule; Sleep; Restless legs syndrome

Contribution of the paper

What is already known about the topic?

- Rates of poor sleep quality are high among nursing staff engaged in rotating shift work.
- Even among nursing staff, the evening chronotype is related to poor sleep quality and has been associated with physical and mental disorders as well as high social jet lag.
- Previous studies have reported that nurses exhibit a high prevalence of restless legs syndrome/Willis-Ekbom disease.

What this paper adds?

- Three-shift rotations were associated with poorer quality of sleep. However, no significant differences in sleep quality were observed between rotating 12.5-hour and 16-hour night shifts.
- The prevalence of restless legs syndrome/Willis-Ekbom disease among Japanese female nursing staff was nearly equal to that among the general population.
- Three-shift rotations, evening chronotype, and the presence of leg motor restlessness exerted significant effects on subjective sleep quality. However, increased social jet lag was not identified as a significant factor.

1. Introduction

1.1. Subjective sleep quality among nursing staff

Decreases in subjective sleep quality have been observed among 50 to 70% of nursing staff (Dong et al., 2017, Kikuchi and Ishii, 2015, Surani et al., 2015, Zhang et al., 2016) , many of whom also report difficulty initiating and maintaining sleep (An et al., 2016). Although shift work is known to influence sleep quality (Kikuchi and Ishii, 2015, Zhang et al., 2016), day shift nursing workers also exhibit a high prevalence of poor sleep or insomnia (Kikuchi and Ishii, 2015). In Japan, nursing shift work is undergoing the transition from a conventional three-shift system to a two-shift system. Although rotations involving 16-hour night shifts are utilized in many hospitals throughout Japan, rotations involving 12-hour night shifts are becoming more prevalent. Despite this decrease, 12-hour shifts have also been associated with significant physical and mental burden (Miyatani et al., 2014). However, the effects of 16-hour and 12-hour night shifts on sleep quality among nursing staff remain to be fully elucidated.

1.1. Chronotype and social jet lag among nursing staff

Social jet lag (SJL) is caused by misalignment between an individual's chronotype (i.e., morning or evening) and daily sleep phases (Wittmann et al., 2006). Among day-shift workers, high SJL is often observed in workers with the evening chronotype, leading to decreases in sleep duration due to delayed sleep onset on working days and increased sleep duration on work-free days. SJL is common among nurses and midwives operating under a rotating shift system. The evening chronotype and high SJL have been associated with higher rates of health-related problems among rotating shift workers than among day-shift workers. The evening chronotype, along with hypnotic use and difficulty initiating sleep, has been associated with an increased risk of work-related musculoskeletal disorders (Zhang et al., 2018). Previous studies have also reported that the evening chronotype is associated with the onset and severity of depression (Togo et al., 2017, Vetter et al., 2018). Among nurses engaging in shift work, the evening chronotype has been associated with poor sleep quality via emotional disturbances (Lee et al., 2015, Yazdi et al., 2014). High SJL and evening chronotype are associated with higher burnout scores in evening-shift workers (Cheng and Hang, 2018). To achieve sustainable nursing, it is therefore necessary to establish a work schedule that considers the effects of chronotype and SJL among shift-working nurses.

1.2. Restless legs syndrome/Willis-Ekbom disease among nursing staff

The prevalence of restless legs syndrome/Willis-Ekbom disease (RLS/WED) among nursing staff is approximately 25%, regardless of work schedule (Waage et al., 2018). The main symptoms of RLS/WED include the urge to move the legs, which may be accompanied by uncomfortable sensations. Because symptoms typically emerge during the evening or middle of the night, RLS/WED disturbs the initiation and maintenance of sleep (Allen et al., 2014). The presence of RLS/WED among nurses is associated with the risk of depression (Li et al., 2012), coronary heart disease (Li et al., 2012), and high cardiovascular mortality (Li et al., 2018). As the prevalence of RLS/WED is high among nursing staff, some researchers have speculated that it may influence poor sleep quality in this population. However, the relationships among RLS/WED, chronotype, SJL, and sleep quality have yet to be determined.

Leg motor restlessness (LMR), which is characterized by the urge to move the legs without additional symptoms of RLS/WED, has recently emerged as a unique clinical entity. Previous studies have noted that patients with Parkinson's disease (PD) who experience LMR tend exhibit depression as well as PD-related sleep disturbances (Gjerstad et al., 2011, Suzuki et al., 2017). Although the prevalence of RLS/WED among nurses has been reported (Waage et al., 2018), its effect on sleep quality and the prevalence of LMR remain to be determined.

Poor sleep quality affects not only the health of nursing staff but also patient outcome and treatment errors (Dorrian et al., 2008, Weaver et al., 2016). In the present study, we primarily aimed to investigate the relationship between differences in work schedules and subjective sleep quality among female nursing staff. Subjective sleep quality is strongly affected by individual chronotype, SJL, and the presence of RLS/WED. Therefore, we investigated whether chronotype, SJL, and symptoms related to RLS/WED also affect sleep quality.

2. Methods

2.1. Study design, ethical consideration, and participants

In this cross-sectional study, we examined self-reported questionnaire responses from female nurses and midwives working at five hospitals in Japan. All these hospitals serve as the core medical institutions of regional communities. In addition to day shift work, rotating schedules were mainly utilized in these hospitals. One regional medical care support hospital utilized 12.5-hour rotating night shifts, while one advanced treatment hospital utilized 16-hour rotating night shifts. Two additional regional medical care support hospitals utilized 16-hour rotating night shifts and a three-shift rotation system, respectively. One remote island core hospital also utilized a three-shift rotation system.

All procedures involving human participants were performed in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The present study was approved by the Ethics Committee of Nagasaki University Graduate School of Biomedical Sciences (Approval No. 16111042). Questionnaires including a statement about this survey were distributed through the department of nursing at each institute. Participants were asked to fill out the selfadministered questionnaires, which were collected in sealed envelopes. Submission of the sealed envelope was considered to indicate agreement on the part of each participant. Data collection was conducted from December 2016 to September 2017.

A total of 2,154 nurses and midwives were asked to participate in survey, and responses were obtained from 1,599 (74.2%). The final analysis of chronotype and SJL utilized data for 1,253 (58.2%) eligible participants who had completed items regarding work schedule and sleep parameters. The numbers of participants engaged in day shift work, rotating 12.5-hour night shifts, rotating 16-hour night shifts, and three-shift rotations were 301 (24.0%), 223 (17.8%), 398 (31.8%), and 331 (26.4%), respectively. The demographic characteristics of the included participants are presented in Table 1.

2.2. Measures

2.2.1. Demographic characteristics

We collected data regarding demographic and clinical characteristics including age, marriage, the presence of a spouse, the presence of children, height, weight, body mass index (BMI), smoking, habitual drinking, comorbidities, and medications. Menstruation-related variables included the presence or absence of menstruation, reasons for lack of menstruation (e.g., pregnancy or menopause), symptoms of premenstrual syndrome, dysmenorrhea, pregnancy, and comorbidities during pregnancy. Premenstrual syndrome is common across women in reproductive age (Direkvand-Moghadam et al., 2014) and is associated with poor sleep quality (Nicolau et al., 2018). In our study, we defined premenstrual syndrome as having any of the symptoms related to premenstrual syndrome before menstruation including irritability, sentimental feeling, melancholic feeling, swelling and/or pain of breasts, sleepiness and/or hypersomnia, insomnia, skin problems, leg discomfort sensation, constipation, general malaise, or fatigue. We also examined work-related variables such as years of nursing experience, the presence or absence of rotating shift work, and the mean number of night shifts.

2.2.2. Pittsburgh Sleep Quality Index

Subjective sleep quality was assessed using the Japanese version of the Pittsburgh Sleep Quality Index (PSQI). This questionnaire consists of seven components including sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbance, hypnotic use, and daytime dysfunction. The score of each component ranges from 0 to 3, with global PSQI scores (GS) ranging from 0 to 21. Higher scores indicate poorer sleep quality with scores ≥6 are considered indicative of poor sleep quality. The Cronbach's α of the seven components PSQI has been reported as 0.83 (Buysse et al., 1989). The sensitivity and specificity of the original version have been reported at 89.6% and 86.5%, respectively, and those of the Japanese version at 80.0–85.7% and 86.6%, respectively (Buysse et al., 1989, Doi et al., 1998, Doi et al., 2000). The original PSQI examines usual bed time, sleep latency (SLat), getting up time, and hours of actual sleep (total sleep time (TST)) during a one-month period. In our study, these time-related items were examined for both working and work-free days, and usual bed time was regarded as equal to light-out time (LOT).

2.2.3. Chronotype and social jet lag

Chronotype was classified based on mid-sleep time (MST), which was calculated as follows: MST = LOT + SLat + TST/2. MST was calculated using a similar method to the Munich Chronotype Questionnaire (MCTQ; Roenneberg et al., 2012), which is reported to be strongly correlated with the Horne-Ostberg Morningness-Eveningness Questionnaire (Kitamura et al., 2014, Zavada et al., 2005). However, in this study MST methodology differed from that of MCTQ in the assessment of TST; TST in the MCTQ is defined as the hours from sleep onset time to wake time before getting out of bed, whereas in this study TST was defined as the subjective measure of hours of actual sleep. Corrected MST was computed as the mid-point of MSTs for working days (MSTwd) and work-free days (MSTwf) as follows: corrected MST = (MSTwd + MSTwf)/2. Participants were divided equally based on corrected MST values, which were used to classify participants into three chronotype categories: morning type, intermediate type, and evening type. SJL was calculated by subtracting MSTwd from MSTwf. We also calculated the absolute value of SJL.

2.2.4. RLS/WED

Symptoms related to RLS/WED were assessed using the Japanese version of the Cambridge-Hopkins questionnaire short form 13 (CH-RLSq13). The CH-RLSq13 is a self-reported questionnaire containing 13 items, 10 of which are related to characteristic symptoms and the exclusion of other conditions (e.g., leg cramping, positional discomfort). The remaining three items are related to the severity and onset of symptoms. The sensitivity and specificity of the original CH-RLSq13 for diagnosis of RLS/WED have been reported at 87.2% and 94.4%, respectively, and those of the Japanese version at 88.9% and 100.0%, respectively (Allen et al., 2009, Kondo et al., 2016). Participants who experienced the urge to move their legs without fulfilling additional RLS/WED criteria were allocated to the LMR group. The remaining participants were included in the no-LMR group.

2.3. Data analysis

R version 3.4.1, EZR version 1.36 (Kanda, 2013), and IBM SPSS Statistics version 22 (IBM Corp., Armonk, NY, USA) were used for statistical analysis. Categorical variables are presented as counts and percentages. Continuous variables are presented as medians and interquartile ranges (IQR) where non-normally distributed. The two-sided alpha level was set at 0.05. Habitual alcohol use was defined when the frequency of drinking was ≥3 days per week and alcohol intake was ≥20 g of ethanol per day. The poor sleep group included participants with PSQI GS ≥6, while the good sleep group included participants with PSQI GS <6.

Comparisons were performed using Mann–Whitney U-tests and the Kruskal–Wallis test. Post hoc analyses were performed using the Steel-Dwass method. Comparisons between working and work-free days were performed using the Wilcoxon signed-rank test. Frequency analyses for categorical data were performed using Fisher's exact test.

Odds ratios (ORs) for poor sleep (PSQI GS ≥6) were calculated via logistic regression analysis. Participants were categorized into four groups based on work schedule: day shift (reference; ref), rotating 12.5-hour night shifts, rotating 16-hour night shifts, and three-shift rotations. Age was categorized based on the following quartiles: <26 years (ref), 26–33 years, 34–43 years, ≥44 years. BMI was categorized into two groups: <22 kg/m^2 (ref) and ≥22 kg/m^2. Smoking was categorized into three groups: never (ref), current smoker, and ex-smoker. Alcohol use was categorized as either non-habitual (ref) or habitual. Menstrual status was categorized into three groups: presence of menstruation (ref), pregnancy, menopause. Participants were also divided based on the presence/absence (ref) of premenstrual syndrome and spouses. Chronotype was categorized into three groups: morning type (ref), intermediate type, and evening type. SJL was categorized into three groups: <60 minutes (ref), 60–120 minutes, and ≥120 minutes. RLS/WED related symptoms were categorized into three groups: no-LMR (ref), LMR, and RLS/WED. The ORs for evening type and intermediate type (*vs*. morning type), SJL of 60–120 minutes and ≥120 minutes (*vs*. <60 minutes), and RLS/WED and LMR (*vs*. no-LMR) were calculated via multinomial regression analysis.

3. Results

3.1. Work schedule, sleep quality, chronotype, and SJL

Regardless of work schedules, rates of poor sleep were high among female hospital nurses and midwives, especially those engaged in three-shift rotations. This tendency was also observed on work-free days. Difficulty initiating sleep was frequent among those working three-shift rotations, while those working 16-hour rotating night shifts reported good sleep quality. For participants working rotating 16-hour night shifts group, longer sleep time was observed on work-free days, and daytime dysfunction was less pronounced than in other groups. Morning chronotype was frequent among day-shift workers, who also reported a lower rate of SJL than the remaining groups (Table 2).

3.2. Chronotype among nursing staff

The median (IQR) corrected MSTs among participants with morning, intermediate, and evening chronotypes were 2:38 (2:09–2:52), 3:36 (3:21–3:50), and 4:33 (4:19–5:02), respectively. Participants with later MSTs exhibited delayed sleep phases, and his tendency was more significant for work-free days than working days (Fig. 1). SJL and sleep latency were greater for the evening chronotype than for the morning and intermediate chronotypes ($p < 0.001$). TST on working days was significantly shorter among those with the evening chronotype than among other chronotypes ($p < 0.001$). In contrast, TST on work-free days was significantly longer among those with the evening chronotype than among other chronotypes ($p < 0.001$). TST on work-free days was also significantly longer in the intermediate group than in the morning group ($p < 0.001$, Supplemental Table 1).

The median (IQR) age among participants with morning, intermediate, and evening chronotypes was 39.0 years (33.0–48.0 years), 32.0 years (25.0–44.0 years), and 28.0 years (25.0–35.5 years), respectively, and significant differences were observed between each of the groups ($p < 0.001$). Dysmenorrhea tended to increase among those with the evening chronotype ($p = 0.003$, Supplemental Table 2). In the multinomial logistic regression analysis for of evening type (*vs*. morning type), the ORs (95% confidence interval: (CI)) of the third and fourth quartile age (*vs* first quartile: <26 years) were 0.27 (0.15–-0.47) and 0.22 (0.12–-0.42), respectively. Being an ex-smoker and the absence of a spouse were associated with morning type. The OR (95% CI) of rotating 16-hour night shifts for evening type was 1.90 (1.12–-3.23, Supplemental Table 3-1 and 3-2). The results of a multinomial regression analysis for of higher SJL (≥120 min *vs*. <60 min) were similar to those for evening type (Supplemental Table 4-1 and 4-2).

Rates of poor sleep on working days among those with morning, intermediate, and evening chronotypes were 44.1%, 43.6%, and 58.3%, respectively. While poor sleep on working days was frequent among those with the evening chronotype ($p < 0.001$), participants with the morning chronotype frequently experienced poor sleep on work-free days ($p < 0.001$, Supplemental Table 5).

3.3. *RLS/WED and LMR among nursing staff*

The RLS/WED, LMR, and no-LMR groups included 31 (2.5%), 194 (15.5%), and 1,028 participants (82.0%), respectively (Supplemental Fig. 1). Rates of premenstrual syndrome and dysmenorrhea tended to be high in the RLS/WED and LMR groups ($p = 0.005$, 0.002, respectively, Supplemental Table 6). In the multinomial logistic regression analysis of LMR and RLS/WED (*vs.* no-LMR), the OR (95% CI) of premenstrual syndrome was 2.21 (1.19–4.10). However, it was not a significant factor for RLS/WED (Supplemental Table 7-1 and 7-2).

Rates of poor sleep were higher in the RLS/WED and LMR groups than in the no-LMR group, with the most marked tendency occurring in the LMR group ($p < 0.001$). The LMR group exhibited longer sleep latency and shorter TST on work-free days than other groups. Participants in the RLS group tended to exhibit the evening chronotype and high SJL, although these results were not statistically significant ($p = 0.07$ and 0.11, respectively, Supplemental Table 8).

3.4. Logistic regression analysis for poor sleep

Good and poor sleep were noted in 645 (50.8%) and 624 participants (49.2%), respectively (Supplemental Table 9). In the univariate analysis, the ORs (95% CI) for three-shift rotations and rotating 12.5-hour night shifts (vs. day shift) for those with poor sleep on working days were 2.18 (1.59–3.00) and 1.49 (1.05–2.12), respectively. The OR for three-shift rotation adjusted for age, BMI, smoking, habitual drinking, menstruation, premenstrual syndrome, and spouse presence remained significant, while that for rotating 12.5-hour night shifts did not. The OR for the evening chronotype (vs. morning chronotype) was 1.79 (1.36–2.35) in the univariate analysis, while the adjusted OR was 1.95 (1.29–2.94). The OR for SJL ≥120 minutes (vs. SJL <60 minutes) was 1.53 (1.16–2.02) in the univariate analysis, while the adjusted OR was 1.13 (0.76–1.69). The highest rates of poor sleep on working and work-free days (67.4% and 50.0%, respectively) were observed among participants with both evening chronotype and SJL <60 minutes (Fig. 2). The OR of the LMR group (vs. no-LMR group) was 1.92 (1.40–2.63), while the adjusted OR was 1.66 (1.15–2.39). RLS/WED was not extracted as a significant factor (Table 3).

Among the adjusted factors, age and premenstrual syndrome were associated with poor sleep, while the presence of a spouse was associated with good sleep. The adjusted OR for age ≥44 (vs. age <26) was 2.12 (1.28–3.50). The adjusted OR for premenstrual syndrome (vs. absence of premenstrual syndrome) was 1.82 (1.19–2.78). The OR for the presence of a spouse (vs. absence of spouse) was 0.63 (0.45–0.89, Supplemental Table 10).

4. Discussion

In the present study, we examined the relationships among sleep quality, shift work systems, chronotype, SJL, and RLS/WED in female nursing staff. Our results indicated that three-shift rotations were associated with poorer sleep quality than other work schedules. However, no significant differences in sleep quality were observed between rotating 12.5-hour and 16-hour night shifts. The prevalence of RLS/WED among Japanese female nursing staff was nearly equal to that among the general population, in contrast to the findings of a recent report, which suggested that rates of RLS/WED are significantly higher among nursing staff (Waage et al., 2018). While our results indicated that three-shift rotations, evening chronotype, and the presence of LMR exert significant effects on subjective sleep quality. However, increased SJL was not identified as a significant factor.

4.1. Rotating work schedules and quality of sleep among nursing staff

Subjective sleep quality among female hospital nursing staff was most affected by three-shift rotations. Insomnia, which was mainly due to difficulty initiating sleep, was observed on both working and work-free days. Previous studies have also investigated the sleep disturbances associated with three-shift work rotations (Ohida et al., 2001). Researchers have hypothesized that the shorter interval between working hours during a three-shift rotation schedule disturbs circadian rhythms, leading to long-term disruptions in biological rhythms and insomnia. Indeed, previous studies have revealed that the risk of circadian sleep/wake disorder increases with insufficient napping during the night shift period (Asaoka et al., 2013). Napping during the middle of the night (Minors and Waterhouse, 1983) is expected to prevent or minimize circadian sleep/wake disorders and chronic insomnia.

The present study is the first to compare sleep quality between two types of rotating night shifts. Although we observed no significant differences in sleep quality between workers working rotating 12.5-hour and 16-hour night shifts, subjective sleep quality on working days tended to be decreased among those working rotating 12.5-hour night shifts. These findings indicate that, when combined with insufficient napping during the night, the longer day shift associated with this schedule may affect sleep quality.

Notably, day shift workers also present with high rates of poor sleep. In general, more than 40% of patients with physical disorders exhibit sleep-related problems, including insomnia (Katic et al., 2015, Manocchia et al., 2001). The rates of poor sleep (PSQI GS $\geq$6) among patients with rheumatoid arthritis and healthy controls were reported to be 38.5% and 13.4%, respectively (Son et al., 2015). Moreover, the rate of poor sleep among day shift workers was higher than that among healthy controls and nearly equal to that of patients with rheumatoid arthritis. Previous studies have also reported that the prevalence of insomnia increases with age (Kaneita et al., 2005). Taken together, these findings suggest that older age and higher rates of comorbid diseases such as hypertension, ischemic heart disease, and malignancy act to decrease sleep quality among day shift workers.

In the present study, the relationship between poor sleep and BMI was significant when the standard cutoff value of 22 kg/m2 was used, rather than a value of 25 kg/m2 (Supplemental Table 10). The number of participants with a BMI ≥25 kg/m2 was 111 (8.9%), and the distribution of BMI was skewed to BMI <22 kg/m2. When participants were categorized into two groups based on BMI values <25 kg/m2 and ≥25 kg/m2, the percentages of poor sleepers were 8.4% and 10.7%, respectively, and we observed no statistically significant difference between the groups ($p = 0.23$). In contrast, when participants were categorized into two groups based on BMI values <22 kg/m2 and ≥22 kg/m2, the percentages of poor sleepers were 27.4% and 34.1%, respectively, and we observed a statistically significant difference between the groups ($p = 0.01$). Therefore, BMI was categorized using a cutoff point of 22 kg/m2. Although the OR for the association between BMI ≥22 kg/m2 and poor sleep was significant in the univariate analysis, it was not significant in the multivariate analysis. Increases in BMI have been associated with obstructive sleep apnea, RLS/WED, and difficulty initiating sleep and/or difficulty maintaining sleep (De Vito et al., 2014, Gao et al., 2009, Huang et al., 2018, Li et al., 2016). However, no such associations were observed in the present study. The low percentage of participants with obesity and the skewed representation of BMI towards 22 kg/m2 may explain the discrepancies between the present and previous studies.

4.2. Sleep phase

In the present study, evening chronotype was an independent risk factor for decreased subjective sleep quality. Although TST on work days was shorter among participants with the evening chronotype due to delayed bed time and sleep latency, TST on work-free days was longer due to extreme delays in wake time. These findings may explain why median SJL was highest among participants with the evening chronotype.

Although the univariate analysis revealed that increases in SJL influence sleep quality, this effect did not remain significant following adjustment for related factors. Increases in SJL were associated with increased rates of poor sleep only among those with the intermediate chronotype. However, a linear trend between SJL and rates of poor sleep was not observed among participants with the evening chronotype. Rates of poor sleep on working and work-free days were highest among participants with the evening chronotype who experienced SJL <60 minutes (Fig. 2). We hypothesize that some patients may have been unable to recover from insufficient sleep, which may have influenced the results of the multiple regression analysis.

4.3. RLS/WED and leg motor restlessness among female nursing staff

The prevalence of RLS/WED among female nurses and midwives was 2.5%, which is nearly equal to that among the general population (Picchietti et al., 2016). Although one previous study reported a high prevalence of RLS/WED among nurses (Waage et al., 2018), this report did not exclude RLS/WED mimics. Thus, a full differential diagnosis should decrease the prevalence of the disease. When RLS/WED mimics (e.g., positional discomfort, leg cramping) were not excluded from the present study, the rate of RLS/WED was approximately 5.6%. However, as the prevalence of RLS/WED is lower in Asian countries than in Western countries (Picchietti et al., 2016), future studies should consider the effects of racial differences in their analyses.

Poor sleep quality was more frequent among the LMR group, which accounted for 15.5% of female nursing staff in the present study, than among the RLS/WED group. LMR refers to a heterogenous collection of symptoms including leg edema, varices, muscle cramping, arthralgia, and others. Although we were unable to identify the cause of LMR, the relationship between poor sleep and LMR warrants further investigation. When symptoms of RLS/WED are very severe, relief by activity or worsening in the evening may not be notable (Allen et al., 2014), and CH-RLSq13 may not be able to not determine the presence of RLS/WED. Therefore, it is possible that some participants with severe RLS/WED were included in the LMR group.

4.4. Limitations

The present study possesses some limitations of note. First, the PSQI has not been validated for the assessment of subjective sleep quality among shift workers. In general, the questionnaire assesses sleep status during the month prior to evaluation. Due to the complexity of rotating schedules, sleep parameters vary based on the shift worked and between working and work-free days. More detailed assessments may be required to assess sleep quality among nursing staff engaged in shift work.

Second, although MST was chosen as the method of classification, the MST methodology used in this study has not been validated. The MST methodology differed from that of MCTQ, which has been validated as a method to evaluate chronotype (Kitamura et al., 2014, Zavada et al., 2005). In this study, the definition of TST, which is required to calculate MST, differed from that of MCTQ. TST in this study was defined as the subjective measure of hours of actual sleep, whereas in the MCTQ, TST is defined as the number of hours from sleep onset time to wake time before getting out from bed. Additionally, the use of an alarm clock is considered in MCTQ, but, in this study, the use of an alarm clock was not taken into account. While MCTQ for shift workers has been developed, there is currently no Japanese version. Additionally, chronotype classification of nursing staff is still difficult using the shift worker MCTQ, because of the complexity of their rotating schedules.

Third, we could not fully evaluate sleep patterns before and after engaging in night-shift work. Sleep patterns are influenced not only by work schedule but also by social weekday, weekend, or holiday. To obtain accurate adjustments for MST and SJL, long-term sleep logs should be utilized for several weeks, and a validated evaluation method should be developed.

Fourth, we did not collect information regarding the type of nursing activities, and we did not exclude replacement staff. Overtime work, stress related to nursing, staff assignment, characteristics of team or unit, and medical error may have influenced sleep quality among participants of the present study.

Fifth, the results of this study do not necessarily represent the situation for nursing staff living throughout Japan. Participants were not randomly selected from the population of all Japanese nurses and midwives. However, the percentages of participating nursing staff working on each work schedule were similar to those of nationwide nursing staff. A nationwide survey, which randomly selected participants throughout Japan, showed that the percentage of nursing staff working at hospitals, excluding clinics and nursing homes, with day shift work, rotating <16-hour night shifts, rotating ≥16-hour night shifts, and three-shift rotations were 23.6%, 12.6%, 36.9%, and 26.9%, respectively (Japanese Nursing Association, 2018). In this study, the percentages of participants engaged in day shift work, rotating 12.5-hour night shifts, rotating 16-hour night shifts, and three-shift rotations were 24.0%, 17.8%, 31.8%, and 26.4%, respectively.

Sixth, our data were not objective, as we only examined self-reported questionnaire responses. Furthermore, diagnoses of RLS/WED were not confirmed by sleep medicine specialists, and we did not evaluate sleep/wake disorders other than RLS/WED in this study.

4.5. Suggestions for further research

Currently, there are continuing efforts to minimize health problems related to rotating shift work and improve patient outcome. In order to propose effective solutions, direct interventions for sleep/wake problems among nursing staff are required. In addition, the use of measures of sleep/wake problems as evaluation metrics of interventions should be considered. For instance, when changes in work schedules are implemented, the evaluation of this intervention should include subjective and/or objective sleep/wake measures. Ensuring the validity and reliability of evaluation methods is difficult as chronotype and SJL are difficult to measure in nursing staff, whose work schedules are complex. Nevertheless, it may be possible to develop long term and more accurate evaluation methods using mobile devices and/or new monitoring techniques. Regarding RLS/WED among nursing staff, in the future it would be beneficial to clarify the association with patient outcome, the pathophysiology of mental and physical disorders, and the effect of therapeutic intervention.

5. Conclusions

Regardless of working schedule, rates of poor sleep were high among female hospital nurses and midwives, especially those engaged in three-shift rotations. Difficulty initiating sleep was also frequent among three-shift workers. Furthermore, we observed no significant differences in sleep quality between 12.5-hour and 16-hour rotating night shifts. However, our findings indicated that the evening chronotype was related to poor sleep quality. Rates of poor sleep on both working and work-free days were highest among those with the evening chronotype and low SJL, who may have experienced greater sleep debt. Although the prevalence of RLS/WED among Japanese female nursing staff was nearly equal to that of the general population, our findings further indicated that the presence of LMR influenced sleep quality.

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Table 1. Demographic and clinical characteristics of included patients based on work schedule.

		Day shift	Rotating 12.5-hour night shifts	Rotating 16-hour night shift	Three-shift rotations	*p* value
N		301	223	398	331	
Number of night shift			4.00 (4.00-5.00)	5.00 (4.00-5.00)	9.00 (8.00-10.00)	
Age	years	43.0 (34.0-52.0)	30.0 (25.0-41.0)	29.0 (25.0-37.0)	34.0 (27.0-42.0)	< 0.001
BMI	kg/m^2	20.8 (19.1-22.5)	20.4 (18.9-22.2)	20.5 (19.1-22.2)	20.7 (19.1-22.8)	0.51
Smoking						
Never	N (%)	263 (87.7)	191 (86.0)	365 (91.7)	294 (88.8)	0.001
Present	N (%)	13 (4.3)	20 (9.0)	7 (1.8)	21 (6.3)	
Ex-smoker	N (%)	24 (8.0)	11 (5.0)	26 (6.5)	16 (4.8)	
Habitual drinking	N (%)	34 (11.3)	29 (13.1)	44 (11.1)	27 (8.2)	0.28
Co-resident	N (%)	252 (83.7)	133 (61.0)	207 (52.5)	231 (70.4)	< 0.001
Spouse	N (%)	190 (63.1)	56 (25.7)	97 (24.6)	114 (34.7)	< 0.001
Child	N (%)	165 (54.8)	47 (21.6)	64 (16.2)	109 (33.1)	< 0.001
Parent	N (%)	63 (20.9)	69 (31.7)	98 (24.9)	110 (33.4)	0.001
Menstruation						
Presence	N (%)	184 (70.0)	195 (90.7)	364 (92.6)	282 (89.5)	< 0.001
Pregnancy	N (%)	18 (6.8)	5 (2.3)	14 (3.6)	13 (4.1)	
Menopause	N (%)	61 (23.2)	15 (7.0)	15 (3.8)	20 (6.3)	
PMS*	N (%)	186 (80.2)	181 (89.2)	335 (87.2)	265 (89.2)	0.01
Dysmenorrhea*	N (%)	110 (50.5)	116 (56.6)	224 (58.6)	163 (54.3)	0.26
Pregnancy experience	N (%)	204 (68.0)	63 (28.5)	98 (24.7)	126 (38.4)	< 0.001
Hypertension	N (%)	20 (7.0)	3 (1.5)	9 (2.4)	8 (2.7)	0.002
Diabetes	N (%)	2 (0.7)	2 (1.0)	3 (0.8)	1 (0.3)	0.83
Dyslipidemia	N (%)	17 (5.9)	4 (1.9)	10 (2.6)	9 (3.0)	0.05
Ischemic heart disease	N (%)	3 (1.0)	0 (0.0)	0 (0.0)	0 (0.0)	0.03
Allergic diseases	N (%)	19 (6.6)	15 (7.3)	12 (3.2)	15 (5.0)	0.10
Rheumatic diseases	N (%)	7 (2.4)	1 (0.5)	2 (0.5)	3 (1.0)	0.09
Malignancy	N (%)	10 (3.5)	4 (1.9)	3 (0.8)	2 (0.7)	0.02
Depression	N (%)	2 (0.7)	0 (0.0)	0 (0.0)	1 (0.3)	0.29

*Only in the presence of menstruation. BMI: body mass index, PMS: premenstrual syndrome.

Table 2. Subjective sleep quality, chronotype, and social jet lag among nursing staff.

		Day shift	Rotation with 12.5-hour night shift	Rotation with 16-hour night shift	Three-shift rotation	*p* value
N		301	223	398	331	
C1：sleep quality ≥2	N (%)	100 (33.2)	85 (38.1)	103 (25.9)	129 (39.0)	0.001
C2：sleep latency ≥2*						
Work days	N (%)	61 (20.3)	69 (30.9)	119 (29.9)	131 (39.6)	< 0.001
Work-free days	N (%)	55 (18.3)	68 (30.5)	119 (29.9)	135 (40.8)	< 0.001
C3：sleep duration ≥2**						
Work days	N (%)	192 (63.8)	149 (66.8)	253 (63.6)	236 (71.3)	0.11
Work-free days	N (%)	76 (25.3)	48 (21.7)	67 (17.0)	80 (24.2)	0.03
C4：sleep efficiency ≥2***						
Work days	N (%)	15 (5.0)	6 (2.7)	16 (4.0)	21 (6.3)	0.21
Work-free days	N (%)	11 (3.7)	7 (3.2)	20 (5.1)	17 (5.1)	0.60
C5：sleep disturbance ≥2	N (%)	13 (4.3)	2 (0.9)	8 (2.0)	7 (2.1)	0.08
C6：hypnotic use ≥2****	N (%)	15 (5.0)	4 (1.8)	8 (2.0)	12 (3.6)	0.09
C7：daytime dysfunction ≥2	N (%)	49 (16.3)	30 (13.5)	28 (7.0)	62 (18.7)	< 0.001
PSQI GS ≥6						
Work days	N (%)	124 (41.2)	114 (51.1)	177 (44.5)	200 (60.4)	< 0.001
Work-free days	N (%)	97 (32.3)	78 (35.3)	103 (26.1)	135 (40.8)	< 0.001
Corrected mid-sleep time	h:mm	3:07[a]	3:50	3:50	3:36[b]	< 0.001
	(IQR)	(2:38-3:36)	(2:52-4:19)	(3:07-4:33)	(2:52-4:19)	
Chronotype						
Morning	N (%)	153 (50.8)	61 (27.4)	94 (23.6)	113 (34.1)	0.007
Intermediate	N (%)	98 (32.6)	80 (35.9)	128 (32.2)	111 (33.5)	
Evening	N (%)	50 (16.6)	82 (36.8)	176 (44.2)	107 (32.3)	
Social jet lag	Min	45.0 [a]	75.0	90.0	60.0	< 0.001
	(IQR)	(15.0-80.6)	(30.0-120.0)	(30.0-120.0)	(15.0-120.0)	
Social jet lag, Absolute value	Min	45.0 [a]	80.0	90.0	60.0	< 0.001
	(IQR)	(30.0-90.0)	(30.0-120.0)	(45.0-120.0)	(30.0-120.0)	

*Sleep latency ≥31 min and the presence of difficulty initiating sleep. **Total sleep time <6 hours. ***Sleep Efficiency <85%. **** More than one time. IQR: interquartile range, PSQI GS: Pittsburgh Sleep Quality Index global score. a: vs. rotating 12.5-hour night shifts, rotating 16-hour night shifts, and three-shift rotations, $p < 0.001$. b: vs. rotating 16-hour night shifts, $p < 0.001$.

Table 3. Logistic regression analysis for poor sleep on work days based on work schedule, chronotype, social jet lag, and RLS/WED-related symptoms.

	Univariable analysis Odds ratio (95% CI)	Adjusted Odds ratio* (95%CI)
Work schedule		
Day shifts（reference）	1	1
Rotating 12.5-hour night shifts	1.49 (1.05-2.12)	1.54 (0.98-2.41)
Rotating 16-hour night shifts	1.14 (0.84-1.55)	1.14 (0.77-1.70)
Three-shift rotations	2.18 (1.59-3.00)	2.20 (1.47-3.30)
Chronotype		
Morning（reference）	1	1
Intermediate	0.93 (0.71-1.22)	0.85 (0.59-1.15)
Evening	1.79 (1.36-2.35)	1.95 (1.29-2.94)
Social Jet lag, absolute value		
<60 min（reference）	1	1
60-120 min	1.04 (0.80-1.35)	1.04 (0.74-1.46)
≥120 min	1.53 (1.16-2.02)	1.13 (0.76-1.69)
RLS/WED-related symptoms		
No-LMR（reference）	1	1
LMR	1.92 (1.40-2.63)	1.66 (1.15-2.39)
RLS/WED	1.61 (0.78-3.31)	1.13 (0.50-2.58)

*Adjusted for age, body mass index, smoking, habitual drinking, menstruation, premenstrual syndrome, and the presence of a spouse. CI: confidence interval, LMR: leg motor restlessness, RLS/WED: restless legs syndrome/Willis-Ekbom disease.

Fig. 1. Chronotype and sleep phase on working and work-free days.

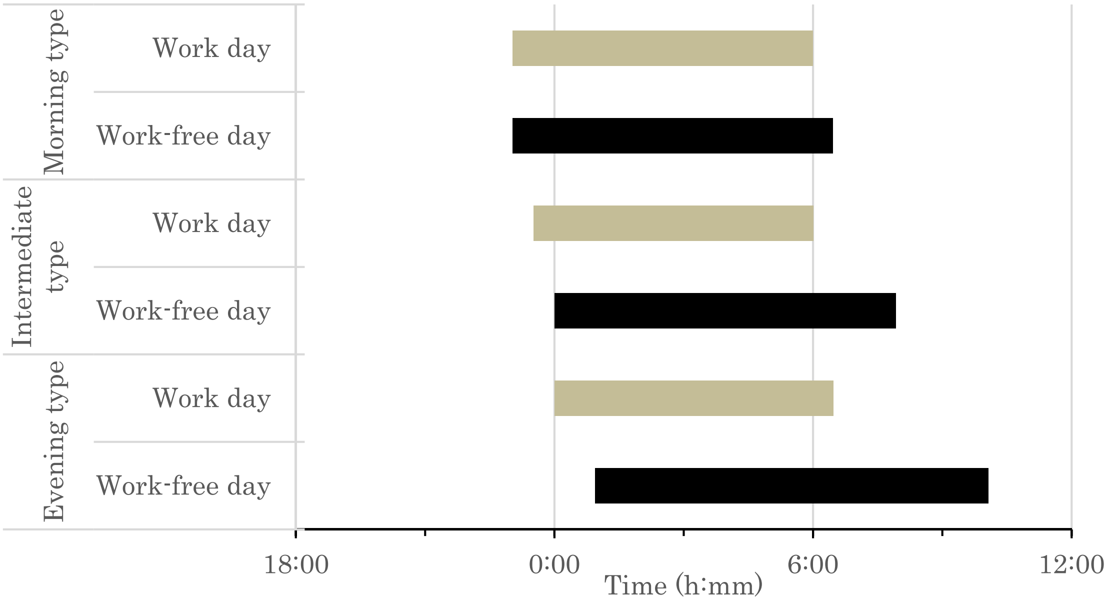
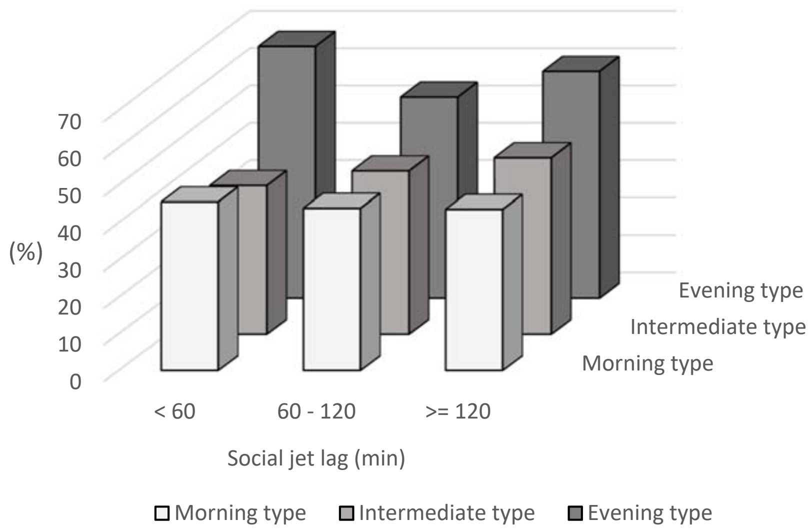
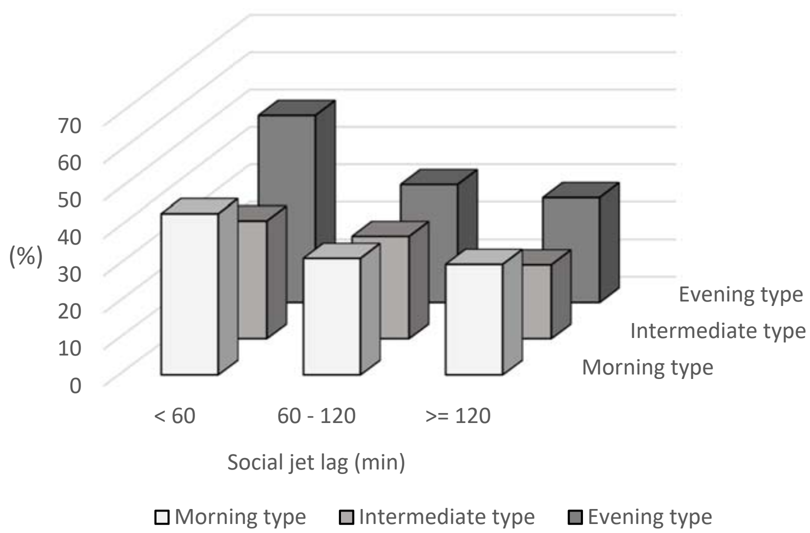


Fig. 2. Rates of poor sleep among each group classified by chronotype and social jet lag.

a. Rates of poor sleep on working days.



b. Rates of poor sleep on work-free days.



Supplemental Table 1. Sleep parameters and chronotype.

		Morning type	Intermediate type	Evening type	*p* value
N		421	417	415	
Corrected MST	h:mm	2:38 (2:09-2:52)	3:36 (3:21-3:50)	4:33 (4:19-5:02)	< 0.001
Work days	h:mm	2:24 (1:55-2:38)	2:52 (2:38-3:21)	3:36 (3:21-4:04)	< 0.001
Work-free days	h:mm	2:38 (2:09-3:07)	4:04 (3:50-4:33)	5:45 (5:02-6:28)	< 0.001
SJL	min	23.8 (0.0-58.1)	60.0 (30.0-90.0)	120.0 (90.0-162.5)	< 0.001
SJL, ab.	min	30.0 (0.0-60.0)	60.0 (30.0-90.0)	120.0 (90.0-165.0)	< 0.001
Bed time					
Work days	h:mm	23:02 (22:04-23:31)	23:31 (23:02-0:00)	0:00 (0:00-0:57)	< 0.001
Work-free days	h:mm	23:02 (22:04-23:31)	0.00 (23:31-0:00)	0:57 (0:00-1:55)	< 0.001
Sleep latency					
Work days	min	15 (10-30)	20 (10-30)	30 (10-30)	< 0.001
Work-free days	min	15 (10-30)	20 (10-30)	30 (10-30)	< 0.001
Sleep onset					
Work days	h:mm	23:16 (22:33-23:45)	0:00 (23:31-0:14)	0:43 (0:14-1:26)	< 0.001
Work-free days	h:mm	23:16 (23:02-23:45)	0:14 (0:00-0:43)	1:26 (0:57-2:09)	< 0.001
Total sleep time					
Work days	hour	6.0 (5.5-7.0)	6.0 (5.5-7.0)	6.0 (5.0-6.0)	< 0.001
Work-free days	hour	7.0 (6.0-8.0)	8.0 (7.0-8.5)	8.5 (8.0-10.0)	< 0.001
Time in bed					
Work days	hour	7.0 (6.0-7.5)	6.5 (6.0-7.2)	6.0 (5.5-7.0)	< 0.001
Work-free days	hour	8.0 (7.0-8.5)	8.0 (7.0-9.0)	9.0 (8.0-10.0)	< 0.001
Getting up time					
Work days	h:mm	6:00 (5:31-6:00)	6:00 (6:00-6:28)	6:28 (6:00-6:57)	< 0.001
Work-free days	h:mm	6:28 (6:00-6:57)	7:55 (6:57-9:07)	10:04 (9:07-11:02)	< 0.001

MST: mid-sleep time, SJL: social jet lag, ab: absolute value.

Supplemental Table 2. Demographic and clinical characteristics in each chronotype.

		Morning type	Intermediate type	Evening type	*p* value
N		421	417	415	
Age	years	39.0 (33.0-48.0)	32.0 (25.0-44.0)	28.0 (25.0-35.5)	< 0.001
BMI	kg/m^2	21.0 (19.5-22.7)	20.3 (18.8-22.4)	20.5 (19.1-22.2)	0.004
Work schedule					
Day shifts	N (%)	153 (36.3)	98 (23.5)	50 (12.0)	0.007
Rotating 12.5-hour night shifts	N (%)	61 (14.5)	80 (19.2)	82 (19.8)	
Rotating 16-hour night shifts	N (%)	94 (22.3)	128 (30.7)	176 (42.4)	
Three-shift rotations	N (%)	113 (26.8)	111 (26.6)	107 (25.8)	
Smoking					
Never	N (%)	360 (85.7)	380 (91.3)	373 (89.9)	0.007
Present	N (%)	17 (4.0)	18 (4.3)	26 (6.3)	
Ex-smoker	N (%)	43 (10.2)	18 (4.3)	16 (3.9)	
Habitual drinking	N (%)	49 (11.7)	34 (8.2)	51 (12.3)	0.11
Co-resident	N (%)	365 (87.3)	273 (65.8)	185 (45.3)	< 0.001
Spouse	N (%)	268 (64.0)	136 (32.8)	53 (13.0)	< 0.001
Child	N (%)	253 (60.4)	108 (26.0)	24 (5.9)	< 0.001
Parent	N (%)	90 (21.5)	128 (30.8)	122 (29.9)	0.004
Menstruation					
Presence	N (%)	310 (80.3)	337 (85.5)	378 (93.1)	< 0.001
Pregnancy	N (%)	23 (6.0)	17 (4.3)	10 (2.5)	
Menopause	N (%)	53 (13.7)	40 (10.2)	18 (4.4)	
PMS*	N (%)	299 (85.2)	319 (86.2)	349 (88.4)	0.43
Dysmenorrhea*	N (%)	178 (51.9)	187 (51.4)	248 (62.3)	0.003
Pregnancy experience	N (%)	292 (70.0)	147 (35.4)	52 (12.6)	< 0.001
Hypertension	N (%)	16 (4.1)	18 (4.6)	6 (1.6)	0.03
Diabetes	N (%)	5 (1.3)	2 (0.5)	1 (0.3)	0.29
Dyslipidemia	N (%)	18 (4.6)	13 (3.3)	9 (2.3)	0.23
Ischemic heart disease	N (%)	0 (0.0)	1 (0.3)	2 (0.5)	0.33
Allergic diseases	N (%)	24 (6.1)	20 (5.1)	17 (4.4)	0.57
Rheumatic diseases	N (%)	4 (1.0)	8 (2.0)	1 (0.3)	0.06
Malignancy	N (%)	10 (2.5)	6 (1.5)	3 (0.8)	0.15
Depression	N (%)	2 (0.5)	1 (0.3)	0 (0.0)	0.78

*Only in the presence of menstruation. BMI: body mass index, PMS: premenstrual syndrome.

Supplemental Table 3-1. Multinomial logistic regression analysis for intermediate type (*vs.* morning type).

	Univariable analysis Odds ratio (95% CI)	Multivariable analysis Odds ratio (95% CI)
Age		
Fist quartile (<26 years, reference)	1	1
Second quartile (26-34 years)	0.39 (0.24-0.63)	
Third quartile (34-44 years)	0.18 (0.11-0.29)	0.37 (0.21-0.65)
Fourth quartile (≥44 years)	0.20 (0.13-0.32)	0.48 (0.26-0.86)
BMI ≥22 kg/m^2 (*vs.* <22 kg/m^2)	0.76 (0.56-1.03)	
Smoking		
Never (reference)	1	1
Present	0.99 (0.50-1.96)	
Ex-smoker	0.39 (0.22-0.69)	0.49 (0.24-0.97)
Habitual drinking (*vs.* non-habitual)	0.67 (0.42-1.06)	
Presence of spouse (*vs.* absence)	0.27 (0.20-0.36)	0.30 (0.21-0.44)
Presence of PMS (*vs.* absence)	1.08 (0.71-1.64)	
Work schedule		
Day shifts（reference）	1	
Rotating 12.5-hour night shifts	2.03 (1.34-3.09)	
Rotating 16-hour night shifts	2.17 (1.50-3.13)	
Three-shift rotations	1.54 (1.07-2.22)	
RLS/WED-related symptoms		
No-LMR（reference）	1	
LMR	0.81 (0.56-1.18)	
RLS/WED	1.76 (0.58-5.30)	

BMI: body mass index, PMS: premenstrual syndrome, LMR: leg motor restlessness, RLS/WED: restless legs syndrome/Willis-Ekbom disease.

Supplemental Table 3-2. Multinomial logistic regression analysis for evening type (*vs.* morning type).

	Univariable analysis Odds ratio (95% CI)	Multivariable analysis Odds ratio (95% CI)
Age		
Fist quartile (<26 years, reference)	1	1
Second quartile (26-34 years)	0.43 (0.27-0.69)	
Third quartile (34-44 years)	0.99 (0.38-2.62)	0.27 (0.15-0.47)
Fourth quartile (≥44 years)	0.12 (0.07-0.19)	0.22 (0.12-0.42)
BMI ≥22 kg/m^2 (*vs.* <22 kg/m^2)	0.79 (0.58-1.07)	
Smoking		
Never (reference)	1	1
Present	1.46 (0.78-2.73)	
Ex-smoker	0.35 (0.20-0.64)	0.45 (0.21-0.97)
Habitual drinking (*vs.* non-habitual)	1.05 (0.69-1.59)	
Presence of spouse (*vs.* absence)	0.08 (0.06-0.12)	0.12 (0.08-0.19)
Presence of PMS (*vs.* absence)	1.31 (0.85-2.01)	
Work schedule		
Day shifts（reference）	1	1
Rotating 12.5-hour night shifts	4.09 (2.58-6.48)	
Rotating 16-hour night shifts	5.88 (3.91-8.84)	1.90 (1.12-3.23)
Three-shift rotations	2.90 (1.92-4.40)	
RLS/WED-related symptoms		
No-LMR（reference）	1	
LMR	0.90 (0.62-1.31)	
RLS/WED	3.45 (1.26-9.46)	

BMI: body mass index, PMS: premenstrual syndrome, LMR: leg motor restlessness, RLS/WED: restless legs syndrome/Willis-Ekbom disease.

Supplemental Table 4-1. Multinomial logistic regression analysis for 60-120 min SJL (*vs.* <60 min SJL).

	Univariable analysis Odds ratio (95% CI)	Multivariable analysis Odds ratio (95% CI)
Age		
Fist quartile (<26 years, reference)	1	1
Second quartile (26-34 years)	0.68 (0.45-1.04)	
Third quartile (34-44 years)	0.29 (0.19-0.44)	0.46 (0.28-0.75)
Fourth quartile (≥44 years)	0.44 (0.13-1.49)	0.57 (0.34-0.96)
BMI ≥22 kg/m^2 (*vs.* <22 kg/m^2)	0.65 (0.48-0.87)	
Smoking		
Never (reference)	1	
Present	0.69 (0.35-1.37)	
Ex-smoker	0.90 (0.53-1.53)	
Habitual drinking (*vs.* non-habitual)	1.03 (0.67-1.58)	
Presence of spouse (*vs.* absence)	0.33 (0.25-0.43)	0.43 (0.30-0.61)
Presence of PMS (*vs.* absence)	1.50 (0.99-2.27)	
Work schedule		
Day shifts（reference）	1	
Rotating 12.5-hour night shifts	1.27 (0.85-1.92)	
Rotating 16-hour night shifts	2.18 (1.54-3.08)	
Three-shift rotations	1.10 (0.77-1.58)	
RLS/WED-related symptoms		
No-LMR（reference）	1	
LMR	0.90 (0.62-1.29)	
RLS/WED	0.91 (0.36-2.34)	

BMI: body mass index, CI: confidence interval, PMS: premenstrual syndrome, LMR: leg motor restlessness, RLS/WED: restless legs syndrome/Willis-Ekbom disease.

Supplemental Table 4-2. Multinomial logistic regression analysis for ≥120 min SJL (*vs*. <60 min SJL).

	Univariable analysis Odds ratio (95% CI)	Multivariable analysis Odds ratio (95% CI)
Age		
Fist quartile (<26 years, reference)	1	1
Second quartile (26-34 years)	0.60 (0.40-0.91)	
Third quartile (34-44 years)	0.14 (0.09-0.23)	0.24 (0.14-0.40)
Fourth quartile (≥44 years)	0.08 (0.05-0.14)	0.18 (0.09-0.34)
BMI ≥22 kg/m^2 (*vs*. <22 kg/m^2)	0.67 (0.49-0.92)	
Smoking		
Never (reference)	1	
Present	1.52 (0.84-2.75)	
Ex-smoker	0.80 (0.44-1.44)	
Habitual drinking (*vs*. non-habitual)	1.18 (0.76-1.83)	
Presence of spouse (*vs*. absence)	0.14 (0.10-0.20)	0.25 (0.16-0.38)
Presence of PMS (*vs*. absence)	1.33 (0.87-2.04)	
Work schedule		
Day shifts（reference）	1	1
Rotating 12.5-hour night shifts	4.20 (2.60-6.77)	
Rotating 16-hour night shifts	5.03 (3.23-7.83)	1.76 (1.01-3.05)
Three-shift rotations	3.31 (2.12-5.17)	
RLS/WED-related symptoms		
No-LMR（reference）	1	
LMR	0.96 (0.66-1.41)	
RLS/WED	1.91 (0.82-4.41)	

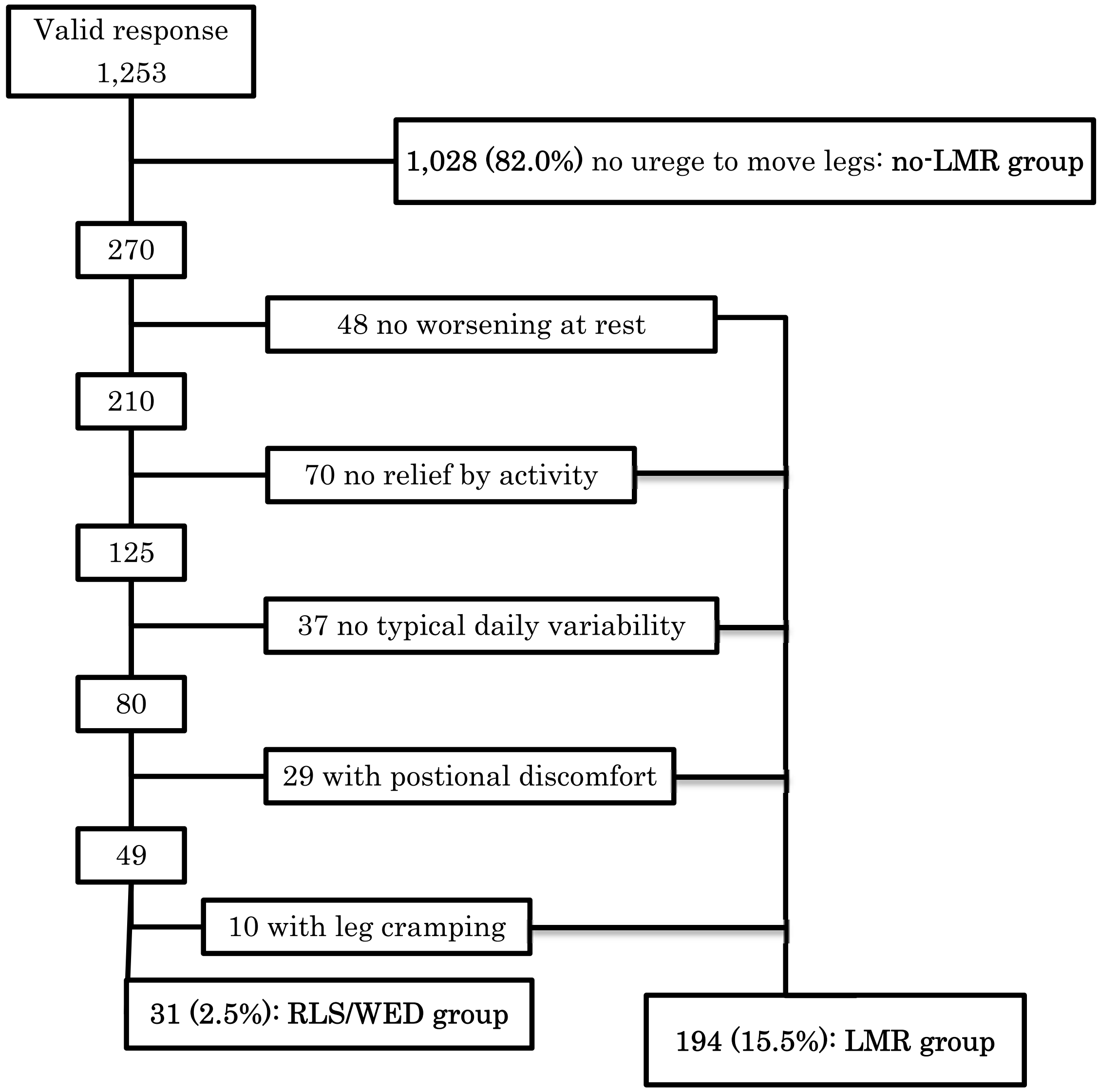
BMI: body mass index, CI: confidence interval, PMS: premenstrual syndrome, LMR: leg motor restlessness, RLS/WED: restless legs syndrome/Willis-Ekbom disease.

Supplemental Table 5. Chronotype and subjective sleep quality.

		Morning type	Intermediate type	Evening type	*p* value
N		421	417	415	
C1：sleep quality ≥2	N (%)	146 (34.7)	118 (28.3)	153 (36.9)	0.02
C2：sleep latency ≥2*					
Work days	N (%)	93 (22.1)	109 (26.1)	178 (42.9)	< 0.001
Work-free days	N (%)	93 (22.1)	108 (25.9)	176 (42.4)	< 0.001
C3：sleep duration ≥2**					
Work days	N (%)	255 (60.6)	263 (63.1)	312 (75.2)	< 0.001
Work-free days	N (%)	153 (36.8)	78 (18.8)	40 (9.6)	< 0.001
C4：sleep efficiency ≥2***					
Work days	N (%)	32 (7.6)	14 (3.4)	12 (2.9)	0.003
Work-free days	N (%)	34 (8.2)	13 (3.1)	8 (1.9)	< 0.001
C5：sleep disturbance ≥2	N (%)	17 (4.0)	4 (1.0)	9 (2.2)	0.02
C6：hypnotic use ≥2****	N (%)	12 (2.9)	18 (4.3)	9 (2.2)	0.20
C7：daytime dysfunction ≥2	N (%)	68 (16.2)	54 (12.9)	47 (11.3)	0.12
PSQI GS ≥6					
Work days	N (%)	189 (44.9)	180 (43.2)	246 (59.3)	< 0.001
Work-free days	N (%)	167 (40.1)	115 (27.6)	131 (31.6)	< 0.001

*Sleep latency ≥31 min and the presence of difficulty initiating sleep. **Total sleep time <6 hours. ***Sleep Efficiency <85%. **** More than one time. PSQI GS: Pittsburgh Sleep Quality Index global score.

Supplemental Fig. 1. Algorithm for determination of RLS/WED and LMR using the Cambridge-Hopkins questionnaire short form 13.



LMR: leg motor restlessness, RLS/WED: restless legs syndrome/Willis-Ekbom disease.

Supplemental Table 6. Demographic and clinical characteristics in the RLS/WED, LMR, and no-LMR groups.

		No-LMR	LMR	RLS/WED	*p* value
N		1028	194	31	
Age	years	33.5 (26.0-43.3)	33.0 (27.0-45.0)	30.0 (25.5-40.0)	0.54
BMI	kg/m^2	20.6 (19.1-22.4)	20.6 (19.3-22.3)	20.7 (18.4-22.8)	0.85
Work schedule					
Day shift	N (%)	259 (25.2)	34 (17.5)	8 (25.8)	0.009
Rotation with 12.5-hour night shift	N (%)	166 (16.1)	46 (23.7)	11 (35.5)	
Rotation with 16-hour night shift	N (%)	333 (32.4)	58 (29.9)	7 (22.6)	
Three-shift rotation	N (%)	270 (26.3)	56 (28.9)	5 (16.1)	
Smoking					
Never	N (%)	61 (5.9)	14 (7.3)	2 (6.5)	0.11
Present	N (%)	922 (89.8)	166 (86.0)	25 (80.6)	
Ex-smoker	N (%)	44 (4.3)	13 (6.7)	4 (12.9)	
Habitual drinking	N (%)	116 (11.3)	16 (8.2)	2 (6.5)	0.38
Co-resident	N (%)	685 (67.3)	121 (62.7)	17 (56.7)	0.23
Spouse	N (%)	384 (37.7)	66 (34.0)	7 (23.3)	0.20
Child	N (%)	324 (31.8)	53 (27.3)	8 (26.7)	0.42
Parent	N (%)	286 (28.1)	48 (24.7)	6 (20.0)	0.47
Menstruation					
Presence	N (%)	832 (85.9)	165 (88.7)	28 (90.3)	0.57
Pregnancy	N (%)	41 (4.2)	7 (3.8)	2 (6.5)	
Menopause	N (%)	96 (9.9)	14 (7.5)	1 (3.2)	
PMS*	N (%)	775 (85.4)	163 (91.6)	29 (93.5)	0.05
Dysmenorrhea*	N (%)	480 (53.5)	113 (64.2)	20 (64.5)	0.02
Pregnancy experience	N (%)	401 (39.2)	78 (40.6)	12 (38.7)	0.95
Hypertension	N (%)	28 (2.9)	11 (6.0)	1 (3.4)	0.09
Diabetes	N (%)	4 (0.4)	4 (2.2)	0 (0.0)	0.05
Dyslipidemia	N (%)	26 (2.7)	13 (7.1)	1 (3.4)	0.01
Ischemic heart disease	N (%)	2 (0.2)	1 (0.5)	0 (0.0)	0.45
Allergic diseases	N (%)	42 (4.4)	18 (9.8)	1 (3.4)	0.01
Rheumatic diseases	N (%)	11 (1.1)	2 (1.1)	0 (0.0)	1
Malignancy	N (%)	15 (1.6)	4 (2.2)	0 (0.0)	0.71
Depression	N (%)	3 (0.3)	0 (0.0)	0 (0.0)	1

*Only in the presence of menstruation. BMI: body mass index, PMS: premenstrual syndrome, LMR: leg motor restlessness, RLS/WED: restless legs syndrome/Willis-Ekbom disease.

Supplemental Table 7-1. Multinomial logistic regression analysis for LMR (*vs.* no-LMR).

	Univariable analysis Odds ratio (95% CI)	Multivariable analysis Odds ratio (95% CI)
Age		
Fist quartile (<26 years, reference)	1	
Second quartile (26-34 years)	1.17 (0.75-1.81)	
Third quartile (34-44 years)	0.84 (0.52-1.35)	
Fourth quartile (≥44 years)	1.24 (0.80-1.93)	
BMI ≥22 kg/m^2 (*vs.* <22 kg/m^2)	1.03 (0.73-1.46)	
Smoking		
Never (reference)	1	
Present	1.64 (0.87-3.12)	
Ex-smoker	1.28 (0.70-2.33)	
Habitual drinking (*vs.* non-habitual)	0.54 (0.13-2.28)	
Presence of spouse (*vs.* absence)	1.16 (0.84-1.60)	
Presence of PMS (*vs.* absence)	1.83 (1.05-3.21)	2.21 (1.19-4.10)
Work schedule		
Day shifts（reference）	1	1
Rotating 12.5-hour night shifts	2.10 (1.30-3.41)	2.21 (1.24-3.94)
Rotating 16-hour night shifts	1.34 (0.85-2.11)	
Three-shift rotations	1.55 (0.98-2.45)	
Chronotype		
Morning（reference）	1	
Intermediate	0.81 (0.56-1.18)	
Evening	0.90 (0.62-1.31)	
Social Jet lag, absolute value		
<60 min（reference）	1	
60-120 min	0.90 (0.62-1.29)	
≥120 min	0.96 (0.66-1.41)	

BMI: body mass index, CI: confidence interval, PMS: premenstrual syndrome, LMR: leg motor restlessness.

Supplemental Table 7-2. Multinomial logistic regression analysis for RLS/WED (*vs.* no-LMR).

	Univariable analysis Odds ratio (95% CI)	Multivariable analysis Odds ratio (95% CI)
Age		
Fist quartile (<26 years, reference)	1	
Second quartile (26-34 years)	0.99 (0.38-2.54)	
Third quartile (34-44 years)	0.99 (0.38-2.62)	
Fourth quartile (≥44 years)	0.44 (0.13-1.49)	
BMI ≥22 kg/m^2 (*vs.* <22 kg/m^2)	1.48 (0.69-3.21)	
Smoking		
Never (reference)	1	
Present	3.34 (1.11-10.00)	
Ex-smoker	1.20 (0.28-5.20)	
Habitual drinking (*vs.* non-habitual)	0.54 (0.13-2.28)	
Presence of spouse (*vs.* absence)	1.98 (0.84-4.65)	
Presence of PMS (*vs.* absence)	2.46 (0.58-10.42)	
Work schedule		
Day shifts（reference）	1	
Rotating 12.5-hour night shifts	2.14 (0.84-5.42)	
Rotating 16-hour night shifts	0.69 (0.25-1.92)	
Three-shift rotations	0.60 (0.19-1.85)	
Chronotype		
Morning（reference）	1	
Intermediate	1.76 (0.58-5.30)	
Evening	3.45 (1.26-9.46)	
Social Jet lag, absolute value		
<60 min（reference）	1	
60-120 min	0.91 (0.36-2.34)	
≥120 min	1.91 (0.82-4.41)	

BMI: body mass index, CI: confidence interval, PMS: premenstrual syndrome, LMR: leg motor restlessness, RLS/WED: restless legs syndrome/Willis-Ekbom disease.

Supplemental Table 8. Subjective sleep quality, chronotype, and social jet lag in the RLS/WED, LMR, and no-LMR groups.

		No-LMR	LMR	RLS/WED	*p* value
N		1028	194	31	
C1：sleep quality ≥2	N (%)	318 (30.9)	87 (44.8)	12 (38.7)	0.001
C2：sleep latency ≥2*					
Work days	N (%)	300 (29.2)	72 (37.1)	8 (25.8)	0.08
Work-free days	N (%)	295 (28.7)	74 (38.1)	8 (25.8)	0.03
C3：sleep duration ≥2**					
Work days	N (%)	674 (65.6)	139 (71.6)	17 (54.8)	0.10
Work-free days	N (%)	217 (21.2)	53 (27.5)	1 (3.2)	0.004
C4：sleep efficiency ≥2***					
Work days	N (%)	48 (4.7)	9 (4.6)	1 (3.2)	1
Work-free days	N (%)	46 (4.5)	8 (4.1)	1 (3.2)	1
C5：sleep disturbance ≥2	N (%)	25 (2.4)	4 (2.1)	1 (3.2)	0.82
C6：hypnotic use ≥2****	N (%)	28 (2.7)	10 (5.2)	1 (3.2)	0.17
C7 : daytime dysfunction ≥2	N (%)	128 (12.5)	34 (17.5)	7 (22.6)	0.05
PSQI GS ≥6					
Work days	N (%)	476 (46.3)	121 (62.4)	18 (58.1)	< 0.001
Work-free days	N (%)	316 (30.9)	86 (44.6)	11 (35.5)	0.001
Corrected mid-sleep time	h:mm (IQR)	3:07 (2:38-3:36)	3:50 (3:07-4:33)	3:36 (2:52-4:19)	0.07
Chronotype					
Morning	N (%)	344 (33.5)	72 (37.1)	5 (16.1)	0.07
Intermediate	N (%)	349 (33.9)	59 (30.4)	9 (29.0)	
Evening	N (%)	335 (32.6)	63 (32.5)	17 (54.8)	
Social jet lag	Min (IQR)	60.0 (30.0-120.0)	60.0 (15.0-120.0)	90.0 (45.0-155.0)	0.11
Social jet lag, Absolute value	Min (IQR)	60.0 (30.0-120.0)	60.0 (30.0-120.0)	90.0 (45.0-155.0)	0.16

*Sleep latency ≥31 min and the presence of difficulty initiating sleep. **Total sleep time <6 hours. ***Sleep Efficiency <85%. **** More than one time. IQR: interquartile range, LMR: leg motor restlessness, PSQI GS: Pittsburgh Sleep Quality Index global score, RLS/WED: restless legs syndrome/Willis-Ekbom disease.

Supplemental Table 9. Demographic and clinical characteristics of workers with good and poor sleep.

		Good sleep (N = 645)	Poor sleep (N = 624)	*p* value
Age	years	32.0 (26.0-42.0)	34.0 (26.0-45.0)	0.02
BMI	kg/m^2	20.6 (19.1-22.2)	20.7 (19.1-22.7)	0.18
Work schedule				
Day shift	N (%)	177 (27.7)	124 (20.2)	< 0.001
Rotation with 12.5-hour night shift	N (%)	109 (17.1)	114 (18.5)	
Rotation with 16-hour night shift	N (%)	221 (34.6)	177 (28.8)	
Three-shift rotation	N (%)	131 (20.5)	200 (32.5)	
Smoking				
Never	N (%)	583 (91.7)	530 (86.2)	0.002
Present	N (%)	19 (3.0)	42 (6.8)	
Ex-smoker	N (%)	34 (5.3)	43 (7.0)	
Habitual drinking	N (%)	56 (8.8)	78 (12.7)	0.03
Co-resident	N (%)	429 (68.1)	394 (64.5)	0.19
Spouse	N (%)	256 (40.6)	201 (32.8)	0.005
Child	N (%)	221 (35.1)	164 (26.8)	0.002
Parent	N (%)			
Menstruation		525 (86.3)	500 (86.5)	0.11
Presence	N (%)	32 (5.3)	18 (3.1)	
Pregnancy	N (%)	51 (8.4)	60 (10.4)	
Menopause	N (%)	479 (83.6)	488 (89.9)	0.002
PMS*	N (%)	276 (48.6)	337 (62.8)	< 0.001
Dysmenorrhea*	N (%)	273 (43.0)	218 (35.7)	0.009
RLS/WED-related symptom	N (%)			
No-LMR	N (%)	552 (86.5)	476 (77.4)	< 0.001
LMR	N (%)	73 (11.4)	121 (19.7)	
RLS/WED	N (%)	13 (2.0)	18 (2.9)	
Chronotype				
Morning	N (%)	232 (36.4)	189 (30.7)	< 0.001
Intermediate	N (%)	237 (37.1)	180 (29.3)	
Evening	N (%)	169 (26.5)	246 (40.0)	
Social Jet Lag				
<60 min	N (%)	266 (41.8)	226 (36.7)	0.006
60-120 min	N (%)	224 (35.2)	198 (32.2)	
≥120 min	N (%)	147 (23.1)	191 (31.1)	

*only in the presence of menstruation. BMI : body mass index, PMS: premenstrual syndrome, LMR: leg motor restlessness, RLS/WED: restless legs syndrome/Willis-Ekbom disease.

Supplemental Table 10. Logistic regression analysis for poor sleep.

	Univariable analysis Odds ratio (95% CI)	Multivariable analysis Odds ratio (95% CI)
Age		
Fist quartile (<26 years, reference)	1	1
Second quartile (26-34 years)	0.99 (0.73-1.34)	
Third quartile (34-44 years)	1.07 (0.78-1.48)	
Fourth quartile (≥44 years)	1.39 (1.02-1.91)	2.12 (1.28-3.50)
BMI ≥22 kg/m^2 (*vs*. <22 kg/m^2)	1.37 (1.07-1.76)	
Smoking		
Never (reference)	1	
Present	2.43 (1.40-4.23)	
Ex-smoker	1.39 (0.87-2.21)	
Habitual drinking (*vs*. non-habitual)	1.51 (1.05-2.17)	
Presence of spouse (*vs*. absence)	0.71 (0.57-0.90)	0.63 (0.45-0.89)
Menstruation		
Presence	1	
Pregnancy	0.59 (0.33-1.07)	
Menopause	1.24 (0.83-1.83)	
Presence of PMS (*vs*. absence)	1.74 (1.22-2.49)	1.82 (1.19-2.78)
Work schedule		
Day shifts（reference）	1	1
Rotating 12.5-hour night shifts	1.49 (1.05-2.12)	
Rotating 16-hour night shifts	1.14 (0.84-1.55)	
Three-shift rotations	2.18 (1.59-3.00)	2.20 (1.47-3.30)
Chronotype		
Morning（reference）	1	1
Intermediate	0.93 (0.71-1.22)	
Evening	1.79 (1.36-2.35)	1.95 (1.29-2.94)
Social Jet lag, absolute value		
<60 min（reference）	1	
60-120 min	1.04 (0.80-1.35)	
≥120 min	1.53 (1.16-2.02)	
RLS/WED-related symptoms		
No-LMR（reference）	1	1
LMR	1.92 (1.40-2.63)	1.66 (1.15-2.39)
RLS/WED	1.61 (0.78-3.31)	

BMI：body mass index, CI: confidence interval, PMS: premenstrual syndrome, LMR: leg motor restlessness, RLS/WED: restless legs syndrome/Willis-Ekbom disease.