

## Sex Differences in Sleep Disturbance Related to Rotating Shift Work: A Cross-Sectional Observation Study in Factory Employees

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To examine the effects of rotating shift work on sleep, mainly focusing on the difference between the sexes. We conducted a sleep quality survey among factory workers using the Pittsburgh Sleep Quality Index (PSQI) questionnaire. Out of 635 employees, 562 workers (319 male and 143 female workers, including 102 male and 18 female rotating shift workers, and 217 male and 125 female nonrotating workers) completed the PSQI questionnaire. Our results showed that women have generally better sleep quality, such as maintaining better concentration than men in dayshift workers. However, this superior sleep quality was not observed in female rotating shift workers. Furthermore, men have worse sleep quantity and quality, whereas female rotating shift workers have difficulty in staying awake during their work regardless of their sleep quantity and/or quality. In conclusion, female rotating shift workers may experience problems, although their sleep quality and/or quantity does not seem to be worse.

Key words: insomnia, rotating shift work, pittsburgh sleep quality index, sex difference, sleep

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## INTRODUCTION

As the number of rotating shift workers increases, sleep disorders due to shift work increasingly become an important public health problem [1, 2]. The effects of rotating shift work on sleep and health have been discussed for decades and many findings have been accumulated [3, 4]. Rotating shift workers are more likely to report sleep-onset difficulties, drowsy driving, and serious accidents at work compared with dayshift workers [5, 6]. However, the effect of the sex difference on sleep due to rotating shift work is still controversial.

Generally, men and women differ in their sleep propensities [7]. Subjectively, women have more trouble with sleep; e.g., subjective insomnia is more prevalent in women [8]. In contrast, women objectively have less trouble than men do with their sleep [9]. Women sleep longer, have more slow-wave sleep (SWS, i.e., deep sleep), shorter sleep latency (fall asleep easily), and less-fragmented sleep. In particular, young women had less sleep disturbance than men [10].

According to a systematic review [11] and recent reports, however, four studies using a subjective questionnaire have shown that female rotating shift workers experience more sleep problems [12-15]. Conversely, another four studies denied that there were sex differences in men and women's tolerance to rotating shift work. Two of the studies used a subjective questionnaire [16, 17], while the other two studies used objective measures: i.e., actigraphy [18] and a saliva hormone assay [19]. One of these studies pointed out that female rotating shift

workers were generally engaged in an environment with less exposure to physical and psychosocial risk factors than male rotating shift workers [20], which complicated the interpretation of the results.

As the number of female shift workers increases, the possible problems for female rotating shift workers have received greater attention [21]. This study aimed to clarify the effects of rotating shift work on the differences in sleep quality and disturbances between female and male workers under equivalent working conditions in a manufacturing environment.

## MATERIALS AND METHODS

We conducted a cross-sectional survey using the Pittsburgh Sleep Quality Index (PSQI) subjective questionnaire [22]. This study was approved by the ethics board of Shimane University Hospital (approval number: 1337). In this study, self-administered questionnaires were delivered to the participants along with a written description of the aims, methods, risks, and benefits of the study through the general affairs department of the factory. The participants were asked to complete the questionnaires anonymously. The greatest consideration was given to the participants' privacy. The return of questionnaires was assumed to constitute the participants' informed consent.

### *Subjects and work environment*

Workers employed at an electronics manufacturer's factory in Shimane Prefecture, Japan, were recruited for this study. All rotating shift workers were engaged in a particular manufacturing line making printed circuit boards. The rotating shift workers rotate their shifts, which last 12 hours from 8 AM to 8 PM or vice versa. They work 4 days in a row and take 2 days off, and then they rotate their shift from day to night, or vice versa. All rotating shift workers were asked about their sleep while they worked during the daytime to compare with the daytime shift workers. Female and male rotating shift workers' workload and working hours were equivalent. The dayshift workers belong to other departments, such as repair service or quality assurance, and all dayshift workers have no nighttime work. This survey was conducted in the winter

of 2012.

### *Evaluation of sleep conditions*

The Japanese version of the Pittsburgh Sleep Quality Index (PSQI) [23] was used to assess the subjective quality of sleep conditions and identify sleep disorders during the previous month. This questionnaire contains nine questions (Q1, bed time; Q2, sleep latency; Q3, wake-up time; Q4, sleep period time; Q5, sleep disturbance; Q6, sleep quality; Q7, sleeping drug usage; Q8, difficulty staying awake; and Q9, difficulty maintaining concentration). The question about sleep disturbance (Q5) comprises 10 secondary questions. In this study, three relevant secondary questions (Q5-i, difficulty falling asleep; Q5-ii, night waking; and Q5-iii, difficulty breathing) from these 10 questions were used to simplify the questionnaire. These 11 questions cover seven components (C1, sleep quality; C2, sleep latency; C3, sleep duration; C4, sleep efficacy; C5, sleep disturbance; C6, use of sleep medications; and C7, sleepiness). Three additional subjects were included (sleep efficacy [C4]; the global PSQI score; and the ratio of the sleep disorder). Sleep efficacy (C4) was obtained by dividing sleep period time (Q4) by the time in bed. The time in bed was calculated by subtracting waking up time (Q3) from bed time (Q1). Each component was scored from 0 to 3. Therefore, the total global PSQI score ranged from 0 to 21. A global PSQI score > 5 was diagnostic for the sleep disorder, with a sensitivity of 89.6% and a specificity of 86.5% in distinguishing between good and poor sleepers [22, 24]. To calculate C5, only two of the questions included in the secondary questions were used instead of all nine secondary questions in Q5 after deleting seven secondary questions.

The participants were also asked to complete questions relevant to their sleep habits, including age, body mass index (BMI), recent weight gain, alcohol consumption, smoking habits, and eating habits. This question was anonymously collected and a reference table was not created.

### *Statistical analysis*

The participants were categorized into four groups to detect sex differences in the effect of rotating

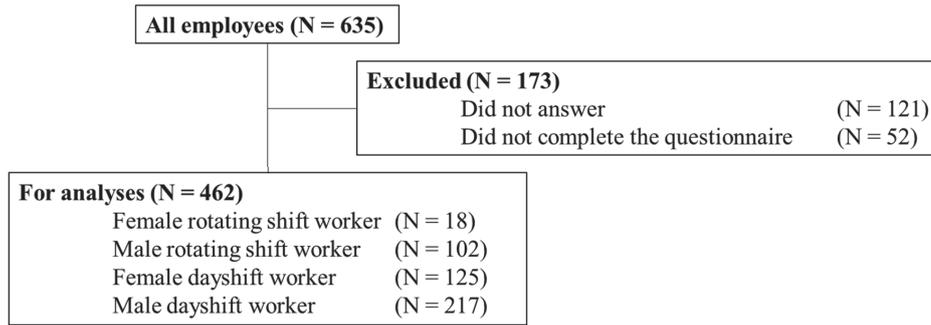


Fig 1. Participant recruitment

Among the 635 factory employees, 462 participants completed the Pittsburgh Sleep Quality Index (PSQI) questionnaire. Employees who did not answer ( $N = 121$ ), and did not complete the questionnaire ( $N = 52$ ) were excluded.

shifts. The first group comprised female rotating shift workers, the second comprised female dayshift workers, the third comprised male rotating shift workers, and the fourth comprised male dayshift workers.

First, the ratios of the sleep disorders were compared within these four groups using a chi-square test to detect the differences between these four groups. The significance was set at  $P < 0.05$ .

Second, when the first analysis detected a significant difference, each pair of these four groups was investigated using a chi-square test to identify the difference, specifically as post-hoc tests. The Bonferroni correction was used to avoid type-one errors. First, female and male dayshift workers were compared to clarify the differences between the sexes without the effect of the rotating shift work. Next, female and male rotating shift workers were compared to investigate the sex difference in sleep disorder among the rotating shift workers. Dayshift and rotating shift workers of each sex were also compared to detect the effect of rotating shift work for each sex, respectively. The significance was set at  $P < 0.0125$  (0.05 divided by 4).

Third, all eleven questions and the three calculated scores were compared (i.e., sleep efficacy, the PSQI global score, and the ratio of the sleep disorder) from the PSQI questionnaire for the four groups of pairs of interest using the Mann-Whitney U test to detect the statistical differences for these scores between each group. The total number of statistical analyses performed was 56 ( $14 \times 4$ ). However, because of the possible presence of a type-

two error, four group differences were examined as explanatory, with the possible limitations of multiple comparisons. Consequently,  $P < 0.00357$  (0.05 divided by 14) instead of  $P < 0.000893$  (0.05 divided by  $56 = 14$  by 4) was set as significant.

The participants' background differences within the four groups were compared using the Kruskal-Wallis test.

SPSS software (version 23; IBM, Tokyo, Japan) was used for the statistical analysis.

## RESULTS

### *Sampling result and participant backgrounds*

Among the 635 employees, 514 workers (159 women and 355 men, 81%) answered the questionnaire, but 52 workers did not answer all questions. Total 462 workers (18 female and 102 male rotating shift workers; 125 female and 217 male dayshift workers) completed the questionnaire (Fig 1). The characteristics of each group are shown in Table 1. Age and BMI tended to be low in women and rotating shift workers. The average ages were obtained for female rotating shift workers ( $28.3 \pm 7.7$  years), male rotating shift workers ( $32.2 \pm 8.3$  years), female daytime workers ( $37.8 \pm 8.7$  years), and male daytime workers ( $37.3 \pm 9.8$  years). Their average BMI was  $19.5 \pm 2.5$ ,  $22.4 \pm 3.8$ ,  $20.9 \pm 3.2$ , and  $22.7 \pm 3.3$ , respectively. Drinking alcohol and smoking were less prevalent in women. The ratios of no-alcohol drinking were 61.1%, 49.5%, 66.7%, and 36.0%, respectively. The ratios of non-smokers were 83.3%, 57.7%, 94.3%, and 64.0%,

Table 1. Participant backgrounds for each examined group

Characteristics	Female rotating shift (N = 18)	Female dayshift (N = 125)	Male rotating shift (N = 102)	Male dayshift (N = 217)	P value
Age[Mean $\pm$ SD]	28.3 $\pm$ 7.7	37.8 $\pm$ 8.7	32.2 $\pm$ 8.3	37.3 $\pm$ 9.8	0.000
BMI[Mean $\pm$ SD]	19.5 $\pm$ 2.5	20.9 $\pm$ 3.2	22.4 $\pm$ 3.8	22.7 $\pm$ 3.3	0.000
Weight gain, 3 kg within a year [%]	11.1	26.1	28.4	35.5	0.038
Weight gain, 10 kg from 20 years old [%]	5.6	12.7	16.5	30.0	0.000
Drink alcohol daily [%]	5.6	8.2	17.1	28.0	0.000
Drink alcohol, but not daily [%]	33.3	25.2	32.4	35.4	
Do not drink alcohol [%]	61.1	66.7	49.5	36.0	
Smoke [%]	16.7	5.7	42.3	36.0	0.000
Do not eat breakfast at least three times a week [%]	22.2	8.2	25.2	22.9	0.001
Do not eat lunch [%]	11.1	1.9	11.7	9.8	0.000
Eat dinner within 2 hours before sleep [%]	55.6	14.5	55.0	33.2	0.000
Eat something after dinner [%]	33.3	21.4	21.6	22.0	0.716
Eat faster than others [%]	27.8	43.4	45.0	57.0	0.004
Exercise twice per week for 1 year [%]	11.1	7.5	18.9	19.2	0.007
Walk 1 hour or more in 1 day [%]	44.4	27.7	56.8	33.2	0.000

Female rotating shift workers tend to be young, have low BMI, eat something within 2 hours before sleep compared with female dayshift workers. Male rotating shift workers tend to be young, have less trouble with weight gain, smoke more, eat dinner within 2 hours before sleep, and walk more compared with male dayshift workers.

Table 2. Sleep quality and disturbances for each sex and work shift

Questions Mean [SD]	Female rotating shift (N = 18)	Female dayshift (N = 125)	Male rotating shift (N = 102)	Male dayshift (N = 217)	All employees (N = 462)
Q1, bed time [hh:mm]	24:00 [1:02]	23:33 [1:02]	23:48 [0:50]	23:50 [1:01]	23:45 [1:00]
Q2, sleep latency [min]	19.4 [13.3]	18.1 [14.8]	26.9 [31.2]	19.5 [24.4]	20.7 [23.8]
Q3, wake-up time [hh:mm]	6:12 [0:33]	6:01 [0:47]	6:25 [0:53]	6:22 [0:44]	6:17 [0:48]
Q4, sleep period time [hour]	5.92 [1.17]	6.15 [0.85]	5.88 [0.93]	6.18 [1.04]	6.10 [0.98]
Q5-i, difficulty falling asleep	1.17 [1.15]	0.79 [1.10]	0.98 [1.10]	0.75 [0.99]	0.82 [1.05]
Q5-ii, night wakening	1.56 [1.10]	1.20 [1.18]	1.47 [1.14]	1.34 [1.18]	1.34 [1.17]
Q5-iii, difficulty breathing	0.17 [0.51]	0.23 [0.63]	0.37 [0.81]	0.68 [1.10]	0.47 [0.93]
Q6, sleep quality	2.22 [0.81]	2.06 [0.67]	2.12 [0.77]	2.10 [0.70]	2.10 [0.71]
Q7, sleep drug usage	0.00 [0.00]	0.14 [0.62]	0.11 [0.57]	0.16 [0.63]	0.14 [0.60]
Q8, difficulty staying awake	1.22 [1.11]	0.48 [0.77]	0.59 [0.88]	0.65 [0.86]	0.61 [0.86]
Q9, maintaining concentration	1.22 [1.06]	0.97 [0.72]	1.31 [0.85]	1.29 [0.89]	1.20 [0.86]
Sleep efficacy [%]	95.0	95.1	88.7	94.7	93.5
PSQI global score	6.78 [2.65]	5.71 [2.83]	7.08 [3.23]	6.32 [2.82]	6.34 [2.94]
Sleep disorder [%]	61.1	41.6	60.8	58.5	54.6

The results of the PSQI questionnaire and calculated numbers for each sex and work shift. Female rotating shift workers tend to have more trouble staying awake compared with female dayshift workers. Male rotating shift workers tend to have more trouble falling sleep, length of sleep, and sleep efficacy compared with male dayshift workers. hh:mm: 2 digits for hour and 2 digits for minutes; SD: standard deviation; PSQI: Pittsburgh Sleep Quality Index.

Table 3. Comparison of sleep quality and disturbances for the four groups

Questions <i>P</i> value	Female and male dayshift	Female and male rotating shift	Female dayshift and rotating shift	Male dayshift and rotating shift
Q1, bed time	0.012	0.469	0.177	0.353
Q2, sleep latency	0.742	0.457	0.411	0.009
Q3, wake-up time	< 0.001	0.108	0.127	0.433
Q4, sleep period time	0.522	0.692	0.468	0.003
Q5-i, difficulty falling asleep	0.707	0.499	0.113	0.077
Q5-ii, night waking	0.274	0.785	0.204	0.336
Q5-iii, difficulty breathing	< 0.001	0.291	0.689	0.031
Q6, sleep quality	0.413	0.594	0.271	0.672
Q7, sleep drug	0.569	0.406	0.332	0.314
Q8, difficulty staying awake	0.037	0.011	0.001	0.424
Q9, maintaining concentration	0.001	0.699	0.337	0.747
Sleep efficacy	0.363	0.040	0.704	< 0.001
PSQI global score	0.013	0.959	0.046	0.102
Sleep disorder	0.003	0.979	0.120	0.702

The results of post-hoc analysis for each group using a chi square test showed that female dayshift workers had fewer sleep disturbances. However, female nightshift workers did not show these optimal characteristics. PSQI: Pittsburgh Sleep Quality Index. Bonferroni *P* value correction to .0125 for the ratio of PSQI sleep disorder and Mann-Whitney *U* test with Bonferroni *P* value correction to .00357.

respectively. Female daytime workers ate breakfast and lunch regularly. The ratios for eating breakfast regularly were 77.8%, 74.8%, 91.8%, and 77.1%, respectively, that for eating lunch regularly were 88.9%, 88.3%, 98.1%, and 90.2%, respectively, and that for not eating anything 2 hours before sleep were 55.6%, 55.0%, 14.5%, and 33.2%, respectively. Female workers exercised less. The ratios for having a regular exercise habit were 11.1%, 18.9%, 7.5%, and 19.2%, respectively. However, rotating shift workers walked more. The ratios for 2 or more hours per day walking were 44.4%, 56.8%, 27.7%, and 33.2%, respectively.

#### ***Sleep questionnaire results***

The results for employees' sleep quality and disturbances are shown in Table 2. The prevalence of sleep disorder, which was defined as a PSQI global score greater than 5, was 54.6%. For rotating shift workers, regardless of their sex, 60.8% of employees had a sleep disorder, whereas 52.3% of dayshift workers regardless of their sex had a sleep disorder. Among women, 44.1% had sleep disorder regardless of their work shift, whereas among men, 59.2% had sleep disorder regardless of their work shift. Regard-

ing the prevalence of sleep disorder in each of the four groups, 61.1% of female rotating shift workers, 41.6% of female dayshift workers, 60.8% of male rotating shift workers, and 58.5% of male dayshift workers had a sleep disorder.

#### ***Main analysis***

A significant difference in the prevalence of sleep disorder was observed between these four groups ( $P = 0.008$ ). The difference between groups was examined in post-hoc analyses. As shown in the final row of Table 3, the prevalence of sleep disorder between female and male dayshift workers differed significantly ( $P = 0.003$ ). However, the prevalence of sleep disorder between female and male rotating shift workers was not significant ( $P = 0.979$ ).

#### ***Exploratory comparison of each question from PSQI for the four pairs***

The differences in scores from the questions and calculated scores in the PSQI were examined among each pair of these four groups in exploratory post-hoc analyses. The scores for each question and calculated numbers are shown in Table 2, while the comparison results are shown in Table 3. First,

the differences between female and male dayshift workers were evaluated. As shown in the second column of Table 3 (Q3), the wake-up time showed that women woke up earlier (6:01 for women and 6:22 for men,  $P < 0.001$ ). Apparently, women complained less about difficulty of breathing during sleep (Q5-iii, 0.23 and 0.68, respectively,  $P < 0.001$ ) and maintaining their concentration (Q9, 0.97, and 1.29, respectively,  $P = 0.001$ ).

The differences between male and female rotating shift workers were investigated. As shown in the third column of Table 3, no significant difference was observed between the sexes.

The fourth column of Table 3 shows that female rotating shift workers had more trouble staying awake (Q8) compared with female dayshift workers (1.22 for female rotating shift workers and 0.48 for female dayshift workers,  $P = 0.001$ ).

As shown in the fifth column of Table 2, sleep period time (Q4) tends to be shorter (5.9 hours for male rotating shift workers and 6.2 hours for male dayshift workers,  $P = 0.0033$ ) and sleep efficacy (C4) tends to be lower for male rotating shift workers compared with male dayshift workers (88.7% of male rotating shift workers and 94.7% of male dayshift workers,  $P < 0.001$ ).

## DISCUSSION

The differences between the sexes in sleep quality and disturbance of male and female dayshift and rotating shift workers were investigated using a subjective sleep quality questionnaire. The good sleep quality and few sleep disturbances of female dayshift workers were not observed in female rotating shift workers. Female dayshift workers woke up earlier, and had less trouble breathing during sleep and maintaining concentration compared with male dayshift workers. Furthermore, female rotating shift workers had more difficulty staying awake compared with female dayshift workers, whereas male rotating shift workers slept fewer hours and had lower sleep efficacy compared with male dayshift workers. Thus, a difference was observed in the effects of shift work on sleep quality and disturbances between the sexes. Male and female rotating shift workers were engaged in a controlled equivalent rotating shift

work environment. In addition, they had an equivalent job task to employees in the same factory, which may overcome a limitation of previous studies [20].

The prevalence of sleep disorder, defined as a PSQI global score  $> 5$  in all participants in this study (54.6%), was within the range of previous studies (54-69%) [25]. The present study shows that sleep disorder is more prevalent in rotating shift workers (60.8%) compared with dayshift workers (52.3%). This tendency was also reported previously (e.g., about 50% for dayshift workers and about 60% for rotating shift workers) [26]. Furthermore, age, BMI, consumption of alcohol, smoking, and regular exercise tended to be low in women (Fig 1). These propensities matched a previous insomnia survey [27]. This study population might not differ from the general population, which suffered from sleep disorders in rotating shift work.

Sleep disorder was less prevalent in female dayshift workers (41.6%) compared with male dayshift workers (58.5%). However, these sex differences were not observed in female rotating shift workers (61.1%) compared with male rotating shift workers (60.8%) in equivalent working conditions. In this study, female rotating shift workers were younger than male rotating shift workers (mean age [standard deviation, SD]: 28.3 [7.7] years and 31.9 [8.5] years, respectively). Previous studies using objective measurement showed that sleep quality is better in young people [28, 29], in addition to superior quality of sleep in woman [10]. Therefore, in the present study population, female rotating shift workers were expected to show good sleep quality. However, our result showed that female rotating workers showed no superior sleep propensity compared with male rotating workers. Consequently, these results can be interpreted to show that rotating shiftwork disturbs sleep more severely in female workers.

As the analyses of the association of rotating shift work with each question in the PSQI showed, female dayshift workers have fewer sleep disturbances, such as difficulty breathing during sleep or maintaining concentration compared to male dayshift workers. Meanwhile, male rotating shift workers showed lower sleep efficacy. This relatively low sleep quality in male rotating shift workers might be

ameliorated by taking naps during the rotating shift or treating sleep itself [30] because male rotating shift workers showed no other deficits, such as losing concentration or having difficulty staying awake. However, female rotating shift workers have trouble keeping awake, although they do not show significantly decreased sleep time or sleep efficacy. This result supports some basic studies, such as woman showed lower alertness and working cognition [31, 32], and woman rotating shift workers have higher risk of injury compared with man [33].

Our result may indicate a clinically important suggestion that physicians may overlook the problem of women losing concentration because female rotating shift workers did not show any difference in subjective sleep quality compared with female dayshift workers. Consequently, female rotating shift workers' sleep problems must be considered carefully because a few questions about sleep may not detect the harmful effect caused by sleep problems in women working rotating shifts.

There are several limitations of the present study. (1) In this study, seven out of 10 questions about sleep disturbance were omitted to increase the expected questionnaire return rate. The accuracy of a shorter version of the sleep disturbance questionnaire has not been tested, which limits generalizations from this result. (2) There is a probability that post-hoc analyses were not reliable because multiple exploratory comparisons were conducted without sufficient statistical corrections. (3) This was a cross-sectional study with unclear causality. Further longitudinal research is needed to examine all effects of shift work. (4) This study was conducted using a subjective measure; thus, a study using an objective assessment of sleep is needed to detect problems more accurately. (5) The effect of housework could not be excluded because the present study did not measure workers' social burden. Previous studies have shown the effect of domestic work on sex differences in sleep disturbance [34, 35]. For example, caring for children may affect sleep quality [1]. Moreover, previous study showed work role stress cause sleep disturbance [36]. And recent study showed effect of mobile phone use on sleep [37]. Further studies controlling other possible related factors in rotating shift workers' sleep are needed. (6)

The number of female rotating shift workers was limited: i.e., only 18 female rotating shift workers were included in this study. Furthermore, the participants' backgrounds differed in each examined group, such as age, BMI, and eating and exercise habits. This may prevent generalizations from our results to daily clinical practice. This preliminary study showed the sex difference in rotating shift workers. A larger population study is worth to be conducted.

## CONCLUSIONS

The results of the present study supported the existence of sex differences in sleep disturbance related to rotating shift work. In addition, a sex difference was found in the harmful effect of rotating shift work caused by sleep disorders. While male rotating shift workers showed sleep problems, female rotating shift workers showed work-time difficulties, although female rotating shift workers' sleep quality and quantity seemed to be normal compared with that of female dayshift workers. Therefore, female rotating shift workers must be observed closely for their ability to function during work and treated carefully in this society where women also work in the manufacturing industry.

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