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SLEEP PATTERNS AND SLEEP DISORDERS AMONG FEMALE SHIFT WORKERS IN A COMPUTER FACTORY OF JAPAN

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Using a repeated questionnaire survey for female workers in a computer factory of Japan, consisting of 45 daytime workers and 84 weekly rotating shift workers (of whom 40 and 44 were respectively engaged in early-shift work and late-shift work during the survey week), the present study aimed to clarify the effects of shift work on their sleep patterns and sleep disorders. The time of retiring, time of rising, duration of sleep, and self-evaluated sleep quality based on four sleep-related problems were investigated for four days (Sunday-Monday, Tuesday-Wednesday, Thursday-Friday, and Saturday-Sunday) in a week. The intergroup comparison revealed that the earlier the rising time and the shorter the duration of sleep, the lower the sleep quality; the lowest sleep quality was observed in the early-shift workers.

INTRODUCTION

In the past several decades, shift workers have rapidly increased worldwide. Monk and Folkard (1983) estimated that they accounted for about 20% of the whole working population in Europe and the United States. In Japan, shift work has become prevailing in association with a reduction of working hours in recent years, and consequently the current number of shift workers is assumed to have exceeded one million (Ohsuga and Shimoyama, 1998).

It has been demonstrated that shift workers tend to suffer from sleep-related problems. A large-scale survey for 6,385 daytime workers and 7,963 shift workers in Denmark, Sweden, and Norway disclosed that 60% of the former complained of sleep problems (Thiis-Evensen, 1958). A comparative study in France for nighttime workers and daytime workers, 1,200 in each group, revealed more frequent sleep disturbances among the former group (Lasfargues et al., 1996). Sleep disruptions of shift workers were caused by disturbed circadian rhythm and noise in their daytime sleeping hours (Koller et al., 1978; Regestein and Monk, 1991). It has been considered that sleep disturbance causes psychological and behavioral problems, since patients of insomnia feel tension, anxiety, worry, and/or depression in the night, and they often take medication or alcohol to cope with their tension (WHO, 1992).

An increase in the female working population is another current occupational pattern in developed countries. In the United States, the proportion of working women has increased to 58.8% in 1994, from 43.3% in 1970 (US Bureau of the Census, 1995). In Japan, female workers numbered 26.7 million in 1997, 380,000 more than in 1996 (Ministry of Labor Women Bureau, 1998). Many occupational health investigations have been conducted for female workers (Waldron and Jacobs, 1988; Kane and Kartha, 1992; Luecken et al., 1997; Hatch and Moline, 1997; Williams et al., 1997; Rose et al., 1997). Since most of these studies focused on work-related stress, however, little has been known about the sleep conditions of working women even though women suffer from insomnia

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more often than men (Griefahn, 1991; Rosekind, 1992).

Using a questionnaire survey for female workers in a computer factory in Japan, consisting of daytime workers and weekly rotating shift workers, the present study aimed to clarify the effects of shift work on their sleep patterns and sleep disorders. For these purposes, the following items were investigated for each subject four days in a week, or one shift cycle, including one off day; the time of retiring, time of rising, duration of sleep, and subjective judgment on four sleep-related problems. These data were analyzed with attention to the maintenance or promotion of female shift workers' health.

MATERIALS AND METHODS

Subjects

The subjects of the self-administered questionnaire survey were 174 female workers in a computer factory in Yamanashi Prefecture, Japan; this number accounted for 87.4% of all female employees of this factory. Since 41 of them were excluded because of incompleteness in their data about sleep disorder and the other 4 were excluded because they did not work on one of the workdays, the analysis was conducted for 129 subjects.

The female workers of this factory are divided into two groups by work patterns: daytime workers engaged in desk work and shift workers engaged in manufacturing work without any physically severe burden. The shift workers are further divided into two subgroups, each of which alternately, week by week, takes early-shift and late-shift schedules. Working days in this factory are five days a week, from Monday to Friday, and the daily working hours for daytime, early-shift, and late-shift workers are, respectively, 465 min from 8:30 to 17:15 (60 min for rest), 420 min from 6:00 to 13:45 (45 min for rest), and 480 min from 13:40 to 22:25 (45 min for rest).

Of the 129 subject females, 45 were daytime workers and 40 and 44 were engaged in the early-shift and late-shift work, respectively, during the week of study. The mean age of the daytime, early-shift, and late-shift workers was 27.3, 26.2, and 24.8 years, with significant difference ($\chi^2 = 7.08$, $p = 0.03$, by the Kruskal-Wallis test, which was applied because their ages in each group did not follow normal distribution). The mean duration of employment in the current job of the daytime, early-shift, and late-shift workers was 6.7, 6.6, and 6.1 years; no significant difference was observed among them ($\chi^2 = 0.31$, $p = 0.86$, by the Kruskal-Wallis test). One daytime worker, one early-shift worker, and two late-shift workers were pregnant, and none was lactating. The percentages of current smokers, former smokers, and nonsmokers were not significantly different in the three groups ($\chi^2 = 2.07$, $p = 0.72$, by the Pearson's Chi-square test). No worker used hypnotics during the survey period. In the study week, 28 early-shift workers (70.0%) did extra work on Saturday; the median (25 and 75 percentiles) of their work duration was 480 (420 to 525) min.

Collection of data

The questionnaire survey was conducted for one week, from 4 to 10 July 1998. The subjects were requested to fill in the same questionnaire sheet on four days, i.e., 4 July (Monday) for sleep on Sunday–Monday night (Sun.-Mon. sleep), 6 July (Wednesday) for Tuesday–Wednesday night (Tues.-Wed. sleep), 8 July (Friday) for Thursday–Friday night (Thurs.-Fri. sleep), and 10 July (Sunday) for Saturday–Sunday night (Sat.-Sun. sleep). Of them, the former three were regarded as workdays, and the last one as an off day. The questionnaire sheets were distributed at meetings held twice in the factory, in the morning and evening, a week before the questionnaire survey. At the meetings, one author (NS) explained the study purpose and the way of filling in the questionnaire. Informed consents were obtained from all participants.

Questionnaire items

For sleep in each of the four study nights, the subject female worker recorded the time of retiring (falling asleep) and the time of rising as precisely as possible. With these records, time of retiring,

time of rising, and sleep duration were analyzed as the time variables.

The quality of sleep was evaluated by the subject worker, using yes/no alternatives for four questions, which were developed by WHO's MONICA Psychosocial Optional Study Group (1988) and translated into Japanese with modifications to adjust to Japanese, for an epidemiological survey on stress and health for workers in various kinds of occupations (Uehata, 1993). The original questions are designed to ask about frequencies of four sleep-related problems in the past month, but in this study the subject was requested to answer yes or no for the sleep of each night. The four questions were "Couldn't sleep well because of being overly tired"; "Woke up several times at night"; "Woke up too early"; and "Had difficulty in falling asleep." These are called, in short, "ill sleep," "intermittent wake-up," "early wake-up," and "difficult falling asleep." It is noted that these four sleep-related problems have been known as the indicators of insomnia (WHO, 1992; Kageyama et al., 1997, 1998). The quality of sleep was also evaluated by the total number of yes answers, called sleep problem score in this paper, which ranges from 0 to 4; the higher the score, the worse the quality of sleep.

Statistical analyses

A one-way analysis of variance (one-way ANOVA) was used to compare the time variables among the three work groups. In the analysis, each subject's times of retiring and rising were calculated as the time (in minutes) passed from 18:00 and 4:00, respectively, which were the earliest times recorded. The intragroup difference in the sleep problem scores between all pairs of four sleeps, i.e., Sun.-Mon. sleep, Tues.-Wed. sleep, Thurs.-Fri. sleep, and Sat.-Sun. sleep, was analyzed by the general linear model (GLM) repeated measures procedure. The intergroup difference in the scores was analyzed by the GLM univariate ANOVA, in which age was controlled as a covariable because the mean age significantly differed among the three groups. A partial correlation between each time variable and sleep problem score or frequency of each sleep problem was examined under control of age as a covariable. The differences in the mean sleep problem score according to categories of time variables were examined by one-way ANOVA. In all analyses, the Bonferroni t test was used for post hoc multiple comparisons. All statistical analyses were performed by using the Statistical Package for Social Sciences (SPSS Inc., 1998).

RESULTS

Sleep patterns

Data of the continuous measures for sleep are shown in Table 1. The time of retiring on the three workdays was earliest in the early-shift workers and latest in the late-shift workers, with a significant intergroup difference. The time of retiring on the off day significantly differed between the daytime and late-shift workers; the daytime workers retired earlier.

The time of rising on the three workdays was significantly different between all pairs of the three groups: the earliest in the early-shift workers and the latest in the late-shift workers. No significant difference was observed on the off day.

The duration of sleep was shortest in the early-shift workers and longest in the late-shift workers on the three workdays. Significant differences were observed between all pairs of the three groups in the Sun.-Mon. and Tues.-Wed. sleeps and between the late-shift workers and either the daytime or early-shift workers in the Thurs.-Fri. sleep. Even in the Sat.-Sun. sleep, the duration of sleep was short in the early-shift workers, though the difference was insignificant.

Sleep problem score

Table 2 shows intragroup comparisons of the sleep problem score between all pairs of the four sleeps. Among the early-shift and late-shift workers, the score of the Sun.-Mon. sleep was significantly higher than that of the Sat.-Sun. sleep; among the early-shift workers, the score of the Sun.-Mon. sleep was higher than that of either the Tues.-Wed. or Thurs.-Fri. sleep. In contrast, no signifi-

Table 1. Mean time of retiring and rising (with range of the mean ± SD), and mean (± SD) duration of sleep by three work groups.

	Daytime	Early-shift	Late-shift
Sun.-Mon. sleep			
Time of retiring	(*N* = 44)	(*N* = 40)	(*N* = 44)
	00:03	23:27 [a]	00:34 [b]
	(23:04-01:01)	(21:58-00:56)	(22:52-02:17)
Time of rising	(*N* = 44)	(*N* = 40)	(*N* = 43)
	06:28 [a]	04:52 [b]	08:55 [c]
	(05:54-07:01)	(04:26-05:16)	(07:11-10:38)
Duration of sleep (min)	(*N* = 44)	(*N* = 40)	(*N* = 43)
	390 ± 65 [a]	328 ± 91 [b]	512 ± 92 [c]
Tues.-Wed. sleep			
Time of retiring	(*N* = 45)	(*N* = 40)	(*N* = 44)
	00:06 [a]	23:34 [a]	02:05 [b]
	(23:11-01:06)	(22:15-00:52)	(00:44-03:26)
Time of rising	(*N* = 45)	(*N* = 40)	(*N* = 44)
	06:31 [a]	04:53 [b]	09:29 [c]
	(06:03-06:58)	(04:23-05:23)	(07:59-10:59)
Duration of sleep (min)	(*N* = 45)	(*N* = 40)	(*N* = 44)
	382 ± 57 [a]	324 ± 78 [b]	446 ± 76 [c]
Thurs.-Fri. sleep			
Time of retiring	(*N* = 45)	(*N* = 39)	(*N* = 44)
	00:06 [a]	23:05 [b]	02:09 [c]
	(22:52-01:09)	(21:41-00:28)	(00:52-03:26)
Time of rising	(*N* = 45)	(*N* = 39)	(*N* = 44)
	06:30 [a]	04:53 [b]	09:29 [c]
	(05:59-07:06)	(04:28-05:18)	(07:44-11:15)
Duration of sleep (min)	(*N* = 45)	(*N* = 39)	(*N* = 44)
	384 ± 71 [a]	351 ± 88 [a]	445 ± 78 [b]
Sat.-Sun. sleep			
Time of retiring	(*N* = 44)	(*N* = 39)	(*N* = 43)
	00:24 [a]	00:50	01:14 [b]
	(23:10-01:38)	(23:28-02:13)	(23:23-03:04)
Time of rising	(*N* = 44)	(*N* = 40)	(*N* = 43)
	08:26	08:29	09:16
	(06:40-10:13)	(06:52-10:07)	(07:26-11:06)
Duration of sleep (min)	(*N* = 44)	(*N* = 39)	(*N* = 43)
	481 ± 109	455 ± 115	495 ± 120

By one-way ANOVA. The different characters, *a* to *c*, refer to the case of significant differences by Bonferroni's multiple comparison at $p < 0.05$.

cant difference was found between all pairs of the four sleeps among daytime workers, though the score was relatively high in the Sun.-Mon. sleep.

Table 3 shows the age-adjusted mean sleep problem scores for the three groups. A multiple comparison analysis revealed significantly higher scores in the early-shift workers than in the late-shift workers for all the four sleeps and significantly higher scores in the early-shift workers than in the daytime workers in the Sun.-Mon. and Sat.-Sun. sleeps.

Table 2. Intragroup comparisons of sleep problem scores between four sleeps.

		Sun.-Mon. sleep		Tues.-Wed. sleep		Thurs.-Fri. sleep		Sat.-Sun. sleep	
	N	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Daytime	45	0.600	0.863	0.378	0.716	0.356	0.570	0.244	0.484
Early-shift	40	1.150 [a]	0.783	0.700 [b]	0.715	0.650 [b]	0.692	0.650 [b]	0.850
Late-shift	44	0.568 [a]	0.625	0.296	0.702	0.341	0.608	0.227 [b]	0.424

General linear model (GLM) repeated measures procedure was conducted for each work group. The different characters, *a* or *b*, refer to the case of significant difference by Bonferroni's multiple comparison at $p < 0.05$.

Table 3. Age-adjusted means and standard errors of sleep problem scores by three work groups.

	Daytime (N = 45)		Early-shift (N = 40)		Late-shift (N = 44)	
Sleep	Mean (SE)	95% CI §	Mean (SE)	95% CI	Mean (SE)	95% CI
Sun-Mon	0.633 (0.115) [a]	0.407-0.860	1.153 (0.120) [b]	0.915-1.391	0.531 (0.116) [a]	0.302-0.761
Tue-Wed	0.410 (0.106)	0.201-0.620	0.703 (0.111) [a]	0.483-0.923	0.260 (0.107) [b]	0.047-0.472
Thu-Fri	0.385 (0.093)	0.201-0.569	0.653 (0.097) [a]	0.460-0.845	0.309 (0.094) [b]	0.122-0.495
Sat-Sun	0.255 (0.090) [a]	0.076-0.434	0.651 (0.095) [b]	0.463-0.838	0.216 (0.091) [a]	0.035-0.397

By general linear model (GLM) univariate ANOVA. Sleep problem score, work-shift type, and age were incorporated into the model as a dependent variable, a fixed factor, and a covariate, respectively. The different characters, *a* or *b*, refer to the case of significant difference by Bonferroni's multiple comparison at $p < 0.05$.
§ CI, Confidence interval.

Table 4. Number (%) of subject workers who had sleep-related problems.

	Sun.-Mon. sleep		Tues.-Wed. sleep		Thurs.-Fri. sleep		Sat.-Sun. sleep	
Daytime (N = 45)								
Ill sleep	2	(4.4)	1	(2.2)	2	(4.4)	0	
Intermittent wake-up	11	(24.4)	6	(13.3)	7	(15.6)	6	(13.3)
Early wake-up	5	(11.5)	2	(4.4)	1	(2.2)	3	(6.7)
Difficult falling asleep	10	(22.2)	8	(17.8)	6	(13.3)	2	(4.4)
Early-shift (N = 40)								
Ill sleep	5	(12.5)	3	(7.5)	2	(5.0)	3	(7.5)
Intermittent wake-up	15	(37.5)	7	(17.5)	7	(17.5)	10	(25.0)
Early wake-up	1	(2.5)	5	(12.5)	6	(15.0)	5	(12.5)
Difficult falling asleep	25	(62.5)	13	(32.5)	11	(27.5)	8	(20.0)
Late-shift (N = 44)								
Ill sleep	1	(2.3)	2	(4.5)	2	(4.5)	1	(2.3)
Intermittent wake-up	4	(9.7)	5	(11.4)	2	(4.5)	3	(7.0)
Early wake-up	8	(18.2)	3	(6.8)	4	(9.1)	1	(2.3)
Difficult falling asleep	12	(27.3)	4	(9.1)	7	(15.9)	5	(11.6)

Sleep-related problems

As shown in Table 4, the proportion of subject workers who had sleep-related problems differed by groups. The most prominent was a high proportion (62.5%) of the early-shift workers who com-

Table 5. Partial correlation coefficients between time variables and sleep problem score.

	Time of retiring	Time of rising	Duration of sleep
Overall sleep problem score	-.081	-.361 **	-.387 **
Ill sleep	-.002	-.157	-.186 *
Intermittent wake-up	-.205 *	-.303 **	-.180 *
Early wake-up	-.078	-.194 *	-.182
Difficult falling asleep	.063	-.175	-.300 **

Correlation coefficients were calculated with control of age. Degrees of freedom: 113. For times of retiring and rising, duration of sleep, and overall sleep problem score, the correlation test was based on the mean of the four sleeps. For the four sleep-related problems, the mean frequency for the four sleeps was used for the test. Significant correlation at $*p < 0.05$, $** p < 0.01$.

plained of "difficult falling asleep" in the Sun.-Mon. sleep. This sleep-related problem was more prevalent in the early-shift workers than in the other two groups, even in sleeps on workdays.

Relation between time variables and sleep problem score

Table 5 shows partial correlation coefficients, when age was controlled, between each of the three time variables and the sleep problem score or frequency of each of the four problems; for any variables, the mean values of the four sleeps were used. There are four major observations in this table. First, the sleep problem score was correlated with two time variables, i.e., time of rising and sleep duration, implying that the later the time of rising and the longer the sleep duration the lower the score. Second, the time of retiring was inversely correlated with frequency of "intermittent wake-up." Third, the time of rising had a significant inverse correlation with frequency of "intermittent wake-up" and "early wake-up." Fourth, the sleep duration had a significant inverse correlation with three of the four sleep-related problems, "ill sleep," "intermittent wake-up," and "difficult falling asleep."

For the two time variables that were significantly correlated with the sleep problem score, the mean (and SD) scores by categorized levels are illustrated in Figures 1 and 2. The score gradually decreased when the duration of sleep increased from <5 hr to 8-9 hr, with significant difference between the score for 8-9 hr and that for <5 hr or 5-6 hr.

For the relationship with the time of rising, the sleep problem score of the subjects who got up before 6:00 differed significantly from that of the subjects who got up at 7:00-8:00, 9:00-10:00 and 10:00 or later; the subjects who got up at 9:00-10:00 had the lowest score.

DISCUSSION

Discussion begins with the possible effects of extra work of some early-shift workers on Saturday on their sleep pattern and sleep disorders. Because there was no significant difference in the sleep problem score in the Sat.-Sun. sleep between the 28 workers who worked on that day and the 12 remaining workers who did not ($t = 0.09$, $p = 0.93$), it can be judged that this effect was negligible.

Effect of early work time on reduction of sleep time

One of the most important results in this study was marked intergroup difference in sleep duration on the three workdays; 324-351 min on average in the early-shift workers, 382-390 min in the daytime workers, and 445-512 min in the late-shift workers. The sleep duration of the early-shift workers (whose work started at 6:00), i.e., 324 to 351 min, was longer than or comparable to that in some other shift workers who started to work at 6:00, e.g., 264 min on average among industrial nurses in England (Smith, 1979) and 355 min among food production workers in England (Tilley et al., 1981). It was slightly shorter than 388 min among hospital nurses who started to work at 7:00 (Costa et al., 1994).

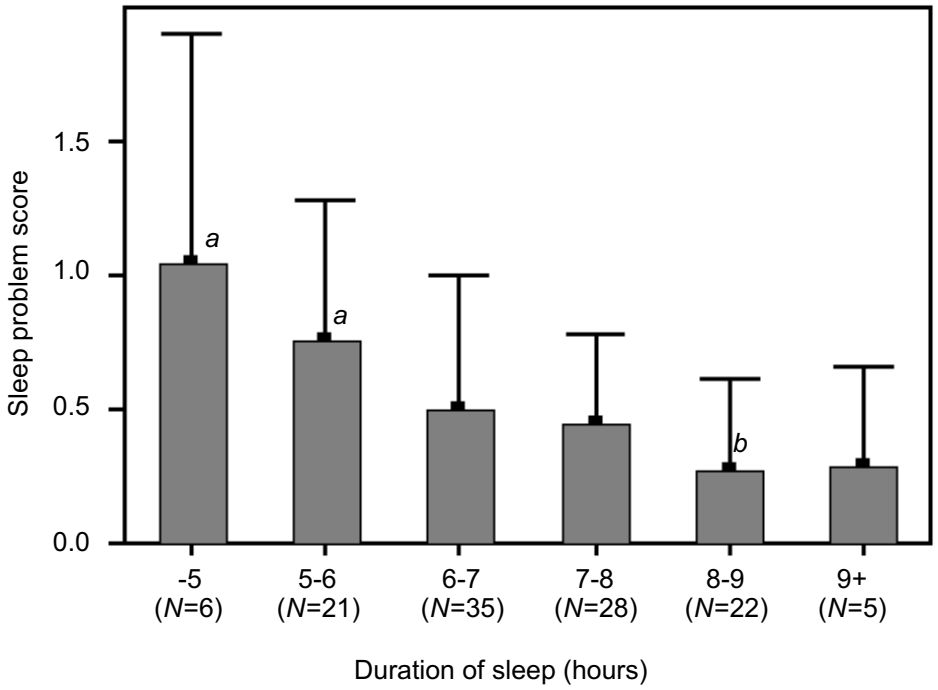

Fig. 1. The relationship between duration of sleep and sleep problem score. Bar shows standard deviation. The different characters, *a* or *b*, refer to the case of significant difference by Bonferroni's multiple comparison at $p < 0.05$.

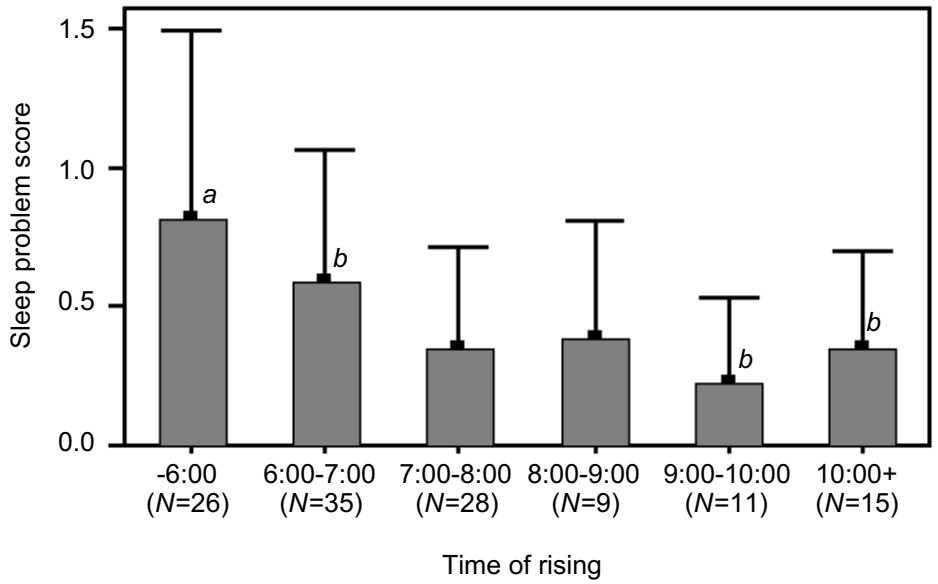

Fig. 2. The relationship between time of rising and sleep problem score. Bar shows standard deviation. The different characters, *a* or *b*, refer to the case of significant difference by Bonferroni's multiple comparison at $p < 0.05$.

In this connection, it is noted that the subject early-shift workers complained of "difficult falling asleep" at a high rate, and the complaint of this problem was inversely correlated with sleep duration (Table 5). This fact implies that the short sleep duration of the early-shift workers was basically caused by their difficulty in falling asleep. Taking into account the similar findings in other working populations (Åkerstedt, 1984; Frese and Harwich, 1984; Costa et al., 1994), it can be judged that short sleep duration was primarily determined by an early starting time of work.

Accumulating effect of early-shift work

The findings about the sleep problem score were characterized by a higher score in the early-shift workers than in the other two groups, between which no significant difference was observed, even though the daytime workers tended to have higher scores than the late-shift workers. The early-shift workers' high scores were consistent with their short sleep duration and early time of rising. Another highlight was observed in the day-to-day differences in sleep problem scores among the late-shift workers whose scores were significantly higher in Sun.-Mon. sleep despite their long sleep duration on that night. This reason may be attributed to an accumulating effect of early-shift work, since the subject late-shift workers had experienced early-shift work in the previous week. This was accorded with the findings of Totterdell et al. (1995), who disclosed that a self-rating score-based full recovery among 61 shift-working nurses took place on the third rest day after the final day of their early-shift work. Thus it is suggested that two rest days are not enough for recovery from damage of early-shift work.

Desired sleep duration and time of rising

The sleep problem score decreased with an increase in sleep duration from <5 hr to 8-9 hr, with a significant difference between 8-9 hr and <5 hr or 5-6 hr (Figure 1). This relation suggests that the shorter the sleep duration, the more problematic the sleep quality. The desired sleep duration has scarcely been examined in relation to sleep quality, like the sleep problem score in this study, though a nine-year follow-up Alameda County Study for mortality disclosed that the individuals whose sleep duration was remarkably short, i.e., <6 hr, or long, i.e., >9 hr, had a significantly higher mortality rate from all causes, compared with the individuals whose sleep duration was 7-8 hr (Wingard et al., 1982). The relation between the sleep problem score and time of rising in this study demonstrated that the vulnerable time of rising was <6:00 and, at most, 6:00-7:00 (Figure 2). Both the effects of sleep duration and of time of rising on the sleep problem score seem to have reflected a common cause because their short sleep duration was largely conditioned by their early time of rising, as previously mentioned.

SUMMARY AND CONCLUSIONS

Two major findings were related to the shift rotation. First, the intergroup comparison revealed higher sleep problem scores in the early-shift workers not only in weekday sleeps, but also in Sat.-Sun. sleep, in which sleep duration did not significantly differ among the groups. Second, the day-to-day comparison among the early-shift workers showed a higher sleep problem score in Sun.-Mon. sleep than in Tues.-Wed. sleep. In relation to the above-mentioned accumulating effect of early-shift work on sleep problem score in the late-shift workers', Sun.-Mon. sleep, the authors consider that the effects of early-shift work continued to the middle of the following late-shift week.

Recommendations for a suitable shift work schedule are beyond the direct scope of this paper. Presupposing that the weekly rotating shift work system in the target factory is not changed, however, the findings of this study suggest that a delay in the commencement time of the early-shift work, for instance, a one-hour delay from 6:00 to 7:00, will improve their sleep disorders.

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