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FATIGUE COMPLAINTS AMONG FEMALE SHIFT WORKERS IN A COMPUTER FACTORY OF JAPAN

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For female workers in a computer factory in Japan, consisting of 41 daytime workers and 74 weekly-rotating shift workers (of whom, 37 each were engaged in, respectively, early-shift work and late-shift work during the survey week), within-day variations in the number of fatigue complaints were elucidated. Based on a repeated questionnaire survey, changes of fatigue complaints in a day were evaluated at three occasions, i.e., just before work, just after work, and before retiring, for three working days and one off day. The occasions of fatigue feelings differed among the three work groups: the complaints were significantly more frequent before work in the early-shift workers, after work in the late-shift workers, and before retiring in the daytime workers. Feeling of fatigue before and after work may be disadvantageous to safety and efficiency of work.
Keywords: subjective fatigue; two-shift work; sleep quality; within-day variation; repeated questionnaire

INTRODUCTION

In the last several decades, shift workers have rapidly increased worldwide. Over 20% of the working population in the United States are shift workers, working the majority of their hours outside the traditional 9:00-to-17:00 schedule from Monday to Friday (Circadian Information, 2000). In Japan, shift works have become prevailing in association with 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).

Shift work alters the workers' normal circadian rhythm and disrupts their sleep patterns in particular (Regestein and Monk, 1991; Martikainen et al., 1998). When shift workers are compared with non-shift workers (i.e., daytime workers), the former tend to suffer more from sleep-related problems. A large-scale survey of 6,385 daytime workers and 7,963 shift workers in Denmark, Sweden, and Norway disclosed that 60% of the latter complained of sleep problems (Thiis-Evensen, 1958). A comparative study of permanent nighttime workers and daytime workers (1,200 in number for each) in France revealed more frequent sleep disturbances among the former group (Lasfargues et al., 1996). In an Austrian oil refinery, an increasing health risk was clearly indicated by increases in sick leave due to unspecific complaints such as sleep disturbances and premature fatigue in the four-shift workers (Koller, 1983).

Persisting fatigue is another clinical sign of intolerance to shift work (Andlauer et al., 1979). It is suggested that shift workers feel fatigue more frequently, worsening their health status on the one hand and reducing work efficiency and safety on the other hand. Psychophysiological adaptation of female workers to rotating shift systems has been examined mostly for nurses by subjective evaluation of fatigue as well as performance measures such as reaction test and memory test, blood pres-

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sure, heart rate, and hormone concentration (Estryn-Behar et al., 1990; Costa et al., 1994; Kobayashi et al., 1997). Nurses usually have a night duty shift and it is suggested that the night shift itself is prejudicial to health (Kobayashi et al., 1997) and recuperative rest days should follow each night duty not to disturb the workers' condition on the following shift (Monk and Folkard, 1983). In Japan, however, female shift workers other than nurses had not been allowed to work in the night shift because of the law which banned females from working 22:30-to-5:00 (International Labour Office, 1995). Even after the abolition of the law in 1999, only 5.4% of female workers were engaged in night shift (Ministry of Health, Labour, and Welfare Japan, 2001a). The effects of shift work schedule without night shift, which is applied to most Japanese female shift workers, should be clarified in female working populations.

Based on a questionnaire survey for female workers in a computer factory in Yamanashi Prefecture, Japan, consisting of 41 daytime workers and 74 weekly-rotating two-shift workers (of whom 37 each were engaged in, respectively, early-shift work and late-shift work during the survey week), the present study aimed to clarify the effects of two-shift work schedule without night shift on their fatigue complaints. For their fatigue assessment, questionnaires were repeatedly administered on three occasions, i.e., just before work, just after work, and before retiring to bed, on the assumption that the early- and late-shift workers would show increased fatigue complaints at different times of a day, affecting differently the efficiency of their work.

METHODS

Subjects

The female workers of the factory studied are divided into two groups by work patterns: the daytime workers who are engaged in desk work and the shift workers who are engaged in manufacturing process with no physically severe burden. The shift workers' major task is to manufacture parts of computers, using a microscope and a pair of tweezers, in a sedentary posture. Physical activity levels, which were assessed by the same questionnaire as used in the National Nutrition Survey (Ministry of Health, Labour, and Welfare Japan, 2001b), did not differ significantly between the daytime and shift workers.

The daytime workers are two-year college graduates whereas the shift workers are mostly high school graduates. The shift workers receive on-the-job training and learn how to operate machines. The shift workers are further divided into two subgroups, each of whom takes alternately, week-by-week, early-shift and late-shift schedules. Working days in this factory are five in a week, from Monday to Friday, and daily working hours for the 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).

The questionnaire survey was conducted from 4 to 10 July 1998. The subjects were requested to participate in this survey on four days, i.e., 4 July (Monday), 6 July (Wednesday), 8 July (Friday), and 10 July (Sunday); the former three were working days and the last was a day off. The questionnaire sheets were distributed at the meetings, which were held in the factory twice, in the morning and evening on the same day, one week before the survey. At the meetings, one of the authors explained the purpose of this study and the way of filling in the questionnaire. Each subject's sociodemographic and behavioral features were asked in the face sheet of the questionnaire. An occupational health nurse in the factory provided the records of their body weight and height measured at annual health check in the factory. Informed consent was obtained from all participants.

There were 199 female workers in the factory. Of those, 174 took part in this study and the remaining 25 did not. Since 57 were excluded due to incompleteness in the records about subjective fatigue complaints, even in one of the 10 occasions, and other two who did not work on one of the working days were excluded, the present analyses were conducted for 115 subjects: 41 daytime workers and 74 shift workers, of whom 37 each were engaged in the early-shift and late-shift works during the

survey week. Information on the remaining 84 workers was limited but the proportions of the participants to the whole workers did not differ between the daytime work group and the shift work group and the mean age did not significantly differ between the 115 participants and the whole workers.

Measurements

Fatigue: The same questionnaire was administered three times in each working day; just before work, just after work, and before retiring to bed. For questions at "just before work" and "just after work" occasions, the subjects filled in the questionnaire at the workplace. On Sunday, the subjects were requested to do once, before retiring.

Fatigue scale, based on a questionnaire on subjective fatigue complaints, which was developed by the Research Committee on Industrial Fatigue of the Japan Society for Occupational Health, called RCIF fatigue scale (Research Committee on Industrial Fatigue, 1969), was applied to the present survey. In the RCIF fatigue scale, the 30 items are classified into three domains of fatigue; the first 10 questions are related to "drowsiness and dullness," the second 10 questions to "difficulty in concentration," and the last 10 questions to "projection of physical disintegration" (Appendix). The subject was requested to answer "yes" or "no" to each question. The total number of "yes" answers for each domain or all domains was used for analysis.

Sleep patterns and sleep-related problems: For sleep in each of the four study nights, the subject female worker recorded time of retiring (falling asleep) and time of rising as precisely as possible. Based on these records, time of retiring, time of rising, and sleep duration were analyzed as the time variables.

At the same time, quality of sleep was evaluated by the subject worker, using yes/no alternatives for the four questions, which were originally proposed by Jenkins et al. (1988). The original sleep questionnaire was designed to ask about frequencies of four sleep-related problems in the past month. The four items were "Have trouble falling asleep," "Wake up several times per night," "Have trouble staying asleep (including waking far too early)," and "Wake up after your usual amount of sleep feeling tired and worn out." They are called, in short, "difficult falling asleep," "intermittent wake-up," "early wake-up," and "ill sleep." It is noted that these four sleep-related problems are known as the indicators of insomnia (WHO, 1992; Kageyama et al., 1997, 1998a).

In this study, the original questionnaire was translated into Japanese and the way of administration was changed. The subject was requested to answer "yes" or "no" to the four questions regarding the sleep on each night: Sunday-to-Monday sleep, Tuesday-to-Wednesday sleep, Thursday-to-Friday sleep, and Saturday-to-Sunday sleep. This change was made because we aimed to simultaneously evaluate fatigue and sleep quality in the previous night, rather than long-term sleep quality for the past. Fatigue assessments were carried out on Monday, Wednesday, Friday, and Sunday, as already described. The quality of sleep was evaluated by the total number of "yes" answers, called sleep problem score (SPS) in this paper, which ranges from 0 to 4; the higher the score the worse the quality of sleep. Intra-class correlation coefficient of SPS for the four nights was 0.65 (95% confidence interval: 0.53-0.74).

Actual working time: The subjects were requested to record the times when they started and ended the work on the three working days. The actual working time, which was calculated by the above two times, was not significantly different among the three working days (χ^2=4.57, p=0.10) and thus the mean values were used for the inter-group comparison.

Statistical analysis

Pearson's Chi-square test was used to compare the categorical variables among the three workers' groups. The Kruskal Wallis test or one-way analysis of variance (one-way ANOVA) was used to compare the continuous variables among the three workers' groups. One-way ANOVA was applied

to the variables that followed a normal distribution, and the Bonferroni *t* test was used for post hoc tests. The Kruskal Wallis test was applied to the variables which did not follow a normal distribution, and Mann-Whitney's *U* test with Bonferroni correction was used for post hoc multiple comparisons. Intra-group difference in the number of fatigue complaints between all pairs at three occasions, i.e., just before and after work and before retiring, was examined by the Friedman test, and the Wilcoxon's signed rank test with the Bonferroni correction was used for post hoc multiple comparisons.

Spearman's correlation coefficients were calculated between the variables of fatigue and those of sleep and personal characteristics. The variables for fatigue included the number of fatigue complaints just before and after work and before retiring and the number of fatigue complaints in each of the three domains, i.e., "drowsiness and dullness," "difficulty in concentration," and "projection of physical disintegration." The variables for sleep were sleep duration and the SPS, and those for personal characteristics were age and body mass index (BMI: [body weight (kg)] / [height $(m)^2$]).

All statistical analyses were performed using the Statistical Package for Social Sciences (SPSS Inc., 1999).

RESULTS

Table 1 shows basic information on the subject workers. The daytime workers were older and had lower BMI, compared to the late-shift workers. The proportion of the subjects who had light or moderate physical activity level did not significantly differ among the three groups. The SPS on working days was significantly different between the early-shift group and the other two groups; the early-shift workers had the poorest sleep. According to the Bonferroni *t* test, duration of sleep was significantly different between any pairs of the three groups: the shortest in the early-shift workers and the longest in the late-shift workers. The average time of retiring on the three working days was the earliest in the early-shift workers and the latest in the late-shift workers, with significant inter-group difference. The time of retiring on the off day significantly differed between the daytime and late-shift workers; the daytime workers retired earlier. The average time of rising on the three working days significantly differed between any pairs of the three groups: the earliest in the early-shift workers and the latest in the late-shift workers.

Figure 1 illustrates the changes in the total number of fatigue complaints, i.e., just before and after work and before retiring, for the three work groups according to time in a day, based on the mean of the three working days.

Table 2 shows the number of fatigue complaints for each of the three fatigue domains and the total number. For the daytime workers, the number of "drowsiness and dullness" complaints was the largest before retiring, differing significantly from that just before or after work. The number of "projection of physical disintegration" complaints was the largest just after work, differing significantly from that before retiring. The total number of the complaints was significantly larger before retiring than that just before or after work.

For the early-shift workers, the number of "drowsiness and dullness" complaints and the total number were significantly larger just before work than just after work, and the number of "difficulty in concentration" complaints was significantly larger just before work than in other two occasions.

For the late-shift workers whose pattern was similar to that of the daytime workers, the number of "drowsiness and dullness" complaints was the largest before retiring, differing significantly from that just before or after work. In the late-shift workers, however, there was also significant difference between those just before and after work. Like the daytime workers, the late-shift workers' total number of complaints was significantly larger before retiring than that just before work, but not significantly differing from that after work. The number of "projection of physical disintegration" complaints was larger just after work than in the other two occasions.

For the inter-group differences, multiple comparisons revealed that the number of "drowsiness and dullness" complaints before retiring on working days was significantly different between the

Table 1. Basic information on the subject workers.

	Daytime workers (DW)	Early-shift workers (EW)	Late-shift workers (LW)	Post hoc analysis
	N = 41	*N* = 37	*N* = 37	
Age (years): Median [25%, 75%]	28.0 [25.0, 31.0]	26.0 [24.0, 29.0]	25.0 [20.0, 28.0]	DW>LW**
Duration of employment (years): Median [25%, 75%]	8.0 [3.0, 9.0]	9.0 [6.0, 10.0]	5.0 [2.0, 10.5]	
Number of single (%) #	25 (61.0%)	34 (91.9%)	32 (86.5%)	
Number of single living with someone (%) #	24 (58.8%)	20 (55.6%)	25 (67.6%)	
Number of pregnant women (%)	1 (2.4%)	1 (2.7%)	0	
Number of current smokers (%)	7 (17.1%)	10 (27.0%)	11 (29.7%)	
Subjective physical activity level: Light (%)	38 (92.7%)	28 (75.7%)	33 (89.2%)	
Subjective physical activity level: Moderate (%)	3 (7.3%)	9 (24.3%)	4 (10.8%)	
Body weight (kg): Median [25%, 75%]	51.0 [48.8, 55.0]	51.0 [46.6, 60.7]	54.1 [48.6, 58.8]	
Height (cm) ± SD	159.7 ± 5.5	156.6 ± 6.9	156.1 ± 5.9	DW>LW*
BMI [weight (kg) / height (m)^2]: Median [25%, 75%]	20.3 [19.3, 21.9]	21.3 [19.5, 23.9]	22.2 [19.9, 24.3]	DW<LW**
One-way commuting time (minutes): Median [25%, 75%]	30.0 [15.0, 35.0]	20.0 [9.0, 30.0]	20.0 [10.0, 30.0]	DW>EW**
Actual working time (minutes): Median [25%, 75%]	550.0 [525.0, 572.5]	465.0 [462.5, 471.7]	525.0 [520.0, 525.0]	DW, LW>EW**, DW<LW**
Sleep problem score (SPS) on working days: Median [25%, 75%]	0.33 [0.00, 0.92]	0.67 [0.33, 1.33]	0.33 [0.00, 0.67]	DW, LW<EW**
Sleep duration on working days (minutes): Mean ± SD	380.7 ± 57.8	332.0 ± 59.7	460.7 ± 72.2	DW, LW>EW*, DW<LW*
Time of retiring: Mean (range of the mean ± SD)	00:07 (23:09-01:06)	23:21 (22:16-00:26)	01:44 (00:24-03:04)	DW, LW>EW**, DW<LW**
Time of rising: Mean (range of the mean ± SD)	06:28 (06:02-06:55)	04:53 (04:29-05:17)	09:25 (09:25-10:46)	DW, LW>EW**, DW<LW**
Sleep problem score (SPS) on rest day: Median [25%, 75%]	0.00 [0.00, 0.00]	1.00 [0.00, 1.00]	0.00 [0.00, 1.00]	
Sleep duration on rest day (minutes): Mean ± SD	477.8 ± 115.1	455.9 ± 117.9	481.4 ± 113.2	
Time of retiring: Mean (range of the mean ± SD)	00:17 (23:07-01:27)	00:52 (23:28-02:15)	01:19 (23:08-03:30)	DW<LW**
Time of rising: Mean (range of the mean ± SD)	08:15 (06:27-10:03)	08:27 (06:50-10:05)	09:20 (07:31-11:10)	DW<LW**

Pearson's Chi-square, $p<0.05$. ** Mann-Whitney's *U* test, $p<0.017$. * Bonferroni *t* test, $p<0.05$.

daytime and early-shift workers; the daytime workers complained more.

Table 3 shows Spearman's correlation coefficients of fatigue complaints at three occasions with sleep and personal variables. Sleep quality expressed by the SPS had significant correlation with fatigue complaints on any occasions or throughout the day. Sleep quality was related with all fatigue

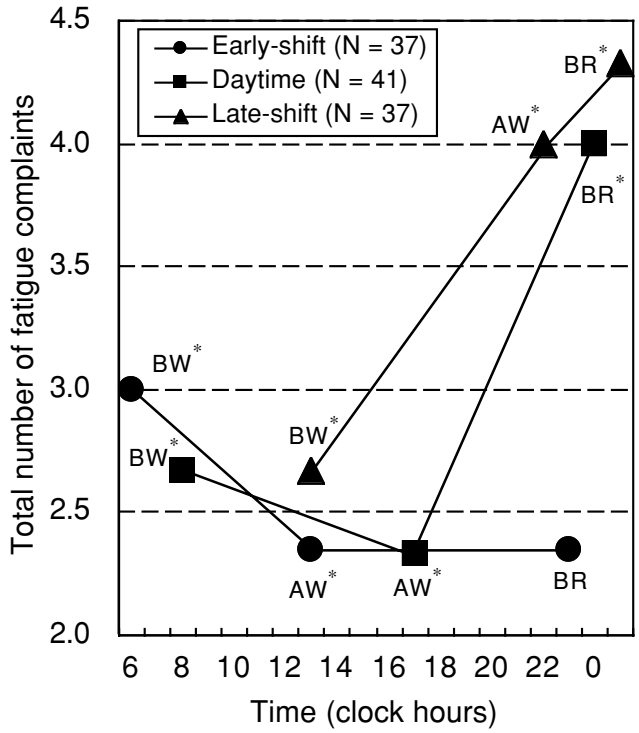

Fig.1. Changes in the total number of fatigue complaints in a day by the three work groups. Symbols show the median values for average number of complaints for three working days. BW: before work, AW: after work, BR: before retiring. * Significant intra-group difference by Wilcoxon's signed rank test at $p<0.017$. Early-shift workers: BW>AW, Daytime workers: BW, AW<BR, Late-shift workers: BW<AW, BR.

complaint domains, i.e., "drowsiness and dullness" (Spearman's $r=0.368$, $p=0.000$), "difficulty in concentration" (Spearman's $r=0.322$, $p=0.001$), and "projection of physical disintegration" (Spearman's $r=0.307$, $p=0.001$).

DISCUSSION

The daytime and shift workers were different in age, BMI, education and job duties. The daytime workers were older and had lower BMI, compared to the late-shift workers (Table 1). The shift workers were high school graduates and engaged in manufacturing processes. More than 70% of all the subjects, however, were on their twenties and had light physical activity level, regardless of job duties. They were classified as normal by WHO's BMI cut-off points of 18.5-25.0 (WHO Expert Committee, 1995). We considered that these differences were not likely to provide significant effects.

Fatigue and sleep factors

Table 3 shows relatively high correlations between the total number of fatigue complaints and the SPS. It seemed that "drowsiness and dullness" was very much like the similar concept with sleep problems and may thus might inflate the resulting correlation with the SPS. Yet the SPS was related to not only the number of "drowsiness and dullness" complaints but also that of "difficulty in concentration" or "projection of physical disintegration" complaints. In order to examine whether the three

Table 2. The number of fatigue complaints just before and after work and before retiring among workers in the three work groups.

	Before work (BW)	After work (AW)	Before retiring (BR)	Post hoc analysis
	Median [25%, 75%]	Median [25%, 75%]	Median [25%, 75%]	
Daytime workers (N = 41)				
Drowsiness and dullness *	1.67 [0.67, 3.33]	1.33 [0.67, 2.67]	3.33 [1.83, 4.17]	BW, AW<BR
Difficulty in concentration	0.33 [0.00, 1.00]	0.33 [0.00, 1.00]	0.00 [0.00, 1.83]	
Projection of physical disintegration *	0.33 [0.00, 1.17]	0.67 [0.17, 1.50]	0.67 [0.00, 1.17]	AW>BR
Total *	2.67 [1.67, 5.00]	2.33 [1.33, 5.17]	4.00 [2.67, 6.83]	BW, AW<BR
Early-shift workers (N = 37)				
Drowsiness and dullness *	2.00 [1.00, 4.33]	1.33 [0.67, 3.50]	1.67 [0.67, 4.00]	BW>AW
Difficulty in concentration *	0.33 [0.00, 1.17]	0.00 [0.00, 0.67]	0.00 [0.00, 0.33]	BW>AW, BR
Projection of physical disintegration	0.67 [0.00, 1.83]	1.00 [0.33, 1.83]	0.67 [0.17, 2.00]	
Total *	3.00 [1.33, 6.67]	2.33 [1.00, 5.67]	2.33 [1.17, 6.50]	BW>AW
Late-shift workers (N = 37)				
Drowsiness and dullness *	1.33 [0.67, 2.33]	2.33 [1.00, 3.67]	3.00 [2.00, 4.00]	BW<AW, BR, AW<BR
Difficulty in concentration	0.00 [0.00, 0.67]	0.00 [0.00, 0.67]	0.00 [0.00, 0.33]	
Projection of physical disintegration *	0.67 [0.00, 1.50]	1.00 [0.67, 1.67]	0.67 [0.33, 1.33]	BW, BR<AW
Total *	2.67 [1.33, 4.33]	4.00 [2.00, 5.67]	4.33 [2.50, 5.33]	BW<AW, BR

* Significant difference by Friedman test at $p<0.05$.

components of the fatigue scale and the four sleep-related problems in the sleep scale had similar characteristics, Cronbach's alpha coefficients were calculated between the SPS and each of the three fatigue components. As the results, they were low: 0.22 for "drowsiness and dullness," 0.29 for "difficulty in concentration," and 0.28 for "projection of physical disintegration" complaints. We concluded that the items of fatigue scale and the sleep scale were independent and were reflected to solely fatigue and sleep quality, respectively; Table 3 shows correlation between fatigue complaints and the SPS.

The SPS was positively correlated with fatigue, and its contribution to the increase in fatigue complaints lasted until the time before retiring. In contrast, the duration of sleep did not significantly affect the number of fatigue complaints. The subjective "sleep quality" variable, i.e., SPS, was related to fatigue complaints more than the "sleep quantity" variable, i.e., sleep duration. This finding

Table 3. Spearman's correlation coefficients of sleep and personal variables with total number of fatigue complaints just before and after work and before retiring.

	Total number of fatigue complaints		
	Just before work	Just after work	Before retiring
Sleep variables			
Duration of sleep	-0.156	-0.038	-0.121
Sleep problem score (SPS)	0.379 **	0.361 **	0.314 **
Personal variables			
Age	-0.090	-0.163	-0.121
Body mass index (BMI)	-0.012	0.043	-0.037

N=115. Fatigue, sleep, and personal variables were the means of the three working days. * $p<0.05$, ** $p<0.01$.

is parallel to that of Pilcher et al. (1997), who reported that average sleep quality was more related to health, affect balance, satisfaction with life, and feelings of tension, depression, anger, fatigue, and confusion than average sleep quantity. Kageyama et al. (1998b) also considered that there are large individual differences in sleep requirement and thus the actual amount of time spent sleeping in general does not indicate the satisfaction of sleep demand. Subjective evaluation of sleep quality is thus more predictive of health status than sleep length.

Within-day variations of fatigue complaints

Nakae and his colleagues (1981, 1983, 1990) investigated the number of fatigue complaints for five times a day among female university students and found J-shaped changes in the number of fatigue complaints from morning to late evening; the complaints decreased from the first assessment at awaking (around 7:00) to the third assessment before lunch (around 12:00), and then turned to increase, reaching the maximum at retiring time (around 23:00). As shown in Figure 1, the present subjects as a whole followed a similar course of changes, represented by a gradual decrease from morning to afternoon and a subsequent increase to night time, with the exception of unchanged level from afternoon to night in the early-shift workers; strictly speaking, however, such diurnal change was not assessed in the late-shift workers. In the daytime workers, who had similar time schedules to the university students, a J-shaped change in fatigue complaints with the maximum number before retiring was observed. There is a possibility that the J-shaped change of fatigue is characteristics of young women who work or study on a 9:00-to-17:00 schedule, though further research is needed to examine this possibility.

More interesting was a unique changing pattern of the early-shift workers, characterized by the small number of complaints before retiring and the large number of complaints before work. For the reasons why their fatigue complaints did not increase before retiring, their early closing time of work is considered to have allowed long free time before retiring to these workers. Although information about how they spent their time in afternoon and evening hours was not obtained, there is a high possibility that they preferred relaxed activities after work (from 13:45) to compensate for their tired morning hour work and, in part, to preserve their vigor for the morning work in the following day. Their strategy for having low physical and psychological stress throughout afternoon hours is recognized as an adaptive reaction to early-shift work.

Regarding the largest number of complaints just before work among the early-shift workers, a plausible reason came from shorter length of time from rising to work, which was approximately one

hour in the early-shift workers and approximately two or four hours in the daytime workers or the late-shift workers. Previous studies of university students also revealed that fatigue complaints decreased from the time at awaking to that before breakfast largely because human body functions smoothly after some time from rising (Nakae, 1981, 1983; Nakae et al., 1990). Such physiological mechanisms are thus judged to play a major role in the large number of complaints just before work in the early-shift workers.

According to the studies among female university students (Nakae, 1981, 1983), complaints of "drowsiness and dullness" decreased drastically in 30-40 minutes after awaking and reached the minimum level at noon, or five hours after awaking. Since the scores measured "just before work," respectively, two hours and four hours after awaking for the daytime workers and the late-shift workers were the same (2.67), we could assume that about two hours are necessary for smooth physical adjustment.

It is necessary to note that the present study examined the subject workers' fatigue feeling and the related conditions not in the two shifts but in either one of them. Thus, it cannot deny a possibility that the differences between the early-shift and late-shift groups were biased by personal characteristics of the subjects, even though there were no inter-group differences in their sociodemographic characteristics. To fully elucidate this possibility, observation of the same subjects over two-week period is needed, when they agree to participate.

Fatigue and shift work

As shown in Table 3, increased fatigue complaints were significantly correlated to poorer sleep quality. Our previous study found out that the earlier the time of rising the higher the SPS (Sudo and Ohtsuka, 1999). The early-shift workers' largest number of fatigue complaints at time of starting work was likely to be due to their increased occurrence of sleep-related problems as well as their shorter length of time between rising and work. Feeling of fatigue just before work might have direct impacts on the subsequent work to cause disadvantageous effects on safety and efficiency of work.

Significant increase of fatigue complaints during work hours was seen only in the late-shift workers. This increase was attributable to their late work hours, during which fatigue complaints increased according to a J-shaped diurnal change. We assume that the number of fatigue complaints of the late-shift workers increases throughout their work hours, gradually lowering efficiency of work and decreasing safety of work.

When the two groups of weekly-rotating shift workers were treated en bloc, their average daily total number of fatigue complaints for the three working days (3.17 [1.53, 5.03]) did not significantly differ from that of the daytime workers (3.22 [1.89, 5.11]) (Mann-Whitney's U=1478.5, p=0.822). This finding implies that shift work without night shift is not likely to affect the workers' persisting fatigue. One possible reason for this comes from younger age of the subjects and thus their relatively short duration of work in their lives (Table 1). It is generally recognized that stress derived from shift work has little impact on young, healthy individuals, though, as mentioned previously, such workers as the subjects of this study complained fatigue feelings on each shift schedule. As pointed out by Koller (1983), the differences in health parameters between shift workers and daytime workers become manifest with increasing age. However, the findings that the early-shift work and the late-shift work increased feeling of fatigue before work and after work, respectively, are of importance in improvement of shift-work-related health conditions, and would be overlooked without repeated assessments.

SUMMARY AND CONCLUSIONS

The effects of shift work on fatigue complaints differed between the early-shift and late-shift work groups, the former complaining more fatigue in early work time and the latter in late work time and before retiring. This finding, which was clarified by means of repeated inquiries in a day, has not

been pointed out clearly in the previous studies. It should be examined further to what extents the fatigue complaints patterns observed in this study affect performance and safety of shift work.

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APPENDIX

Fatigue scale by Research Committee on Industrial Fatigue of Japan Society for Occupational Health (1969)

Drowsiness and dullness		Difficulty in concentration		Projection of physical disintegration	
1	Feel heavy in the head	11	Feel difficulty in thinking	21	Have a headache
2	Get tired over the whole body	12	Become weary of talking	22	Feel stiff in the shoulders
3	Get tired in the legs	13	Become nervous	23	Feel a pain in the back
4	Give a yawn	14	Unable to concentrate attention	24	Feel oppressed in breathing
5	Feel the brain hot or muddled	15	Unable to take interest in things	25	Feel thirsty
6	Become drowsy	16	Become apt to forget things	26	Have a husky voice
7	Feel strained in the eyes	17	Lack of self-confidence	27	Feel dizzy
8	Become rigid or clumsy in motion	18	Anxious about things	28	Have a spasm on the eyelids
9	Feel unsteady in standing	19	Unable to straighten up in a posture	29	Have a tremor in the limbs
10	Want to lie down	20	Lack patience	30	Feel ill