Industrial Health 2015, **53**, 361–367

Original Article

Relationship between morningness-eveningness typology and cumulative fatigue or depression among Japanese male workers

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Received April 1, 2013 and accepted March 30, 2015
Published online in J-STAGE June 6, 2015

Abstract: This study clarified relationships between morningness-eveningness typology and cumulative fatigue or depressive state in Japanese male workers. 959 male chemical factory workers answered a questionnaire that included the MEQ, SDS, CFSI, age, marital status, sleep indexes, life habits, and labor load. Logistic regression analysis was performed with SDS and CFSI as objective variables. We obtained valid responses from 884 subjects, who were classified according to MEQ into definitely morning type (4.1%), moderately morning type (38.6%), intermediate type (55.1%), moderately evening type (2.3%), and definitely evening type (0%). The results of logistic regression analysis show that the odds ratio of a subscale among CFSI, chronic fatigue in the moderately evening type (3.33, p=0.046) was elevated compared with that in the intermediate type (2.07, p=0.004). However, the odds ratio of SDS (1.67, p=0.028) and two subscales among CFSI, decreased vitality (1.67, p=0.021), and depressive feelings (2.02, p=0.001), for which significant relationships were found only in the intermediate type, were higher in the moderately evening type than in the intermediate type. These results suggest that relationships between cumulative fatigue or depressive state and circadian typology exist among workers independent of working hours, sleep indexes, or life habits.

Key words: Circadian typology, Depressive state, Fatigue, Logistic regression analysis, Morningness-Eveningness Questionnaire, Workers

Introduction

Circadian rhythm in human social life results from both an endogenous rhythm that is inherent in all living beings and an exogenous rhythm that is caused by environmental variations. It seems meaningful for us to classify individual differences in circadian rhythm into morning or evening type to understand appropriate scheduling of physical and mental activities and to use this information to understand individuals' business or life design.

A self-administered questionnaire created by Horne and Östberg, the Morningness-Eveningness Questionnaire

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(MEQ) comprises 19 questions in English, classifying circadian rhythm into five types[1]. Following MEQ, many modified questionnaires and questionnaires for specific age groups have been published and used[2]. However, the original MEQ by Horne and Östberg has been standardized in German[3], Italian[4], Portuguese[5], and Spanish[6].

Much research with the MEQ has examined the relationship between circadian typology and mental health[7]. Torsvall and Akerstedt [8], Ishihara *et al.* [9], and Neubauer[10] reported that more people in the evening type than in the morning type developed severe neuroticism. Furthermore, Meccaci *et al.*[11] and Wilson[12] documented that more people in the morning than in the evening type have severe psychoticism. Regarding depressive state, after Drennan *et al.*[13] showed that more evening-type patients were diagnosed with depression; some researchers even indicated that depression scores were higher in the evening than in the morning type even among healthy subjects[14–17]. However, an evaluation of whether the evening preference relates directly to onset of depression is lacking, except for research by Kitamura *et al.*[17], who reported that the evening preference correlated to depressive state independent of sleeping hours or qualities. Furthermore, only a few researchers have examined the relationship between circadian rhythm and depression among workers[16, 17].

Measuring fatigue is certainly an important issue in workers' health management. Because human beings have varied suitable times for particular activities depending on circadian typology; circadian typology is expected to affect the onset of workers' cumulative fatigue. However, no research has yet investigated this relationship.

Therefore, to clarify this relationship, we employed the Cumulative Fatigue Symptoms Index (CFSI) to measure cumulative fatigue, the Self-Rating Depression Scale (SDS) as an index of depressive state, and the MEQ to classify circadian typology, adjusting for effects of age, labor load, life habits, sleep indexes, and marital status using multivariate analysis.

Subjects and Methods

Survey method

Conducted in December 2003, this study was a cross-sectional survey of 959 day-shift male chemical factory employees. A supervisor at the workplace distributed questionnaires, and they were collected in a sealed condition. Informed consent to participate in the study was obtained from each worker.

Survey items covered MEQ, SDS, CFSI, age, marital status, working hours on weekdays and holidays, the number of working holidays, sleeping hours per night, subjective sleep qualities (sleep-onset insomnia, sleep-maintaining insomnia, and early morning awakenings), and life habits (drinking, smoking, and regular exercise). Table 1 displays these profiles. As a variable of labor load, the number of monthly on-duty hours was calculated from questionnaire responses according to the following formula:

Monthly on-duty hours = Average working hours × 20 + number of working holidays × working hours on holidays + the time spent on commuting (h) × (20 + number of working holidays)

Weekly alcohol consumption (g/wk) in pure ethanol equivalents was calculated by multiplying the number of days on which alcohol was consumed by the amount consumed per day.

We converted sleeping hours, as a continuous variable, into a categorical variable comprising the group that slept less than six hours and the group that slept six hours or more.

The Ethical Committee of Chiba University approved the study before its initiation.

Morningness-Eveningness Questionnaire (MEQ)

The MEQ, a questionnaire developed by Horne and Östberg (1976), was translated into Japanese for this study. The MEQ comprises 19 questions regarding wake-up times and bedtimes, appropriate times for physical and mental activities, and state of consciousness before going to bed and immediately after waking. Among the 19 questions, 10 are answered on a 5-point scale, and 9 are multiple-choice questions with a score range of 1–4 points. The total score is the MEQ score. Depending on the MEQ score, circadian typology was classified into five categories: definitely morning type (70–86 points), moderately morning type (59–69 points), intermediate type (42–58 points), moderately evening type (31–41 points), and definitely evening type (19–30 points).

Severity of depressive state

As an index of depressive state, the 20-question Self-Rating Depression Scale (SDS), originally developed by Zung and translated by Fukuda *et al*. into a Japanese version was used[18, 19]. The cutoff value of SDS scores was 45 points.

Cumulative Fatigue Symptoms Index (CFSI)

As an index of fatigue, we used the CFSI developed by Kosugo[20–23]. The CFSI evaluates signs of workers' cumu-

Table 1. Characteristics of male day-shift chemical workers grouped according to MEQ class

	Moderately evening type		Intermediate type		Moderately morning type		Definitely morning type		Total		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Sig.
Age (yr)	33.0	8.6	42.2	9.9	48.5	8.8	50.9	7.2	44.8	10.1	***
Monthly on-duty hours (*100 h/month)	2.2	0.4	2.2	0.4	2.2	0.4	2.3	0.5	2.2	0.4	
Weekly alcohol consumption (g/wk)	97.5	97.5	117.5	110.0	110.0	115.0	152.5	145.0	115.0	112.5	
Sleeping hours per night	5.6	0.8	6.4	0.8	6.6	0.8	6.9	0.9	6.5	0.8	***
SDS score (point)	44.6	10.5	39.7	6.8	36.4	6.6	34.3	9.2	38.3	7.2	***
	Prevalence		Prevalence		Prevalence		Prevalence		Prevalence		
Marital status (not married)	77.8%		28.8%		14.8%		14.3%		23.8%		***
Smoking habit (smoker)	52.9%		51.7%		39.8%		25.0%		46.1%		**
Regular exercise											**
Absent	70.6%		49.9%		41.2%		40.6%		46.7%		
1–4 times/wk	23.5%		18.6%		15.1%		12.5%		17.2%		
More than 4 times/wk	5.9%		31.5%		43.7%		46.9%		36.2%		
Subjective sleep qualities (presence)											
Sleep-onset insomnia	60.0%		46.8%		37.8%		22.2%		42.6%		**
Sleep-maintaining insomnia	52.6%		42.3%		40.5%		52.9%		42.2%		
Early morning awakenings	52.6%		50.7%		69.8%		88.6%		59.7%		***
SDS (>45)	55.0%		27.6%		13.6%		14.3%		22.3%		***
Decreased vitality (≥18.8 %)	40.0%		26.5%		15.0%		8.3%		21.6%		***
General fatigue (≥22.7 %)	55.0%		47.4%		41.9%		52.8%		45.7%		
Physical disorders (≥17.4 %)	35.0%		15.8%		10.6%		22.2%		14.5%		**
Irritability (≥17.7 %)	40.0%		19.3%		15.5%		11.1%		18.0%		*
Unwillingness to work (≥17.2 %)	35.0%		22.4%		13.8%		13.9%		19.0%		**
Anxiety (≥17.9 %)	35.0%		28.3%		21.1%		11.1%		25.0%		*
Depressive feelings (≥19.4%)	55.0%		30.2%		16.1%		25.0%		25.1%		***
Chronic fatigue (≥31.7 %)	45.0%		22.6%		10.3%		19.4%		18.2%		***
Number of subjects	20 (2.3%)		487 (55.1%)		341 (38.6%)		36 (4.1%)		884 (100%)		

SD: Standard deviation, Sig.: Significant, MEQ: Morningness-Eveningness Questionnaire, SDS: Self-rating Depression Scale. One-way ANOVA was conducted for Age, Monthly on-duty hours, Weekly alcohol consumption and SDS score, and χ^2 test was conducted for other items. *: $p<0.05$, **: $p<0.01$, ***: $p<0.001$. The number in parentheses indicates cut-off prevalence such as (=18.8%) for Decreased vitality, etc.

lative fatigue and comprises 81 questions about clinical and psychological symptoms. The examinee answers each question by choosing between two options. CFSI has eight subscales, including decreased vitality (NF1), general fatigue (NF2-1), physical disorders (NF2-2), irritability (NF3), unwillingness to work (NF4), anxiety (NF5-1), depressive feelings (NF5-2), and chronic fatigue (NF6), where the rate of positive items is shown as the complaint rate. According to Kosugo's criteria, the complaint rate was calculated as follows[21]:

Complaint rate (%) = Number of positive items / Number of items × 100

As the cutoff value of CFSI, the average value for male workers obtained in previous research was used. Kosugo *et al.*, the developers of the scale, conducted their research with 37,406 male and 23,835 female workers.[23]

Statistical analysis

One-way ANOVA was conducted for age, monthly on-duty hours, weekly alcohol consumption, and SDS score; a χ^2 test was conducted for other items.

Logistic regression analysis was performed with SDS and CFSI as objective variables and circadian typology, number of working hours, marital status, sleep indexes, and life habits as explanatory variables. In this analysis, moderately morning type was defined as the reference group among the five circadian typology groups because the complaint rate of chronic fatigue was lowest in this group. SPSS software package Ver. 16.0 J was used for all statistical analyses. Statistical significance was set at $p<0.05$.

Results

Among the 959 respondents, 884 submitted valid responses (collection rate 100%, valid response rate 92.2%). MEQ classified these workers into five categories: definitely morning type (4.1%), moderately morning type (38.6%), intermediate type (55.1%), moderately evening type (2.3%), and definitely evening type (0%) (Table 1). Average sleeping hours were 5.6 in the moderately evening type, 6.4 in the intermediate type, 6.6 in the moderately morning type, and 6.9 in the definitely morning type. The prevalence of sleep-onset insomnia was 60.0% in the moderately evening type, 46.8% in the intermediate type, 37.8% in the moderately morning type, and 22.2% in the definitely morning type. The prevalence of sleep-maintaining insomnia was 52.6% in the moderately evening type, 42.3% in the intermediate type, 40.5% in the moderately morning type, and 52.9% in the definitely morning type. The prevalence of early morning awakenings was 52.6% in the moderately evening type, 50.7% in the intermediate type, 69.8% in the moderately morning type, and 88.6% in the definitely morning type.

Table 2 shows logistic regression analysis results. Among circadian typology groups, the odds ratio of SDS significantly increased in the intermediate type to 1.67 (95% confidence interval (95%CI: 1.06–2.64)). Among the eight CFSI subscales, the odds ratios for certain subscales were significantly higher in some typologies. In the intermediate type, decreased vitality was 1.67 (95%CI: 1.08–2.59), depressive feelings were 2.02 (95%CI: 1.32–3.07), and chronic fatigue was 2.07 (95%CI: 1.26–3.40). Chronic fatigue in the moderately evening type was 3.33 (95%CI: 1.02–10.85). For chronic fatigue, odds ratios were elevated in the moderately evening rather than in the intermediate type.

For the relationship between the number of working hours and SDS or CSFI, odds ratios significantly increased in chronic fatigue (1.95, 95%CI: 1.13–3.36).

For the relationship between increase in age and SDS or CSFI, odds ratios significantly decreased in decreased vitality (0.97, 95%CI: 0.95–0.99); irritability (0.96, 95%CI: 0.94–0.98); unwillingness to work (0.97, 95%CI: 0.95–1.00); anxiety (0.96, 95%CI: 0.94–0.98); depressive feelings (0.96, 95%CI: 0.94–0.98); and chronic fatigue (0.96, 95%CI: 0.94–0.98).

Odds ratios of the group that did not engage in regular exercise compared with those of the group that did (exercise ≥5 times/wk) revealed a significant increase in SDS (1.89, 95%CI: 1.09–3.28); decreased vitality (1.87, 95%CI: 1.11–3.15); physical disorders (1.91, 95%CI: 1.01–3.60); unwillingness to work (2.51, 95%CI: 1.45–4.35); anxiety (1.73, 95%CI: 1.02–2.92); and depressive feelings (1.93, 95%CI: 1.16–3.20). Odds ratio for the group that engaged in exercise 1–4 times/wk compared to the group that exercised ≥5 times/wk significantly increased in anxiety to 1.94 (95%CI: 1.29–2.94). Odds ratios of the group that slept less than six hours compared to those of the group that slept more than six hours revealed a significant increase in SDS (2.02, 95%CI: 1.17–3.43) and irritability (2.27, 95%CI: 1.33–3.87). As for the relationship between sleep-onset insomnia and SDS or CSFI, the odds ratios significantly increased in SDS (1.60, 95%CI: 1.05–2.44) and general fatigue (1.62, 95%CI: 1.15–2.27). In the relationship between sleep-maintaining insomnia and SDS or CSFI; odds ratios significantly increased in SDS (2.82, 95%CI: 1.81–4.41); decreased vitality (2.32, 95%CI: 1.51–3.57); general fatigue (1.45, 95%CI: 1.02–2.05); physical disorders (2.79, 95%CI: 1.68–4.64); irritability (2.69, 95%CI: 1.71–4.24); unwillingness to work (2.59, 95%CI: 1.65–4.05); anxiety (1.85, 95%CI: 1.23–2.77); depressive feelings (1.56, 95%CI: 1.04–2.34); and chronic fatigue (1.87, 95%CI: 1.17–2.98). In the relationship between early morning awakenings and SDS or CSFI, odds ratios significantly increased in general fatigue (1.64, 95%CI: 1.17–2.30); physical disorders (1.75, 95%CI: 1.04–2.92); anxiety (1.65, 95%CI: 1.11–2.47); and depressive feelings (1.77, 95%CI: 1.18–2.63).

No significant relationship was found between smoking habits, alcohol consumption, or marital status and SDS or CSFI.

Discussion

This study's major characteristic is that our results are more precise than those of previous studies because the targeted population was limited and homogenized to male day-shift workers and because various confounding factors such as age, marital status, life habits, sleep indexes, and labor load were adjusted by multivariate analysis.

There were no definitely evening-type workers and a small number of moderately evening-type workers because, from the healthy worker effect, workers of these types have possibly been excluded from the population over the years. In Ishihara *et al.*'s (1988) study of 346 workers, there were none (0%) of the definitely evening type and 24 (6.9%) of the moderately evening type.

Although cumulative fatigue is an issue of occupational medicine, the only presently established evaluation

Table 2. Logistic regression analyses for the influence of MEQ class on symptoms of mental and physical fatigue

	SDS (>45)			Decreased vitality (≥18.8%)			General fatigue (≥22.7%)			Physical disorders (≥17.4%)			Irritability (≥17.7%)		
	OR[a]	95% CI[b]	*p* value	OR[a]	95% CIb	*p* value	OR[a]	95% CI[b]	*p* value	OR[a]	95% CI[b]	*p* value	OR[a]	95% CI[b]	*p* value
MEQ class (moderately morning type[c])															
Moderately evening type	3.00	0.90–10.03	0.074	2.06	0.63–6.69	0.231	1.78	0.58–5.44	0.313	2.02	0.54–7.49	0.294	1.31	0.38–4.46	0.666
Intermediate type	1.67	1.06–2.64	0.028	1.67	1.08–2.59	0.021	1.21	0.86–1.72	0.274	1.36	0.81–2.31	0.247	0.97	0.62–1.51	0.889
Definitely morning type	1.39	0.47–4.11	0.549	0.64	0.18–2.32	0.501	1.68	0.76–3.69	0.201	2.28	0.81–6.47	0.120	0.53	0.15–1.88	0.327
Monthly on-duty hours (*100 h/month)	1.48	0.86–2.53	0.157	1.08	0.64–1.83	0.776	1.44	0.93–2.23	0.102	1.28	0.70–2.36	0.420	1.34	0.78–2.29	0.287
Age (yr)	0.98	0.96–1.01	0.155	0.97	0.95–0.99	0.007	1.01	0.99–1.03	0.191	0.98	0.96–1.01	0.149	0.96	0.94–0.98	<0.001
Marital status (not married/married[c])	1.40	0.87–2.27	0.170	1.04	0.65–1.67	0.861	0.73	0.48–1.10	0.131	1.44	0.84–2.48	0.183	0.64	0.38–1.07	0.089
Smoking (nonsmoker/smoker[c])	0.80	0.54–1.19	0.274	0.74	0.50–1.09	0.126	0.85	0.62–1.16	0.298	0.83	0.53–1.31	0.425	1.11	0.74–1.66	0.612
Alcohol consumption (g/wk)	0.96	0.92–1.00	0.068	0.98	0.94–1.02	0.393	0.98	0.94–1.01	0.194	0.99	0.94–1.04	0.751	0.99	0.95–1.04	0.698
Regular exercise (more than 4 times/wk[c])															
Absent	1.89	1.09–3.28	0.022	1.87	1.11–3.15	0.019	1.36	0.86–2.16	0.188	1.91	1.01–3.60	0.046	1.47	0.84–2.58	0.178
1–4 times/wk	1.44	0.92–2.26	0.109	1.10	0.72–1.70	0.653	1.29	0.91–1.82	0.148	1.66	0.98–2.80	0.058	1.24	0.79–1.94	0.349
Subjective sleep qualities (presence)															
Sleep-onset insomnia	1.60	1.05–2.44	0.028	1.34	0.89–2.02	0.160	1.62	1.15–2.27	0.005	1.60	0.98–2.61	0.062	1.15	0.75–1.78	0.519
Sleep-maintaining insomnia	2.82	1.81–4.41	<0.001	2.32	1.51–3.57	<0.001	1.45	1.02–2.05	0.039	2.79	1.68–4.64	<0.001	2.69	1.71–4.24	<0.001
Early morning awakenings	0.97	0.63–1.48	0.874	1.47	0.97–2.24	0.072	1.64	1.17–2.30	0.004	1.75	1.04–2.92	0.034	1.28	0.82–1.98	0.278
Sleeping hours (less than 6 h/6 h or more)	2.00	1.17–3.43	0.012	1.60	0.94–2.73	0.085	1.48	0.91–2.40	0.112	1.70	0.92–3.13	0.089	2.27	1.33–3.87	0.003

	Unwillingness to work (≥17.2%)			Anxiety (≥17.9%)			Depressive feelings (≥19.4%)			Chronic fatigue (≥31.7%)		
	OR[a]	95% CI[b]	*p* value	OR[a]	95% CI[b]	*p* value	OR[a]	95% CI[b]	*p* value	OR[a]	95% CI[b]	*p* value
MEQ class (moderately morning type[c])												
Moderately evening type	1.40	0.41–4.78	0.592	0.64	0.18–2.22	0.476	2.79	0.89–8.71	0.077	3.33	1.02–10.86	0.046
Intermediate type	1.33	0.84–2.11	0.217	1.17	0.78–1.76	0.444	2.02	1.32–3.07	0.001	2.07	1.26–3.40	0.004
Definitely morning type	1.26	0.43–3.68	0.678	0.59	0.19–1.82	0.354	1.78	0.69–4.57	0.233	2.19	0.74–6.48	0.158
Monthly on-duty hours (*100 h/month)	0.73	0.42–1.29	0.280	1.47	0.90–2.42	0.127	0.81	0.49–1.34	0.407	1.95	1.13–3.36	0.016
Age (yr)	0.97	0.95–1.00	0.025	0.96	0.94–0.98	<0.001	0.96	0.94–0.98	<0.001	0.96	0.94–0.98	0.001
Marital status (not married/married[c])	1.26	0.78–2.05	0.349	0.95	0.60–1.49	0.809	0.84	0.54–1.33	0.463	0.72	0.42–1.22	0.218
Smoking (nonsmoker/smoker[c])	1.11	0.74–1.67	0.600	0.86	0.60–1.24	0.432	0.92	0.64–1.32	0.640	0.93	0.62–1.41	0.735
Alcohol consumption (g/wk)	0.99	0.94–1.03	0.518	1.00	0.96–1.04	0.879	1.00	0.96–1.04	0.988	0.96	0.92–1.01	0.111
Regular exercise (more than 4 times/wk[c])												
Absent	2.51	1.45–4.35	0.001	1.73	1.02–2.92	0.041	1.93	1.16–3.20	0.012	1.77	0.99–3.16	0.053
1–4 times/wk	1.44	0.91–2.28	0.122	1.94	1.29–2.94	0.002	1.39	0.93–2.09	0.112	1.40	0.88–2.25	0.158
Subjective sleep qualities (presence)												
Sleep-onset insomnia	1.49	0.97–2.29	0.067	1.36	0.92–2.01	0.126	1.23	0.83–1.82	0.302	1.31	0.83–2.05	0.243
Sleep-maintaining Insomnia	2.59	1.65–4.05	<0.001	1.85	1.23–2.77	0.003	1.56	1.04–2.34	0.032	1.87	1.17–2.98	0.009
Early morning awakenings	1.35	0.87–2.10	0.177	1.65	1.11–2.47	0.014	1.77	1.18–2.63	0.005	1.03	0.66–1.61	0.899
Sleeping hours (less than 6 h/6 h or more)	1.64	0.94–2.86	0.083	1.34	0.80–2.27	0.266	1.41	0.84–2.37	0.197	1.38	0.78–2.44	0.264

MEQ: Morningness-Eveningness Questionnaire, SDS: Self-rating Depression Scale

[a]Odds ratios. [b]95% confidence interval. [c]Control categories.

method is CFSI. CFSI was validated by Kosugo *et al.*, who implemented the survey with 37,406 male and 23,835 female workers in multiple fields, such as manufacturing industries, medical and financial institutions, and the information industry, to derive an average complaint rate for the standard of each CFSI subscale[20]. No previous study has examined the direct relationship between circadian typology and cumulative fatigue. Regarding the relationship between CFSI and the number of working hours, Nagashima *et al.*[24] and Suwazono *et al.*[25] studied 843 and 3,472 male day-shift workers, respectively. They revealed that complaint rates in CFSI significantly increased with longer working hours. Our logistic regression analysis results also confirm that chronic fatigue relates significantly to the number of working hours.

This study linked circadian typology to three of eight CFSI subscales. Odds ratios of chronic fatigue in the intermediate and moderately evening types were elevated compared with those in the moderately morning type. However, odds ratios of decreased vitality and depressive feelings, for which significant relationships were found only in the intermediate type, were higher in the moderately evening than in the intermediate type. In addition, because the number of subjects in the moderately evening-type group was fewer than expected, their results showed no statistical significance. Thus, we can presume that the risk of developing these symptoms increased from the definitely or moderately morning type to the moderately evening type.

Furthermore, this study suggests that circadian typology influences depressive state. SDS odds ratios were 1.67 (p=0.028) in the intermediate and 3.00 (p=0.074) in the moderately evening. Results in the moderately evening type were insignificant due to small sample size, as shown in Table 1, and the power was not high enough to detect any significance.

For the relationship between circadian rhythm and depressive state, Drennan *et al.* reported that patients diagnosed as depressed included more of the evening type[13]. After that study, Chelminski *et al.*[14], Hidalgo *et al.*[15], and Kim *et al.*[16], conducted studies with 1,617 university students, 200 local residents, and 361 local residents, respectively. These studies revealed that the evening-type group included more depressives feelings among healthy subjects. Research by Kitamura *et al.*[17], conducted with 1,170 employees (and their families) at research institutes and hospitals, documented that evening preference related to depressive state independent of sleeping indexes, such as the number of sleeping hours or subjective sleep qualities. In this study, consistent with previous studies, results indicated that the evening-type tendency relates to depressive state, even considering life habits, marital status, labor load, and sleep indexes.

Our study revealed a relationship between sleeping hours or subjective sleep qualities and MEQ typology. Considering that the MEQ questionnaire categorizes sleep tendency, these results are not contradictory.

With increase in age, the odds ratios of decreased vitality, irritability, anxiety, chronic fatigue, and depressive feelings decreased. These findings are consistent with those reported by Kosugo *et al*[20, 21].

For participants who did not engage in regular exercise, the SDS odds ratios and the five CSFI subscales increased. However, we cannot discuss this relationship in the design of this study, because depressive symptoms or chronic fatigue might possibly prevent people from exercising, and regular exercise might improve depressive symptoms or cumulative fatigue. These findings suggest the necessity of future longitudinal or interventional studies.

This study has some limitations. Because the targeted population was limited to male workers, we could not obtain information about female workers. We did not examine caffeine consumption, which was included in previous studies, for adjustment in life habits. In addition, because this study was cross-sectional, we could clarify the relationship only between the number of working hours, life habits, or sleep indexes and fatigue. Because the Japanese system is characterized by lifetime employment, people who cannot adapt to their work due to a depressive state or cumulative fatigue might resign or relocate to a department with a lighter load. Thus, effects of circadian typology might be underestimated. Therefore, we should avoid these issues by conducting a longitudinal study with a population that includes female workers and newly recruited employees to explore these populations further. In addition, we should conduct future research on interventions to prevent chronic fatigue and depressive states and also to prove these methods' efficacy using MEQ.

This study suggests that relationships between cumulative fatigue or depressive state and circadian typology exist independent of labor load, sleep indexes, or life habits. Findings show that consideration of circadian typology is meaningful for measuring cumulative fatigue and preventing depressive states.

Acknowledgement

This study was conducted using solely internal funds.

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