

Influence of Overtime Work, Sleep Duration, and Perceived Job Characteristics on the Physical and Mental Status of Software Engineers^a

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Abstract: To investigate the impact of overtime work, sleep duration, and perceived job characteristics on physical and mental status, a cross-sectional study was conducted on 377 workers (average age; 28 years old) in an information-technology (IT) company, engaged in consultation, system integration solution, and data management relevant to IT system. The psychophysical outcomes of overtime work were assessed using the Hamilton Depression Scale (HDS), Profile of Mood Status (POMS), major physical symptoms, and overtime work data for the preceding three-months. Sleep duration was directly asked by a physician. A job strain index was defined as the ratio of job-demands to job-control scores evaluated using the Job Content Questionnaire (JCQ). In a univariate analysis, overtime work was significantly related with HDS scores, POMS anger-hostility scores, and the total physical symptom count in both sexes (all $p < 0.05$), but not in multiple regression models, after controlling for sleep duration and the job strain index. Sleep duration was negatively related to the symptom count in men and to POMS tension-anxiety scores in women (both $p < 0.05$); the job strain index was positively related to POMS anger-hostility scores in both sexes and to HDS scores and POMS tension-anxiety scores in men (all $p < 0.05$). Although overtime work was associated with physical and mental complaints, sleep duration and the job strain index seemed to be better indicators for physical and mental distress in overloaded workers.

Key words: Job strain, Overtime work, Physical and mental status, Sleep, Worker's health examination

Introduction

In Japan, the total number of cases of occupational accidents and diseases has decreased since 1955¹⁾. However, the results of regular medical examinations showed that 47.3% of workers had some abnormalities in 2003²⁾. According to a survey undertaken by the Japanese Ministry of Health, Labour and Welfare (JMHLW), the number of workers who complain mental fatigue rather than physical fatigue has been increasing, and there are many more workers

experiencing anxiety, distress, and mental pressure in the workplace²⁾. Overtime work tends to be longer for young- and middle-aged employees, especially in large companies³⁾. The JMHLW has recently established a guideline, "Comprehensive Program for the Prevention of Health Impairment Due to Overwork (2002)"⁴⁾. According to the guideline⁴⁾, Japanese employers are required to limit extra working hours to less than 45 h/month, because epidemiological studies have been shown that the risks of cerebro- and cardio-vascular diseases increase when employees work more than 45 overtime h/month^{5,6)}. Moreover, if overtime work exceeds 100 h in any month, or averages 80 h/month for 2 to 6 months, employers are required to have employees consult an occupational health physician⁴⁾.

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There are no current guidelines for physicians when caring for these workers. It is difficult to establish such guidelines because symptoms related to overtime work are mainly attributed to individual lifestyle factors and greatly affected by each working environment⁷. It is important, therefore, to assess the effects of lifestyle factors and working environment simultaneously when evaluating physical and mental status in association with overtime work. Of the lifestyle factors, short sleep duration is one of the most important problems among overloaded workers, because individuals who do not sleep well tend to have impaired work productivity and to consume more medical resources^{8,9}. As for working environment, perceived job characteristics have been extensively investigated in relation to health outcomes like elevated blood pressure and hemoglobin A1c^{10,11}. According to NIOSH (National Institute for Occupational Safety and Health) occupational stress model, long-working hours, as well as lifestyle factors and working environment, were known to aggregate workers' health status^{12,13}. However, there were few studies¹⁴ comparing all these factors to assess the effect of workload on physical and mental status comprehensively. The hypothesis of the present study is that the two factors of sleep duration representing lifestyle factors and perceived job characteristics representing working environment can independently predict the physical and mental status of those who are exposed to overtime work at health examinations. A simple monitoring of working time may be not sufficient to screen distressed workers; to maintain the physical and mental health of all workers, it may be necessary to monitor their life style and working environment in addition to their working time.

To test the hypothesis, we examined how overtime work, sleep duration, and perceived job characteristics are associated with the physical and mental status of young Japanese workers assigned to the same type of job.

Materials and Methods

Study setting and subjects

The survey was carried out during a mandatory periodic health examination in an information service company in Tokyo. The workers were employed in the development and management of office software and, during most of their working time, they operated computers.

Among approximately 1,000 employees, 524 individuals (438 men and 86 women) aged 40 yr or younger received annual examinations at the health center of the company. The company referred individuals over 40 to an external health examination center. Among the 524 eligible subjects,

we excluded managers and shift-workers, and selected 377 individuals (304 men and 73 women) who reported their working time for analysis in the study.

The company's Safety and Health Committee approved the study as ethical, and it was conducted with written informed consent.

Indexes of workload

The following three variables were selected to measure workload:

Overtime work: This was defined as any working hours that exceed normal daily hours. Data about overtime work were obtained from employees' computerized attendance records, and an overtime work group was defined as those who worked more than 45 h/month of overtime in any month during the preceding three-month period, based on the guidelines of the JMHLW⁴.

Sleep duration: Information regarding three health-related lifestyles (drinking alcohol, smoking, and sleep duration) was obtained using a health examination check sheet, and a physician confirmed it during the interview segment of the health examination. Sleep duration was specifically selected for the analysis because researchers have reported that insufficient sleeping hours are closely related to work overload and can induce adverse health outcomes^{8,9}.

Perceived job characteristics: These were measured using the Japanese version of the Job Content Questionnaire (JCQ), which researchers have already confirmed as reliable and valid¹⁵. The questionnaire consists of three scales: job demands, control, and social support. A job strain index was selected rather than a job demands scale during our analysis, because the job strain index is used more often to assess an individual's risk of cerebro- and cardiovascular diseases^{6,10,16,17}. Individuals completed the JCQ prior to their interview with the physician.

Physical and mental status

Subjects completed the following three questionnaires for the assessment:

Hamilton Depression Scale (HDS): The 17-item version of the HDS was used to assess the degree of depression¹⁸. Because the HDS items need to be confirmed by an interviewer, the HDS was completed by individuals during their interview with the physician.

Profile of Mood State (POMS): The POMS was administered to assess mood states; the reliability and validity of the POMS has been established in a Japanese population¹⁹. Both tension-anxiety and anger-hostility scales were selected for the analysis.

Total physical symptom count: A medical checklist about 26 physical symptoms was distributed during the last week and the last month before the interview. Based on our previous studies²⁰⁾ and on Western studies among primary care patients²¹⁾, the following 12 common major medical symptoms were selected for the analysis: fatigue, headache, insomnia, back pain, abdominal pain, joint or limb pain, dizziness, chest pain, constipation, palpitation, nausea, and shortness of breath. Symptoms once a week or more frequently were defined as positive, and the total number of positive symptoms (0–12) was used to predict impairment in physical, psychological, and social functioning^{20–22)}.

Statistical methods

The effects of overtime work on physical and mental status were analyzed at the cut-off level of 45 overtime h/month, and then at two additional cutoff points of 80 and 100 overtime h/month. Student’s t-test or Wilcoxon’s rank sum test was used for continuous variables, and a chi-square test or Fisher’s exact test was used for categorical variables.

After simple correlational analyses, multiple regression analyses were conducted to estimate the independent effects of overtime work, sleep duration, and job strain index on each of the four outcome variables with controlling for the effect of age.

Data analyses were conducted using STATA version 8.0²³⁾. All the tests were two-sided with a significance level of 5%.

Results

Subject characteristics

Table 1 shows characteristics of age, overtime work, sleep duration, and job strain index in each sex. According to the definition, 170 (45%) were allocated to the overtime work group in the total; the average overtime work in this group was 59 h/month for men and 51 h/month for women (p>0.05). For women, the habit of smoking was more prevalent in the overtime work group than in the non-overtime work group (Table 2).

Comparison of physical and mental status according to overtime work

There were no significant differences in the variables of physical and mental status, in either sex, between the overtime work group and the non-overtime work group; however, there was a higher total physical symptom count in women who worked overtime than in those who did not (Table 2).

When the cut-off point was changed to be 80 overtime h/month for the definition of overtime work group, 59 subjects

Table 1. Characteristics of age and exposure variables; overtime work, sleep duration, and job strain index in both sexes (values are percentages with observation numbers in parentheses)

% (n)	Men (n=304)	Women (n=73)
Age^a		
<25 yr	22 (67)	41 (30)
25–30 yr	43 (130)	49 (36)
30–35 yr	24 (74)	7 (5)
≥35 yr	11 (33)	3 (2)
Overtime work^b		
<45 h/month	65 (198)	83 (61)
45–80 h/month	30 (91)	15 (11)
80–100 h/month	2 (6)	1 (1)
≥100 h/month	3 (9)	0 (0)
Sleep duration^c		
<5 h/night	6 (18)	8 (6)
5–6 h/night	24 (74)	18 (13)
6–7 h/night	46 (138)	40 (29)
≥7 h/night	24 (73)	33 (24)
Job strain index^d		
<0.4	16 (49)	19 (14)
0.4–0.5	35 (105)	40 (29)
0.5–0.6	31 (93)	27 (20)
≥0.6	19 (57)	14 (10)

^a Mean age (yr) and standard deviation in parenthesis were 28 (5) in men and 26 (3) in women (p<0.001 between sexes).

^b Overtime work (h/month) was defined as average value a month of preceding three-month period, and the mean overtime work and standard deviation in parenthesis were 36 (28) in men and 23 (23) in women (p<0.001 between sexes). ^c One man and one woman were missing with respect to sleep information. Mean sleep duration (h/night) and standard deviation in parenthesis were 6.0 (0.9) in men and 6.1 (0.9) in women (p>0.05 between sexes). ^d Mean job strain index and standard deviation in parenthesis were 0.5 (0.1) in both sexes (p>0.05 between sexes).

(16%) became part of the overtime work group, and 32 male subjects (8%) became part of the overtime work group when the cut-off point to be 100 overtime h/month. The differences in physical and mental status between the overtime work group and the non-overtime work group were consistent with the new definition.

Predictors of physical and mental status

Table 3 shows the correlation between workload variables and physical and mental status. Both overtime work and the job strain index had a significant positive relation with HDS scores, POMS anger-hostility scale scores, and the total physical symptom count in both sexes. Job strain also had a significant positive relation with POMS tension-anxiety

Table 2. Basic characteristics of the subjects and outcome variables of depression (Hamilton Depression Scale: HDS), tension-anxiety and anger-hostility (Profile of Mood States: POMS), and physical symptoms (total physical symptom count), and group comparison between overtime work and non-overtime work groups (≥ 45 h/month)

	Total	Group assignment	
		Overtime work	Non-overtime work
Men:	<i>n</i> =304	<i>n</i> =148	<i>n</i> =156
Age (yr)	28 (5)	28 (4)	29 (5)
Body mass index (kg/m ²)	22.4 (3.2)	22.4 (3.1)	22.3 (3.3)
Mean blood pressure (mmHg)	87 (9)	87 (8)	87 (9)
Drinking habits (%) [<i>n</i> of "yes"]	75 (223)	75 (106)	76 (117)
Alcohol (/wk)	2.7 (2.0)	2.9 (2.1)	2.5 (1.9)
Alcohol consumption (g ethanol/d)	18 (22)	17 (19)	19 (24)
Smoking habit (%) [<i>n</i> of "yes"]	47 (139)	51 (72)	43 (67)
Tobacco consumption (cigarettes/d)	16 (7)	15 (7)	16 (7)
Mental: HDS: Total scores	6.8 (4.7)	7.1 (4.4)	6.4 (5.0)
POMS: Tension-anxiety	9.8 (5.9)	10.1 (6.1)	9.4 (5.8)
POMS: Anger-hostility	6.0 (6.7)	6.5 (7.1)	5.5 (6.6)
Physical: Total physical symptom count	1.4 (1.6)	1.6 (1.6)	1.3 (1.6)
Women:	<i>n</i> =73	<i>n</i> =22	<i>n</i> =51
Age (yr)	26 (3)	26 (3)	26 (4)
Body mass index (kg/m ²)	19.4 (1.9)	19.1 (1.8)	19.6 (2.0)
Mean blood pressure (mmHg)	78 (8)	76 (9)	78 (7)
Drinking habits (%) [<i>n</i> of "yes"]	70 (50)	71 (15)	70 (35)
Drinking (/wk)	2.3 (1.8)	2.7 (2.4)	2.1 (1.5)
Alcohol consumption (g ethanol/d)	11 (22)	11 (18)	10 (24)
Smoking habit (%) [<i>n</i> of "yes"]	15 (11)	36* (8)	6 (3)
Tobacco consumption (cigarettes/d)	10 (6)	9 (5)	12 (10)
Mental: HDS: Total scores	6.4 (4.8)	7.5 (5.2)	5.9 (4.5)
POMS: Tension-anxiety	9.0 (5.8)	10.4 (6.7)	8.5 (5.3)
POMS: Anger-hostility	5.1 (4.4)	5.7 (3.9)	4.8 (4.6)
Physical: Total physical symptom count	2.3 (2.1)	3.2* (2.4)	2.0 (2.0)

Values are arithmetic means with standard deviations, or percentages with observation numbers in parentheses. **p*<0.05 between overtime and non-overtime groups (chi-square test).

Table 3. Correlation coefficient between exposure variables (overtime work, sleep duration, and job strain index) and outcome variables of depression (Hamilton Depression Scale: HDS), tension-anxiety and anger-hostility (Profile of Mood States: POMS), and physical symptoms (total physical symptom count)

	Overtime work	Sleep duration	Job strain index
Men (<i>n</i> =304):			
Mental: HDS: Total	0.135*	-0.072	0.186**
POMS: Tension-anxiety	0.097	-0.114*	0.228**
Anger-hostility	0.121*	-0.133*	0.200**
Physical: Total physical symptom count	0.126*	-0.210**	0.118*
Women (<i>n</i> =73):			
Mental: HDS: Total	0.257*	-0.197	0.231*
POMS: Tension-anxiety	0.081	-0.257*	0.159
Anger-hostility	0.236*	-0.073	0.270*
Physical: Total physical symptom count	0.422**	-0.194	0.244*

p*<0.05, *p*<0.01 (Spearman's correlation coefficient).

Table 4. Effects of overtime work, sleep duration, and job strain index on mental status (HDS and POMS tension-anxiety and anger-hostility) and physical status (total physical symptom count); results of multiple linear regression analysis (underlining indicates that β values are significant)

	Indexes of workload: β^a (p value)			R ^b (p value)
	Overtime work (h/month)	Sleep duration ^c (h/night)	Job strain index	
Men (n=304):				
Mental: HDS: Total scores	0.056 (p=0.338)	-0.022 (p=0.713)	<u>0.179</u> (p=0.002)	0.196 (p=0.020)
POMS: Tension-anxiety	0.046 (p=0.428)	-0.060 (p=0.299)	<u>0.209</u> (p<0.001)	0.235 (p=0.002)
POMS: Anger-hostility	0.073 (p=0.199)	-0.068 (p=0.237)	<u>0.243</u> (p<0.001)	0.281 (p<0.001)
Physical: Total physical symptom count	0.020 (p=0.730)	<u>-0.175</u> (p=0.003)	0.065 (p=0.256)	0.239 (p=0.002)
Women (n=73):				
Mental: HDS: Total scores	0.115 (p=0.351)	-0.214 (p=0.076)	0.225 (p=0.063)	0.382 (p=0.029)
POMS: Tension-anxiety	0.064 (p=0.595)	<u>-0.392</u> (p=0.001)	0.092 (p=0.431)	0.435 (p=0.007)
POMS: Anger-hostility	0.069 (p=0.570)	-0.009 (p=0.940)	<u>0.272</u> (p=0.023)	0.417 (p=0.011)
Physical: Total physical symptom count	0.234 (p=0.064)	-0.123 (p=0.310)	0.172 (p=0.159)	0.366 (p=0.047)

^a β : Standardized partial regression coefficient adjusted for age. ^b R: Multiple correlation coefficient. ^c One man and one woman were missing with respect to sleep information.

scale scores in men. Sleep duration had a significant negative relation with POMS tension-anxiety scale scores in both sexes, and with POMS anger-hostility scale scores and the total physical symptom count in men.

In the multivariate models, overtime work showed no significant relation with any of the physical and mental variables (Table 4). One or other of the two remaining independent variables of sleep duration and job strain index was significantly associated with each of the mental variables in the multivariate models. In men, sleep duration was also significantly associated with the physical variable of the total physical symptom count (Table 4).

Discussion

In this study, overtime work was significantly associated with HDS scores, POMS anger-hostility scale scores, and the total physical symptom count, in both sexes. In these analyses, the three mental indicators (HDS, POMS tension-anxiety, and POMS anger-hostility) were also significantly predicted by either job strain index or sleep duration. On the other hand, there were no significant relationships between overtime work and the four variables of physical and mental status in either sex. These findings do not support the JMHLW guidelines, regarding the careful monitoring of employees working more than 45 overtime h/month to maintain their health conditions. In spite of the official guidelines, there are no specific methods to monitor mental health status of overtime workers objectively. In this situation it might be more useful to simply ask about sleeping hours and perceived job stress when screening exhausted workers

with mental distress.

Although overtime workers were grouped based on JMHLW guidelines, the difference in the workload between the two groups may not be large enough to cause a difference in the health status. Assuming 20 work d/month, the overtime work group worked more than two and a half overtime hours in a day, while it was estimated that the non-overtime work group had less than one hour of overtime work in a day. The same analyses were performed using the cut-off points of 80 and 100 overtime h/month, but the results were consistent.

It was noteworthy that the average sleeping duration was only less than 6 h/night in the overtime work group, for both sexes, and in this study, a short sleep duration predicted the reported number of physical symptoms (in men) and the tension-anxiety levels (in women). Previous studies^{24, 25} have suggested that short sleep duration is closely associated with overtime work. It was reported that 6 h of sleep or less results in male workers perceiving a higher level of stress and a lower quality of life when they work for 10 h or longer a day (40 h/month of overtime work)²⁶. Researchers have recently estimated the prevalence of insomnia in Japanese workers at 16–30%, and suggest that increasing mental stress at work increases the risk of insomnia¹³. Thus, in Japan, sleep duration seems to be an important index for screening mental and physical disorders caused by overtime work; more intensive research is needed to verify this point.

In this study, the job strain index had a significant relation with POMS anger-hostility scale scores in both sexes, and with HDS scores and POMS tension-anxiety scale scores in men. There are many studies showing the relationship

between the job strain index and physical conditions. For example, the job strain index has been reported to have a significant association with blood pressure¹⁰⁾, hemoglobin A1c¹¹⁾, and subtypes of immunocytes in male Japanese workers²⁷⁾. Compared with these studies, focused on physiological variables, there have been few studies examining the relationship between the job strain index and psychological variables in Japanese workers. Given that Japanese individuals are generally less likely to express emotions, it is noteworthy that this study shows that the job strain index predicts a number of variables of mental status, even after controlling for the effects of overtime work and sleep duration.

One of the limitations of this study concerns the generalizability of the results. The study subjects were young employees in a common Japanese IT company. However, the percentage of female subjects was small, and so the results might be generalizable only to young Japanese IT workers, especially male workers. The second limitation concerns the comparability between the overtime work group and the non-overtime work group. One could say that the two groups have been derived from a single population, and assigned without bias, because the basic characteristics of age and physical examination data (data not shown in the table) were not significantly different between the two groups, for both sexes. Third, the cross-sectional nature of the study does not permit any conclusions about the direction of causality between overtime work and workers' physical and mental status. A large cohort study involving a number of companies would give us deeper insight into how workers' health is related to overtime work.

In summary, this study demonstrates that overtime work hours may not well indicate the health effects of overtime work. Alternatively, additional information about sleep duration and job strain index might better indicate the physical and mental distress of overloaded workers.

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