Overtime, psychosocial working conditions, and occurrence of non-insulin dependent diabetes mellitus in Japanese men

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Abstract

***Objectives*—To ascertain the effects of overtime and psychosocial job conditions on the occurrence of non-insulin dependent diabetes mellitus (NIDDM) in Japan.**

***Design*—An eight year prospective cohort study.**

***Setting*—An electrical company in Japan.**

***Participants*—In 1984, a mailed questionnaire was sent to industrial workers of an electrical company in Japan. After excluding those who had a history of diabetes mellitus or other chronic diseases, 2597 male respondents were prospectively followed up for the succeeding eight years. Data from 2194 (84%) who were completely followed up were analysed. The occurrence of NIDDM during the follow up period was assessed according to the WHO criteria on the basis of an annual screening programme.**

***Main results*—The age adjusted incidence of NIDDM was significantly higher in those who worked overtime more than 50 hours per month than in those who worked 25 hours or less per month (p<0.05). It was significantly higher in those who worked with new technology at baseline than in those who did not (p<0.05). Cox's proportional hazard model indicated that those who worked overtime more than 50 hours per month had 3.7 times higher risk of NIDDM after controlling for known risk factors (p<0.01) and those who worked with new technology had 2.4 times higher risk of NIDDM (p<0.05).**

***Conclusions*—It is suggested that longer overtime and use of new technology are risk factors of NIDDM in Japanese men.**

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There are few epidemiological studies on the effects of working conditions on the occurrence of non-insulin dependent diabetes mellitus (NIDDM). One cross sectional study reported that diabetes mellitus was more prevalent in rotating shift labourers than in day labourers.[1] However, evidence linking shift work and NIDDM is still conflicting and inconclusive.[2 3] Long working hours or overtime has received an increasing attention for its adverse effects on health including cardiovascular diseases.[4] Long overtime is a public health concern in Japan because it is thought to be a cause of a stress related fatal cardiovascular episode that is called "karoshi" (death from overwork) in Japanese.[5] A study reported that blood concentration of glycosylated haemoglobin was higher in shift workers who worked 12–18 hours of overtime per week than in office clerks,[6] although the author did not relate this finding specifically to increased risk of NIDDM. Long overtime has been linked to increased sympathetic activity[7] and increased concentrations of counterregulatory hormones,[8] which in turn might be associated with increased risk of NIDDM.[9 10]

Psychological job strain, which is defined as the combination of high psychological job demands and low job control,[11] and its interaction with a lack of social support at work[12] have been linked to coronary heart diseases and its risk factors.[13 14] A previous study reported that air traffic controllers who engaged in a high demand job had a higher prevalence of diabetes than other workers.[15] It was also reported that job strain[16] and job stressors including a lack of worksite social support[17] were associated with increased levels of glycosylated haemoglobin among non-diabetic populations. The introduction of new technology, including computers, at work has been also considered to be a source of job related strain in industrialised countries, although the adverse health effects are not clear.[18 19] Both animal and human experimental studies have reported that psychological stress increases blood glucose and decreases insulin activity, which then could lead to glucose intolerance.[10] These psychosocial working conditions, as well as long overtime, may influence the development of NIDDM.

To date, evidence linking overtime and psychosocial working conditions to the risk of NIDDM is very limited and prospective evidence is completely lacking. To learn the effects of overtime and psychosocial working conditions on the occurrence of NIDDM, we analysed data from an eight year prospective follow up study of male industrial workers in Japan.[20]

Methods

SUBJECTS

In 1984, a baseline survey was conducted of 3862 employees of a large electrical company in Japan using a mailed questionnaire concerning job related variables including shift work, overtime, and psychosocial working conditions. They were also interviewed by trained nurses to assess their medical histories, and their height and weight were measured. A total of 3551 (92%) returned the questionnaires. Because of the small number of female respondents (n=485), analysis was limited to the 3066 male respondents. Forty six male respondents were excluded because they had a medical history of diabetes mellitus before the baseline survey based on the interview by nurses or company medical records, and 169 were excluded because that they had a medical history of hypertension, cardiovascular diseases or cerebrovascular disorders. Three hundred and eleven had a missing response in the questionnaire or no information on height or weight, and they were also excluded from the study. This left a total of 2597 male respondents who were followed up for the succeeding eight years and then were surveyed in 1992 using a questionnaire to assess their family histories of diabetes mellitus. A total of 342 did not respond to the follow up survey. We excluded 61 respondents who moved to subsidiary companies during the follow up period, because their job or working conditions may have greatly changed. Analyses were conducted for data from 2194 (84%) male respondents who were still in the same factory and completed the 1992 survey.

INCIDENCE OF DIABETES MELLITUS

Diagnosis of NIDDM was made according to the WHO criteria.[21] The occurrence of NIDDM during the follow up was assessed based on a company wide annual screening programme for diabetes. During the follow up, all subjects received a medical check up once a year that included a semi-quantitative test for glucose in a urine sample. Fasting plasma glucose (FPG) was measured for those who had glucosuria, and then 75 g oral glucose tolerance test (OGTT) was conducted for those who had 110 mg/dl or higher FPG to determine the final diagnosis of NIDDM. This screening programme started in 1972—that is, 12 years before the baseline survey. The information was also used for the identification of subjects with a history of diabetes before the baseline survey.

JOB RELATED VARIABLES

The baseline questionnaire asked each subject about occupation, type of work shift, overtime hours in the past month and four psychosocial working conditions. Occupation was categorised into three groups: managers/technicians/clerks, mechanics/repairers and machine operators. None of the subjects were exposed to high levels of chemicals that are known to be associated with the development of NIDDM.[22] The type of work shift was classified into day only and rotating shift work. Rotating shift workers engaged in two or three shift work schedules including night shift, with a weekly clockwise rotation. Overtime was classified into three categories—that is, 0–25, 26–50, and more than 50 hours per month. The company's regular work hours were 40 hours per week (eight hours per day for five days per week). Subjects in these three categories worked about 8–9, 9–10, and 10+ hours per day, respectively (or worked about 40–46, 47–52, and 53+ hours per week, respectively).

Three single item questions were used to assess psychosocial work conditions according to the job demands-control model[11 13] and the demand-control-support model.[12] The responses were dichotomised so that approximately an upper quartile of subjects were classified as having a high level of job stressor.[23] For quantitative job overload, we asked "How would you rate the amount of your work?" using four response categories ("very much", "much", "moderate", and "little"); subjects who answered "very much" were classified as having high job overload (32%). For job control, we asked "To what extent can you determine the pace of your work?" using four response categories ("very much", "much", "not much", and "little"); subjects who answered "not much" or "little" were classified as having low control over workpace (23%). For social support at work, we asked "How would you rate human relations at your workplace" using four response categories ("very good", "good", "fair" and "poor"); subjects who answered "fair" or "poor" were classified as having low social support at work (19%). When a respondent had both high job overload and low control over workpace, the person was classified as being under "high strain" according to the job demands-control model.[11] Another single item question was used to assess whether subjects experienced using business or production machines that involved new technology at work ("In your job, has new technology or a new machine been introduced?" using dichotomised response categories, "yes" and "no"). Test-retest reproducibility and one year stability of these four questions on psychosocial work stress ranged from 0.51 to 0.70.[23] Spearman's rank correlation coefficient was 0.35 ($p<0.01$) for overtime hours between baseline and at one year follow up in 1985 among 2057 subjects (94%) who responded to the baseline survey and the 1985 survey.

OTHER COVARIATES

Other covariates included age, years of education, obesity, leisure time physical activity, alcohol consumption, smoking, and family history of diabetes mellitus. The variables except for family history were assessed at the baseline survey. Age was classified into 18–34, 35–44, and 45–60 years (39%, 39%, and 22% of the subjects, respectively). Years of education were categorised into three groups—that is, 5–9 years, 10–12 years, and 13+ years (38.7%, 46.8%, and 14.5%, respectively). Obesity was measured by the body mass index (kg/m^2) (average value, 22.0; standard deviation, 2.4). Frequency of physical activity in leisure time was assessed using a single question and was dichotomised into two groups—that is, physically active (sometimes or often) and inactive (hardly none) (63% and 37%, respectively). Drinking habit was assessed by inquiring if they drank any alcohol beverages. Drinkers were further asked to recall the average amount of alcohol beverages per week that they had

Table 1 Age adjusted incidence rates of diabetes mellitus during the eight year follow up (1984–1992) by occupation, shift work, overtime, and psychosocial job conditions

Variable in 1984	*Subjects (n)*	*Age adjusted incidence per 1000 person years*
Work shift		
Day only	1179	1.90
Rotating shift	1015	2.04
Occupation		
Managers/technicians/clerks	664	1.89
Mechanic/repair	266	3.65
Machine operators	1264	1.67
Overtime (hours/month)		
0–25	744	1.09
26–50	1099	1.82
More than 50	351	4.32**
Job overload		
Low	1495	1.84
High	699	2.19
Control over workplace		
High	1684	1.91
Low	510	2.02
Job strain		
High strain (high job overload + low workplace control)	226	2.80
Other combinations	1968	1.85
Social support at work		
High	1784	1.75
Low	410	2.83
Use of technology		
No	1875	1.59
Yes	319	4.30**

** p<0.01, difference from the first category (Cox's proportional hazard analysis controlling for age). Otherwise, p>0.05.

typically consumed in the past year. The amount of alcohol consumed per week was estimated by multiplying the concentration of ethanol and the amount of each beverage, then adding them together (average alcohol consumption in pure ethanol per week, 111 mg; standard deviation, 154 mg). Furthermore, subjects were asked about the number of cigarettes that they currently smoked per day at that time (average, 12.9; standard deviation, 12.1). Family history of diabetes mellitus was assessed using the questionnaire at the 1992 survey. When a respondent reported that any first degree relative had ever a medical history of diabetes mellitus, we classified the person as having a family history of diabetes mellitus (family history positive, 11.5%).

KEY POINTS

- Those who worked more than 50 hours overtime per month had 3.7 times higher risk of NIDDM.
- Those who experienced the use of new technology had a higher risk of NIDDM than those who did not.
- Disturbance in glucose metabolism may be a common underlying mechanism of the development of NIDDM, cardiovascular diseases and the "karoshi".
- Avoiding chronic long overtime and reducing distress caused by the new technology may be important for the prevention of NIDDM.

Table 2 Effects of age, occupation, work shift, overtime, psychosocial job conditions, and other covariates on eight year incidence of non-insulin dependent diabetes mellitus (1984–1992) in male industrial workers in Japan: Cox's proportional hazard model†

Variable	*Hazard ratio (95% confidence intervals)*	*p for trend*
Age at baseline (y)		
18–34	1.00	
35–44	2.85 (0.99, 8.16)	
45–60	5.91 (1.95, 17.89)**	p=0.001
Years of education		
5–9	1.00	
10–12	1.36 (0.64, 2.89)	
13+	0.63 (0.11, 3.75)	p=0.866
Occupation		
Managers/technicians/clerks	1.00	
Mechanics/repairers	1.58 (0.53, 4.76)	
Machine operators	0.56 (0.15, 2.06)	NA
Work shift (rotating shift *v* day only)	1.67 (0.57, 4.90)	
Overtime (hours/month)		
0–25	1.00	
26–50	1.67 (0.70, 3.97)	
More than 50	3.73 (1.41, 9.90)**	p=0.009
Job strain		
(High overload + low control *v* others)	1.34 (0.50, 3.55)	
Social support at work (low *v* high)	1.27 (0.58, 2.79)	
Use of technology (yes *v* no)	2.44 (1.13, 5.23)*	
Body Mass Index (for an increase of 1 kg/m^2)	1.20 (1.06, 1.37)**	
Alcohol consumption (for an increase of 10 mg ethanol/week)	1.00 (0.99, 1.02)	
Smoking (for an increase of 10 cigarettes smoked per day)	1.47 (1.14, 1.89)**	
Leisure time physical activity (active *v* inactive)	0.52 (0.26, 1.05)	
Family history of diabetes mellitus (any *v* none)	2.45 (1.09, 5.53)*	

† Family history was assessed at the follow up survey in 1992. Other variables were assessed at baseline in 1984. All variables were entered simultaneously in the model. * p<0.05, ** p<0.01. NA = not applicable.

STATISTICAL ANALYSIS

Age adjusted incidence rates of NIDDM were compared among groups classified on the basis of occupation, type of work shift, overtime, and four psychosocial job conditions (as well as job strain). The age adjusted incidence rates were calculated with the direct method using the total male subjects as a standard population. Cox's proportional hazard model with discrete failure time was used to test the significance of difference in the age adjusted incidence among the groups. Cox's proportional hazard model was also used to determine the unique effects of type of occupation, work shift, overtime, and four psychosocial job conditions on the eight year incidence of NIDDM, controlling for other covariates (that is, age, education, body mass index, alcohol consumption, smoking, leisure time physical activity, and family history). The analyses were carried out on a PC with the computer program SAS version 6.11.[24]

Results

Among 17 451 person year observations, 34 subjects were found to have developed NIDDM during the follow up. The incidence rate was 1.95 per 1000 person years. Age specific incidence rates were 0.73, 2.19, and 3.70 per 1000 person years for those aged 18–34, 35–44, and 45 years or older, respectively, with the two older groups having significantly higher incidence rates than the youngest group (p<0.05, Cox's proportional hazard model). The age adjusted incidence rate of NIDDM was significantly higher in those who worked overtime more than 50 hours per month than in those who worked overtime 25 hours or less per month (table 1). Age adjusted incidence rate of NIDDM was also significantly higher in those who experienced the use of new technology than in those who did not. Although those who were classified as high strain and as having low social support at work had slightly higher age adjusted incidence rates of NIDDM, they did not reach a significance level (p>0.05).

The Cox's proportional hazard model analysis indicated that overtime was significantly associated with a risk of NIDDM, after controlling for the covariates (table 2). Those who worked more than 50 hours overtime per month had 3.7 times higher the risk of NIDDM compared with those who worked 0–25 hours overtime per month. Those who experienced the use of new technology had a significantly higher risk of NIDDM than those who did not. Age, body mass index, smoking, and family history of diabetes mellitus were significantly associated with a higher risk of NIDDM. Leisure time physical activity was marginally associated with a lower risk of NIDDM (p=0.067). Although machine operators or those who worked with a rotating shift had a slightly higher risk of NIDDM, the effects did not reach a level of significance (p>0.05). Furthermore, hazard ratios of NIDDM were identical between two shift and three shift work schedules. These tendencies were similar among the three occupational groups or between day and rotating shift workers.

Multiple logistic regression analysis of those who were lost to follow up (n=403) among the initial 2597 respondents indicated that people who fell into the categories of being older, day workers, managers/technicians/clerks were significantly more likely to be lost to follow up (p<0.05). Those who worked 26–50 hours of overtime per month were significantly less likely to be lost to follow up than those who worked 0–25 hours of overtime per month. The other variables were not significantly associated with drop out from the follow up (p>0.05).

Discussion

This study first demonstrated that long overtime was associated with a higher risk of NIDDM. The use of new technology at work was also associated with a higher risk of NIDDM. These associations remained significant after controlling for other covariates relevant to the development of NIDDM (that is, age, education, obesity, smoking, alcohol drinking, leisure time physical activity, and family history). A dose response relation was observed between overtime and the risk of NIDDM. It is suggested that long overtime and the use of new technology are associated with increased risk of NIDDM.

The prevalence of NIDDM in 1984 was the same as that in the male general population aged 20–59 years old (1.5%) from a community-based study in Japan.[25] The incidence rate during the follow up was slightly lower than that (3–7/1000/y) for all men in this community study,[25] which might be attributable to a younger sample in our study. Comparison of several indicators (for example, mean height, weight, and body mass index) with a Japanese national sample suggest that our sample are not greatly deviant from the Japanese male population.[26] The eight year follow up rate was relatively high, and more than 50 hours overtime per month or use of new technology was not significantly associated with being lost to follow up. The findings are less likely to be biased because of being lost to follow up. Although we identified diabetes cases using the same screening programme at baseline and during the follow up, we did not conduct 75 g OGTT for all subjects. Some subjects in our sample may have had potential diabetes or impaired glucose tolerance (IGT) at baseline and been later found as incident cases during the follow up. Thus the incidence rates need to be interpreted with caution. It seems less likely that these undetected diabetic cases worked longer overtime or more likely to report the use of new technology, because diabetic cases at such early stages were usually asymptomatic and subjects would not be aware of the disease. However, it is still possible that overtime or stress caused by the use of new technology exclusively affected blood glucose control among potential diabetic or IGT cases at baseline, leading to an overt diagnosis. On the other hand, possible failure to identify some new NIDDM cases during the follow up period could lead the odds ratio to the null value, resulting in underestimation of the effects of these variables on NIDDM.

A moderate correlation (Spearman's *r*, 0.35) between overtime hours at the baseline and one year follow up indicates that those who worked longer overtime tended to do so during the follow up. The observed association between overtime at baseline and the increased risk of NIDDM might reflect the effects of long overtime work over a long period of time. Studies have reported that long overtime causes sustained higher levels of catecholamines at work and even after work.[8] A recent study has suggested that long overtime is also associated with activation in sympathetic nervous system at rest.[7] Longer overtime might lead to increased blood glucose concentrations and increases insulin resistance through these pathways, and then might increase risk for the development of NIDDM. Another possible explanation is dietary change because of long overtime, such as overeating after a long interval between meals, which may lead to the development of NIDDM. Disturbance in glucose metabolism[25] associated with long overtime may be a common underlying mechanism of increased risk of NIDDM, cardiovascular diseases[4] and a stress related fatal cardiovascular episode like the "karoshi".[5]

Psychological effects of the use of new technology at work may not be equal among occupations,[18] but it has been generally accepted that the use of new technology is associated with increased job demands, increased work speed, decreased control over job, and decreased chance to interact with coworkers,[19] as well as effort to adapt to work with machines using new technology.[18] In fact, the company under the study was at a transitional stage with regard to the use of new technology during the observation period. White collar employees claimed that the rapid introduction of personal computers at work caused distress. Automated production machines that were newly introduced had frequent breakdown, causing greater demands and distress among blue collar workers. The context should be considered in the interpretation of the findings. We found in a previous study that the use of new technology was associated with an increase in blood pressure during the succeeding one year observation,[27] and blood pressure has been closely related to disturbance in glucose metabolism.[28] Psychological strain derived from the use of machines with new technology might be associated with the development of NIDDM through such stress related physiological changes. Another possible explanation is that the introduction of new technology, such as an automated production system, in the workplace might reduce physical activity of workers during work hours and then influence the development of NIDDM. However, despite these connections, our method to assess the use of new technology might be too simple to measure a complex process associated with the use of new technology. Future research is needed to replicate our findings and to learn the effects of more specific situations related to new technology, for example, the use of personal computers or automated production machines, on the development of NIDDM.

We failed to demonstrate a statistically significant association of job strain defined in the demands-control model[11] or lack of social support at work with NIDDM, although these variables were associated with a slightly higher risk of NIDDM. One of the limitations of our study is that the sample size was not large, including only 34 incidence cases of NIDDM during the follow up period. The study has limited statistical power and there was the risk to fail to detect the effects of some important psychosocial work conditions. Non-significant results are also attributable to a possible methodological problems—that is, the use of single item questions for assessment of these variables. Those who worked in rotating shift also had 1.7 times higher the risk of NIDDM, but the effect was not significant. This again may be because of a small sample size. This is also attributable to changes in work shift during the follow up: 18% of initial rotating shift workers were changed to day shift during the follow up; 13% of initial day workers were changed to rotating shift. Such a change could attenuate the hazard ratio. A previous study reported that NIDDM was more prevalent among rotating shift labourers,[1] a more recent study in Japan found that shift work was not significantly associated with the occurrence of diabetes.[3] Improved rotating shift schedule and preventive health care for rotating shift workers might reduce the association between shift work and NIDDM. Future studies are needed to examine the effects of job strain, social support, and shift work on NIDDM in a larger sample using standardised measures of these psychological working conditions.

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Conflicts of interest: none.

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