Association between job strain and prevalence of hypertension: a cross sectional analysis in a Japanese working population with a wide range of occupations: the Jichi Medical School cohort study

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Abstract

***Objectives*—To explore the association between the prevalence of hypertension in a Japanese working population and job strain (a combination of low control over work and high psychological demands), and to estimate this association in different sociodemographic strata.**

***Methods*—From a multicentre community based cohort study of Japanese people, sex specific cross sectional analyses were performed on 3187 men and 3400 women under 65 years of age, all of whom were actively engaged in various occupations throughout Japan. The baseline period was 1992–4. The association between job characteristics—measured with a Japanese version of the Karasek demand-control questionnaire—and the prevalence of hypertension defined by blood pressure and from clinical diagnoses were examined. Adjustments were made for possible confounders. The analyses were repeated for stratified categories of occupational class, educational attainment, and age group.**

***Results*—In men, the level of job strain (the ratio of psychological job demands to job control) correlated with the prevalence of hypertension. In a multiple logistic regression model, job strain was significantly related to hypertension (odds ratio 1.18; 95% confidence interval 1.05 to 1.32), after adjustment for age, employment (white collar *v* blue collar), marital status, family history of hypertension, cigarette smoking, alcohol intake, physical activity, and body mass index. The stratified analyses showed significant excess risks in the subordinate groups compared with managers, blue collar workers, less educated workers, and the older age groups. This association was not significant in women. Multiple linear regression analyses, with systolic and diastolic blood pressures as dependent variables, did not show any significant association.**

***Conclusions*—The findings provided limited proof that job strain is related to hypertension in Japanese working men. Older men in a lower social class may be more vulnerable to the hypertensive effects of job strain.**

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Comprehensive reviews conclude that job strain, a combination of low control over the job and high psychological demands, is related to the incidence and prevalence of cardiovascular diseases in western countries.[1–3] It was postulated that one of the underlying mechanisms through which job strain leads to cardiovascular diseases is high blood pressure due to chronic physiological arousal.[2] Several studies have been conducted to substantiate this hypothesis; and evidence has been accumulating to prove a cause-effect relation between job strain and high blood pressure.[4–8] However, the results have not been completely consistent.[9–13] Also, cross cultural evidence has been very limited.[2]

It might be expected that a clearer association between job strain and hypertension would emerge in some social strata. Occupational class and educational level are variables to be taken into consideration.[14] Low occupational class has often been reported to be associated with high blood pressure.[15 16] Other levels of social class and education may also determine levels of blood pressure independently or together from work conditions.[9] Many researchers have controlled for these variables, if taken into account, in their statistical analyses, but a stratified analysis has seldom been done. Furthermore, a sex difference seems to exist in the association between job strain and blood pressure. Light *et al*[17] and Niedhammer *et al*[18] (not job strain, but job control) reported a positive association in men but not in women, whereas positive associations in women were found by others.[19 20] Age differences have also been suggested. The effect that job strain has on blood pressure seems to be more likely in the older age groups.[6 11] Sampling from a diverse population would be appropriate to determine in which populations the most prominent effects of job strain will emerge.

The Jichi Medical School cohort study, a multicentre community based cohort study, which is designed to explore coronary risk factors in the Japanese people, provides the tools to examine whether job strain is associated with the prevalence of hypertension among male and female Japanese workers across various occupations. This was tested for some sociodemographic categories in non-western occupational settings.

Methods

The aim of the Jichi Medical School cohort study was to investigate the risk factors for cardiovascular disease in Japan. Data were collected between 1992 and 1994. Ultimately, 12 490 Japanese workers from 12 rural communities across Japan participated.[21 22] In Japan in accordance with the Health and Medical Service Law for the Aged, mass screening examinations for cardiocerebrovascular diseases have been conducted since 1983. The subjects for these examinations were residents with ages between 30 and 69 years in four of the 12 communities and between 40 and 69 years in the other eight. In each community, the local government office sent letters to all potential participants inviting them to take part in the programme. The invitation mentioned that people who were visiting hospitals or clinics because of cardiovascular diseases did not have to take the examination. The overall response rate was 65.4%. People other than those involved in these age groups (n=282 for the younger age group and 699 for those over 69), who voluntarily participated in the study were included in the database. The final database comprised 4911 men and 7579 women.

PROCEDURE

Sociodemographic and behavioural variables were investigated through a standardised questionnaire, which requested information on age, occupational environment, marital status, education, family medical history, smoking, alcohol consumption, and physical activity. The questionnaire was given to the participants to complete on their own before the physical examination. Informed consent was obtained from all prospective participants.

The physical examinations took place in each community. Height was measured without shoes. Body weight was recorded with the subject clothed, and 0.5 kg in summer or 1 kg in the other seasons was subtracted from the recorded weight. Body mass index was calculated as weight (kg)/height $(m)^2$. The systolic and diastolic blood pressures were measured with a fully automated sphygmomanometer (BP203RV-II, Nippon Colin, Komaki, Japan), which was placed on the right arm of the subject, after he or she had been sitting for 5 minutes. People were classified as hypertensive if (*a*) their systolic blood pressure was equal to or greater than 160 mm Hg, (*b*) their diastolic blood pressure was equal to or greater than 90 mm Hg, or (*c*) they had been clinically diagnosed as hypertensive. The last group included not only patients who were on antihypertensive medication but also those who were undergoing treatment other than drug treatment. It was decided to use this definition; however, separate analyses, with this criterion including only those who took medication, gave us similar results.

Two scales were used to define job characteristics—psychological job demands and job control. Psychological job demands was defined by five elements (work fast, work hard, demand for extra work, insufficient time to do work, and conflicting demands). Job control was defined as the sum of two subscales that were given equal weight: (*a*) skill discretion, measured by four elements (continuous need to acquire new knowledge, skill requirement, requirement for creativity, and repetitiveness); and (*b*) decision authority, measured by two elements (freedom to make decisions and choice in the approach to work). The psychometric property of the Japanese version of the demand-control questionnaire has been reported elsewhere.[23 24] All questions were scored on a Likert scale of 1 to 4. Cronbach's coefficient α for the psychological demands index was 0.70 and for the job control index it was 0.64 for our sample. Job strain was defined as the ratio of demands to job control. Participants were grouped into one of three strata for each job characteristics index (low, medium, or high) based on tertiles, defined according to the distribution of scores in the total working population, and separately for men and women.

The following variables were selected as potential confounders: (*a*) age, <35, 36–45, 46–55, and 56–65; (*b*) job, managerial (self employed or a manager in their company) or not, and employment of white collar versus blue collar; (*c*) work hours, the number of hours spent at work on any given weekday; (*d*) marital status, currently married or single; (*e*) educational attainment, lower or higher than the level of compulsory education; (*f*) family history of hypertension, positive if participant's mother or father had ever had high blood pressure; (*g*) smoking habits, never smoked, ex-smoker, 1–20 cigarettes/day, or ⩾21 cigarettes/day for men, and never smoked, ex-smoker, or current smoker for women; (*h*) alcohol intake, non-drinker, <1 *go* daily (*go*=a traditional Japanese alcohol unit, 1 *go*=28.9 g alcohol), 1–3 *go* daily (28.9–86.6 g alcohol), or ⩾3 *go* daily (⩾86.7 g alcohol) for men, and non-drinker or current drinker for women; (*i*) physical activity index,[25] low (⩽28), medium (29–36), or high (⩾37); and (*j*) body mass index, categorised into tertiles based on the total sample distribution (<21.6, 21.6–23.9, or ⩾24.0 kg/m^2).

STUDY POPULATION

The study population was restricted to actively working men and women under 65 because the aim of this analysis was to find the association between job characteristics and the prevalence of hypertension. A total of 6994 men and women who were employed and had a record of hypertension (from their medical history or blood pressure measured at the medical examination) were subjected to the analysis. Ninety four per cent of this sample completed the occupational psychosocial questionnaire, giving a final study population of 3187 male and 3400 female workers for whom both the blood pressure and questionnaire data were available. The following occupations were included: farming or forestry (n=954 men, 1093 women); fishery (236, 34); security (19, 1); transportation (85, 4); construction (607, 84); production (336, 654); business (247, 356);

office work (196, 333); professional (199, 193); service industry (251, 547); and unclassified (57, 101). The first six groups were designated blue collar occupations and the next four categories, white collar occupations. More than 99% of the workers were either self employed or employed by companies with less than 300 employees, which may be representative of the current industrial structure in Japan.[26] Those who were employed on a part time basis may have been included in the study population, but this was not ascertained.

A comparison of the people who completed the job characteristics questionnaire with those who did not, showed that those who did not were older, had a lower educational level, were more likely to be employed as blue collar workers, and were slightly more likely to have hypertension than those who did.

STATISTICS

Sex specific analyses were performed. Comparisons among sociodemographic, behavioural, and job characteristics were done with the χ^2 test and analysis of variance (ANOVA). Because hypertension was highly correlated with age, comparisons on hypertension were adjusted for age by the Mantel extension method. Only reported work hours (continuous variable) were compared by analysis of covariance (ANCOVA) with an adjustment for age. The age adjusted prevalence for each defined category was shown.

A logistic regression model was developed with hypertension as the outcome variable. Only age and the variables that were correlated with hypertension in the bivariate analyses were included as independent variables. For logistic regression analyses, job strain was coded from 1 to 3, from a low to high level of strain. Participants with missing values for covariates in the adjusted multiple logistic model were excluded from that particular analysis. Because adjustment for the areas under study did not substantially change the association between job strain and hypertension, the variable was excluded from the analyses. Analyses classified by job and employment, educational attainment, and age (younger *v* older) were also performed. Multiple linear regression was used when mean systolic and diastolic blood pressures were the outcome. All statistics were two tailed and values $p<0.05$ were considered to be significant.

Table 1 Mean job characteristics scores according to sociodemographic characteristics, stratified by job, employment, education, and age

	Men				*Women*			
	n	*Demand*	*Control*	*Strain*	*n*	*Demand*	*Control*	*Strain*
All participants	3187	11.9	16.9	0.718	3400	10.8	14.9	0.753
Job:								
Manager	1595	12.3***	17.5***	0.711***	945	11.1***	15.4***	0.744**
Subordinate	1290	11.5	16.1	0.736	2029	10.7	14.5	0.768
Employment:								
White Collar	893	12.1**	17.4***	0.705**	1429	10.6**	15.3***	0.718***
Blue Collar	2241	11.8	16.7	0.724	1931	10.9	14.7	0.778
Education:								
Less than compulsory	1253	11.8	16.5***	0.732***	1466	10.7	14.7***	0.764*
Higher	1912	11.9	17.2	0.708	1920	10.8	15.1	0.743
Age group:								
≤55	1863	12.2***	17.3***	0.718	2133	11.0***	15.0	0.761**
56–65	1324	11.5	16.4	0.718	1267	10.5	14.8	0.738

*p<0.05; **p<0.01; ***p<0.001.
Gender differences were all p<0.001.
ANOVA was performed among the categories.

Results

The mean (SD, range) age of the study population was 50.8 (10.4, 18–65) for men and 50.8 (9.4, 19–65) for women. There were more single men than single women. Compared with women, more men had attained a higher managerial status or were engaged in blue collar occupations, worked longer hours, and listed higher educational levels. Men smoked and consumed alcohol much more than women. The physical activity level was also higher for men than women (all $p<0.01$).

The job characteristics scores, according to sex and selected variables, are shown in table 1. Men had higher job demands and job control scores than women. Because of a substantial difference in the level of job control, the job strain level (the ratio of demands to control) was significantly higher for women than men. The younger men and women had higher job demand scores than the similarly placed older workers. The job control score was higher for younger than older men, thus both groups yielded the same level of strain. Younger women workers had higher strain scores than the older women. In both sexes, similar trends were found within the same occupational strata and level of educational attainment. With the exception of job demands for women, workers in managerial jobs and employment as white collar workers had higher demands and control scores than their respective counterparts. Better educated workers had higher control scores. The level of strain was significantly higher for the subordinates, blue collar workers, and those who were less educated.

According to the hypertension criterion, its prevalence in our sample was 25.1% (n=790) for men and 18.6% (n=631) for women. When compared with a representative population in Japan, the sample used here seemed to have lower blood pressure levels.[27]

Table 2 shows the prevalence of hypertension and normotension for the respective groups with selected variables. The prevalence of hypertension rose with increasing age for both sexes. In men, the age adjusted prevalence of hypertension was higher for those employed as white collar workers, those who were unmarried, had a family history of hypertension, were ex-smokers, consumed more alcohol, were physically more inactive, and were heavier than their respective counterparts. Similar associations were found in women for family history of hypertension, physical activity, and body mass index. However, hypertension in women was more common in less well educated women and in smokers. Marital status or alcohol intake was not associated with the prevalence of hypertension among women.

For men, the prevalence of hypertension increased as the level of job control decreased and the levels of psychological demands and job strain increased. Only the association between job strain and the prevalence of

Table 2 Association among studied variables and hypertension

Variables	Men				Women			
	Hypertension % (n)	Normotension % (n)	χ^2	p Value	Hypertension % (n)	Normotension % (n)	χ^2	p Value
Age:								
⩽35	4.4 (12)	95.6 (260)	163.1	0.000	3.1 (6)	96.9 (190)	169.5	0.000
36–45	15.1 (121)	84.9 (682)			8.8 (77)	91.2 (797)		
46–55	26.1 (206)	73.9 (582)			17.6 (187)	82.4 (876)		
56–65	34.1 (451)	65.9 (873)			28.5 (361)	71.5 (906)		
Job:								
Manager	25.0 (406)	75.0 (1189)	0.0	0.885	19.6 (190)	80.4 (755)	0.8	0.387
Subordinate	24.8 (311)	75.2 (979)			18.1 (362)	81.9 (1667)		
Employment:								
White collar	27.5 (215)	72.5 (678)	3.9	0.049	19.7 (239)	80.3 (1190)	1.6	0.216
Blue collar	23.7 (555)	76.3 (1686)			17.9 (381)	82.1 (1550)		
Mean work hours (h)	9.4	9.5	1.6*	0.200	8.6	8.7	0.9*	0.336
Marital status:								
Married	24.3 (725)	75.7 (2166)	5.9	0.017	18.4 (586)	81.6 (2587)	0.9	0.363
Unmarried	30.1 (62)	69.9 (224)			21.3 (43)	78.7 (170)		
Education:								
Less than compulsory	24.7 (357)	75.3 (896)	0.1	0.740	20.7 (346)	79.3 (1120)	8.1	0.005
Higher	24.4 (428)	75.6 (1484)			16.6 (279)	83.4 (1641)		
Family history of hypertension:								
Positive	32.0 (307)	68.0 (647)	42.7	0.000	27.1 (280)	72.9 (806)	81.7	0.000
Negative	21.2 (442)	78.8 (1639)			14.2 (321)	85.8 (1879)		
Smoking:								
Never smoker	24.9 (181)	75.1 (508)	4.3	0.041	18.2 (569)	81.8 (2487)	4.0	0.046
Ex-smoker	27.9 (239)	72.1 (544)			22.6 (11)	77.4 (69)		
Current (⩽20/day)	22.8 (259)	77.2 (879)			26.4 (39)	73.6 (167)	†	
Current (⩾21/day)	21.1 (105)	78.9 (460)			—	—		
Alcohol intake (g/day):								
Never and ex-drinker	18.6 (131)	81.4 (531)	21.9	0.000	17.8 (427)	82.2 (1855)	0.8	0.404
<28.9	24.0 (204)	76.0 (703)			19.1 (168)	80.9 (816)	‡	
28.9–86.6	26.3 (336)	73.7 (894)			—	—		
⩾86.7	30.4 (85)	69.6 (209)			—	—		
Physical activity index:								
⩽28	30.0 (159)	70.0 (434)	9.2	0.003	20.4 (157)	79.6 (709)	3.3	0.074
29–36	25.0 (303)	75.0 (893)			18.7 (321)	81.3 (1374)		
⩾37	22.7 (320)	77.3 (1052)			17.2 (146)	82.8 (643)		
BMI (kg/m^2):								
<21.6	14.9 (148)	85.1 (827)	125.1	0.000	11.8 (117)	88.2 (988)	102.0	0.000
21.6–23.9	23.0 (253)	77.0 (858)			15.1 (173)	84.9 (963)		
⩾24.0	35.7 (376)	64.3 (679)			27.9 (329)	72.1 (787)		
Menopausal status:								
Postmenopausal	—	—	—	—	20.3 (475)	79.7 (1449)	0.9	0.375
Premenopausal	—	—	—	—	7.5 (145)	92.5 (1286)		
Job characteristics:								
Demand:								
Low	23.6 (242)	76.4 (718)	1.7	0.206	18.9 (206)	81.1 (837)	0.0	0.895
Middle	24.6 (234)	75.4 (730)			18.2 (194)	81.8 (899)		
High	25.9 (314)	74.1 (949)			18.7 (231)	81.3 (1033)		
Control:								
High	23.8 (218)	76.2 (753)	1.9	0.182	18.4 (215)	81.6 (958)	0.1	0.800
Middle	24.1 (243)	75.9 (777)			18.4 (222)	81.6 (979)		
Low	26.6 (329)	73.4 (867)			18.8 (194)	81.2 (832)		
Strain:								
Low	22.2 (227)	77.8 (771)	8.8	0.003	19.1 (219)	80.9 (885)	0.0	0.974
Middle	24.2 (249)	75.8 (805)			17.6 (185)	82.4 (919)		
High	27.6 (314)	72.4 (821)			18.9 (227)	81.1 (965)		

Values are age adjusted prevalence % (n), except for age adjusted mean work hours. Comparisons among variables other than age were adjusted for age by the Mantel extension method for categorical variables and by analysis of covariance for work hours.
*F value.
†Those women who smoked cigarettes were rounded as current smokers irrespective of their amount of cigarettes they smoked per day.
‡Those women who drank alcohol were rounded as current drinkers irrespective of their amount of consumption.

hypertension was significant, whereas neither job control nor demands was significantly related to the prevalence of hypertension. In women, the associations between job characteristics and the prevalence of hypertension were inconsistent.

Table 3 shows the results of multiple logistic analyses. For men, age, marital status, family history of hypertension, alcohol intake, physical activity index, and body mass index were significantly and independently associated with the prevalence of hypertension. Job strain had a significant association with hypertension after adjusting for associated variables. Even after adjusting for all the possible confounders, including working conditions and education, the association remained significant (odds ratio (OR) 1.17; 95% confidence interval (95% CI) 1.04 to 1.32). In women, age, lower educational status, family history of hypertension, and body mass index were significantly associated with hypertension; however, the association between job strain and hypertension was not significant.

Table 4 shows the results of multiple logistic analyses based on four sociodemographic strata: manager or subordinate; white collar or blue collar worker; lower or higher than compulsory education level; and younger or older(<55 or 56–65) workers (all separated by sex). For men, each stratified category consistently showed an increased relative risk of job strain; but a significant excess risk of job strain was found for the categories of: subordinate, blue collar, lower educational attainment, and older age. Particularly, the differences between

Table 3 Results of multiple logistic analysis

	Men (n=2819)		Women (n=3180)	
Variables	*OR*	*95% CI*	*OR*	*95% CI*
Age	2.14	1.90 to 2.40	2.01	1.77 to 2.29
Employment	0.90	0.72 to 1.13	—	—
Marital status	1.58	1.10 to 2.26	—	—
Education	—	—	1.30	1.07 to 1.59
Family history of hypertension	1.76	1.45 to 2.14	2.44	2.01 to 2.98
Smoking	0.94	0.86 to 1.03	1.21	0.99 to 1.48
Alcohol intake	1.29	1.16 to 1.43	—	—
Physical activity index	0.87	0.76 to 0.99	—	—
Body mass index	1.87	1.65 to 2.11	1.82	1.61 to 2.07
Job strain	1.18	1.05 to 1.32	1.01	0.90 to 1.13

The reduced number of participants is due to selective missing data.
For men, age, employment, marital status, family history of hypertension, smoking, alcohol intake, physical activity index, body mass index, and job strain were included in the model.
For women, age, education, family history of hypertension, smoking, body mass index, and job strain were included in the model. Each factor adjusted for each other factor.
Age is coded from 1 (⩽35) to 4 (56–65). Smoking habits are coded from 1 (never smoker) to 4 (smoked cigarettes ⩾21/day) for men, and from 1 (never smoker) to 3 (current smoker) for women. Alcohol intake is coded from 1 (never and ex-drinker) to 4 (drank ⩾86.7 g/day of alcohol). Physical activity index, body mass index and job strain are coded from 1 (the lowest level) to 3 (the highest level).
The OR values for variables with more than two categories were the ORs for each step.
Reference categories of the dichotomous variables are white collar workers, currently married, higher educational level, and no family history of hypertension.

Table 4 Odds ratios (95% CI) of job strain on prevalence of hypertension according to sociodemographic characteristics, stratified by job, employment, education, and age

	Men			Women		
Categories	*n*	*OR*	*95% CI*	*n*	*OR*	*95% CI*
Job:						
Manager	1415	1.08	0.92 to 1.27	871	0.93	0.74 to 1.16
Subordinate	1149	1.31	1.09 to 1.58	1919	0.99	0.85 to 1.15
Employment:						
White collar	821	1.11	0.90 to 1.37	1330	1.02	0.84 to 1.24
Blue collar	1998	1.20	1.05 to 1.38	1820	1.01	0.87 to 1.17
Education:						
Less than compulsory	1067	1.21	1.01 to 1.45	1367	1.06	0.91 to 1.24
Higher	1735	1.15	0.99 to 1.34	1813	0.94	0.79 to 1.11
Age:						
⩽55	1687	1.15	0.98 to 1.36	1997	1.02	0.86 to 1.22
56–65	1132	1.19	1.02 to 1.39	1183	0.99	0.84 to 1.15

The reduced number of participants is due to selective missing data.
For men, age, employment, marital status, family history of hypertension, smoking, alcohol intake, physical activity index, and body mass index were adjusted for in the model. For the analysis in the employment strata, employment status was not included as an independent variable.
For women, age, education, family history of hypertension, smoking, body mass index were adjusted for in the model. For the analysis education was not included as an independent variable.
Job strain is coded from 1 (the lowest level) to 3 (the highest level).

jobs (manager or subordinate) and employment (white or blue collar) were substantial. For women, no association between job strain and hypertension could be detected by the stratified analysis.

Although adjustment for occupation may lead to an overadjustment for the effect of job strain on health outcomes,[14 28] adjustments were made for occupation in the final model. The magnitude of the association was slightly lower but remained significant (OR 1.14; 95% CI 1.01 to 1.28).

The analyses were performed for each occupation. Relatively high ORs were found for male and female construction workers and male transport workers. For male construction workers, a significant OR was found despite the few cells (see appendices 1 and 2 for the job characteristics scores and the results of multiple logistic regression analyses for each occupation).

Multiple regression analyses were conducted to see the linear effect of the job strain index on mean systolic and diastolic pressures. In these analyses, adjustment was made for the use of antihypertensive medication as well as the other confounders noted. No significant associations were found.

Discussion

Job strain was positively associated with the prevalence of hypertension in Japanese men over a wide range of occupations. The excess prevalence amounted to 18% after adjustments for age, employment, marital status, family history of hypertension, smoking habits, alcohol intake, physical activity, and body mass index. With a crude assumption of the worst tertile job strain score defined as exposed, the aetiological fraction (population attributable risk) of the study population with hypertension was estimated to be 5.6%, which, from a public health point of view, would not be negligible.[1] As in other studies, only a combination of high demands and low control was related to the prevalence of hypertension.[4 5 20 29] The magnitude of the association seemed to be strongest for the lower social classes, where the level of job strain was higher than for their respective counterparts, and less so in the older age group. For the women in this sample, job strain was not associated with hypertension.

This sample seemed to underrepresent hypertension, perhaps because the invitation to participate in the study did not insist that those who were receiving care in hospitals and clinics for cardiovascular diseases should sign up with the others. However, this in itself is unlikely to produce a selective bias that would lead a normotensive worker who perceived his or her job as psychologically less demanding or one where the control was high to participate in the study. Observed associations between hypertension and behavioural variables other than job characteristics were similar to those reported in earlier epidemiological studies.[30–33] Although the studied sample was not truly representative of the Japanese working population, these findings may reflect a profile of hypertension among Japanese workers.

One of the debates about the research methodology of the job strain model is: has the study population been selected from a few well chosen occupations or from a wide range of occupations?[1] It is thought that a few well chosen occupations may be suitable for scrutinising specific job characteristics that affect workers' health in the selected occupations. Homogeneous samples may make it possible to illuminate the pure job strain effect on health outcome. However, the job demand-control questionnaire is often criticised as being too simple a tool to provide an adequate description of the psychosocial work environment. This low level of sophistication may not be powerful enough to produce a contrast in the exposure to stress within the small variance of a homogeneous sample. Occupation specific measures of job strain would be necessary to study a specific occupation in depth.[34] Alternatively, in a diverse population such as this sample, a relatively wide variability of the stress level within the occupations is expected, which may increase the power to establish

associations. Another advantage is the possibility of testing the job strain effect in several strata that the heterogeneity provides. Although only a weak association was found in our total sample, the stratified analyses showed some clear associations.

The finding of a job strain effect in male blue collar workers was similar to those obtained in recent studies, in which it was proved that the demand-control model is a more powerful predictor of cardiovascular disease in male blue collar workers than in their white collar counterparts.[7 35 36] The consistent finding about job and education may provide support for the notion that work related psychosocial factors explain the reported health disadvantage of populations from the lower social classes.[37 38] The findings that even in Japan where the general belief is that there is relatively high homogeneity of wealth and health, show the importance of the social class issue in any analysis of job strain.

The association between job strain and hypertension seemed to be stronger in the older than in the younger age group. Because the study population was recruited from relatively rural communities, and changing occupation is unlikely (particularly in the older age group), this finding might indicate a cumulative effect of job strain on hypertension.[6] However, because the oldest male category (56–65, 57.1% of the hypertensive men) accounted for most of the relation between job strain and hypertension, a definitive conclusion must await further studies.

Men and women may be affected differently by job characteristics. The sex differences found were unlikely to emerge from the difference in their stress related coping patterns—such as alcohol drinking[5 39]—because many lifestyle variables were adjusted for in the analysis. However, a sex difference may exist in the effectiveness of coping.[40] The following, which might explain the sex differences, were not considered here: full time versus part time work, work preferences, and concepts about the value of work.[41 42] It should be noted that, according to the findings of this study, single male workers had a higher prevalence of hypertension than those who were married, which suggests that factors outside of work may affect the workers' health. Sex differences in the regulation of the sympathetic nervous system is another possible explanation.[43]

Appendix 1: *Mean job characteristics scores according to occupation*

	Men				*Women*			
Occupations	*n*	*Demand*	*Control*	*Strain*	*n*	*Demand*	*Control*	*Strain*
Farming	954	11.2	17.0	0.67	1093	10.6	15.9	0.69
Fishery	236	12.2	16.9	0.73	34	9.9	11.8	0.90
Guard	19	9.1	13.2	0.71	1	10.0	15.0	0.67
Transport	85	11.2	13.9	0.84	4	11.8	14.5	0.85
Construction	607	12.4	16.9	0.76	84	10.8	12.9	0.88
Production	336	12.4	16.5	0.78	654	11.6	13.0	0.92
Business	247	11.7	17.5	0.68	356	10.5	16.0	0.67
Office work	196	12.4	17.0	0.74	333	10.3	15.2	0.69
Professional	199	12.6	18.0	0.71	193	11.3	16.2	0.72
Service industry	251	11.8	17.2	0.69	547	10.7	14.6	0.76

The magnitude of the association found was very weak: the linear analyses did not produce any significant associations. One of the reasons may be due to a methodological weakness—the use of casual blood pressure measurements for the outcome instead of ambulatory blood pressure monitoring. Previous studies indicate that ambulatory blood pressure monitoring is more sensitive for detecting an association.[5 19 20 29] In our study, blood pressure was measured at the person's health examination, not at his or her work site. Because a fully automated sphygmomanometer was used to measure blood pressure, observer errors in measurement were unlikely. The self reported history of hypertension and actual blood pressure levels were highly correlated. Thus substantial misclassification of the subjects was unlikely. However, particularly in occupational stress research, introducing ambulatory blood pressure monitoring in several situations (including at work) may make the association more precise,[19 20 29] which is difficult to do in large scale epidemiological studies.

The manner in which the psychological job characteristics are measured should be considered. The reliability and validity of the questionnaire on job characteristics were confirmed in other Japanese settings.[23 24] In this sample, too, the questionnaire was found to be internally consistent. Interrelations among the job characteristic scores, sex, and occupation were in concordance with previous studies.[35 41 44] However, the bias associated with self reporting is often criticised in job strain research. For example, those who are aware that their blood pressure is increased may let their health be affected by external work conditions.[45] Because 50%–70% of our cohort members have undergone yearly medical examinations, most of the participants were presumably aware of their blood pressure levels. This may account for some bias. It should be noted that participants were asked questions about their job characteristics, not their feelings about stress. The demand-control model may relate more to objective measures of stressor than other questionnaires.[46] Still, cultural differences may exist in reporting patterns for psychosocial measures.[47] To confirm this, more objective measures, such as an average measure of job characteristics and measures by outside expert observers are needed.[1 28] Although changing occupation is considered to be unlikely in the rural settings used here, the cumulative effects of job strain should be considered to confirm the results by using such a measure as the job exposure matrix.[48]

Our findings provide limited support for the hypothesis that job strain is related to high blood pressure among Japanese male workers, which is independent of possible confounding factors. Male workers in the lower social classes and who are older seem to be more susceptible to the effect of job strain on hypertension. These populations may be target groups for further analyses or intervention.

Appendix 2 *Odds ratio (95% CI) of job strain on prevalence of hypertension according to occupation*

	Men			*Women*		
Occupations	*n*	*OR*	*95% CI*	*n*	*OR*	*95% CI*
Farming	824	1.19	0.97 to 1.47	941	0.95	0.77 to 1.18
Fishery	211	0.82	0.52 to 1.28	31	0.19	0.02 to 2.08
Guard	15	—	—	1	—	—
Transport	75	1.90	0.65 to 5.55	3	—	—
Construction	557	1.38	1.03 to 1.85	75	1.95	0.58 to 6.48
Production	313	0.96	0.67 to 1.37	605	0.96	0.69 to 1.34
Business	221	0.94	0.59 to 1.48	316	1.04	0.70 to 1.56
Office work	181	1.26	0.78 to 2.02	300	1.00	0.60 to 1.67
Professional	187	1.16	0.71 to 1.88	177	0.81	0.42 to 1.55
Service industry	232	0.93	0.63 to 1.38	493	0.87	0.65 to 1.18

The reduced number of participants is due to selective missing data.
For men, age, employment, marital status, family history of hypertension, smoking, alcohol intake, physical activity index, body mass index, and job strain were included in the model.
For women, age, education, family history of hypertension, smoking, body mass index, and job strain were included in the model. Each factor adjusted for each other factor.
Job strain is coded from 1 (the lowest level) to 3 (the highest level).
—Estimates could not be calculated.

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