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Occupational status and job stress in relation to cardiovascular stress reactivity in Japanese workers

Kumi Hirokawa [a,b], Tetsuya Ohira [b,c,*], Mako Nagayoshi [b,d], Mitsugu Kajiura [e], Hironori Imano [b], Akihiko Kitamura [b,e], Masahiko Kiyama [e], Takeo Okada [e], Hiroyasu Iso [b]

[a] Department of Nursing, Baika Women's University, 2-19-5 Shukunosho, Ibaraki, Osaka 567-8578, Japan
[b] Public Health, Department of Social Medicine, Osaka University Graduate School of Medicine, 2-2 Yamadaoka, Suita-shi, Osaka 565-0871, Japan
[c] Department of Epidemiology, Fukushima Medical University, 1 Hikariga-oka, Fukushima 960-1295, Japan
[d] Department of Community Medicine, Nagasaki University Graduate School of Biomedical Science 1-12-4 Sakamoto, Nagasaki 852-8523 JAPAN
[e] Osaka Medical Center for Cancer and Cardiovascular Disease Prevention, 1-3-2 Nakamich, Higashinari-ku, Osaka 537-0025, Japan

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ABSTRACT

This study aimed to investigate the effects of occupational status and job stress factors on cardiovascular stress reactivity in Japanese workers. In this baseline assessment between 2001 and 2009 in Osaka, Japan, we examined 928 healthy Japanese employees (330 men, 598 women) from two occupational statuses: managers/professionals and general workers. A brief job stress questionnaire was used to evaluate job stress levels. Systolic and diastolic blood pressure (SBP, DBP), heart rate, heart rate variability (high-frequency [HF], low-frequency [LF], LF/HF), and peripheral blood flow were measured at rest and during two stressful tasks. Changes in stress reactivity were calculated as the difference between the measured variables during the tasks and the rest period. Men showed inverse associations between quantitative job overload and DBP, heart rate, and LF/HF, between physical demands and blood pressure (SBP, DBP), and between a poor physical environment and HF. Men also had positive associations between qualitative job overload and heart rate, and between physical demands and peripheral blood flow (all $p < 0.05$). Women showed inverse associations between qualitative job overload and SBP, and showed positive associations between qualitative job overload and peripheral blood flow, and between a poor physical environment and SBP (all $p < 0.05$). When stratified by occupational status, significant associations between job stress and changes in stress reactivity were observed in male managers/professionals and female general workers ($p < 0.05$). Job stress levels are associated with changes in cardiovascular stress reactivity in men and women. Occupational status may modify these associations.

1. Introduction

There are inverse associations between socioeconomic status and the incidence of cardiovascular disease and cardiovascular disease mortality (Davey Smith et al., 1992, 1998). Psychological job stress is postulated to mediate/modify the effects of socioeconomic status on health (Hallqvist et al., 1998). Workers with low occupational status are more vulnerable to job stress than those with higher occupational status (Wege et al., 2008). A prospective study showed that women with lower occupational status and job control had a significantly higher risk of stroke mortality than those with higher occupational status and job control (Toivanen and Hemström, 2008). A study in Japan also showed that job stress was associated with a higher risk of stroke incidents among men with low occupational status (Tsutsumi et al., 2011).

Cardiovascular stress reactivity is a predictor of atherosclerosis and cardiac events (Gianaros et al., 2005). Heart rate variability is a widely used method for studying autonomic modulation of heart rate (Taylor, 2010). Findings regarding associations between socioeconomic status and cardiovascular stress reactivity have been inconsistent. In one study, women with higher socioeconomic status had less marked systolic blood pressure (SBP) and diastolic blood pressure (DBP) reactions to stressful tasks than those with lower socioeconomic status; however, these reactions did not differ by socioeconomic status in men (Steptoe et al., 2002). Heart rate reactions to stressful tasks are greater among participants with high socioeconomic status, whereas participants with low socioeconomic status have a more delayed recovery in heart rate variability after stressful tasks than those with a high socioeconomic status (Steptoe et al., 2002). In a cohort study, persons with higher socioeconomic status showed greater heart rate reactivity

* Corresponding author at: Department of Epidemiology, Fukushima Medical University, 1 Hikariga-oka, Fukushima 960-1295, Japan.
E-mail addresses: k-umi@umin.ac.jp (K. Hirokawa), teoohira@fmu.ac.jp (T. Ohira).

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and DBP reactions to a stress task than those with lower socioeconomic status (Carroll et al., 2000).

Reported cardiovascular reactions to chronic and acute stress are inconsistent. High levels of chronic stress might be associated with increased cardiovascular reactions to acute stress (Roy et al., 1998; Lepore et al., 1997). However, high levels of chronic stress are inversely associated with cardiovascular reactions to acute stress (Schaubroeck and Ganster, 1993). A recent prospective study showed that heart rate reactivity to a stress task was negatively associated with deterioration in physical ability over the following 5 years (Phillips et al., 2011). Accordingly, the number of life events, including work-related events (an index of chronic stress levels), is negatively associated with cardiovascular reactivity to stress tasks (Schaubroeck and Ganster, 1993; Phillips et al., 2005; Ohira et al., 2011).

There are sex differences in the effects of socioeconomic status on health (Kopp et al., 2007). Furthermore, in Japan, there are greater sex differences in associations between socioeconomic status, stress levels, and health outcomes than in Western countries (Kawachi and Knodo, 2007). Women with a high occupational status who are exposed to high job stress have a higher risk of stroke incidents than those who are exposed to low job stress, but this association does not hold for men (Tsutsumi et al., 2011). Japanese men with lower occupational status perceive themselves to have poorer health and physical functioning than men with higher occupational status, which is also the case in men in Western countries. However, there is little socioeconomic difference in perceived health status among Japanese women (Martikainen et al., 2004). A large proportion of Japanese women are still homemakers. Employed Japanese women may be exposed to higher stress related to home and work than homemakers (Kawachi and Knodo, 2007).

The present study aimed to investigate the effects of occupational status on associations between chronic levels of perceived job stress and cardiovascular reactivity to mental stress tasks. Specifically, we aimed to determine the following: (1) whether lower occupational status is associated with higher cardiovascular stress reactivity than higher occupational status; (2) whether job stress levels are associated with cardiovascular stress reactivity; and (3) whether occupational status and job stress levels have an interactional effect on cardiovascular stress reactivity. Because there are sex differences in social functioning, we analyzed men and women separately.

2. Materials and methods

2.1. Study participants

This was a baseline assessment of a prospective cohort study. The participants in the present study were 979 Japanese people (338 men and 641 women) aged 16–82 years who underwent mental health checks at the Osaka Medical Center for Health Science and Promotion between 2001 and 2009. The mental health checks were performed to examine associations between mental stress levels and somatic and psychological symptoms. The applicants were obtained from companies around the Osaka area, Japan, as well as via the website of the Osaka Medical Center for Health Science and Promotion. The present study was explained to all applicants and those who gave written consent to the study were enrolled. This study was conducted after obtaining approval from the Ethics Committee of the Osaka Medical Center for Health Science and Promotion.

Most of the participants were employed persons (98% of men and 93% of women). Among the employed participants, the most frequent occupation in this study was teaching (44% of men and 54% of women). Unemployed persons comprised 1.5% of men and 6% of women; of the latter, 65% were housewives. Unemployed persons and those with missing data (0.9% of men and 0.5% of women) were excluded from the analyses. Data for 330 men and 598 women were analyzed. The distribution of participants' occupations is shown in Table 1. Participants were categorized as managers/professionals or general workers based on the preceding studies and vital statistics in Japan (Fukuda et al., 2005; Saeki et al., 2000). No participants had a history of stroke or myocardial infarction.

Table 1
Participants' occupation by sex.

	Men		Women	
	N	%	N	%
Manager	36	10.7	6	0.9
Professional	184	54.4	398	62.1
General: white-collar job	94	27.8	189	29.5
General: blue-collar job	15	4.4	5	0.8
General: unclassified job	1	0.3	0	0
Unemployed	5	1.5	40	6.2
Missing	3	0.9	3	0.5
Total	338	100	641	100

The data were collected between 2001 and 2009 in Osaka, Japan.

2.2. Experimental tasks

The experimental tasks consisted of a modified mirror drawing stress (MDS) task and a maze task (Hirokawa et al., 2014). In the MDS task, a complex pathway was presented to participants on a computer screen for 2 min, and they were asked to trace the pathway with a mouse as accurately and as rapidly as possible. The horizontal and/or vertical axis controls of the mouse were reversed. The maze task (Amthat: The Brain Medical, Japan) was designed to assess perceptual functioning, especially thinking ability. A maze was presented on a computer screen for 2 min and participants were required to plan how to reach a goal by passing through invisible walls with five lines and five columns. The interval of the tasks was 2 min. These tasks were administered in the following sequence: pre-task rest, MDS task, interval, maze task, and post-task rest.

2.3. Measurements

The Brief Job Stress Questionnaire was used to measure participants' job stressors (Shimomitsu et al., 2000). The 57 items are graded on a four-point Likert-type scale to measure job stressors, psycho-physical complaints, and support for workers. In this study, the effects of quantitative (three items: alpha = 0.80) and qualitative job overload (three items: alpha = 0.77), physical demands (one item), interpersonal conflicts (three items: alpha = 0.65), and poor physical environment (one item) were assessed. Sample items are as follows: “You have to do an enormous amount of work” for quantitative job overload, “You have to focus your attention quite a lot” for qualitative job overload, “You do a lot of physical work” for physical demands, “There are differences of opinion within your department” for interpersonal conflicts, and “The environment of your workplace (noise, light, humidity, and ventilation) is not so good” for a poor physical environment.

Cardiovascular reactivity was assessed by measuring SBP (mm Hg) and DBP (mm Hg) by a tonometry method and heart rate (beats/min) was assessed by electrocardiogram (ECG) (BP-508SD: Omron Colin, Japan) during pre-task rest (pre) for 2 min, the MSD task for 2 min, the maze task for 2 min, and post-task rest (post) for 2 min. Participants' ECGs were monitored from electrodes on the left subclavicular area and the right lower chest. The RR intervals were measured by using the MemCalc (GMS Co., Ltd., Japan), which analyzes data while eliminating abnormal cardiac rhythms. When atrial fibrillation and/or greater than 10% of abnormal cardiac rhythms were observed, these data were omitted from the analyses. A power spectral analysis for RR intervals on the ECGs was performed for every 128 beats to ascertain the low-frequency (LF) (0.04–0.15 Hz) and the high-frequency (HF) components (0.15–0.40 Hz) and their ratio (LF/HF).

Table 2
Characteristics and job stressors by sex and occupational status.

	Men				Women			
	Total	Managers/professionals	General workers	p value[#]	Total	Managers/professionals	General workers	p value[#]
	n = 330	n = 220	n = 110		n = 598	n = 404	n = 194	
Mean (SD)								
Age	46.5 (8.6)	47.8 (7.9)	43.9 (9.4)	<0.001	46.4 (8.4)	47.5 (7.8)	44.2 (9.1)	<0.001
Body mass index (kg/m^2)	23.8 (3.2)	23.8 (2.9)	24.0 (3.8)	0.56	22.3 (3.5)	22.2 (3.3)	22.4 (3.7)	0.67
Depressive symptoms	14.9 (10.0)	14.1 (8.9)	16.5 (11.8)	0.06	15.9 (10.1)	15.1 (9.4)	17.6 (11.2)	0.01
Job stressors								
Quantitative job overload	9.0 (2.3)	9.5 (2.2)	8.2 (2.3)	<0.001	9.4 (2.2)	9.9 (2.0)	8.5 (2.4)	<0.001
Qualitative job overload	8.8 (2.0)	9.2 (1.8)	8.0 (2.1)	<0.001	9.0 (1.9)	9.5 (1.7)	8.0 (2.0)	<0.001
Physical demands	2.1 (1.0)	2.3 (1.0)	1.7 (0.9)	<0.001	2.5 (1.0)	2.8 (0.9)	1.9 (1.1)	<0.001
Interpersonal conflict	7.0 (2.0)	7.0 (2.0)	6.9 (2.0)	0.69	6.7 (1.9)	6.7 (1.8)	6.8 (2.0)	0.96
Poor physical environment	2.3 (1.0)	2.4 (1.0)	2.3 (1.0)	0.43	2.6 (1.0)	2.6 (1.0)	2.5 (1.0)	0.47
Hypertention, %	27.9	30.5	22.7	0.14	11.5	9.9	14.9	0.07
Physically active, %	26.4	30.9	17.3	0.01	32.3	37.6	21.1	<0.001
Current smoker, %	24.2	20.5	31.8	0.02	9.7	7.7	13.9	0.02
Current drinker, %	64.8	64.5	65.5	0.87	40.6	40.3	41.2	0.84
Menopause, %					36.1	39.4	29.4	0.02

The data were collected between 2001 and 2009 in Osaka, Japan.
[#] Comparison between managers/professionals and general workers.

Peripheral blood flow (laser Doppler perfusion units: PU) was measured on the third finger with a laser Doppler blood flowmeter (PriFlux PF-4000; PERIMED, Sweden) during the specified experimental periods. Blood flow was obtained from the product of the number of red blood cells and blood flow velocity. The laser Doppler blood flowmeter measures intracapillary blood flow approximately 0.5 mm below the skin's surface (Yamada and Ohta, 2005).

Blood was collected and placed into a plain siliconized glass tube and the serum was separated immediately by centrifugation. The interval since the last meal was 0.2–21.2 h; fasting was defined as ≥8 h. Serum glucose and total cholesterol levels were measured according to a previous study (Cui et al., 2014). All blood tests were performed at the laboratory of the Osaka Medical Center for Health Science and Promotion.

Hypertension was defined as SBP ≥ 140 mm Hg, and/or DBP ≥ 90 mm Hg, and/or use of antihypertensive medication. Diabetes mellitus was defined as a fasting glucose level of ≥126 mg/dL or a non-fasting glucose level of ≥200 mg/dL, and/or the use of medication for diabetes mellitus. Hyperlipidemia was defined as total cholesterol levels ≥220 mg/dL and/or use of medication for hyperlipidemia.

Height in stockinged feet and weight in light clothing were measured. Body mass index was calculated (kg/m^2). The participants were asked about their smoking status (never, ex- and current smokers) and alcohol drinking status (never, ex- and current drinkers). Physical activity was evaluated using the scale of the Japan Arteriosclerosis Longitudinal Study (Naito et al., 2003). Participants were asked whether they had exercised regularly for more than 15 min within the previous 3 months and were categorized as physically active if they answered "Yes." Depressive symptoms were assessed using the Japanese translation of the Center for Epidemiologic Studies Depression Scale (CES-D scale) (Shima et al., 1985), of which 20 items ($\alpha = 0.89$) were scored from 0 (not at all) to 3 (for longer than 5 days).

2.4. Statistical analyses

The Student's *t*-test was used to compare age, body mass index, and scores for job stressors between occupational statuses (managers/professionals and general workers). The χ^2 test was used to compare categorical variables between occupational statuses. Because vital measurements were higher during pre- than post-task rests, post-task periods were treated as rest periods (Hirokawa et al., 2014). Differences between mean values for the two tasks and post-task rest were calculated as changes in reactivity. SBP, DPB, heart rate, and the LF/HF ratio during the stress tasks were increased compared with the post-task rest, whereas HF and peripheral blood flow during the stress tasks were decreased. Analysis of covariance was performed to compare changes in reactivity between occupational status, with adjustment for age. Bonferroni's post hoc test was performed. Multiple linear regression analyses were performed for each change in reactivity as an objective variable and occupational status (managers/professionals as a reference), age, body mass index, depressive symptoms, alcohol drinking status, smoking status, and hypertension status for men and women as explanatory variables. Menopausal status was also included for women. Multiple linear regression analyses stratified by occupational status were performed to examine associations between changes in reactivity and job stressors, with adjustment for potential confounders. All statistical analyses were performed with SPSS version 23. All probability values for statistical tests were two-tailed, and values of $p < 0.05$ were regarded as statistically significant.

Table 3
Age-adjusted mean values and standardized errors (SE) of changes in cardiovascular reactivities to the tasks.

	Men					Women				
	Managers/professionals		General workers		p value[#]	Managers/professionals		General workers		p value[#]
	Mean	SE	Mean	SE		Mean	SE	Mean	SE	
Changes in systolic blood pressure (mm Hg)	12.18	0.62	12.12	0.89	0.95	13.52	0.53	12.98	0.77	0.57
Changes in diastolic blood pressure (mm Hg)	8.39	0.52	8.68	0.75	0.75	9.27	0.40	9.13	0.58	0.85
Changes in heart rate (beats/min)	0.83	0.42	0.63	0.61	0.78	1.62	0.28	2.39	0.40	0.12
Changes in LF (ms^2/Hz)	0.37	4.47	7.84	6.40	0.35	15.69	3.22	18.24	9.04	0.66
Changes in HF (ms^2/Hz)	−22.14	2.66	−17.95	3.80	0.37	−24.55	1.94	−20.07	2.82	0.20
Changes in LF/HF	1.48	0.11	1.49	0.15	0.97	1.35	0.08	1.49	0.11	0.27
Changes in peripheral blood flow (PU)	−27.07	2.84	−19.04	4.07	0.11	−32.00	2.40	−34.91	3.48	0.50

The data were collected between 2001 and 2009 in Osaka, Japan.
[#] p value was based on a result of t-test to compare between managers/professionals and general workers.

Table 4
Results of multiple linear regression analyses for associations between job stressors and changes in cardiovascular reactivities to the tasks.

	Men						
	Systolic blood pressure (mm Hg)	Diastolic blood pressure (mm Hg)	Heart rate	LF (ms^2/Hz)	HF (ms^2/Hz	LF/HF	Peripheral blood flow (PU)
	Standardized-beta[a]	Standardized-beta[a]	Standardized-beta[a]	Standardized-beta[a]	Standardized-beta[a]	Standardized-beta[a]	Standardized-beta[a]
General workers[b]	−0.04	−0.01	−0.02	0.03	−0.01	−0.08	0.07
Quantitative job overload	−0.05	−0.15*	−0.17*	−0.02	−0.07	−0.21**	−0.14
Qualitative job overload	0.07	0.11	0.16*	0.04	0.00	0.04	−0.01
Physical demands	−0.17**	−0.14*	−0.04	−0.06	−0.02	−0.09	0.17**
Interpersonal conflict	−0.03	−0.01	0.07	0.02	0.00	0.01	0.07
Poor physical environment	0.01	0.02	−0.03	0.01	−0.16*	0.05	−0.09

The data were collected between 2001 and 2009 in Osaka, Japan.
[a] Adjusted for age, body mass index, depressive symptoms, alcohol habits, smoking status, physical activity, and hypertension treatment for both men and women, and adjusted for menopause for women.
[b] Managers/professionals were treated as reference.
* $p < 0.05$.
** $p < 0.01$.

Table 5
Results of multiple linear regression analyses for associations between job stress and cardiovascular reactivities to the tasks, stratified by occupational status.

	Men						
	Systolic blood pressure (mm Hg)	Diastolic blood pressure (mm Hg)	Heart rate	LF (ms^2/Hz)	HF (ms^2/Hz)	LF/HF	Peripheral blood flow (PU)
	Standardized-beta[a]	Standardized-beta[a]	Standardized-beta[a]	Standardized-beta[a]	Standardized-beta[a]	Standardized-beta[a]	Standardized-beta[a]
Managers/professionals							
Quantitative job overload	−0.04	−0.19*	−0.17	−0.11	−0.05	−0.29**	−0.14
Qualitative job overload	0.06	0.15	0.10	0.10	−0.06	0.11	−0.05
Physical demands	−0.22**	−0.18*	−0.09	−0.14	−0.10	−0.04	0.21**
Interpersonal conflict	0.01	0.04	0.07	0.11	0.00	0.07	0.06
Poor physical environment	−0.01	−0.01	−0.04	0.06	−0.18*	0.07	−0.07
General workers							
Quantitative job overload	−0.06	−0.09	−0.17	0.12	−0.04	−0.08	−0.12
Qualitative job overload	0.05	0.04	0.28*	−0.10	0.04	−0.09	0.04
Physical demands	−0.07	−0.07	0.07	0.06	0.04	−0.17	0.08
Interpersonal conflict	−0.11	−0.06	0.11	−0.14	0.04	−0.08	0.11
Poor physical environment	−0.01	−0.01	−0.04	0.00	−0.12	−0.05	−0.12

The data were collected between 2001 and 2005 in Osaka, Japan.
[a] Adjusted for age, body mass index, depressive symptoms, alcohol habits, smoking status, physical activity, and hypertension treatment in both men and women, and adjusted for menopause in women.

3. Results

Table 2 shows relevant participants' variables according to occupational status. Male and female managers/professionals were older and had greater job stressors, including quantitative job overload, qualitative job overload, and physical demands compared with general workers. However, female managers/professionals scored less for depressive symptoms than female general workers. Men showed the same tendency, but this was not significant. A greater proportion of male and female managers/professionals than that of general workers were physically active, whereas there were fewer current smokers among managers/professionals than among their counterparts. The proportion of menopausal participants was greater among managers/professionals than among general workers.

Table 3 shows age-adjusted mean values of changes in cardiovascular reactivity between stress tasks and the post-task periods. There was no significant difference between occupational status for men and women. SBP, DBP, heart rate, LF, and the LF/HF ratio were increased after acute stress, whereas HF and peripheral blood flow were decreased.

Table 4 shows the results of multiple linear regression analyses for associations between job stressors and cardiovascular reactivity to tasks. In men, quantitative job overload was inversely associated with changes in DBP, heart rate, and the LF/HF ratio. Qualitative job overload was positively associated with changes in heart rate. Physical demands were inversely associated with changes in SBP and DBP, but were positively associated with peripheral blood flow. A poor physical environment was inversely associated with changes in HF. In women,

Women						
Systolic blood pressure (mm Hg)	Diastolic blood pressure (mm Hg)	Heart rate	LF (ms^2/Hz)	HF (ms^2/Hz)	LF/HF	Peripheral blood flow (PU)
Standardized-beta[a]	Standardized-beta[a]	Standardized-beta[a]	Standardized-beta[a]	Standardized-beta[a]	Standardized-beta[a]	Standardized-beta[a]
−0.08	−0.04	0.07	−0.02	0.03	0.01	0.02
0.09	0.09	−0.02	−0.06	0.02	−0.02	−0.07
−0.12*	−0.11	−0.08	−0.06	−0.06	0.02	0.10
−0.04	−0.02	0.05	0.07	−0.03	−0.03	0.07
−0.07	−0.04	0.01	−0.01	0.03	−0.01	0.01
0.10*	0.07	0.08	0.01	−0.03	−0.05	0.03

Women						
Systolic blood pressure (mm Hg)	Diastolic blood pressure (mm Hg)	Heart rate	LF (ms^2/Hz)	HF (ms^2/Hz)	LF/HF	Peripheral blood flow (PU)
Standardized-beta[a]	Standardized-beta[a]	Standardized-beta[a]	Standardized-beta[a]	Standardized-beta[a]	Standardized-beta[a]	Standardized-beta[a]
0.09	0.10	−0.03	−0.03	−0.01	−0.03	−0.02
−0.12	−0.07	−0.01	−0.08	−0.05	−0.03	0.13
−0.04	−0.03	0.01	0.02	−0.02	−0.03	−0.03
0.00	0.01	−0.02	−0.01	0.07	0.02	−0.03
0.10	0.05	0.10	0.06	−0.05	−0.03	0.04
0.09	0.09	0.05	−0.12	0.03	0.01	−0.08
−0.09	−0.14	−0.19	0.03	−0.03	0.10	0.00
−0.05	0.00	0.06	0.13	0.03	−0.02	0.23*
−0.22**	−0.14	0.06	−0.02	−0.09	−0.11	0.07
0.15*	0.14	0.03	−0.08	0.05	−0.08	0.05

qualitative job overload was inversely associated and a poor physical environment was positively associated with changes in SBP. The results were not altered when pre-task rest data were included in the models as baseline data.

When stratified by occupational status, significant associations between job stressors and changes in stress reactivity remained among male managers/professionals (Table 5). In male managers/professionals, quantitative job overload was inversely associated with changes in DBP and LF/HF. Physical demands were inversely associated with changes in SBP, DBP, and peripheral blood flow. A poor physical environment was inversely associated with changes in HF. However, qualitative job overload was positively associated with changes in heart rate in male general workers. In contrast to the findings in men, no significant associations were found for female managers/professionals. However, among general workers, physical demands were positively associated with changes in peripheral blood flow, and interpersonal conflicts were inversely associated and a poor physical environment was positively associated with changes in SBP.

4. Discussion

The current study showed that occupational status did not significantly affect cardiovascular reactivity to stress in men and women. However, we found that most of the job stressors were inversely associated with changes in cardiovascular reactivity in both sexes, except for associations between qualitative job overload and change in heart rate in men, physical demand and change in peripheral blood flow in men, and a poor physical environment and change in SBP in women. These associations may be modified by occupational status, and significant associations remained in male managers/professionals. Sex differences were also significant. In contrast to the findings in men, female general workers showed significant associations between job stressors and changes in cardiovascular reactivity.

In this study, blood pressure, heart rate, LF, and the LF/HF ratio were increased, while peripheral blood flow and HF were decreased because of stressful tasks. However, some previous studies have reported that chronic job stress levels were inversely associated with blood pressure reactivity to stressful tasks (Schaubroeck and Ganster, 1993; Phillips et al., 2011, 2005; Ohira et al., 2011). Recently, several studies have shown that large and small stress reactions can indicate poor homeostasis and a possible risk of disease (Carroll et al., 2009). Large cardiovascular system responses have been assumed to indicate systemic dysfunction (Manuck et al., 1989), and this may also be the case for small responses (Carroll et al., 2009). Frequent exposure to chronic stressors is thought to result in a gradual decline in their effect on the cardiovascular system. Ohira et al. (2011) suggested that chronic job stress levels may lead to a weaker connection between the brain and cardiovascular activities. Similarly, high depression scores are negatively associated with cardiovascular reactions to acute stress (Taylor, 2010). We found a negative association between depression scores and heart rate reactivity in women (data not shown). McEwen (1998) focused on allostatic load, which is manifested through failure of recovery mechanisms to acute stress, when overloaded with chronic stress and lifestyle factors, such as smoking and alcohol habits. In the present study, because post-task periods were treated as rest periods, a small change in cardiovascular reactivity might have indicated impaired post-stress recovery. Weaker responses to stress are postulated to reflect downregulation or other types of physiological accommodation to chronic sympathetic receptor density and sensitivity (Taylor, 2010).

In the current study, there was no significant effect of occupational status on cardiovascular reactivity. However, when stratified by occupational status, significant associations between job stressors and cardiovascular reactivity were found in male managers/professionals. Male Japanese managers/professionals may be more susceptible to stress effects than general male workers. Male Japanese managers show high stress levels in daily life (Fukuda et al., 2005), and tend to have more job involvement or organizational commitment (Lincoln and Kallengerg, 1990) and to work longer hours than their equivalents in Western countries (Maruyama and Morimoto, 1996). Accordingly, cardiovascular disease mortality has been increasing among male Japanese managers since the late 1990s (Wada et al., 2012). In the present study, teachers, who comprised the majority of professionals, were combined with managers in a higher occupational status category. In Japan, teachers are subjected to high stress. In 2009–2011, 0.6% of Japanese teachers were suspended from their jobs because of mental disorders (Ministry of Education, Culture, and Sports, Science and Technology Kyo shokuin no mental health taisaku ni tsuite, 2013). Male and female teachers had higher job stress levels than other occupational categories in the present study (data were not shown). Associations between job stressors and changes in cardiovascular reactivity could vary depending on occupations. The sample of the present study did not allow us to distinguish the effect of occupational status or occupational differences of teachers on cardiovascular reactivity. Future studies should consider occupational effects on those associations.

Hallqvist et al. (1998) described mediating and moderating roles of job stress factors on associations between socioeconomic status and myocardial infarction. In our study, occupational status did not significantly affect cardiovascular reactivity, but the magnitude and type of job stressors may vary by occupation. Additionally, cardiovascular reactivity to stress could be influenced by the magnitude and type of job stressors. Vulnerability or susceptibility to job stressors by occupation could be reflected by cardiovascular function. In terms of prevention, types of job stressors by occupation should be clarified, and then a stress management program targeted to a specific type of stressor should be implemented in the workplace.

In the present study, we also found significant sex differences. In contrast to the findings in men, female general workers showed significant associations between job stressors and changes in cardiovascular reactivity. Although female general workers showed lower job stressor levels than female managers/professionals, their depressive symptom scores and the percentage of current smokers were higher, and the percentage of being physically active was lower than in female managers/professionals. In the present study, most of the female general workers were white-collar workers, and were engaged in supportive roles (Kawakami and Haratani, 1999). Female workers in service and sales have high stress levels and unhealthy lifestyles (Fukuda et al., 2005). Japanese women in white-collar jobs have higher concentrations of fibrinogen (Hirokawa et al., 2009) and also show a tendency towards a higher mortality risk than female managers (Hirokawa et al., 2013). The sex differences in associations between socioeconomic indicators and health in Japanese workers may be attributable to economic development, culture, and historic backgrounds (Alves et al., 2012). In Japan, the idea that men should go to work while women should stay at home has persisted in the public mind. Only a small percentage of Japanese managers are women (8.7% of all managers in 2012) (Ministry of Health, Labour, and Welfare Heisei 23 Nendo Koyo Kinto Kihon Chosa, 2012). The effects of occupational status on working women's health should be further investigated in future studies.

There are several limitations of this study. The participants were not representative of the Japanese working population in that the majority of professionals were teachers (44% of men and 54% of women), as explained above. Selection bias may have affected the results because we could not distinguish the effects of occupational status and occupational differences on cardiovascular reactivity. Additionally, we classified occupational status based on vital statistics that were published in Japan (Fukuda et al., 2005; Saeki et al., 2000), and accordingly, combined managers with professionals and white- with blue-collar workers. This combination may have led to biased results. Multiple linear regression analyses stratified by professionals and general workers with white-collar jobs showed that results for women and those for LF/HF, HF, and peripheral blood flow in men showed the same tendencies as our original stratification (data not shown). Although we consider our classification of occupational status to be valid, large samples for managers and blue-collar general workers would be of interest. Furthermore, managers and professionals may be more successful people than general workers. Because the age of managers and professionals was higher than that of general workers, their working career may be longer than that of their counterparts. Length of service should be taken into account, but this was not measured in the present study. Although job stressors of managers and professionals were higher than those in general workers, their depressive symptoms were lower and their physical activity was higher than those in general workers. The effect of a healthy worker cannot be ruled out in this study.

The present study has several strengths. Analyses were performed on a large sample of healthy Japanese participants. No participants had a major past history of stroke or myocardial infarction, which might have affected cardiovascular reactivity. Furthermore, various potential confounders were taken into account in our analyses. Cardiovascular reactivity was evaluated by various measures, including blood pressure, heart rate, heart rate variability, and peripheral blood flow.

In conclusion, our study shows that job stressors are associated with changes in stress reactivity in men and women. These associations may be modified by occupational status. Male managers/professionals and female general workers show significant associations between job stressors and changes in stress reactivity. Occupational status should be considered when assessing stress-related cardiovascular risk in working men and women in future studies. This is because socioeconomic status may affect associations between chronic job stressors and cardiovascular reactivity to stress.

Ethics

This study was conducted after obtaining approval from the Ethics Committee of the Osaka Medical Center for Health Science and Promotion.

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Conflict of interest

None.

Data sharing

No additional data available.

Authors' contributions to the study

Kumi Hirokawa analyzed the data and wrote the manuscript; Tetsuya Ohira contributed to writing the manuscript and data analyses, and also participated in data collection; Mako Nagayoshi participated in data collection and supervised management of the data set; Mitsugu Kajiura, Hironori Imano, Akihiko Kitamura, Masahiko Kiyama, and Takeo Okada participated in data collection and critically revised the manuscript; Hiroyuki Iso engaged in conception of the manuscript and critically revised the manuscript.

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