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Arterial blood pressure and blood lipids as cardiovascular risk factors and occupational stress in Taiwan

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Abstract

Background: This study is to determine whether occupational stress (defined as high psychological demands and low decision latitude on the job) is associated with increased blood pressure and abnormal level of blood lipids as cardiovascular risk factors. *Methods:* We conducted a cross-sectional study at three work sites of 526 white-collar male workers aged 20 to 66 years without evidence of cardiovascular disease. Systolic, diastolic blood pressure, serum total, high-density lipoprotein cholesterol and plasma triglyceride were measured. Occupational stress index was derived from data collected in the job strain questionnaire. *Results:* In multiple linear regression models, occupational stress index was significantly related to diastolic blood pressure and plasma triglyceride, after adjusting for age, education, smoking, and alcohol consumption. A higher occupational stress index was directly associated with higher systolic, diastolic blood pressure and higher level of plasma triglyceride. *Conclusions:* These data from a white-collar working population confirm independent relations between occupational stress defined in the job demand–control model and diastolic blood pressure observed in predominantly Western populations and extend the range of associations to plasma triglyceride than do previous studies. © 2001 Elsevier Science Ireland Ltd. All rights reserved.

Keywords: Blood pressure; Triglyceride; Occupational stress; Job strain

1. Introduction

The importance of behavioral and psychosocial factors is increasingly recognized in the prevention, development, and treatment of cardiovascular diseases (CVD) [1]. Mental stress is considered one of these factors [2,3]. The role of occupational stress in the etiology of CVD has recently received considerable attention. Occupational stress, in Karasek's job strain model, is characterized by the work environment and the extent to which it may allow individuals to modify the stress response [4,5]. The concept holds that stress caused by an imbalance between demands on a worker and the worker's ability to modify those demands. Low decision-making control coupled with high job demands leads to high strain or to a stressful situation. High demands and low control work synergistically to have more impact than either factor alone. Workers reporting high levels of occupational stress were found to have elevated risks of psycho-

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logical distress, psychosomatic and physical health complaints [6–10].

The cardiovascular health consequences of occupational stress are well documented in Western populations: individuals with high occupational stress are at increased risk of smoking [11–13], hypertension [13–15], CVD and its risk factors [16]. However, it remains unclear whether the relations between occupational stress and cardiovascular risk factors observed among individuals in Western work culture also apply to individuals in East Asian work culture. Hence, data from working populations in East Asian countries can be informative. Unfortunately, scant data are available on the association between job strain and cardiovascular risk factors in East Asian countries. We therefore examined the relation of occupational stress to systolic, diastolic blood pressure, serum total, high-density lipoprotein (HDL) cholesterol and plasma triglyceride using data from a cross-sectional survey of a male white-collar working population in Taiwan.

2. Materials and methods

2.1. Subjects

A cross-sectional study was conducted in Taipei City, Taiwan. All white-collar male workers employed in three private insurance companies were invited to participate. Almost all of the workers were professionals, technicians, managerial or clerical workers. Recruitment of participants was performed through announcements in the internal newsletters and a personalized e-mail of invitation to each worker. A total of 684 white-collar male workers aged 20 to 66 with more than 40 working hours per week were invited. Non-respondents were contacted by telephone calls. Among the recruited, those with clinical hypertension ($n=45$) or taking medication for CVD ($n=18$), which may lead to modification of regular health behaviors were excluded from the study. Missing data on systolic, diastolic blood pressure, serum total, HDL cholesterol or plasma triglyceride profiles ($n=12$) or on the occupational stress index ($n=8$) were also excluded. The study sample was comprised of 526 male white-collar workers. The overall participation rate was 77%. In comparison, there were no differences between study subjects and subjects excluded due to missing data in age, education, smoking, alcohol consumption, blood pressure, blood lipids and occupational stress index.

2.2. Cardiovascular risk factors

After overnight fasting, blood specimens were collected by venous puncture and handled according to prevailing clinical practice for analysis of serum total, HDL cholesterol, and plasma triglyceride in the company clinics. Immediately after specimen collection, vials were stored under appropriate conditions, refrigerated (4–8°C), or frozen (−20°C) until they were shipped to a single analytical laboratory for testing.

Blood pressure measurements were obtained by trained nurses after subjects had been seated for 10 min by using a mercury manometer and appropriately sized cuffs according to standard protocols. Triplicate measurements on the same arm were taken, with at least 30 s between readings. Each subject's systolic and diastolic blood pressures were calculated as the mean of the three independent measures.

2.3. Occupational stress indicators

A self-administered occupational stress questionnaire embedded with the Karasek job strain model and its measures was used to measure workers' perception of job strain, psychological demands and decision latitude. Psychological demands were measured by a five-item scale including quantity of work, quality of work intellectual requirements, conflicting demands, and time constraints. Decision latitude was measured by an eight-item scale including skill discretion factors: learning new things, skill development, skill requirement, task variety, repetition, creativity requirement and decision authority factors: freedom of making decisions, choice of ways to perform work. All questions were scored on a Likert scale of 1 to 5. Scale reliability was acceptable for decision latitude (Cronbach's $\alpha=0.80$), and psychological demands (Cronbach's $\alpha=0.76$). Occupational stress index was defined as a ratio of psychological demands score to decision latitude score.

2.4. Sociodemographic information and health-related behaviors

Data of sociodemographic information, and health-related behaviors were collected during interviews. These variables were used as confounders to control for potential confounding. Demographic variables included education and age at examination. The health-related behaviors included current smoking and alcohol consumption. Weight and height were measured during a physical examination before blood specimen collection. The body mass index (BMI) was calculated from weight and height using the equation: body mass index=weight (kg)/height $(m)^2$.

2.5. Statistical analysis

Descriptive statistics including means, standard deviations, and percentages were used to summarize the cardiovascular risk factors, occupational stress indicators, sociodemographic information and health-related behaviors of the study sample.

Multivariate linear regression was used in our study to examine the relations between occupational stress index and cardiovascular risk factors, simultaneously controlling for age, education, current smoking, and alcohol consumption. In separate models, we used systolic, diastolic blood pressure, serum total, HDL cholesterol and plasma triglyceride as dependent variables. In analyses treating occupational stress index as a categorical variable, average differences were calculated in systolic, diastolic blood pressure, serum total, HDL cholesterol and plasma triglyceride and their 95% confidence intervals. The significance level for all statistical analyses was set at a probability of less than 0.05 (two-tailed test). All data in this study were analyzed by the Statistical Package for Social Sciences version 10.0 (SPSS Inc, Chicago, IL).

3. Results

Characteristics of the study population are presented in Table 1. Table 2 presents the mean values and standard deviation of cardiovascular risk factors and occupational stress indicators of the study sample. Table 3 shows parameter estimates and standard errors from separate regression models predicting systolic, diastolic blood pressure, plasma triglyceride, serum total and HDL cholesterol. In all these models, occupational stress index was treated as a continuous variable. After adjusting for age, education, BMI,

Table 1
Characteristics of study sample

	N=526 Percentage
Sociodemographic data and health-related behaviors	
Smoker	29.5
Drinking alcohol	39.4
Education illiterate or elementary school	1.3
high school	20.6
college or above	78.1
	Mean (S.D.)
Age (years)	48.25 (11.56)
Body mass index (kg/m^2)	28.24 (5.69)

Table 2
Mean values of cardiovascular risk factors and occupational stress indicators

	N=526 Mean (S.D.)
Cardiovascular risk factors	
Systolic blood pressure (mmHg)	122.68 (23.18)
Diastolic blood pressure (mmHg)	76.84 (19.57)
Serum total cholesterol (mg/dl)	180.58 (24.61)
Serum HDL[a] cholesterol (mg/dl)	53.29 (10.47)
Plasma triglyceride (mg/dl)	98.94 (11.78)
Occupational stress indicators	
Psychological demand (5–25)	17.03 (1.79)
Decision latitude (8–40)	22.54 (2.12)
Occupational stress index[b]	0.77 (0.18)

[a] HDL, high density lipoprotein.
[b] Occupational stress index, ratio of psychological demand to decision latitude.

Table 3
Regression coefficients for cardiovascular risk factors by occupational stress index

Dependent variables	Beta	S.E.
Systolic blood pressure (mmHg)	8.21	0.79
Diastolic blood pressure (mmHg)	17.32*	3.42
Serum total cholesterol (mg/dl)	−2.14	1.56
Serum HDL cholesterol (mg/dl)	6.37	1.44
Plasma triglyceride (mg/dl)	18.61*	3.31

*$P<0.05$.
Age, education, BMI, smoking, and alcohol consumption were adjusted for using multiple linear regression.
Beta, regression coefficient for the occupational stress index; S.E., standard error; HDL, high density lipoprotein.

Table 4
Estimated average differences in means and 95% confidence intervals for cardiovascular risk factors by occupational stress index

	Quartiles of occupational stress index (median value)						
	1 (0.46)	2 (0.68)		3 (0.84)		4 (0.93)	
		Average difference	95% CI	Average difference	95% CI	Average difference	95% CI
Systolic blood pressure (mmHg)	0 (ref)	3.42	1.34, 5.12	7.63	6.57, 8.94	10.21	8.83, 12.75
Diastolic blood pressure (mmHg)	0	6.84	4.54, 8.11	10.79	8.22, 13.54	17.97	14.95, 19.62
Serum total cholesterol (mg/dl)	0	8.35	4.18, 10.75	6.25	4.09, 9.98	9.12	6.77, 12.15
Serum HDL cholesterol (mg/dl)	0	1.51	0.46, 3.57	−3.17	−6.67, −2.11	6.94	4.36, 8.86
Plasma triglyceride (mg/dl)	0	6.93	4.43, 8.15	11.73	7.89, 14.13	13.06	8.73, 16.25

Age, education, body mass index, smoking, and alcohol consumption were adjusted for using multiple linear regression.
CI, confidence interval; HDL, high density lipoprotein.

smoking, and alcohol consumption, occupational stress index was found to significantly predict diastolic blood pressure. Occupational stress index was also positively and significantly associated with plasma triglyceride level. In the models predicting systolic blood pressure and serum total cholesterol, occupational stress index had positive regression coefficients, indicating that higher occupational stress index might be associated with increased levels of these two factors. However, none of the regression coefficients reached statistical significance. Table 4 presents the average differences in means and 95% confidence intervals for systolic blood pressure, diastolic blood pressure, serum total, HDL cholesterol and plasma triglyceride across quartiles of occupational stress index after adjusting for all confounders of interest. Compared with the lowest quartile of occupational stress index (median value=0.46), the value of systolic, diastolic blood pressure and plasma triglyceride increased monotonically with increasing levels of occupational stress index. A higher occupational stress index was directly associated with higher systolic, diastolic blood pressure and higher level of plasma triglyceride.

4. Discussion

These cross-sectional analyses of the data from a sample representative for the white-collar male working population in Taiwan support the existence of significant relations between occupational stress and cardiovascular risk factors. We observed significant and positive associations between occupational stress index and diastolic blood pressure and plasma triglyceride. No significant association between occupational stress index and systolic blood pressure, serum total or HDL cholesterol was detectable in our study sample.

The observed association is supported by the stress–response pathophysiologic link. Stress response involves two neuroendocrine systems — the sympathoadrenal medullary system, which secretes the catecholamines: adrenalin, and noradrenalin, and the pituitary–adrenal cortical system, which secretes corticosteroids such as cortisol. Under demanding conditions where the organism can exert control in the face of controllable and predictable stressors, adrenalin level increases, but cortisol decreases [17–19]. In low demand–low control situations, cortisol elevates, although catecholamines elevate only mildly [17]. However, in demanding low control situations (analogous to the increase of occupational stress index in our study), both adrenalin and cortisol are elevated [17–19]. Elevated levels of both catecholamines and cortisol appear to have severe consequences for myocardiac pathology [20]. The effect of high occupational stress status on the well-established cardiovascular risk factors may explain, at least in part, the association between occupational stress and increased cardiovascular disease risk observed in a number of previous studies [8,21–29].

This study has several strengths. Firstly, it is conducted in a representative sample of white-collar male workers. The response rate was reasonably high (77%), which therefore limited the potential of selection bias. Participants having conditions that could lead to modification of health behaviors were excluded, which limited the potential of information bias. Secondly, statistical analyses were performed with adjustment for a number of potential confounders. Confounders such as age, educational attainment, cigarette smoking, alcohol consumption and body mass index were included, which limited confounding bias.

It also needs to be kept in mind that this study may be subject to several limitations. The observed association between occupational stress index and diastolic blood pressure and plasma triglyceride generally supports the existence of possible pathways that link occupational stress to cardiovascular diseases. However, differences in genetic predisposition for variations in diastolic blood pressure and plasma triglyceride could not be taken into account. The cross-sectional design could result in information bias and selection bias, which could lead to either over- or underestimation of the true association. Lack of evaluation of the effect of occupational stress duration due to cross-sectional data used could lead to an underestimation of the true association. The use of a self-administered questionnaire to measure occupational stress may be subject to response bias. However, no reliable objective measurement of occupational stress was available. Perceptual measure of occupational stress may be a better indicator than some external stressors that might not be perceived or felt like stressors by workers. Objective formulation of the questionnaire used in this study is also an appropriate way.

In our study, diastolic blood pressure was associated with occupational stress. This is consistent with previous studies with similar measures of occupational stress [15,30]. Other studies of the association between occupational stress and diastolic blood pressure have produced mixed findings. Negative results were reported for Israeli workers and the Framingham study, although in the Framingham study, female clerical workers, who are likely to have high stress, had higher rates of coronary heart disease [31,32]. On the other hand, the Air Traffic Controllers study reported higher prevalence of hypertension in workers in high-traffic density situations, who are usually under high stress [33]. The negative finding may be due to lack of statistical power associated with the use of a proxy measure for occupational stress.

The degree of increase in diastolic blood pressure associated with occupational stress among white-collar male workers in our study is similar to that observed in previous studies in Western countries [16]. The underlying psychophysiological mechanisms of the association between occupational stress and blood pressure might be common between Western countries and Taiwan, suggesting the involvement of a biological response or basic cognitive process rather than a culture-dependent response.

Our study did not support previous findings of a relation between occupational stress and systolic blood pressure [13,34]. However, our result is consistent with an Australian baseline study [35] and a study done among employed Danish workers [36]. As Chapman et al. pointed out in a prospective study on perceived work stress and blood pressure change [14], the cross-sectional design may be responsible for the lack of support to the hypothesis. Another reason for the negative or weak findings could be the utilization of casual measures of blood pressure conducted away from the work, which may be less reliable and less relevant than ambulatory measures.

Occupational stress where the level of job demands exceeds the individual's ability to control or deal with those demands creates a challenge that activates the sympathetic nervous system and leads to an elevation of blood pressure at work. Long-term exposure to occupational stress ultimately results in a sustained elevation of blood pressure that then causes structural and functional damage in the cardiovascular system.

To the best of our knowledge, this is the first time occupational stress has been found to be related to plasma triglyceride. This finding requires replication in other designs and settings to establish its validity. The exact role of hypertriglyceridemia as a risk factor for cardiovascular disease remains elusive [37]. Although high plasma triglyceride levels are generally predictive of cardiovascular risk, multivariate adjustment for other risk factors weakens this association [38,39]. Furthermore, significant individual variation exists in plasma triglyceride levels, which probably leads to substantial bias [40].

We failed to show an association between occupational stress, serum total and HDL cholesterol. Previous studies in Western countries have reported no significant effect of occupational stress on serum total and HDL cholesterol [13,30]. The effect of occupational stress on serum total and HDL cholesterol might be less clear than that on blood pressure.

It is also noteworthy that the results cannot be over-generalized. Our sample was small and was not representative of the general population. The differences of means were small and some associations may have appeared by chance in our analyses. Not many cohort studies so far have evaluated the relation between occupational stress and cardiovascular risk factors and even fewer among East Asian populations. Further data will be collected on a longitudinal basis for this study sample of white-collar male workers to evaluate the long-term effect of occupational stress exposure.

In conclusion, this study suggests that occupational stress index is associated with diastolic blood pressure and plasma triglyceride which may explain the link between occupational stress and increased cardiovascular disease risk.

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