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Job Stress and Coronary Heart Disease: A Case-control Study using a Chinese Population

Weixian XU[1], Yiming ZHAO[2], Lijun GUO[1], Yanhong GUO[1] and Wei GAO[1]

[1]Department of Cardiology, Peking University Third Hospital and Key Laboratory of Molecular Cardiovascular Science, Ministry of Education and [2]Research Center of Occupational Medicine, Peking University Third Hospital, China

Abstract: Job Stress and Coronary Heart Disease: A Case-control Study using a Chinese Population: Weixian XU, *et al.* Department of Cardiology, Peking University Third Hospital and Key Laboratory of Molecular Cardiovascular Science, Ministry of Education, China—Objectives: This study was to examine the association between job stress and coronary heart disease (CHD) in a Chinese population. **Methods:** The 388 participants aged 30 to 70 yr who received coronary angiography for suspected or known ischemic heart disease were enrolled in this series, which included 292 CHD cases and 96 controls. The job stress before CHD onset was measured by the effort-reward imbalance (ERI) model. **Results:** In the results, compared with the baseline, high ERI, high extrinsic effort or high overcommitment increased the risk of CHD with odds ratios (OR) of 2.8, 2.7 and 2.8 respectively after adjustment for the traditional CHD risk factors, such as age, gender, primary hypertension, diabetes mellitus, hyperlipidemia, smoking, body mass index, CHD family history, educational level, and marital status. The combination of high ERI and high overcommitment led to the highest risk of CHD with adjusted OR 5.5. However, high reward reduced the risk of CHD with an adjusted OR of 0.4 in comparison to low reward. Dose-response relationships were also observed. **Conclusions:** Job stress evaluated by the ERI model significantly increased the risk of CHD, and it may be an important risk factor independent of the traditional risk factors of CHD in the Chinese population.
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Key words: Coronary artery disease, Job stress, Risk factors

With the development of economic globalization and rising competition, job stress has attracted increasing public concern in the developed countries. The effort-reward imbalance (ERI) model[1)] is one of the most widely used models for evaluating job stress and includes three scales: extrinsic effort, reward and overcommitment. It has been documented that job stressors evaluated by the ERI model may be important new risk factors for coronary heart disease (CHD)[2–10)]. Peter *et al.*[2)] reported job stress was associated with myocardial infarction in the retrospective SHEEP study. In the prospective Whitehall II cohort study, Kuper *et al.*[9)] found job stress increased the risk of CHD. Kivimäki *et al.*[10)] also reported the same results in a meta-analysis. However, most of the studies were conducted in Western societies. Studies of this issue in Asia are still at the starting stage except in Japan[11)]. Today, due to rapid industrialization China is regarded as the "world's factory", and stress at work has become a risk factor which threatens the health of Chinese workers[12, 13)]. CHD is the leading cause of death in the world. Mortality rates of CHD have been halved in many developed countries since the 1980s, but are still rising in most developing countries, including China[14)]. Meanwhile, the knowledge about the association between job stress and CHD in the Chinese population is limited. Jian Li *et al*. developed the Simplified Chinese Version of the Effort-Reward Imbalance Questionnaire (C-ERIQ) based on the ERI model, and found that C-ERIQ was a reliable and valid instrument for measuring psychosocial stress at work in Chinese working populations[15, 16)]. Xu[17)] reported job stress was associated with the systolic blood pressure of Chinese working women. However, Asian study has yet examined the association between ERI and CHD. Furthermore, previous studies were limited by assessment of recent job stress at only one point in time and an outcome dependent on the subjective experience

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Correspondence to: W. Gao, Department of Cardiology, Peking University Third Hospital and Key Laboratory of Molecular Cardiovascular Science, Ministry of Education, No.49, North Garden Road, Beijing 100191, P.R. China
(e-mail: dr_gaowei@medmail.com.cn)

of CHD symptoms leading to their underestimation or over-estimation[18]. Therefore, the purpose of the present study is to assess the association between job stress and CHD in a Chinese population.

Methods

Subjects

Four hundred consecutive patients aged 30 to 70 yr with chest pain, who had a full time job for more than 5 yr, underwent coronary angiography for suspected or known ischemic heart disease at Peking University Third Hospital from October 2005 to December 2006. This hospital is the largest comprehensive hospital in the Haidian District of Beijing. It is also an appointed hospital for coronary angiography under medical insurance, and the patients who need coronary angiography in this area attend this hospital. Therefore this sample was representative of coronary angiography patients. Twelve patients were excluded because they had cardiac diseases such as valvular (7 patients), congenital (1 patient), or pericardial diseases (1 patient) or myocardiopathy (3 patients). The final sample size was 388 (the participation rate of the patients was 97%) with various occupations. Their mean age was 55.5 yr old and 75.5% of the population was male. Among the sample, 320 patients underwent coronary angiography for the first time and 68 patients had received it more than once. This study was in accordance with Declaration of Helsinki and all patients provided their informed consent.

Diagnosis of coronary heart disease

The diagnosis of CHD was based on the coronary artery angiography and the clinical manifestation. The assessment of coronary arteries was done by physicians who didn't take part in the research and were blind to the patients' job stress levels. Coronary artery luminal stenosis was assessed in accordance with the American Heart Association method[19]. CHD cases were defined as a 50% or greater luminal stenosis of one or more major coronary arteries, and the patients with normal or less than 50% stenosis of all arteries and without the typical ischemic manifestation were defined as controls.

Procedures

A questionnaire based interview elicited details of job stressors, medical and family history, and lifestyle factors. The interview was done by a research physician face-to-face with every patient. The interviewer was blind to the results of the coronary angiography. First, the patients were requested to list all the full time job titles before the first occurrence of a symptom or an abnormal clinical test suggestive of CHD. Then, the patients described the job stressors in general and completed the ERI questionnaire. If there was more than one job title and job stress level largely varied, the patients were asked to report the status of the relatively more stressful job title. To reduce potential information bias, the interviewer sat with each patient and explained the questions which the patient did not understand clearly during the time they completed the questionnaire. Finally, the interviewer reviewed the questionnaire and questioned the patients about any inconsistent information to make sure that the information was an accurate reflection of the patient's job characteristics.

Job stressors

Job stressors were assessed in accordance with Siegrist's ERI questionnaire (ERI-Q) whose validated Chinese version was developed by Li *et al*[15, 16]. The 23-item ERI-Q consists of three scales termed extrinsic effort representing job demands imposed on the employee (6 items), reward which consists of income, respect, job security and career opportunities (11 items), and overcommitment which defines a set of attitudes, behaviors, and emotions reflecting excessive striving in combination with a strong desire for approval and esteem (6 items). The response to each item of the effort scale is scored on 5-point scale, in which the value increases with rising stress level; that is, a value of 1 indicates no respective stressful experience, and a value of 5 indicates a very high stressful experience. Each item of the reward scale is also scored on 5-point scale, in which the value increases with reward level; that is, a value of 1 indicates very low reward, and 5 indicates very high reward. Each item of overcommitment is scored on a 4-point scale (1=full disagreement, 4=full agreement with statement). Cronbach's coefficients of effort, reward, and overcommitment were 0.67, 0.72, and 0.84, respectively.

The relation between the two scales of extrinsic effort and reward (equally weighted) , that is effort-reward imbalance (ERI), is calculated to quantify the degree of mismatch between high cost and low gain (ERI=11*effort/6*reward). The subjects were respectively grouped into one of three strata (low, intermediate, or high) for each job stressor based on tertiles defined according to the distribution of scores: 6–11, 12–15, 16 or greater, for extrinsic effort; 30–47, 48–52, 53 or greater, for reward; 8–13, 14–17, 18 or greater for overcommitment; 0.20–0.42, 0.43–0.58, 0.59 or greater, for ERI. Moreover, the combination of high level ERI and high level overcommitment was defined as high ERI*OVC, and the combination of low ERI and low overcommitment as low ERI*OVC, and all other combinations as intermediate ERI*OVC.

Traditional CHD risk factors

Traditional CHD risk factors were also collected. Laboratory data and medical treatments regarding primary hypertension, diabetes mellitus and hyperlipidemia were extracted from medical records. History of hypertension

Table 1. Sociodemographic variables and traditional coronary risk factors in cases and controls

	Cases (N=292)	Controls (N=96)	*p*
Mean age (yr)	55.7	54.9	0.472
Male	242 (82.9%)	51 (53.1%)	<0.001
Length of employment (yr)	32.5	31.1	0.103
Married	276 (94.5%)	89 (92.7%)	0.514
Education			
≤9 yr	101 (34.6%)	33 (34.4%)	0.969
10–12 yr	130 (44.5%)	46 (47.9%)	0.562
>12 yr	61 (20.9%)	17 (17.7%)	0.500
CHD family history	58 (19.9%)	8 (8.3%)	0.009
Primary hypertension	177 (60.6%)	64 (66.7%)	0.289
Hyperlipidemia	209 (71.6%)	57 (59.4%)	0.026
Diabetes mellitus	84 (28.8%)	16 (16.7%)	0.019
Smoker	210 (71.9%)	39 (40.6%)	<0.001
BMI (kg/m^2)	25.9 ± 3.0	26.5 ± 3.1	0.080

CHD: coronary heart disease; BMI: body mass index.

was defined as positive if subjects were under drug treatment for hypertension or if they had systolic blood pressure of 140 mmHg or higher and/or diastolic blood pressure of 90 mmHg or higher. Diabetes mellitus was defined as present when subjects were under dietary or drug treatment for diabetes mellitus or when they had casual plasma glucose of 200 mg/d*l* or higher or a fasting glucose level of 126 mg/d*l* or higher on two occasions. Hyperlipidemia was defined as present when subjects used lipid-lowering drugs or had serum total cholesterol of 220 mg/d*l* or greater, or total triglyceride of 150 mg/d*l* or greater. Height and body weight were also measured and BMI (kg/m^2) was divided into three groups: normal (≤24), overweight (>24 and <28), and obesity (>28). Other risk factor data were collected by questionnaire, including smoking (yes/no) and CHD family history (yes/no). Marital status was categorized as currently married or single. Educational level was determined by years of school completed, and divided into three groups: low (≤9 yr), medium (>9 yr and ≤12 yr) and high (>12 yr).

Statistical analysis

Differences in traditional CHD risk factors were statistically tested by the chi-square test or unpaired *t*-test. The association between each stressor and the presence of CHD was tested in logistic regression analysis in which the presence of CHD was used as the dependent variable with each job stressor as independent variables, and covariates were indicator variables representing categories of age, sex, primary hypertension, diabetes mellitus, hyperlipidemia, smoking, BMI, CHD family history, educational level, and marital status. Odds ratios (OR) and 95% confidence intervals (CI) were used to examine the association between job stressors and presence of CHD. The dose-response relationship was shown by a test for the trend. All computations were performed by the SPSS software package version 13.0.

Results

The final sample size was 388 comprising 292 (75%) cases and 96 controls. Differences between cases and controls are shown in Table 1. There were no significant differences with respect to mean age, length of service (years employed), education level, marital status, prevalence of hypertension, and BMI between the two groups. Cases were more likely to be male, to be smokers, and to have diabetes mellitus, hyperlipidemia, and CHD family history (p<0.05).

Table 2 summarizes the relation between each stressor and the presence of CHD. Compared with low ERI, high ERI increased the CHD risk significantly, OR=3.0 (95% CI 1.7 to 5.4). After adjustment for confounders, the association remained significant, OR=2.8 (95%CI 1.4 to 5.4). In addition, high extrinsic effort was associated with CHD presence (adjusted OR=2.7, 95%CI 1.4 to 5.3). Also, as hypothesized, high reward was associated with reduced CHD risk in comparison to low reward (adjusted OR=0.4, 95%CI 0.2 to 0.8). High overcommitment was significantly associated with increased CHD risk (OR2.8, 95%CI 1.4 to 5.3), and the combination of high ERI and high overcommitment (high ERI*OVC) led to the highest CHD risk, OR=5.5 (95%CI 2.2 to 13.4) after adjustment for confounders.

A dose-response relationship between job stressors and CHD was observed and Table 3 shows the results of a test for trend across the three groups: risk of CHD

Table 2. Logistic regression analysis: associations between the variables of the effort-reward imbalance model and prevalence of coronary heart disease

Variables	OR (95% CI)	OR (95% CI) †	OR (95% CI) ‡
Extrinsic effort			
Low	1.0	1.0	1.0
Intermediate	2.1 (1.2 to 3.7)**	2.3 (1.3 to 4.1)**	2.4 (1.3 to 4.6)**
High	3.0 (1.6 to 5.3)***	2.8 (1.5 to 5.2)**	2.7 (1.4 to 5.3)**
Reward			
Low	1.0	1.0	1.0
Intermediate	0.7 (0.4 to 1.2)	0.7 (0.4 to 1.2)	0.7 (0.4 to 1.4)
High	0.5 (0.3 to 0.8)**	0.4 (0.2 to 0.8)*	0.4 (0.2 to 0.8)**
Overcommitment			
Low	1.0	1.0	1.0
Intermediate	2.0 (1.1 to 3.5)*	1.8 (0.9 to 3.2)	1.8 (0.9 to 3.5)
High	2.9 (1.6 to 5.1)***	2.7 (1.5 to 4.9)**	2.8 (1.4 to 5.3)**
ERI			
Low	1.0	1.0	1.0
Intermediate	2.6 (1.5 to 4.6)**	2.5 (1.4 to 4.5)**	2.9 (1.5 to 5.5)**
High	3.0 (1.7 to 5.4)***	2.9 (1.6 to 5.4)**	2.8 (1.4 to 5.4)**
ERI*OVC			
Low	1.0	1.0	1.0
Intermediate	3.2 (1.8 to 5.6)***	2.8 (1.5 to 5.0)**	3.2 (1.8 to 6.2)***
High	6.0 (2.8 to 13.2)***	5.4 (2.4 to 12.2)***	5.5 (2.2 to 13.4)***

ERI: effort-reward imbalance; OVC: overcommitment.
†Adjusted for age, and sex; ‡Additionally adjusted for hypertension, hyperlipidemia, diabetes mellitus, smoking, BMI, CHD family history, education level, and marital status; *p<0.05; **p<0.01; ***p<0.001.

Table 3. Dose-response relationship between variables of the effort-reward imbalance model and presence of coronary heart disease

Variable	CHD		Total	Chi-square Tests Linear-by-Linear association	
	Yes	No		Value	*p*
Extrinsic effort					
Low	86	49	135	14.482	<0.001
Intermediate	97	26	123		
High	109	21	130		
Reward					
Low	117	26	143	7.497	0.006
Intermediate	98	32	130		
High	77	38	115		
Overcommitment					
Low	69	41	110	13.415	<0.001
Intermediate	97	29	126		
High	126	26	152		
ERI					
Low	80	49	129	15.355	<0.001
Intermediate	104	25	129		
High	108	22	130		
ERI*OVC					
Low	39	35	74	24.103	<0.001
Intermediate	179	50	229		
High	74	11	85		
Total	292	96	388		

CHD: coronary heart disease; ERI: effort-reward imbalance; OVC: overcommitment.

increased with the level of job stressor (except for the reward scale).

Discussion

In the Chinese population, we found that patients reporting high ERI had a three fold higher risk of CHD than the patients scoring low in this dimension, and a high level of overcommitment also increased the risk of CHD compared with a low level of overcommitment. Our findings are in accordance with previously reported findings from Western populations[2–10].

In this study, we found a dose-response relationship with respect to the association between job stressors and the presence of CHD. The patients exposed to high ERI/overcommitment had higher risk of CHD than those exposed to intermediate levels who in turn had higher risk of CHD than those in the low levels. Our results are in line with Kivimäki's study[7] which is the only study previously reporting the dose-response relationship between ERI and cardiovascular disease.

The combination of high level ERI and high overcommitment led to the highest risk of CHD (OR=5.5) after adjustment for potential confounding factors in the Chinese population. Few studies[9] have assessed the combination effect of ERI and overcommitment, and the findings from Western populations show no evidence of the combination effects. The difference between these earlier findings and that of the present study may be due to the assessment of job stressors. In this study we investigated the job stress in general in the lifetime before CHD onset. As CHD develops over a long time span, long-term rather than short-term levels of job stress are assumed to affect CHD incidence[20]. From imposition of job stressors to appearance of CHD there is a time lag, similar to the traditional risk factors for CHD observed in the MONICA study[21]. The effect of job stressors in a past time period may be more important than those in recent time periods on risk of CHD. For example, Chandola *et al*.[22] examined the association between ERI at two different times (1985–88 and 1997) and new CHD cases from 1997 to 2001 in the Whitehall II cohort, and found that ERI in the former phase (1985–88), but not the latter phase (1997), was associated with new CHD cases among women, and that there was cumulative effect of burden of exposure to ERI on CHD risk. Kivimäki *et al*.[23] assessed job stressors twice (3-yr time lag) in the Whitehall II cohort and compared the associations between the different stress scores and the incidence of new CHD in a 10-yr follow-up. For job strain, maximal scores and mean scores across the two time points were better predictors of CHD than the scores at the second time. Many studies likely underestimate the effect of chronic exposure to job stressors on CHD risk because job stressors were measured at only one point in time[18]. For employees with stable employment, a single-time measurement may provide an accurate estimate of long-term exposure to stressors, but that is not necessarily the case for others. Many participants with a long history of exposure to job stressors might be currently classified as having no job stress because of recent promotions or other job changes. This can result in misclassification and bias results toward the null hypothesis. However, job status was relatively stable in our sample due to the effect of the state-planning-oriented economic policy of China. In this sample, many patients (37%) had never changed their job title, 24% patients had changed their job title only one time in their lifetime, and the mean number of job changes for all patients was 1.7. Furthermore, job changes resulted in similar circumstances and job status didn't change a lot. So the job stress level in general was a reasonable approximation of job stressor exposure throughout a patient's career. Another reason for the difference between the findings of previous studies and those of the present study may be culture differences between Western countries and China, but this needs more study.

Another feature of our study is the use of an objective measure of the endpoint. That is, CHD was measured by combining angiography and clinical ischemic symptoms, ECG, and myokinase. This method can reduce reporting bias. Macleod *et al*.[24] reported that the association between psychosocial factors and self-reported heart disease probably resulted from reporting bias, namely, the tendency of participants' reporting higher stress to also report more symptoms. Garber *et al*.[25] found a poor relation between the "Rose questionnaire" which was used to measure angina and exercise thallium-201 scintigraphy, an objective measure of myocardial ischemia. The Whitehall II study[9] found that ERI was significantly related to the incidence of all CHD, but not to the "hard" endpoints such as fatal CHD or nonfatal myocardial infarction. A similar finding was also reported in the Framingham study[26]. Therefore, self-reported endpoints can lead to a spurious association between job stressors and CHD due to reporting bias.

Good quality control is strength of our study. Data were collected by physicians, who were familiar with patients' job careers, in face-to-face interviews using standard procedures. With the help of the physicians, patients provided information as accurately as possible. Physicians were blind to the results of the angiography. Moreover, the results of angiography were also read blindly to patients' job stressor data. In addition, the data were input into a computer by two different persons and data consistency was tested by Epidata software.

Several limitations of the present study need to be considered. First, as this was a case-control study, causal relationships cannot be determined. Second, we can't rule out recall bias due to the retrospective design and self-reported job stressors. However, our results are consistent with those of previous studies. The validity of self-reported ERI measurement has been substantiated in a number of recent findings[15, 16]. Previous studies using subjective and objective methods to assess job characteristics have tended to give reasonably consistent results[8, 27], and correlations between subjective assessment and expert rating of job characteristics are high[28]. In our study, the 68 patients with recurrent CHD were not excluded because we assessed the job stress before their first CHD onset. Taking into account that these patients were perhaps more likely to exaggerate their past job stress, than patients who did not know they had CHD, we repeated the analysis in Table 2 using only the 320 patients with first–time angiography and the results were similar (results not shown). So the recall bias is apparently not a source of major bias in our study. Third, the potential for selection bias exists. The cases and controls were all the patients undergoing coronary angiography. It has been shown that patients undergoing coronary angiography who do not have CHD have a high prevalence of psychosocial and occupational difficulties[29]. Thus, it is most likely that patients with adverse psychosocial profiles, including stressful job characteristics, were overrepresented among those without CHD. This type of selection bias may trend to attenuate the true association and lead to null results[30, 31]. Even though the association might be underestimated due to such selection bias, we found a significant association between job stressors and the presence of CHD. Another limitation is that we didn't assess other psychosocial factors, such as long working hours, shift work, and depression, which are possible confounders of CHD. Finally, the potential gender difference in the relationship between job stress and CHD was not detected because of the small sample number. We hope to improve the sample size in further studies.

In summary, the present study showed that high levels of ERI or overcommitment were associated with an increased risk of CHD. Moreover, a dose-response relationship was observed with regard to the effect of job stressors on CHD. Further studies with larger sample sizes and improved prospective design will be needed to confirm the role of job stressors on coronary atherosclerosis in the Chinese population.

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