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The relationship between job strain and coronary heart disease: evidence from an English sample of the working male population

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ABSTRACT

Background. Many, but not all, studies have reported that job strain is related to cardiovascular morbidity and mortality. To date, this relationship has not been tested on an English full population sample. This study examines whether the demand–control model of job strain contributes to our understanding of the determinants of coronary heart disease.

Methods. The analysis uses data from 4350 working men aged 20–64 in the 1993 Health Survey for England. Job demand and control characteristics were determined by questionnaire. Several health outcomes were examined: self-rated health; psychiatric health; angina and possible myocardial infarction, measured by the Rose questionnaire; doctor-diagnosed heart disease; any heart disease. The relationship between job strain and the health outcomes was determined by logistic regression analyses after controlling for known confounders.

Results. Those in high strain jobs consistently reported poorer health on all measures than men with lower strain. Similarly, men reporting low job strain were least likely to report poor health in 5/6 health outcomes. Those with intermediate levels of strain tended to have intermediate prevalence rates for poor health. The pattern of association between job strain and the CHD was independent of coronary risk factors.

Conclusions. The analyses broadly support Karasek's demand–control model of job strain. Health selection into low strain jobs may account for the lack of an association between job strain and doctor diagnosed heart disease while independent associations between job strain and all CHD measures considered together indicate that job strain may have aetiological significance for heart disease.

INTRODUCTION

The role of job strain, defined as high job demands combined with low levels of discretion or control over how the work is carried out, in the aetiology of coronary heart disease (CHD) is still open to question. Although many studies have reported positive associations between job strain and CHD morbidity and mortality (Alfredsson *et al.* 1982, 1985; Karasek *et al.* 1982, 1988; Johnson & Hall, 1988; Johnson *et al.* 1989; Hammar *et al.* 1994), other more recent studies have not found support for the relationship (Reed *et al.* 1989; Alterman *et al.* 1994; Hlatky *et al.* 1995; Steenland *et al.* 1997). Few studies have examined the association of job strain with CHD in a British setting. The Whitehall II study of British civil servants has examined the role of job demands and job control in the aetiology of psychological and physical ill-health, including CHD (North *et al.* 1993; Bosma *et al.* 1997; Stansfeld *et al.* 1997, 1998). In their sample, with a limited range of occupations, high demands were positively related to high control. This study seeks to extend that work to an English full population sample,

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covering a wider range of occupational situations, including those in which low control is combined with high demands.

The demand–control model (Karasek & Theorell, 1990) suggests that work psychological demands and decision latitude or control act together to affect physiological and psychological health. Four distinct job types are identified by combinations of high and low levels of control over work and demands of work. Active jobs are those where demands are high but so is work discretion or control. Typically, active jobs are both challenging and rewarding with individuals having resources to meet challenges. Thus, work stresses tend to be resolved with little residual job strain to affect health. Passive jobs have low demands together with little control or decision latitude. Karasek hypothesized that those in passive jobs would have average levels of psychological strain or illness risk, similar to that found in active workers. The detrimental effects of passive work are said to be in a decline in motivation and a loss of previously acquired skills. Low strain jobs are those where low demands are placed on an individual who has high levels of control over the execution of work. Thus, individuals experiencing low strain are hypothesized to have a lower than average risk of illness and psychological disturbance. The final category is the high strain job where demands are high but control over executing work is low. Those experiencing high levels of strain are expected to be at greatest risk of suffering physical or mental illness.

This work reports associations between job strain and health. A test of the explicit predictions of the Karasek model is carried out using the four job strain types outlined above. In line with the predictions of the Karasek model, the relationship between job strain and both self-rated and psychiatric health is examined. These general health measures have been found to predict later CHD (Moller *et al.* 1996; Glassman & Shapiro, 1998). The Karasek model is also tested against several heart disease measures to assess its utility for identifying those at risk for CHD. In line with Schnall *et al.*'s (1994) review of job strain and cardiovascular disease, results will be presented after adjustment for socio-economic position so that they are not confounded by the well-reported social gradient in health (Marmot, 1996). The adverse effects of health behaviours such as smoking, lack of exercise and a poor diet on coronary heart disease have been widely reported (Bovens *et al.* 1993; Posner *et al.* 1993; Eaton *et al.* 1995; Woodward & Tunstall Pedoe, 1995; Robertson & Platt, 1996; Bjerregaard *et al.* 1997; Singh *et al.* 1997; Byers *et al.* 1998; Gartside *et al.* 1998; Gensini *et al.* 1998). Relationships between job strain and these health behaviours have also been observed (Mensch & Candel, 1988; Green & Johnson, 1990; Netterstrom *et al.* 1991; Georges *et al.* 1992; Hellerstedt & Jeffery, 1997). Similarly, there have been reports of associations between job strain and some of the well-known physiological risk factors for heart disease, namely hypertension, high glucose and high cholesterol levels (Peter *et al.* 1998; Tsutsumi *et al.* 1998). We also present results after separately adjusting for behavioural and physiological risk factors to determine whether either set of factors mediate the relationship between job strain and health.

METHOD

Study population

The data were taken from the 1993 Health Survey for England (HSFE). The sampling procedure for the HSFE was designed to achieve a representative sample comprising approximately 17000 adults over 16 years of age living in private households. A random sample of addresses was selected using a multi-stage sample design stratified by Regional Health Authority, socio-economic group and lack of car. Survey interviews were attempted with all adults in each selected household. The sample considered here consists of men aged 20–64 years in full-time paid employment ($N = 4350$), with job strain data available in 97% of cases ($N = 4235$). Women were not included in this study because prevalence rates for heart disease in working-aged women are too low to detect effects and because the employment history of women tends to be more fragmented than that for men.

Health measures

Self-rated health

Respondents were asked 'How is your health in general? Would you say it was very good, good, fair, bad or very bad?' The responses were

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dichotomized into 'very good/good' *v.* 'fair/bad/very bad'.

Psychiatric health

This was assessed using the 12-item General Health Questionnaire (GHQ-12) (Goldberg *et al.* 1997) designed to detect non-psychotic psychiatric disorders. Scores > 2 on the GHQ-12 indicate minor psychiatric morbidity or psychological distress. The sound reliability and validity of the GHQ-12 using this threshold has been demonstrated in many studies (Banks, 1983; Gureje & Obikoya, 1990; Politi *et al.* 1994; Goldberg *et al.* 1997; Jacobs *et al.* 1997).

Angina

Angina was measured by the Rose angina questionnaire (Rose, 1962) and is defined as pain over the sternum or in both the left chest and arm that is precipitated by exertion, that causes the person to stop, and that usually remits within 10 min of standing still.

Possible myocardial infarction (MI)

This was also determined by responses to the Rose questionnaire. The definition of possible myocardial infarction is 'one or more attacks of severe pain across the front of the chest lasting for $\geqslant 30$ min'. The reliability of the Rose questionnaire and the validity of the measures of angina and possible MI have been replicated in several studies (Cook *et al.* 1989; Sorlie *et al.* 1996).

Doctor diagnosed heart conditions

Individuals were classified with a doctor diagnosed heart condition if they reported that they had been informed by a doctor that they suffered from 'angina, a heart attack, an abnormal heart rhythm or other heart trouble'.

Any heart disease

Men who were positive for angina, possible MI or doctor diagnosed heart conditions were classed as suffering from 'any heart disease'.

Employment characteristics

Job strain

Job strain was assessed using responses to nine questions in the HSFE self-completion questionnaire. These questions were developed for the Whitehall II study based on the Job Content Questionnaire (Karasek *et al.* 1998). There was some minor rewording and changes in the response categories for the items used in the Whitehall II and HSFE studies. The length of the full Job Content Questionnaire (42 items) prohibited its use in a large national survey of health trends, so items were selected for use in the HSFE which were shown to have high internal consistency on the two dimensions of work control and demands in the Whitehall II study (North, 1990). Work control was assessed from the answers to six items about decision latitude and variety. Study participants were asked whether the items referred to them 'often', 'sometimes', 'seldom' or 'never/almost never'. A high score (maximum 24) indicates a high level of control over work done. Work demands were assessed by three questions relating to pace of work, giving a maximum possible score of 12. High scores on the summed scale indicate high work demands on the individual. To create the four job strain categories described by Karasek, high and low control and demands were defined by median cutpoints on the two summed scales. These cutpoints were derived from all individuals who took part in the HSFE and were in work at the time and had completed the nine job strain items.

Socio-economic position

This was measured by the Erikson–Goldthorpe (E–G) schema (Erikson & Goldthorpe, 1992). The E–G schema was developed as a measure as part of a comparative study of social mobility patterns in industrial societies. The schema distinguishes between those who are employers or employees, perform manual or non-manual work, and have different employment relations. A similarly based measure has been used in the work of the European Union's working group on Socio-economic Inequality in Health (Kunst, 1997; Mackenbach & Kunst, 1997) and it is also the basis for the new socio-economic classification (SEC) to be implemented in the 2001 census (Rose & O'Reilly, 1997). In the analyses presented here, employment relations and conditions are measured by the six class E–G schema (Erikson & Goldthorpe, 1992).

Behavioural risk factors

Diet

A poor diet score was created by summing the number of dietary habits consistent with govern-

ment recommendations (Cardiovascular Review Group Committee on Medical Aspects of Food Policy, 1994) which the individual failed to adopt. These habits were: eating wholemeal or granary bread; eating high fibre breakfast cereal; drinking semi-skimmed or skimmed milk; using soft margarine or other low fat spreads; using oil not hard fat or lard for frying; reduced salt intake; eating fruit at least once every day; eating vegetables or salad at least once every day. Those failing to adopt at least three dietary habits consistent with government recommendations are considered to have a poor diet.

Smoking

This is an ordinal scale based on the number of cigarettes smoked in a week. The categories are: never smoked; ex-smoker; currently smokes < 10 cigarettes per day; smokes between 10 and 19 cigarettes per day; smokes $\geqslant 20$ cigarettes per day.

Leisure exercise

A count was made of the number of occasions when the study member had participated in a sports session lasing at least 30 min during a 2 week period prior to interview. A sports session included participation in activities such as cycling, exercises such as sit-ups, keep-fit or aerobics, dance, weight training, swimming, football, tennis, jogging, among others. The count is reclassified into an ordinal scale representing no exercise; < 4 sessions; 4–8 sessions; $\geqslant 9$ sessions.

Physiological risk factors

Blood pressure

Systolic and diastolic blood pressure were measured using the Dinamap 8100 monitor (an automatic machine). Three readings of each were taken, and the average of the second and third readings used as the measures of blood pressure. Hypertension, or high blood pressure, was considered to be present where either systolic blood pressure exceeded 159 mm Hg or diastolic pressure exceeded 94 mm Hg, or where a participant was on medication for high blood pressure.

Diabetes

Individuals were classified as diabetic if they reported that they had been informed by a doctor that they suffered from diabetes.

Body mass index (BMI)

This is defined as weight in kilograms/height in metres^2. Study members are considered obese if their BMI exceeded 30.

Cholesterol

Serum total cholesterol levels were recorded in mmol/l. High cholesterol is defined as a level $\geqslant 6{\cdot}5$ mmol/l.

Stastistical analysis

A series of logistic regression models are fitted to each outcome health measure in turn. All independent variables are treated as continuous measures except for E–G class and job strain, which are categorical. There are six E–G classes: higher professionals, lower professionals, routine non-manual, self-employed, skilled manual and non-skilled manual. Job strain has four levels: low strain, passive, active and high strain. The low strain group is selected as the reference category with the odds ratio set to unity. The 95% confidence intervals for the odds ratios are computed using the methods for summarizing the effects of a categorical explanatory variable on the dependent variable in the model suggested by Ridout (1989) and Easton *et al.* (1991), and implemented by Firth (1998). A conventional presentation of the regression coefficients, for a categorical variable with k groups, has $k-1$ estimated odds ratios and associated standard errors, each of the $k-1$ being relative to the same, arbitrarily chosen 'reference group'. Standard errors for comparisons other than with the reference group cannot be obtained from such a presentation. The method of floating absolute risk overcomes this by providing k quantities, one for each group, to be used in place of the usual standard errors in constructing approximate confidence intervals. Formal statistical comparisons of all groups with each other are then possible using t tests. Thus, we are able to test the predictions of the Karasek model, namely that high job strain is associated with poorest health, low job strain with better health and active and passive jobs occupy similar, intermediate positions. The series of models are as follows.

Model I

A logistic regression model is fitted for each outcome health measure, adjusting for linear and quadratic terms for age in years. This allows for a baseline test of the Karasek model.

Model II

A logistic regression model is fitted for each outcome health measure adjusting for age, age^2 and socio-economic position (E–G class), thus determining whether job strain is confounded by socio-economic position.

Model III

A logistic regression model is fitted to each outcome health measure in turn, adjusting for age, age^2, diet, smoking and leisure exercise to ascertain whether job strain is related to heart disease because both are associated with adverse health behaviours.

Model IV

A logistic regression model is fitted to each outcome health measure in turn, adjusting for age, age^2, BMI, diabetes, cholesterol, systolic and diastolic blood pressure to determine the strength of the relationship between job strain and health independent of known physiological risk factors for heart disease.

Model V

A logistic regression model is fitted to each outcome health measure in turn, adjusting for age, age^2, socio-economic position, diet, smoking, leisure exercise, BMI, diabetes, cholesterol, systolic and diastolic blood pressure. This provides a rigorous test of the Karasek model.

RESULTS

Table 1 shows the prevalence of all the health measures and other risk factors in the 1993 Health Survey for England. In common with other studies, psychiatric morbidity rates, as defined by a score of $\geqslant 3$ on the GHQ-12, were higher than rates of poor self-rated health in this sample of employed working aged men. Possible MI rates also tend to be higher than doctor diagnosed heart conditions since not all those who experience chest pain are aware of the need to visit their doctor for a diagnosis (Shaper *et al.* 1984). Men in high strain jobs had the poorest health behaviour profiles but this was not reflected in the physiological measures. However, all the behavioural and physiological risk factors were related to heart disease status (results not shown). The pattern of occupational classes was similar for high strain and passive jobs, both being concentrated in manual occupations. Active and low strain jobs were also distributed amongst occupational classes in similar ways, with low prevalence in routine and non-skilled occupations.

Using the general measures of health status, Karasek's demand–control model is broadly supported by the data (Table 2). As predicted, men in high strain jobs had significantly poorer self-rated health than other men. The odds of poor self-rated health was twice as great in men experiencing high job strain as in men exposed to low job strain. Men in passive jobs also had better self-rated health than men in low strain, but contrary to the hypothesized differences, men in low strain jobs did not enjoy better health than men in active forms of work. In turn, men with active jobs had poorer self-rated health than men in passive jobs. In Model II, the odds ratios are adjusted for socio-economic position, resulting in less ambiguous support for Karasek's model. Passive and active jobs are now associated with similar amounts of poor self-rated health with weak support for better health in low strain occupations than in the three other groups. The relationship between job strain and self-rated health was independent of any associations with the behavioural and physiological risks for heart disease (Models III and IV).

The ordering of the odds ratios for psychiatric morbidity is in agreement with Karasek's model. Men in high strain jobs were again about twice as likely to have psychiatric problems as men in low strain jobs. Active and passive jobs were associated with intermediate odds of psychiatric problems. All pairwise comparisons of the odds ratios for psychiatric morbidity were significant except for that between passive and low strain jobs. In Model II it can be seen that high job strain is not a proxy for manual work. Independent of E–G class, high job strain was associated with poorer psychiatric health than the other three strain categories. Levels of psychiatric problems were similar in men with active and passive jobs and there was weak

Table 1. *Distribution* of health ratings, CHD risk factors and socio-economic position by job strain categories among working men aged* 20–64 *in the* 1993 *Health Survey for England*

	Low strain %	Active %	Passive %	High strain %	Total %
Poor health ratings					
Poor self-rated health	10	10	15	19	12
Poor psychiatric health	12	19	13	23	17
Angina	0·4	0·9	1·8	1·8	1·1
Possible MI	5	6	5	7	6
Doctor diagnosed heart conditions	5	4	4	6	5
Any heart disease	8	9	8	12	9
Behavioural risk factors					
Smokers	26	23	29	33	26
Poor diet	9	9	12	14	10
No leisure exercise	56	53	61	61	57
Physiological risk factors					
High cholesterol	29	24	23	24	25
High blood pressure	13	11	12	13	12
Obesity	12	13	11	13	13
Diabetes	1·6	1·4	2·9	1·7	1·8
Socio-economic position					
Higher professional	23	35	4	7	21
Lower professional	22	24	11	12	19
Routine non-manual	6	3	10	9	6
Self-employed	18	16	9	10	14
Skilled manual	23	18	28	29	23
Non-skilled manual	8	4	38	33	16
Max *N*	1041	1746	799	649	4235

* Definitions of the categories used for health status/risk factors are given in the Method section.

evidence for an excess of psychiatric ill-health in passive jobs compared with low strain jobs. The results were largely unaffected by the CHD risk factors (see Models III–IV).

Table 3 gives the odds ratios for each of the CHD outcomes. Because the prevalence of angina was low (1%), confidence intervals around the estimates are necessarily wide. Nevertheless, in Model I, the odds of reporting angina symptoms was around five times greater in the high strain group than the low strain group, a statistically significant difference. Men in passive and active jobs, as predicted by Karasek, had non-significantly different rates of angina symptoms, and there was evidence for lower rates of angina in the low strain group than either the active or passive groups. The results were largely unaffected by controlling for the behavioural risk factors (Model III) but the odds ratios in the high strain and passive groups were attenuated by controlling for E–G class, and to a lesser extent, the physiological risk factors (Models II and IV). Controlling for all confounders, angina was still more likely to be associated with high strain than with low strain or active work.

The odds of reporting chest pain indicative of possible MI varied with job strain in the predicted manner. Men in high strain jobs were most likely to have had a possible MI and men in low strain jobs were least likely. Passive and active jobs were associated with odds ratios lying between these two extremes. After adjustments, the comparison between high and low levels of job strain showed a moderate effect, the other comparisons with high strain jobs indicated differences of marginal significance. Unlike angina symptoms, there was no evidence that the relationship of job strain with possible MI was confounded by socio-economic position.

The likelihood of having a doctor diagnosed heart condition in working men did not clearly conform with the predictions of the model. The odds ratio for men in high strain jobs was higher than the odds in the other three job strain groups, but men in low strain jobs did not appear to be protected from a concurrent heart condition. It was men in passive jobs who were least likely to report doctor diagnosed heart conditions. These results were observed in all five models.

Job strain was found to predict cases of 'any

Table 2. *Odds ratios* (95% *confidence intervals*) *for general health in working men aged* 20–64 *in the* 1993 *Health Survey for England by job strain categories*

	Model I*	Model II†	Model III ‡	Model IV §	Model V ¶
Poor self-rated health					
High strain	2·26 (1·86–2·75)	1·87 (1·52–2·29)	2·09 (1·71–2·55)	2·18 (1·73–2·75)	1·69 (1·32–2·16)
Passive	1·55 (1·27–1·89)	1·24 (1·00–1·54)	1·47 (1·20–1·79)	1·50 (1·19–1·91)	1·21 (0·93–1·56)
Active	1·03 (0·88–1·21)	1·16 (0·97–1·40)	1·07 (0·91–1·26)	1·07 (0·89–1·28)	1·23 (0·99–1·51)
Low strain	1·00 (0·82–1·23)	1·00 (0·81–1·24)	1·00 (0·81–1·23)	1·00 (0·79–1·27)	1·00 (0·78–1·28)
$\Delta\chi^2$ (df = 3)	45	18	33	28	9
P	<0·0001	<0·0001	<0·0001	<0·0001	0·03
N	4233	3950	4214	3302	3067
Poor psychiatric health					
High strain	2·04 (1·69–2·45)	2·24 (1·84–2·74)	2·00 (1·66–2·41)	2·11 (1·71–2·61)	2·28 (1·82–2·85)
Passive	1·13 (0·92–1·39)	1·27 (1·01–1·59)	1·11 (0·90–1·37)	1·21 (0·96–1·52)	1·32 (1·03–1·69)
Active	1·60 (1·42–1·81)	1·54 (1·33–1·78)	1·59 (1·41–1·80)	1·64 (1·43–1·88)	1·62 (1·38–1·91)
Low strain	1·00 (0·83–1·20)	1·00 (0·83–1·21)	1·00 (0·83–1·20)	1·00 (0·81–1·23)	1·00 (0·80–1·24)
$\Delta\chi^2$ (df = 3)	37	36	36	30	30
P	<0·0001	<0·0001	<0·0001	<0·0001	<0·0001
N	4177	3895	4158	3263	3028

* Controlling for age and age².
† Controlling for age, age² and socio-economic position.
‡ Controlling for age, age², diet, smoking, leisure exercise.
§ Controlling for age, age², cholesterol, BMI, diabetes, systolic and diastolic blood pressure.
¶ Controlling for age, age², socio-economic position, diet, smoking, leisure exercise, cholesterol, BMI, diabetes, systolic and diastolic blood pressure.

Table 3. *Odds ratios* (95% *confidence intervals*) *for heart disease in working men aged* 20–64 *in the* 1993 *Health Survey for England by job strain categories*

	Model I*	Model II†	Model III‡	Model IV§	Model V¶
Angina					
High strain	5·10 (2·89–9·03)	3·57 (2·00–6·38)	4·94 (2·77–8·81)	4·01 (2·08–7·76)	2·46 (1·23–4·92)
Passive	4·25 (2·48–7·29)	2·50 (1·36–4·58)	4·19 (2·43–7·23)	2·98 (1·52–5·84)	1·61 (0·79–3·42)
Active	2·65 (1·62–4·39)	2·61 (1·38–4·94)	2·81 (1·69–4·67)	2·01 (1·13–3·60)	2·23 (1·10–4·54)
Low strain	1·00 (0·37–2·67)	1·00 (0·37–2·70)	1·00 (0·37–2·67)	1·00 (0·37–2·68)	1·00 (0·37–2·73)
$\Delta\chi^2$ (df = 3)	12	6	11	7	3
P	0·01	0·13	0·01	0·08	0.40
N	4231	3948	4212	3302	3067
Possible MI					
High strain	1·66 (1·23–2·23)	1·60 (1·16–2·20)	1·63 (1·20–2·20)	1·43 (1·01–2·04)	1·46 (1·01–2·12)
Passive	1·10 (0·80–1·51)	1·10 (0·78–1·55)	1·10 (0·80–1·52)	1·10 (0·77–1·57)	1·16 (0·79–1·72)
Active	1·20 (0·98–1·48)	1·23 (0·97–1·57)	1·25 (1·01–1·54)	1·12 (0·88–1·42)	1·16 (0·88–1·53)
Low strain	1·00 (0·75–1·33)	1·00 (0·75–1·34)	1·00 (0·75–1·33)	1·00 (0·73–1·37)	1·00 (0·72–1·38)
$\Delta\chi^2$ (df = 3)	6	5	6	6	2
P	0·11	0·19	0·13	0·13	0·54
N	4235	3952	4216	3304	3069
Doctor diagnosed heart conditions					
High strain	1·37 (0·98–1·92)	1·37 (0·96–1·95)	1·44 (1·03–2·03)	1·38 (0·95–1·98)	1·50 (1·02–2·20)
Passive	0·80 (0·56–1·16)	0·77 (0·52–1·14)	0·83 (0·57–1·20)	0·86 (0·58–1·27)	0·87 (0·57–1·33)
Active	0·99 (0·78–1·25)	1·01 (0·77–1·32)	1·03 (0·81–1·31)	0·88 (0·67–1·16)	0·95 (0·70–1·30)
Low strain	1·00 (0·75–1·34)	1·00 (0·74–1·35)	1·00 (0·75–1·34)	1·00 (0·73–1·37)	1·00 (0·72–1·39)
$\Delta\chi^2$ (df = 3)	5	5	5	4	5
P	0·21	0·18	0·18	0·25	0·21
N	4235	3952	4216	3304	3069
Any heart disease					
High strain	1·70 (1·34–2·16)	1·69 (1·31–2·18)	1·72 (1·35–2·19)	1·53 (1·16–2·00)	1·60 (1·20–2·13)
Passive	1·04 (0·81–1·35)	1·03 (0·78–1·36)	1·06 (0·82–1·37)	1·03 (0·77–1·37)	1·06 (0·78–1·46)
Active	1·19 (1·01–1·41)	1·21 (1·00–1·47)	1·25 (1·05–1·48)	1·07 (0·88–1·29)	1·12 (0·89–1·40)
Low strain	1·00 (0·80–1·26)	1·00 (0·79–1·26)	1·00 (0·80–1·26)	1·00 (0·78–1·28)	1·00 (0·77–1·29)
$\Delta\chi^2$ (df = 3)	11	10	11	6	6
P	0·01	0·01	0·01	0·11	0·10
N	4231	3948	4212	3302	3067

* Controlling for age and age².
† Controlling for age, age² and socio-economic position.
‡ Controlling for age, age², diet, smoking, leisure exercise.
§ Controlling for age, age², cholesterol, BMI, diabetes, systolic and diastolic blood pressure.
¶ Controlling for age, age², socio-economic position, diet, smoking, leisure exercise, cholesterol, BMI, diabetes, systolic and diastolic blood pressure.

heart disease' when all three heart disease measures were combined to define caseness. The order of likelihood of having any form of heart disease was in agreement with the model although low strain jobs did not confer any significant extra protection above that found in passive and active jobs. Again, high strain jobs were associated with an increased risk for a heart disease. Men in high strain jobs were significantly more likely to have any form of heart disease than men in the other three categories, even after adjustment for social class based on occupational characteristics and behavioural and physiological risk factors for heart disease.

DISCUSSION

Despite there being around 4000 men in our sample, the power of statistical tests is low for the detection of moderate differences when prevalence of health outcomes falls below 9% (Cohen, 1992; Williams *et al*. 1997). The low power using any single measure of CHD may lead to a misleading interpretation that the full four category job strain measure was not related to coronary heart disease. The four strain categories did not have significant discriminatory power to identify those with chest pain indicative of possible MI or those with doctor diagnosed heart conditions. Nevertheless, for every CHD outcome, those who reported high job strain had significantly higher odds of CHD morbidity than men in lower strain categories.

Although these data are cross-sectional, general health measures are strong predictors of later heart disease. These results replicate full-population studies from other countries which find job strain associated with ill-health (Johnson & Hall, 1988; Karasek *et al*. 1988; Lerner *et al*. 1994). However, the results are not fully consistent with the only other large scale study in a British setting. The Whitehall II study found prospective evidence for the relationship between job control and similar CHD outcomes to those employed here (Bosma *et al*. 1997). High demands were not associated with an increased incidence of CHD, but in their sample of civil servants, higher demands tended to go along with higher control.

A graded relationship between job control and doctor diagnosed heart disease was observed for the sample of civil servants in Whitehall II but a graded relationship between job strain and doctor diagnosed heart disease was not found in our full population sample. The HSFE is a cross-sectional study, unlike the Whitehall II study, so it is possible that there is selection into low strain jobs among men in the HSFE sample who know they have heart disease. This would account for the odds ratios for doctor diagnosed disease in the low strain category being similar to or higher than that found for men with average levels of job strain. Where heart disease was ascertained by means which do not imply awareness of disorder on the part of the study participant, then low strain jobs were associated with lower rates of heart disease. Selection into low strain jobs may be more pertinent for men who were in manual occupations when they were given a diagnosis than for white collar civil servants. The disparity between the Whitehall II findings and ours is therefore unsurprising, but has important implications for health inequalities research. Given this interpretation, Karasek's model of job strain is fully supported by the data from our population sample of English men.

It has been suggested that job strain measures may simply act as a proxy for socio-economic position (Marmot *et al*. 1997), although the Karasek model proposes that job strain is not equivalent to low socio-economic status (Schnall *et al*. 1994). Nevertheless, in their review of job strain and cardiovascular disease, Schnall *et al*. stress the necessity to control for socio-economic position to determine the independent effect of job strain on health. We reported the association of job strain with the health measures after controlling for a measure of social class that is based on employment relations and conditions. This is a stronger test of the independence of job strain from socio-economic position than tests based on measures of educational level or prestige. As it is more likely that strain at work is a factor which lies on the causal pathway between employment relations and general health, this may be an over-adjustment, and the analysis here represents a conservative estimate of the link between job strain and health. It is interesting to note that while estimates for self-rated health are attenuated after adjustment for socio-economic position, the opposite effect is observed for psychiatric health. Stansfeld &

Marmot (1992) found that the GHQ-12 underestimates psychiatric disorder in individuals in lower socio-economic positions. Controlling for socio-economic position has the effect of adjusting for this reporting bias.

This study has also shown clear evidence that the association between job strain and heart disease is independent of many known behavioural and physiological risk factors. Unlike other studies (Peter *et al*. 1998; Tsutsumi *et al*. 1998), we did not find any relationship between high job strain and the physiological risk factors. Moreover, obesity, diabetes, blood pressure and total serum cholesterol only attenuated the relationship of job strain with heart disease to a limited extent. Neither did we find evidence in support of the hypothesis that job strain is related to heart disease because strain increases the likelihood of adverse health behaviours which in turn increase the risk of CHD. The relationship between high job strain and ill-health was independent of smoking, lack of exercise and a poor diet. These findings are supported by evidence from the Copenhagen City Heart Study showing the association between high job strain and angina was independent of coronary risk factors (Netterstrom *et al*. 1998).

In this representative English sample of employed men, job strain was associated with both general health and heart disease status. This relationship was independent of the associations between ill-health, socio-economic position and coronary risk factors. As predicted by the Karasek model, high job strain was related to poorer health and low job strain to better health than average. Not all studies employed the full quadrant-term approach adopted here. Many only differentiated between high strain jobs and others. This study found support for the full model including the possible protective effects of working in a low strain job.

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