RESEARCH REPORT

Job strain, job demands, decision latitude, and risk of coronary heart disease within the Whitehall II study

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The belief that stress at work has a damaging effect on health is widely held by the general public and various constructs have been developed to explain how the worker and job environment interact to produce stress. The most widely cited of these models is the Karasek-Theorell job strain model, the two central components of which are high job demands (the need to work quickly and hard) and low decision latitude (lack of control over skill use, time allocation and organisational decisions). The theory purports that workers who have concurrent low decision latitude and high demands cannot moderate the stress caused by the high demands through time management or learning new skills, and so become subject to high stress at work and are at increased risk of disease. It is therefore the constraints on decision making, together with high demands, which produce the unhealthy condition of stress at work, or “job strain”.

The job strain model was initially used to explain patterns of depression, exhaustion, and job dissatisfaction, but was later expanded to include cardiovascular disease (reviewed by Schnall and Hemingway), poor health functioning, and sickness absenteeism. As the literature has accumulated, the model has been refined. The iso-strain model argues that job strain is particularly deleterious for people with low social support at work, as adequate social networks can buffer the effects of job strain. Similarly, high income and the availability of tangible resources may reduce the effect of job strain on health, hence strain might be more deleterious among workers with low socioeconomic status (SES) and in younger age groups.

The early results from the Whitehall II study were promising, finding that low decision latitude, whether through self report or independent assessment, predicted self reported incident coronary heart disease (CHD) and higher rates of short term and long term sickness absence. In fact, adjusting for low decision latitude reduced the odds of development of any CHD in the lowest compared with the highest grade from 1.5 to 1.2. Moreover, both high psychological demands and low decision latitude predicted higher rates of psychiatric disorder, and in women high demands predicted poor health functioning.

Our purpose in this paper is to extend these earlier analyses to investigate the role of the full job strain model, that is simultaneous low decision latitude and high psychological job demands, in relation to validated incident CHD events including an extra six years of follow up compared with previous reports. As subsidiary analyses we will investigate the effect of the individual components of the model, that is decision latitude and job demands, on risk of CHD. We will attempt to clarify the role of social position and traditional coronary risk factors in driving the association between work characteristics and CHD risk. Furthermore, we will test for effect modification, as we hypothesise that the health effects of job strain will be more pronounced in people with low social support at work, lower employment grades, lower father’s social class, and of younger age.

METHODS

Study population

Full details of the study are reported elsewhere. Briefly, the Whitehall II study is a new cohort of civil servants that was established between 1985 and 1988 (phase 1). All non-industrial civil servants aged 35–55 working in the London offices of 20 departments were sent an introductory letter and screening questionnaire, and were offered a screening examination for cardiovascular disease. The overall response rate was 73% (74% for men, 71% for women), but the true response rate was probably higher, as about 4% of the civil servants on the lists provided by the civil service had moved before the study and were therefore ineligible for inclusion. In total, 10 308 civil servants participated, of whom 67% (6895) were men and 33% (3413) were women. Participants were approached again in 1989–90 (phase 2: postal questionnaire, 8129 respondents), in 1991–93 (phase 3: postal questionnaire and screening questionnaire, 8548 respondents), in 1995–96 (phase 4: postal questionnaire, 8700 respondents) and 1997–99 (phase 5: postal questionnaire, and screening examination, 7830 respondents). The length of follow up from phase 1 to phase 5 was a median of 11.2 years (range

Participants: 6895 male and 3413 female civil servants aged 35–55.

Outcome measures: Incident validated CHD.

Main results: People with concurrent low decision latitude and high demands (job strain) were at the highest risk for CHD. High job demands, and, less consistently, low decision latitude, predicted CHD incidence. The effect of job strain on CHD incidence was strongest among younger workers, but there was no effect modification by social support at work, or employment grade.

Conclusions: Job strain, high job demands, and, to some extent, low decision latitude, are associated with an increased risk of CHD among British civil servants.
Written informed consent for participation in the study was obtained from the subjects as part of the questionnaire.

**Coronary heart disease events**

Altogether 10,300 (99.9%) participants were flagged at the National Health Service Central Registry, who notified us of the date and cause of death. Participants were defined as having a coronary death if the underlying cause had an ICD-9 code 410–414. Potential non-fatal myocardial infarction (MI) and angina events were ascertained by questionnaire items on: chest pain (the World Health Organisation Rose questionnaire), recall of a doctor's diagnosis, investigation (exercise electrocardiography, stress imaging, or angiography), and treatment (nitrates or revascularisation). Details of physician diagnoses and investigation results were sought from clinical records for all potential cases of MI and angina. Twelve lead resting electrocardiograms were performed at study phases 1, 3, and 5 (Simmons Mingorec) and classified according to the Minnesota code. Classification of MI and angina was carried out independently by two trained coders, with adjudication by a third in the (rare) event of disagreement.

**Demographic and socioeconomic characteristics**

Information on demographic characteristics was obtained from a self completed questionnaire at baseline. Within the Whitehall II study civil service employment grade provides an excellent measure of SES. Administrative grades were condensed into six categories, in order of decreasing salary: permanent secretary through senior principal; unified grade 7 (principal); senior executive officer; higher executive officer; executive officer; and clerical officer, clerical assistant, and office support staff. Professional and technical staff were classified with administrative grades with equivalent salaries. However, as grade is an occupational characteristic, grade and work characteristics are highly collinear; the correlation between decision latitude and grade was 0.51 in men and 0.55 in women, and the correlation between job demands and grade was 0.51 in men and 0.55 in women.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Mean baseline job control (decision latitude) and job demands for each category of demographic, socioeconomic, and health behaviour characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Men</td>
</tr>
<tr>
<td>Age [y]</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>≥39–&lt;45</td>
<td>67.0 (14.6)</td>
</tr>
<tr>
<td>≥45–&lt;50</td>
<td>68.9 (14.8)</td>
</tr>
<tr>
<td>≥50–&lt;55</td>
<td>69.4 (14.8)</td>
</tr>
<tr>
<td>≥55–&lt;64</td>
<td>68.6 (15.7)**</td>
</tr>
<tr>
<td>Administrative</td>
<td></td>
</tr>
<tr>
<td>Professional</td>
<td>75.5 (10.9)</td>
</tr>
<tr>
<td>Clerical</td>
<td>66.9 (12.9)</td>
</tr>
<tr>
<td>Non-home owner</td>
<td>55.5 (18.9)</td>
</tr>
<tr>
<td>Home owner</td>
<td>69.4 (14.1)**</td>
</tr>
<tr>
<td>Car owner</td>
<td>69.8 (14.1)</td>
</tr>
<tr>
<td>Non-car owner</td>
<td>60.2 (17.0)**</td>
</tr>
<tr>
<td>Never smoker</td>
<td>68.7 (14.7)</td>
</tr>
<tr>
<td>Former smoker</td>
<td>69.5 (14.6)</td>
</tr>
<tr>
<td>Current smoker 1–10</td>
<td>64.8 (15.9)</td>
</tr>
<tr>
<td>Current smoker 11–20</td>
<td>64.9 (15.7)</td>
</tr>
<tr>
<td>Current smoker ≥20</td>
<td>66.9 (16.3)**</td>
</tr>
<tr>
<td>Non-drinker</td>
<td>64.1 (16.8)</td>
</tr>
<tr>
<td>Below limit</td>
<td>69.0 (14.6)</td>
</tr>
<tr>
<td>≥1.5 h exercise/wk</td>
<td>68.7 (14.3)**</td>
</tr>
<tr>
<td>≥1.5 h exercise/wk</td>
<td>65.3 (16.6)</td>
</tr>
<tr>
<td>&gt;20 BMI</td>
<td>64.1 (15.5)</td>
</tr>
<tr>
<td>20–24.99</td>
<td>68.8 (14.9)</td>
</tr>
<tr>
<td>25–29.99</td>
<td>68.5 (15.4)</td>
</tr>
<tr>
<td>≥30</td>
<td>66.2 (16.2)**</td>
</tr>
<tr>
<td>No hypertension</td>
<td>68.5 (14.9)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>67.0 (16.1)**</td>
</tr>
<tr>
<td>Low job control</td>
<td>51.9 (21.2)</td>
</tr>
<tr>
<td>Medium job control</td>
<td>60.3 (18.9)</td>
</tr>
<tr>
<td>High job control</td>
<td>65.1 (18.2)**</td>
</tr>
<tr>
<td>Low job demands</td>
<td>61.8 (17.0)</td>
</tr>
<tr>
<td>Medium job demands</td>
<td>69.0 (14.0)</td>
</tr>
<tr>
<td>High job demands</td>
<td>72.5 (12.9)**</td>
</tr>
<tr>
<td>Low support at work</td>
<td>64.2 (16.5)</td>
</tr>
<tr>
<td>Medium support work</td>
<td>69.3 (13.9)</td>
</tr>
<tr>
<td>High support at work</td>
<td>71.5 (13.4)**</td>
</tr>
</tbody>
</table>

*Significant at p<0.05 level; **significant at p<0.01 level. There are some missing values.

www.jech.com
Table 2
Proportional hazards derived adjusted hazard ratios (and 95% confidence intervals) for the association between baseline job control and job demands and incidence of fatal CHD/non-fatal MI and all CHD. Serially adjusted for potential confounders

<table>
<thead>
<tr>
<th>Age, car, and homeownership adjusted</th>
<th>Age and grade adjusted</th>
<th>Age and coronary risk factors adjusted</th>
<th>Age adjusted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low control</td>
<td>1.55 (1.26 to 1.90)</td>
<td>1.37 (1.08 to 1.74)</td>
<td>1.43 (1.15 to 1.86)</td>
</tr>
<tr>
<td>Medium control</td>
<td>1.35 (1.12 to 1.64)</td>
<td>1.29 (1.06 to 1.57)</td>
<td>1.34 (1.11 to 1.63)</td>
</tr>
<tr>
<td>High control</td>
<td>Baseline</td>
<td>Baseline</td>
<td>Baseline</td>
</tr>
<tr>
<td>p for trend</td>
<td>0.0001</td>
<td>0.006</td>
<td>0.55</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fatal CHD/non-fatal MI</th>
<th>6797 (239)</th>
<th>6797 (239)</th>
<th>6742 (238)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium control</td>
<td>1.32 (0.99 to 1.76)</td>
<td>1.18 (0.87 to 1.59)</td>
<td>1.30 (0.97 to 1.74)</td>
</tr>
<tr>
<td>High control</td>
<td>Baseline</td>
<td>Baseline</td>
<td>Baseline</td>
</tr>
<tr>
<td>p for trend</td>
<td>0.30</td>
<td>0.33</td>
<td>0.65</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>All CHD</th>
<th>6618 (591)</th>
<th>6618 (591)</th>
<th>6565 (585)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium demand</td>
<td>1.02 (0.83 to 1.25)</td>
<td>1.12 (0.91 to 1.38)</td>
<td>1.06 (0.86 to 1.31)</td>
</tr>
<tr>
<td>High demand</td>
<td>1.07 (0.86 to 1.33)</td>
<td>1.27 (1.00 to 1.60)</td>
<td>1.12 (0.90 to 1.38)</td>
</tr>
<tr>
<td>p for trend</td>
<td>0.0001</td>
<td>0.006</td>
<td>0.55</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Exercise per week</th>
<th>1.5 or &lt;1.5 hours of moderate or vigorous exercise</th>
<th>1.5 or &lt;1.5 hours of moderate or vigorous exercise</th>
<th>1.5 or &lt;1.5 hours of moderate or vigorous exercise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical activity</td>
<td>0.32 in men and 0.40 in women</td>
<td>0.32 in men and 0.40 in women</td>
<td>0.32 in men and 0.40 in women</td>
</tr>
</tbody>
</table>

Psychosocial work characteristics

Work characteristics were measured at baseline through a self-administered questionnaire. The self-report items were derived from well-known questionnaires for the central components of the job strain model, that is, psychological job demands, decision latitude, and social support at work (see appendix). A measure of physical job demands was considered inappropriate for this white collar population, and therefore was not included. Four items dealt with psychological job demands, and 15 items dealt with decision authority and skill discretion, which were combined into an index of decision latitude (or job control). Scores for each scale were calculated as the sum of the item scores and all scales were divided into tertiles. The few subjects missing one item in a scale were assigned an average score based on the items that they did answer. Four quadrants of job strain (high demand and high decision latitude; high demand and low decision latitude; low demand and high decision latitude; low demand and low decision latitude) were constructed, by cross-tabulating job demands and decision latitude, both divided in two groups at the median.

Traditional coronary risk factors

Data on classic coronary risk factors were measured in standard ways at the baseline questionnaire. Coronary risk factors included: cigarette smoking (“never smokers”, “ex smokers”, and “current smokers”; ≤10, 11–20, or >20 cigarettes/day), serum cholesterol (mmol/l), hypertension (diastolic blood pressure ≥95 mm Hg, systolic blood pressure ≥160 mm Hg or drug treatment for hypertension), exercise (≥1.5 or <1.5 hours of moderate or vigorous exercise per week), alcohol consumption (non-drinker, drink at or below the recommended limit set by the British Department of Health, drink above the recommended limit), and body mass index (BMI) (BMI <20, 20–24.9, 25–29.9, ≥30 kg/m²).

Statistical analysis

The mean and standard deviations of self-reported decision latency and job demand scores were calculated for each category of baseline variables, separately for men and women. Analysis of variance was used to test for significant differences in means.

Survival analyses were conducted to determine whether baseline decision latency, job demands, and social support at work, in turn, predicted age adjusted incident CHD during follow up, stratified by gender. The models were successively adjusted for employment grade, other SES indicators, and traditional coronary risk factors.

Next, again through survival analyses, the four job strain quadrants were modelled against CHD events. Test for a significant interaction between high job...
demands and low decision latitude on the multiplicative scale in predicting CHD events, an interaction term for job demand and decision latitude was introduced into a regression model along with the main components (that is, high job demands and low decision latitude). These models were also successively adjusted for employment grade, other SES indicators and traditional coronary risk factors. The analyses were stratified, in turn, by social support at work, grade (at three levels), age (four age groups), and father’s social status (at four levels).

All analyses were performed on complete datasets using the statistical package SAS. Dummy indicators represented ordinal variables, such as employment grade level, in the analyses. Tests for trends were performed by modelling the group scores of psychosocial work variables (1, 2, 3) as one variable. As we are testing a number of hypotheses the level of statistical significance will be \( p < 0.01 \).

### RESULTS

Job demand and decision latitude generally had the same relation with the baseline variables (table 1). Men reported higher decision latitude and job demands than women, as did people in higher SES, whether measured through employment grade or home ownership and car ownership. Non-smokers were more likely to claim they had high decision latitude, whereas heavy smokers were more likely to report high job demands. For the rest, healthy lifestyle variables were most closely related to CHD risk in the youngest age group. Administrative workers, which is in contrast with our hypothesis, were also analysed net of other SES indicators, and this had little effect on the associations. Although some confounding by coronary risk factors was apparent, neither the effect estimates nor trend in the association between decision latitude and all CHD lost significance.

The effect of high demands on CHD events was most apparent for fatal CHD/non-fatal MI in both men and women, although there was also some increase in risk of all CHD. The associations became stronger after adjustment for grade. The grade adjusted risk in the groups with highest demands were apparent for all CHD in both men (HR 1.27, 95% CI 1.00 to 1.60) and women (HR 1.57, 95% CI 1.10 to 2.15) and fatal CHD/non-fatal MI in men (HR 1.64, 95% CI 1.10 to 2.44). Adjusting for other SES variables strengthened the association between demand and CHD events somewhat, but including traditional coronary risk factors in the model had little effect. There was no apparent association between social support at work and CHD events, in either men or women, with or without adjustment for grade level (data not shown).

There was no significant interaction by sex in the relation between job strain and CHD events, and so the following analyses were adjusted for, rather than stratified by, gender. People with job strain consistently had the highest risk for both categories of CHD events during follow up (table 3). In the age and sex adjusted analyses those with job strain had significantly increased risk for all CHD (HR 1.57, 95% CI 1.26 to 1.96) and increased risk of fatal CHD/non-fatal MI (HR 1.42, 95% CI 0.99 to 2.05). Adjustment for grade diminished the effect of job strain on CHD events. The effect of job strain on CHD events was relatively unchanged net of other indicators of SES, but adjustment for coronary risk factors did weaken the associations. The final model, which included both grade and coronary risk factors, demonstrated a statistically significant increased risk for all CHD among those with job strain (HR 1.38, 95% CI 1.10 to 1.75), but little association with fatal CHD/non-fatal MI remained. There was no evidence of statistical interaction between low decision latitude and high demand in their relation to all CHD events or fatal CHD/non-fatal MI.

There was no evidence of a strengthened effect of job strain in people who reported low social support at work for either CHD outcome (table 4). Job strain seemed, if anything, to be more deleterious with respect to risk of all CHD among administrative workers, which is in contrast with our hypotheses. Stratifying on age at entry showed that job strain was most closely related to CHD risk in the youngest age group. There was no apparent difference in the association between

<table>
<thead>
<tr>
<th>Table 3</th>
<th>Proportional hazards derived adjusted hazard ratios (and 95% confidence intervals) for the association between baseline job strain and incidence of fatal CHD/non-fatal MI and all CHD.</th>
<th>Serially adjusted for potential confounders</th>
<th>Age and sex adjusted</th>
<th>Age, sex, and grade adjusted</th>
<th>Age, sex, and SES adjusted</th>
<th>Age, sex, and coronary risk factors adjusted</th>
<th>Age, sex, grade, and coronary risk factors adjusted</th>
</tr>
</thead>
<tbody>
<tr>
<td>All CHD</td>
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<tr>
<td>Low demand high control</td>
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<tr>
<td>High demand low control</td>
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<tr>
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<tr>
<td>High demand high control</td>
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<tr>
<td>p for interaction</td>
<td>0.59</td>
<td>0.71</td>
<td>0.43</td>
<td>0.85</td>
<td>0.96</td>
<td></td>
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</tr>
<tr>
<td>Fatal CHD/ non-fatal MI</td>
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<tr>
<td>p for interaction</td>
<td>0.15</td>
<td>0.12</td>
<td>0.15</td>
<td>0.19</td>
<td>0.18</td>
<td></td>
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</tr>
</tbody>
</table>

This figure was slightly, but significantly higher in men than in women (24.7% versus 20.7%, \( p < 0.01 \)). Some 11.2% of men had both low decision latitude and high job demands, whereas 16.9% of women. Furthermore, 9.1% of men had both high job demands and job strain, compared with 9.4% of women.

In men (table 2), low decision latitude was a significant predictor of all CHD (hazard ratio (HR) for low decision latitude 1.55, 95% CI 1.26 to 1.90, \( p \) for trend 0.0001), and some increase in risk of fatal CHD/non-fatal MI was apparent. In women, the presence of an association between low decision latitude and risk for CHD was less evident. Adjusting for grade somewhat reduced the strength of the association between decision latitude and all CHD in men, although both the effect estimates and trend remained significant. Adjustment for grade may be over-adjustment, hence associations were also analysed net of other SES indicators, and this had little effect on the associations. Although some confounding by coronary risk factors was apparent, neither the effect estimates nor trend in the association between decision latitude and all CHD lost significance.

The effect of high demands on CHD events was most apparent for fatal CHD/non-fatal MI in both men and women, although there was also some increase in risk of all CHD. The associations became stronger after adjustment for grade. The grade adjusted risk in the groups with highest demands were apparent for all CHD in both men (HR 1.27, 95% CI 1.00 to 1.60) and women (HR 1.57, 95% CI 1.10 to 2.15) and fatal CHD/non-fatal MI in men (HR 1.64, 95% CI 1.10 to 2.44). Adjusting for other SES variables strengthened the association between demand and CHD events somewhat, but including traditional coronary risk factors in the model had little effect. There was no apparent association between social support at work and CHD events, in either men or women, with or without adjustment for grade level (data not shown).

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There was no evidence of a strengthened effect of job strain in people who reported low social support at work for either CHD outcome (table 4). Job strain seemed, if anything, to be more deleterious with respect to risk of all CHD among administrative workers, which is in contrast with our hypotheses. Stratifying on age at entry showed that job strain was most closely related to CHD risk in the youngest age group. There was no apparent difference in the association between
Discussion

The combination of high job demands and low decision latitude in the job strain model is the focus of this study. The job strain model, which is based on the hypothesis that stressful jobs are associated with increased risk of CHD, is consistent with previous findings in the literature. In our study, high job demands were associated with increased risk of CHD, whereas low decision latitude was not statistically significant. However, high demands were related to future occurrence of all CHD, especially fatal CHD, whereas low decision latitude was predictive only of all CHD in men. The combination of high job demands and low decision latitude was associated with risk of CHD, and this association was stronger among younger age groups.

Possible explanations

One possible explanation for our findings is that people choose to work in high-strain jobs. However, this is counterintuitive as people at high risk for CHD are unlikely to choose stressful jobs, and people with preclinical disease may choose stressful jobs. Another possible explanation is that people with high demands and low decision latitude are more susceptible to the harmful effects of a stressful work environment. These people may be lacking resources that could help them deal with stress, and their decisions in the face of stress may be more malleable. These individuals may be more likely to choose high-strain jobs, and this may explain why people with high demands and low decision latitude are at increased risk for coronary heart disease.

Conclusion

Our results support the job strain model and highlight the importance of considering both job demands and decision latitude in the assessment of work-related risk factors. The combination of high job demands and low decision latitude appears to be a key predictor of CHD, and this combination may be more prevalent among younger age groups. Our findings suggest that interventions targeting both job demands and decision latitude may be necessary to reduce the risk of CHD.

Key points

- People with job strain are at increased risk for coronary heart disease.
- People with high job demands and low decision latitude are at increased risk for coronary heart disease.
- People with job strain are at increased risk for heart disease.
- The combination of high job demands and low decision latitude is a key predictor of CHD.
- Interventions targeting both job demands and decision latitude may be necessary to reduce the risk of CHD.
actually switch to less hectic jobs.\textsuperscript{29} Self report bias, or negative affectivity, is unlikely to be important because validated events were used as our outcome variables and the study design was prospective. Bias attributable to loss to follow up is also improbable, as the rate of follow up was high and adjusting for leaving the civil service did not affect the associations (data not shown).

Of course we cannot claim to have eliminated entirely the effect of confounding, but as adjustment for traditional CHD risk factors did not reduce the associations substantially uncontrolled confounding by these risk factors is unlikely to fully explain our findings. Furthermore, because deleterious health behaviours may be part of the causal pathway by which adverse psychosocial work characteristics influence CHD risk, adjustment for these variables may be over-adjustment. Confounding of the associations between psychosocial work characteristics and CHD events by other psychosocial variables, suggested by other researchers,\textsuperscript{25} is unlikely in this setting, because in the Whitehall II study psychological attributes, including hostility, negative affectivity, and minor psychiatric disorders, could not explain the association between low decision latitude and CHD events.\textsuperscript{26}

In most occupational cohorts job strain is a more common condition in lower employment grades and this could partly explain the social gradient in health. Within Whitehall II, low decision latitude is indeed more common in the lower employment grades, but high demands are usually found in the highest employment grades. This creates a fundamental problem of whether or not to adjust for grade, as adjusting for employment grade could be over-adjustment with respect to decision latitude, but necessary with respect to job demands. As a compromise other measures of SES were adjusted for, that is car and house ownership, because this would allow the confounding effect of SES to be reduced, yet these variables are less highly collinear with work characteristics. As adjustment for grade was probably over-adjustment with respect to decision latitude, yet some association with future CHD events persisted, it is unlikely that the association merely reflects the effect of social position on CHD risk.

The association between job strain and CHD may be true and causal. Adverse work characteristics can induce biological arousal through neuroendocrine mechanisms affecting blood lipids\textsuperscript{27} and blood fibrinogen\textsuperscript{12,28} and increasing blood pressure;\textsuperscript{27}\textsuperscript{29} or neuroendocrine mechanisms that increase catecholamines and cortisol.\textsuperscript{12,30} An increased left ventricular mass index has also been noted in men with high job strain.\textsuperscript{30} Moreover, job strain could exert its influence on CHD risk through modification of future coronary risk factors, such as the uptake of smoking or failure to adhere to medical regimens.\textsuperscript{34}\textsuperscript{36}

Furthermore, taking analogy from other emotionally stressful events, job strain could acutely trigger coronary events in vulnerable people in the final stages of CHD.\textsuperscript{37}

\textbf{Study strengths}

This study was large and had extended follow up. The study had a prospective design and investigated only validated incident CHD among people who were disease free at baseline, excluding the possibility of recall bias. Furthermore, we used valid and reliable measures of disease outcomes, minimising the potential for information bias. Both men and women were included in this cohort, as was a representative sample of workers from different employment grades. Information on psychosocial work characteristics was obtained through self report, rather than assigning scores based on job description, hence the score more accurately represents a person's work environment. Subjective assessment of work characteristics may further be preferable to objective assessment, because perceptions of the work environment may impact on health over and above the effect of actual work conditions.

\textbf{Study limitations}

It could be argued that as the Whitehall II population is organisationally specific it is difficult to make inferences to other populations. However, the previous findings from the Whitehall II study in relation to the effects of psychosocial factors on CHD events were closely in line with the findings from other similar studies.\textsuperscript{29} Furthermore, the study participants came from a range of social classes. We investigated the effect of work characteristics measured at only one point in time, so there is room for misclassification of the exposure variable. However, as the correlation between work characteristics measured at phases 1, 2, 3, and 5 is high (data not shown) and any misclassification is likely to be non-differential, any bias will be small and towards the null.

There are specific limitations of the job strain model. High demands and low decision latitude are the only measures of pressure at work included, so other potential sources of stress, such as low pay, hazardous conditions, or job insecurity, are ignored. Furthermore, Siegrist and his colleagues argued that stress at work depends not on specific job task characteristics alone, but also on individual attributes that influence the ability to cope.\textsuperscript{38} Job strain does not influence risk of CHD in all studies,\textsuperscript{39}\textsuperscript{41} possibly because of methodological differences in the design of the studies and the measures of job strain used. In addition, any investigation into the effects of work characteristics must be limited to people with jobs, and so there is a potential for bias through the healthy worker effect. The question of whether investigations on job strain and CHD are generalisable to non-working populations and aspects of life outside of work, however, and whether this may explain part of the social gradient in CHD in people who are not working, could be fruitfully explored in the future.

\textbf{Conclusions}

Job strain is associated with an increased risk of CHD among men and women employed in the civil service. The separate components of this model, job demands, and to a lesser extent decision latitude, also predicted incidence of CHD. These associations cannot be entirely explained by confounding by SES or traditional coronary risk factors. This research adds to a body of data showing an effect of deleterious psychosocial work characteristics on health. Specifically, the results of this research suggest that policies reducing psychological demands on workers may contribute to better cardiovascular health, particularly in women. In addition, giving people a stronger say in decisions about their work, providing them with more variety in work tasks or developing leadership may improve long term health. Therefore we can focus the strategies for work place health promotion on redesigning jobs, as well as identifying high risk people, such as those with job strain. Intervention studies to evaluate the effect of reducing job strain are therefore timely and necessary to assess the potential utility with respect to improving health of implementing policy changes.

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\textbf{APPENDIX}

\textbf{Job demands}

Do you have to work very fast?

Do you have to work very intensively?

Do you have enough time to do everything?

Do different groups at work demand things from you that you think are hard to combine?

\textbf{Skill discretion}

Do you have the possibility of learning new things through your work?
REFERENCES

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How often is your immediate superior willing to listen to your

How often do you get help and support from your immediate

How often do you get help and support from your colleagues?

Do you get consistent information from line management

I have a great deal of say in planning my work environment.

I have a say in choosing with whom I work.

My working time can be flexible.

I can decide when to take a break.

I have a say in choosing with whom I work.

I have a great deal of say in planning my work environment.

Social support at work

Do you get sufficient information from line management

(your superiors)?

Do you get consistent information from line management

(your superiors)?

How often do you get help and support from your colleagues?

How often are your colleagues willing to listen to your

work related problems?

How often do you get help and support from your immediate

superior?

How often is your immediate superior willing to listen to your

problems?

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Does your work demand a high level of skill or expertise?

Does your job require you to take the initiative?

Do you have to do the same thing over and over again?

Does your job provide you with a variety of interesting things?

Is your job boring?

Decision authority

Do you have a choice in deciding HOW you do your work?

Do you have a choice in deciding WHAT you do at work?

Others take decisions concerning my work.

I have a good deal of say in decisions about work.

I have a say in my own work speed.

My working time can be flexible.

I can decide when to take a break.

I have a say in choosing with whom I work.

I have a great deal of say in planning my work environment.

Social support at work

Do you get sufficient information from line management

(your superiors)?

Do you get consistent information from line management

(your superiors)?

How often do you get help and support from your colleagues?

How often are your colleagues willing to listen to your work

related problems?

How often do you get help and support from your immediate

superior?

How often is your immediate superior willing to listen to your

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