Work stress and risk of cardiovascular mortality: prospective cohort study of industrial employees

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Abstract

Objective To examine the association between work stress, according to the job strain model and the effort-reward imbalance model, and the risk of death from cardiovascular disease.
Design Prospective cohort study. Baseline examination in 1973 determined cases of cardiovascular disease, behavioural and biological risks, and stressful characteristics of work. Biological risks were measured at 5 year and 10 year follow up.
Setting Staff of a company in the metal industry in Finland.
Participants 812 employees (545 men, 267 women) who were free from cardiovascular diseases at baseline.
Main outcome measure Cardiovascular mortality 1973-2001 from the national mortality register.
Results Mean length of follow up was 25.6 years. After adjustment for age and sex, employees with high job strain, a combination of high demands at work and low job control, had a 2.2-fold (95% confidence interval 1.2 to 4.2) cardiovascular mortality risk compared with their colleagues with low job strain. The corresponding risk ratio for employees with effort-reward imbalance (low salary, lack of social approval, and few career opportunities relative to efforts required at work) was 2.4 (1.3 to 4.4). These ratios remained significant after additional adjustment for occupational group and biological and behavioural risks at baseline. High job strain was associated with increased serum total cholesterol at the 5 year follow up. Effort-reward imbalance predicted increased body mass index at the 10 year follow up.
Conclusions High job strain and effort-reward imbalance seem to increase the risk of cardiovascular mortality. The evidence from industrial employees suggests that attention should be paid to the prevention of work stress.

Introduction

Concern is increasing about the adverse effects that work stress may have on health, particularly the risk of cardiovascular disease. The job strain model posits that a combination of high work demands and low job control at work, called job strain, is a health risk for employees.[1] The few studies on cardiovascular mortality partly support this model.[2–5] The effort-reward imbalance model considers the impact of labour market conditions on health in addition to the more proximal job conditions.[6] Health risk derives from the mismatch between high efforts at work and low reward received in turn. Rewards concern money, social approval, job security, and career opportunities. Direct evidence of cardiovascular mortality has been lacking. Results from the Whitehall II study showed an association between effort-reward imbalance and incidence of coronary heart disease, as indicated by self reports.[7] Cross sectional findings have revealed associations of effort-reward imbalance with precursors of cardiovascular disease, such as hypertension, high concentrations of low density lipoprotein cholesterol, lowered vagal tone, and impaired fibrinolytic capacity.[8–10] We aimed to test the extent to which the work stress models can explain deaths from cardiovascular disease.

Methods

Study population

The study sample was drawn from the employees of the Valmet factories in Jyväskylä, central Finland, which manufacture paper machines, tractors, firearms, gauges, and so on. The work tasks varied from foundry work and heavy engineering to precision engineering and clerical and administrative work. The study population comprised people who had been employed by Valmet for at least 15 months in January 1973 (n=2653). We selected a systematic sample of 902 participants in strata by sex, age (born in 1925 or earlier, born in 1926-45, born in 1946 or later), and occupational group (managers, other office staff, skilled workers, semiskilled workers).[11] People who refused to participate were replaced by new participants from a reserve list. We gathered data by questionnaire, interviews, and clinical examinations. After exclusion of people with cardiovascular disease at baseline, the study cohort comprised 812 employees. Follow up examinations included measurement of blood pressure, cholesterol concentration, and body mass index in 1978 (n=674) and in 1983 (n=594).

Work stress questionnaire

We used self assessment scales to measure the components of the job strain model and the effort-reward

Table 1 Hazard ratios for cardiovascular mortality by levels of work characteristics. Adjusted for age and sex

Characteristic	No of participants (No of deaths)	Hazard ratio (95% CI)
Job strain:		
Low	215 (16)	1.00
Intermediate	389 (32)	1.53 (0.83 to 2.82)
High	201 (25)	2.20 (1.16 to 4.17)
Demands (a component of job strain):		
Low	298 (23)	1.00
Intermediate	232 (22)	1.58 (0.88 to 2.84)
High	282 (28)	1.35 (0.77 to 2.36)
Job control (a component of job strain):		
High	264 (20)	1.00
Intermediate	259 (21)	1.17 (0.63 to 2.16)
Low	282 (32)	1.90 (1.08 to 3.37)
Effort-reward imbalance:		
Low	269 (15)	1.00
Intermediate	272 (29)	2.21 (1.17 to 4.15)
High	271 (29)	2.36 (1.26 to 4.42)
Effort (a component of effort-reward imbalance):		
Low	263 (17)	1.00
Intermediate	277 (24)	1.54 (0.82 to 2.90)
High	272 (32)	1.63 (0.90 to 2.96)
Reward (a component of effort-reward imbalance):		
High	280 (32)	1.00
Intermediate	252 (14)	0.79 (0.41 to 1.51)
Low	280 (27)	2.04 (1.21 to 3.43)

imbalance model.[11] The questions on work demands deal with the degree of responsibility at work, task difficulty, and mental load. The questions on job control concern decision authority and skill discretion. The questions on effort at work indicate pace of work and physical and mental load, and the questions on rewards measure satisfaction with income, fairness of supervision, job security, and promotion prospects. All the questions required responses on Likert-type response formats (for example, 1="no strain" to 5="very great strain"). Each scale was constructed by summing the response scores on the individual questions. We divided the resulting scores into thirds to indicate low, intermediate, and high levels on each scale.

We used the work demand and job control scales to create the job strain indicator. This indicator had three categories: high job strain (high or intermediate demands combined with low control), low job strain (low demands combined with high or intermediate control), and intermediate job strain (all other combinations of demands and control).

We created the indicator of effort-reward imbalance by calculating the ratio between the sum response score in the effort scale and the sum response score in the reward scale.[8–10] We divided the resulting quotient into thirds to indicate low, intermediate, and high effort-reward imbalance.

Cardiovascular mortality

We collected mortality data from the Statistics Finland national mortality register, using the participants' personal identification codes. We obtained the date and cause of death for all participants who died between the date of their clinical examination (which took place between 5 February and 30 June 1973) and 1 November 2000. We pooled all deaths due to cardiovascular diseases.

Demographic, behavioural, and biological factors

We measured sex, age, occupational group, smoking status, physical activity, systolic blood pressure, diabetes, serum total cholesterol concentration, and body mass index.

Statistical analysis

We used Cox proportional hazard models to assess associations between baseline characteristics and cardiovascular mortality. See bmj.com for the detailed modelling strategies.

Results

During the mean follow up of 25.6 (range 0.9-27.8) years, 73 deaths from cardiovascular causes occurred among the participants who had been free from overt cardiovascular diseases at baseline. As expected, higher age, male sex, low worker status, smoking, sedentary lifestyle, high blood pressure, high cholesterol concentration, and high body mass index increased the risk of death (see bmj.com). After adjustment for age and sex, we found excess risks of cardiovascular mortality for high job strain, low job control, high effort-reward imbalance, and low reward, but not for high demands or high efforts (table 1).

After additional adjustment for occupational group, job control no longer predicted mortality (table 2). The hazard ratio for the reward component also became non-significant after adjustment for behavioural risk factors. Adjustment for baseline covariates had little effect on the associations of job strain and effort-reward imbalance with cardiovascular mortality. Employees scoring high on job strain and effort-reward imbalance had a twofold risk of death compared with their colleagues with low strain and low effort-reward imbalance (table 2). Exclusion from the analyses of the four participants who had diabetes at baseline did not change these results.

A stratified analysis of the 584 employees (55 deaths) whose occupational group remained unchanged five years after the assessment of work stress revealed a strengthened association between job strain and cardiovascular mortality—the hazard ratio for high job strain was 2.90 (95% confidence interval 1.25 to 6.71). The association between reward-effort imbalance and mortality remained unaltered—hazard ratio for high imbalance of 2.59 (1.18 to 5.68). The individual components of the work stress models were not significantly associated with death from cardiovascular disease.

At follow up, concentrations of total cholesterol increased for employees with high job strain and low job control, and body mass index increased for employees with low job control and high effort-reward imbalance (see bmj.com). Work stress was not associated with blood pressure at follow up.

Discussion

To our knowledge, this is the first study of cardiovascular mortality that tests the validity of the two main work stress models in a single working population. We found that employees reporting high job strain and high effort-reward imbalance had a twofold higher risk of death from cardiovascular disease than

Table 2 Adjusted hazard ratios (95% confidence intervals) for cardiovascular mortality by levels of work characteristics

Characteristic	Covariates in addition to age and sex			
	Occupational group	Behavioural risk factors*	Biological risk factors†	All aforementioned
Job strain:				
Low	1.00	1.00	1.00	1.00
Intermediate	1.36 (0.72 to 2.57)	1.71 (0.92 to 3.17)	1.58 (0.84 to 2.95)	1.64 (0.85 to 3.19)
High	1.89 (0.93 to 3.81)	2.20 (1.12 to 4.32)	2.35 (1.22 to 4.52)	2.22 (1.04 to 4.73)
Job control (a component of job strain):				
High	1.00	1.00	1.00	1.00
Intermediate	0.94 (0.48 to 1.82)	1.06 (0.57 to 1.98)	1.14 (0.62 to 2.11)	0.74 (0.39 to 1.50)
Low	1.55 (0.80 to 3.01)	1.79 (0.98 to 3.27)	1.89 (1.06 to 3.38)	1.42 (0.72 to 2.82)
Effort-reward imbalance:				
Low	1.00	1.00	1.00	1.00
Intermediate	2.16 (1.04 to 4.49)	2.00 (1.06 to 3.78)	2.07 (1.09 to 3.91)	1.91 (0.90 to 4.05)
High	2.36 (1.06 to 5.46)	2.18 (1.15 to 4.13)	2.29 (1.21 to 4.35)	2.42 (1.02 to 5.73)

*Smoking and physical activity.
†Systolic blood pressure, cholesterol concentration, and body mass index.

their colleagues scoring low in these dimensions. The specific strengths of our investigation were a long follow up period, comprehensive questionnaires to indicate stressful work characteristics, control for a large set of potential confounding factors, and the use of reliable mortality registers.

In this study of initially healthy employees adjustment for baseline variation resulted in no or only a minor attenuation of hazard ratios. However, high job strain and high effort-reward imbalance were associated with increased cholesterol concentration and body mass index at follow up (see bmj.com). These associations may reflect pathophysiological changes related to the development of cardiovascular disease.

The work stress models are aimed at identifying characteristics of work life that are likely to cause frequent and longlasting stress and therefore be predictive of disease endpoints.[12] Stable levels of work stress are more likely among employees who do not change their job or workplace. In line with this, we found the adverse effects of high job strain to be greatest for employees who remained with the same employer and in the same occupation during the five years after assessment of their work stress. The results for effort-reward imbalance remained unaltered in this stratified analysis.

Many recent studies on the job strain model emphasise the importance of low job control rather than its interaction with high demands.[13] We found low job control to be associated with cardiovascular mortality before, but not after, adjustment for occupational group. The 40% attenuation in the hazard ratio after the adjustment suggests that job control varies according to occupational group or that part of the effect of job control may be attributable to its relation to low socioeconomic status, a major determinant of public health.[14 15] Our results are in line with those of Lynch et al, who reported that the effect of low resources (a construct close to job control) on mortality and acute myocardial infarction was evident only for employees with low socioeconomic status.[3]

High work demands and high mobilisation of efforts at work may not always indicate harmful stress. In this study, the levels of demands and effort did not independently predict cardiovascular mortality, and corresponding results have been reported previously.[2 4–7 16] However, people with a very high workload, as indicated by working continuously over 11 hours a day, may be at increased risk of cardiovascular disease.[17]

Assessment of work stress with self reports is apparently not a source of major bias in our study. Previous studies using subjective and objective methods have tended to give reasonably consistent results,[13] and the correlations between subjective assessments and expert ratings of job conditions are high.[18]

Policy implications

In the promotion of cardiovascular health, the traditional advice for people to stop smoking, cut down drinking, eat less fat, and engage in physical activity has been shifted towards a more holistic view. Structural and psychosocial factors, in addition to behavioural ones, are increasingly seen as important determinants of public health. Our findings on work stress are consistent with this interpretation.

However, excess health risk in employees with high stress might not exclusively reflect a causal relation. For example, a selection into a stressful work environment may partly reflect early risk factors and adverse environments during childhood and adolescence.[19] Research on organisational interventions is needed to evaluate the additional gains achievable from efforts to change work life.

What is already known on this topic

Job strain (high demands and low job control) and effort-reward imbalance (high demands, low security, few career opportunities) elicit stress at work

Their status as risk factors for cardiovascular mortality has, however, remained uncertain

What this study adds

Job strain and effort-reward imbalance were each associated with a doubling of the risk of cardiovascular death among employees who were free from overt cardiovascular diseases at baseline

Job strain and effort-reward imbalance also predicted adverse changes in biological factors such as cholesterol concentration and body mass index

MK is also a senior researcher at the Finnish Institute of Occupational Health, Helsinki. We thank Hans Helenius for his help with statistical analysis.

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Implementing intensive control of blood glucose concentration and blood pressure in type 2 diabetes in England: cost analysis (UKPDS 63)

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Abstract

Objective To estimate the incremental cost of implementing policies for more intensive control of blood glucose concentration and blood pressure for all patients with type 2 diabetes in England.
Design Extrapolation of resource use and cost data derived from a randomised controlled trial.
Setting General practice, outpatient care, and inpatient care.
Population Trial population with diagnosed type 2 diabetes in England extrapolated to the population of England.
Main outcome measures Total costs based on use of healthcare resources including costs of management, treatment, and hospitalisation.
Results The incremental net annual cost of implementing more intensive control of blood glucose and blood pressure to all people with diagnosed type 2 diabetes in England is estimated to be £100.5m ($156m; €159m), which is equivalent to less than 1% of the proposed additional annual expenditure on the NHS in 2001-5. This estimate varied in sensitivity analyses from £67m to £121m.
Conclusions Policies to improve control of blood glucose and blood pressure of people with type 2 diabetes are effective in reducing complications associated with the disease and are also cost effective. The total cost represents a small fraction of the NHS's spending plans.

Introduction

The United Kingdom prospective diabetes study (UKPDS) has established that a policy for more intensive control of blood glucose concentration (aiming for a fasting plasma glucose concentration <6 mmol/l) is a cost effective means of increasing the time free of complications in patients with type 2 diabetes, with the cost per year free of complications less than £1200 ($1862; €1903).[1] Similarly, data from the UKPDS show that tighter control of blood pressure (aiming at a blood pressure of less than 150/85 mm Hg) in hypertensive patients with type 2 diabetes has a cost effectiveness ratio of £720 per year of life gained.[2] However, adopting a new intervention requires either identifying within a fixed budget a range of other activities that are less cost effective, have similar total costs, and can be halted, or funding the new intervention from additional resources. In either case, it is important to know not only the cost effectiveness of the new intervention but also the total cost of implementing it.