Psychological stress and incidence of ischaemic heart disease

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Background We assessed the relationship between psychological stress and ischaemic heart disease (IHD) incidence in a population of 868 men over a 10-year follow-up period.

Methods In 1981, 869 men aged 42–60, free from IHD and living around Quebec City completed a questionnaire assessing the presence of psychological stress in different areas of their life. They also underwent a medical examination and provided information on IHD risk factors. From 1981 to 1991, the incidence of IHD events was ascertained. The relationship between 13 stress dimensions and IHD incidence was investigated using Cox regression while controlling for important IHD risk factors. Cross-sectional analyses were also performed to investigate the relationship between stress dimensions and IHD risk factors.

Results Between 1981 and 1991, 79 men (9%) experienced a first IHD event. The following risk factors were associated with the risk of IHD: age, (rate ratio (RR) = 1.93, 95% CI : 1.21–3.09), hypertension (RR = 1.90, 95% CI : 1.22–2.98), triglycerides (RR = 1.87, 95% CI : 1.19–2.95) and high density lipoprotein (HDL) cholesterol (RR = 1.64, 95% CI : 1.05–2.55). After controlling for risk factors, none of the psychological stress dimensions significantly altered the risk of IHD.

Conclusions While confirming the influence of hypertension, age, triglycerides and HDL cholesterol on IHD incidence, this study suggests that there is no important connection between the explored stress dimensions and IHD incidence. It is unlikely that this lack of association is due to the stress questionnaire since the 13 stress dimensions were rigorously developed through independent evaluation of the questions by three specialists and many statistically significant relationships were observed between stress dimensions and IHD risk factors.

Keywords Ischaemic heart disease, psychological stress, risk factors

Accepted 6 January 1999

In recent years many psychosocial factors have been suggested as potential risk factors for ischaemic heart disease (IHD) and strong evidence has been put forward for several personality factors such as type A behaviour pattern,1–3 hostility,4 and depression5–7 or social factors such as low socioeconomic status8,9 and lack of social support.10,11 Studies concentrating on occupational stress12–19 or life events20,21 however, have provided contradictory results. Occupational stress research has been dominated by the Karasek model of job demand and decision latitude.22 Very few of these studies have been prospective and most of them have relied on surrogate outcomes.23–25 Similarly, studies looking at the association between life events and IHD have very rarely been prospective. Moreover, most of them have used the Holmes and Rahe model of disturbing life changes26 which does not take into account the self-perceived impact of these events but gives a predetermined and universal score for each life change experienced. The assessment of psychological stress in this study was inspired by the transactional model of stress and the appraisal process, first developed by Lazarus and Launier in 1977.27 This model is based on the assumption that it is an individual’s reaction to events rather than events per se which leads to the stress response. For this reason, we aimed to evaluate individuals’ perception of potentially stressful situations. Directly targeting appraisal allows us to encompass contextual factors such as vulnerability and resistance. Despite the fact that in the public eye psychological stress is one of the major risk factors for cardiovascular disease,28 very few prospective studies have
addressed this issue using an instrument measuring self-perceived stress from diverse areas of life.

The present study investigates the relationship between 13 self-perceived stress dimensions grouped in three main categories (occupation, lifestyle and life events) and the incidence of IHD in a population of middle-aged, Caucasian men over a 10-year follow-up period.

**Subjects and Methods**

The original selection of participants has been described previously. In brief, 4637 men aged 35–64 in 1973 and living in Quebec City suburbs were enrolled in a prospective study investigating the incidence, mortality and determinants of cardiovascular disease. In 1981, a cross-sectional study was undertaken to establish lipid and lipoprotein profiles and their relation to other risk factors for IHD. For this study, a random sample of 2077 men was taken from the 3515 men from the original cohort who were ≤60 years and had no history of IHD. Of these, 74 (3.6%) had died and 60 (2.9%) could not be located. The remaining 1943 men were invited to participate in the study: 427 (22%) were not interested in participating, 158 (8.1%) were not eligible for the study since they were receiving medication known to have an effect on lipid metabolism, 36 (1.8%) did not present to the clinic, and 153 (7.9%) had left the Quebec City area. Thus, 1169 men (60.2%) participated in the study. These men underwent a medical examination including two blood pressure measurements and determination of fasting serum lipids. Height and weight were measured and information was collected on smoking habits and physical activity.

Quebec City area. Thus, 1169 men (60.2%) participated in the study. These men underwent a medical examination including two blood pressure measurements and determination of fasting serum lipids. Height and weight were measured and information was collected on smoking habits and physical activity. Among these 1169 subjects, 923 (79%) completed a questionnaire assessing their levels of self-perceived psychological stress. Thirty-eight (4%) were excluded because they had prevalent IHD and 16 (2%) were excluded because their medical data was incomplete. Thus, 869 men free of IHD formed the study population. Of these men, 94% had a job at the time of the interview.

Subjects completed the stress questionnaire individually under the supervision of a research assistant while they were waiting for their medical examination. The questionnaire contained three main categories of questions. The first category assessed occupational stress and investigated the level of satisfaction (4-point Likert scale: very satisfied–very dissatisfied) with diverse aspects of work, the frequency (4-point Likert scale: often–never) of stressful factors of work and the level of anxiety caused by these factors (4-point Likert scale: low–high). The second category concerned stress related to lifestyle and evaluated topics such as satisfaction with social life, family life and living environment. Questions from these two categories were originally developed by a research team from Montreal who adapted a validated instrument used in a study by Dolan and Arsenault. The questionnaire underwent a pre-test among a group of workers from Montreal and went on to be used in a cross-sectional study of 1530 office workers to evaluate the association between psychological stress at home and at work and physical symptoms. The investigators found many stress dimensions to be related to an increased risk of various physical symptoms such as gastrointestinal problems and insomnia. The third category of questions assessed life events. This questionnaire, including 49 different events, was adapted from the measure developed by Holmes and Rahe which is often used with a point system giving a universal score to each event. For our study, information was collected not only on the occurrence of an event but also on the date and the persisting subjective emotional impact of events at the time of questionnaire completion (5-point Likert scale: negligible–important).

In 1990, cohort members were contacted and vital status was obtained for all of them. Information on IHD morbidity and mortality was acquired from five possible sources: hospital records, death certificates, the Quebec death registry, close relatives or the family physician. The events considered for our study were angina pectoris, myocardial infarction and IHD death. Angina pectoris was diagnosed exclusively on a clinical history of a retrosternal burning, squeezing or heavy discomfort of <5 min duration, brought on by exertion and relieved by rest. This diagnosis was always made by a physician and subsequently confirmed by a cardiologist of the study group. Myocardial infarction was diagnosed according to either evolutive ECG changes of myocardial infarction, ECG evidence of myocardial necrosis according to the Minnesota code 1.1 or two of the three following situations: a typical history of retrosternal discomfort of ≥20 min duration, not relieved by rest or nitroglycerin; twofold elevation of creatine phosphokinase above the upper normal value; ECG evidence of myocardial necrosis according to Minnesota codes 1.21 to 1.25 and 1.27, or changes in repolarization code 9.2 and 5.1 or 5.2. The ECG interpretations were conducted by the same cardiologist blinded to the participants’ risk status and other clinical data. Fatal myocardial infarction was diagnosed when death occurred within 4 weeks of either the acute event or an event documented at autopsy.

**Analyses**

The content validity of the stress scale was examined using a committee approach. Specifically, we independently consulted three health psychologists from Laval University to select those questions from the first two categories of our questionnaire which were pertinent to the assessment of psychological stress. Subsequently, a meeting was held to resolve any divergence of opinions and questions conserved by all three specialists were grouped into distinct stress dimensions. Of 53 questions assessing occupational stress, 12 were excluded and the remaining 41 items were grouped in six dimensions. For example, the following items were grouped to form the dimension ‘satisfaction with work schedule’: At work, to what extent are you satisfied or dissatisfied; (1) with the number of hours you work, (2) with the amount of overtime you do, (3) with the time allocated for meals and breaks, (4) with the flexibility/rigidity of your work schedule. Among others, the item, ‘does your work often put you in contact with the public?’ was not considered pertinent for the measure of stress under study and was therefore excluded from this section. In the lifestyle category nine out of 46 questions were excluded and six dimensions were formed. For example, the following items were grouped to form the dimension ‘satisfaction with relationship with children’: To what extent are you satisfied or dissatisfied; (1) with the time you have to spend with your children, (2) with the emotional relationship between you and your children, (2) with the communication between you and your children. From this section, one of the items excluded was ‘do you often drive a motor vehicle?’ The
internal consistency of these dimensions was studied using Cronbach’s alpha coefficients, which were all superior to 0.70. For analysis of the life events questionnaire we created a variable which was the sum of the persisting emotional impact for all events experienced. Furthermore, in order to avoid probable memory recall bias and since the emotional impact of a given event is expected to have only a short-term effect, we restricted the analysis to life events occurring within 12 months of questionnaire completion. Various analyses were performed using binary stress dimension variables with several different cutoff points, categorical variables and continuous variables. Since all results were similar the stress dimensions are presented as dichotomous variables with approximately 20% of the population in each ‘high stress’ group. For example, the dimension ‘satisfaction with work schedule’, regrouping three items with four possible values, had a range of values 3–12. We dichotomized this variable whereby men with a value >9 (17.6%) were classed as ‘high stress’. Additional analyses were performed with the life events questionnaire using the conventional point system of Holmes and Rahe where a fixed score is given to each event and these scores are added for all events experienced.

Analyses assessing the association between psychological stress dimensions and IHD incidence were performed using Cox’s proportional hazards model. Follow-up times were calculated from questionnaire completion in 1981 to the date of the first IHD event or to the end of the follow-up period, 1 September 1990. Twenty-three deaths from other causes were treated as censored observations at the date of death. Analyses were performed for 869 individuals. For the analysis of occupational stress dimensions, 54 individuals who were not working at the time of questionnaire completion were excluded, leaving 815 individuals. Due to the small frequency of each distinct IHD event, angina pectoris, myocardial infarction and IHD death were combined to create one variable. Rate ratios (RR) and their 95% CI were adjusted for four IHD risk factor variables: age, hypertension (defined as a mean of two diastolic blood pressure measurements ≥90 mmHg, a mean of two systolic blood pressure measurements ≥140 mmHg and/or a medical history of hypertension), triglyceride level and high density lipoprotein (HDL) cholesterol. Total cholesterol, sedentary behaviour, smoking and body mass index (BMI) were not included in the models as initial analyses revealed that they were not confounding variables.

To investigate the relationship between IHD risk factors and stress dimensions, logistic regression models were used while simultaneously adjusting for all IHD risk factors.

### Results

Among the 869 subjects free of IHD in 1981, 15 (2%) deaths were attributed to IHD, 44 men (5%) had experienced angina and 39 men (4%) had experienced myocardial infarction. Seventy-nine men (9%) had experienced at least one IHD event between 1981 and 1991. The distribution of risk factors and their association with the incidence of IHD is shown in Table 1. After adjustment for all important risk factors, age (RR = 1.93, 95% CI: 1.21–3.09), hypertension (RR = 1.90, 95% CI: 1.22–2.96), triglycerides (RR = 1.87, 95% CI: 1.19–2.95) and HDL cholesterol (RR = 1.64, 95% CI: 1.05–2.55) were predictors of IHD risk. The RR associated with sedentary behaviour and elevated total cholesterol were relatively high but were not statistically significant. No significant association was observed between smoking or BMI and IHD incidence.

The relationship between stress dimensions and IHD incidence is shown in Table 2. Whether or not adjustment was made for IHD risk factors, not one of the 13 stress dimensions was significantly related to IHD incidence. Relatively important but statistically non-significant RR were observed for the variables ‘considers he’s in bad health’ (RR = 1.63, 95% CI: 0.89–3.00) and ‘dissatisfied with living environment’ (RR = 0.44, 0.20–1.02).

### Table 1 Major ischaemic heart disease (IHD) risk factors, their prevalence in 1981 and their relation to the occurrence of IHD events between 1981 and 1991. Rate ratios and corresponding CI obtained from Cox’s proportional hazards model are adjusted for age

<table>
<thead>
<tr>
<th>Risk factors</th>
<th>%</th>
<th>Rate ratio</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age &gt;50 years</td>
<td>52.2</td>
<td>1.93</td>
<td>1.21–3.09</td>
</tr>
<tr>
<td>Hypertension</td>
<td>30.0</td>
<td>1.90</td>
<td>1.22–2.96</td>
</tr>
<tr>
<td>Triglycerides &gt;200</td>
<td>24.9</td>
<td>1.87</td>
<td>1.19–2.95</td>
</tr>
<tr>
<td>HDL cholesterol &lt;0.9 mmol/l</td>
<td>37.8</td>
<td>1.64</td>
<td>1.05–2.55</td>
</tr>
<tr>
<td>Total cholesterol 5.2–6.2 mmol/l</td>
<td>36.6</td>
<td>1.34</td>
<td>0.75–2.41</td>
</tr>
<tr>
<td>Total cholesterol &gt;6.2 mmol/l</td>
<td>32.9</td>
<td>1.56</td>
<td>0.87–2.79</td>
</tr>
<tr>
<td>Sedentary behaviour</td>
<td>72.0</td>
<td>1.54</td>
<td>0.89–2.67</td>
</tr>
<tr>
<td>Smoking &gt;20 cigarettes/day</td>
<td>15.0</td>
<td>0.93</td>
<td>0.48–1.80</td>
</tr>
<tr>
<td>Smoking &gt;20 cigarettes/day</td>
<td>27.7</td>
<td>1.08</td>
<td>0.65–1.78</td>
</tr>
<tr>
<td>Body mass index &gt;27</td>
<td>32.6</td>
<td>1.22</td>
<td>0.77–1.93</td>
</tr>
</tbody>
</table>

### Table 2 Psychological stress dimensions, their prevalence in 1981 and their relation to ischaemic heart disease (IHD) incidence. Rate ratios (RR) and their corresponding CI are adjusted for age, hypertension, triglycerides and high density lipoprotein (HDL) cholesterol

<table>
<thead>
<tr>
<th>Psychological stress dimension</th>
<th>%</th>
<th>RR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dissatisfied with work environment</td>
<td>15.4</td>
<td>1.16</td>
<td>0.62–2.15</td>
</tr>
<tr>
<td>Dissatisfied with work schedule</td>
<td>17.6</td>
<td>1.30</td>
<td>0.73–2.29</td>
</tr>
<tr>
<td>Dissatisfied with job context</td>
<td>24.5</td>
<td>1.01</td>
<td>0.52–1.97</td>
</tr>
<tr>
<td>Dissatisfied with level of responsibility at work</td>
<td>13.4</td>
<td>0.89</td>
<td>0.44–1.80</td>
</tr>
<tr>
<td>Dissatisfied with level of support at work</td>
<td>21.4</td>
<td>1.06</td>
<td>0.61–1.86</td>
</tr>
<tr>
<td>Frequently confronted with stressful situations at work</td>
<td>25.4</td>
<td>1.19</td>
<td>0.70–2.02</td>
</tr>
<tr>
<td>Lifestyle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low level of coping activity</td>
<td>21.5</td>
<td>0.97</td>
<td>0.56–1.68</td>
</tr>
<tr>
<td>Dissatisfied in a relationship (n = 810)</td>
<td>16.4</td>
<td>0.82</td>
<td>0.42–1.60</td>
</tr>
<tr>
<td>Dissatisfied with relationship with children (n = 778)</td>
<td>14.6</td>
<td>1.14</td>
<td>0.60–2.17</td>
</tr>
<tr>
<td>Dissatisfied with social life</td>
<td>24.9</td>
<td>0.68</td>
<td>0.32–1.42</td>
</tr>
<tr>
<td>Dissatisfied with living environment</td>
<td>15.6</td>
<td>0.44</td>
<td>0.20–1.02</td>
</tr>
<tr>
<td>Considers he’s in bad health</td>
<td>11.9</td>
<td>1.63</td>
<td>0.89–3.00</td>
</tr>
<tr>
<td>Life events</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Highly effected by life events</td>
<td>15.8</td>
<td>0.92</td>
<td>0.50–1.70</td>
</tr>
</tbody>
</table>
Study participants. The subjective nature of the questionnaire implied a considerable reduction of statistical power. However, RR were similar to those reported above. Finally, in order to verify whether risk factors are intermediates in the relationship between stress and IHD incidence, Cox regression analysis was performed with adjustment made for age only. Again, results were similar to those reported above.

In contrast, many significant relationships were observed between IHD risk factors and stress dimensions (Table 3). Men who were physically inactive were more frequently confronted with stressful situations at work, obviously had a lower level of coping activity, were less satisfied in a relationship and considered their health to be worse than active men. As expected, men who smoked had a lower level of coping activity and considered their health to be worse than non-smokers. Younger men were less satisfied with their relationship with their children and their social life than their counterparts. Men with HDL cholesterol <0.9 mmol/l were less satisfied with their level of responsibility at work and with their living environment than men without this risk factor. Finally, BMI >27 was associated with a higher frequency of stressful situations at work. No significant associations were observed between stress and hypertension, total cholesterol or triglycerides.

### Discussion

Our results suggest that among middle-aged, Caucasian men, the psychological stress measured has little or no impact on the incidence of IHD. Total cholesterol and sedentary behaviour were associated with an increased incidence of IHD while age, hypertension, triglycerides and HDL cholesterol were statistically significant predictors of IHD risk. The prospective nature of the analyses and scientific evidence acquired in this field are a strong indication that these relationships are of a causal nature. Psychological stress was related to sedentary behaviour, smoking, HDL cholesterol, BMI and age. Due to the transversal nature of the analyses, no conclusions can be drawn on the nature of these relationships. However, the lack of association between psychological stress dimensions and IHD incidence could be explained by the fact that they are related to different IHD risk factors.

This was a prospective study with a long follow-up period and a large sample size. Through a rigorous ascertainment of IHD morbidity and mortality we achieved complete follow-up for all study participants. The subjective nature of the questionnaire enabled us to capture subjects’ individual perception of stressful situations. Unlike many questionnaires concentrating on stress in one particular area of life, our questionnaire covered a wide variety of potentially stressful situations, thus increasing the probability of finding significant associations. It is possible that information bias was caused by the fact that, due to the small number of IHD cases, angina pectoris, myocardial infarction and IHD death were pooled into one category. Apart from one study in a population of 7219 men which found psychosocial work organization to be related to both cardiovascular disease mortality and morbidity,18 very few studies have had sufficient statistical power to analyse these different IHD events separately in the same population. It is therefore unclear whether certain IHD events could be more strongly associated with psychological stress. Due to the use of non-validated questions in our questionnaire, we used a rigorous approach to assess the content validity and internal consistency of our stress measure with the help of experts in the field of health psychology. Despite the fact that our instrument was not fully validated, the questionnaire we used...
had already undergone a pre-test and been used to demonstrate an association between certain psychological stress dimensions and physical symptoms in a previous study.\textsuperscript{32} In addition, many important associations were observed between stress dimensions and IHD risk factors in our cross-sectional analyses. This indicates that the stress questionnaire was able to capture the aspects of psychological stress that we wanted to measure.

It is difficult to compare our results with those of previous studies; firstly, because very few are prospective and secondly, because their measure of psychological stress was either very specific (limited to occupational stress or life events)\textsuperscript{12–21} or was oversimplified.\textsuperscript{36} However, among seven prospective studies investigating the relationship between job strain and cardiovascular disease (new events, morbidity and mortality) using the Karasek model, two found that high demand and low decision latitude increased the risk of IHD among men,\textsuperscript{16,17} two found that only low control increased this risk\textsuperscript{12,14} and three reported absence of any relationship.\textsuperscript{13,15,18} The only prospective study using Holmes and Rahe’s scale which has been published to date was conducted among a population of male workers from Sweden.\textsuperscript{20} The investigators found no association between life events and myocardial infarction in a 12–15-month follow-up period. The association between global, self-perceived stress and cardiovascular disease has rarely been investigated but using this stress conceptualization a prospective study from Sweden found a relationship between psychological stress and IHD. In this case however, stress was assessed using only one question which was conceived on a purely intuitive basis and which the authors themselves described as ‘broad and non-specific’.\textsuperscript{36}

It is possible that the lack of association between stress and IHD incidence in our study is related to the fact that stress was only assessed once, at the beginning of the 10-year follow-up period. It is highly conceivable that psychological stress has only a short-term effect on IHD risk and therefore that stress measured at one point in time is only weakly related to IHD incidence up to 10 years later. However, many studies have used a similar design, including Lacroix\textsuperscript{18} who, in a prospective study from Sweden found a relationship between psychological stress and IHD. In this case however, stress was assessed using only one question which was conceived on a purely intuitive basis and which the authors themselves described as ‘broad and non-specific’.\textsuperscript{36}

References

At work, to what extent are you satisfied or dissatisfied with:
- The number of regular hours you have to work?
- The amount of overtime you do?
- The time allocated to meals and breaks?
- The flexibility/rigidity of your work schedule?

Satisfaction with job context (very satisfied–very dissatisfied)
At work, to what extent are you satisfied or dissatisfied with:
- The level of challenge your job offers you?
- The nature of the work in general or the tasks which you perform?
- Your own performance at work?
- Your choice of profession?
- Your aptitude/competence to perform the work?

Satisfaction with level of support at work (very satisfied–very dissatisfied)
At work, to what extent are you satisfied or dissatisfied with:
- The level of support between you and your colleagues?
- The level of confidence between you and your colleagues?
- The communication between you and your colleagues?
- The support provided by your immediate superior?
- The confidence your immediate superior accords you?
- The communication between you and your immediate supervisor?

Frequency of confrontation with stressful situations (always–never)

Is/does your job:
- Physically difficult?
- Stimulating?
- Monotonous?
- Repetitive?
- Demand that you work at an accelerated pace?
- Complex, difficult?
- Require a lot of concentration?
- Imply receiving complaints?

Level of coping activity (very satisfied–very dissatisfied)
Are you satisfied with:
- The leisure activities that you have presently?
- The number of hours per week that you have available for leisure activities?
- The time available for relaxation or rest in a week?

Do you participate in the following activities:
- Yoga?
- A relaxation technique?
- Sport, physical activity?
Satisfaction in a relationship (very satisfied–very dissatisfied)
To what extent are you satisfied or dissatisfied with:
  The communication between you and your partner?
  Your sex life?
  The relationship between you and your partner’s parents?

Satisfaction with relationship with children (very satisfied–very dissatisfied)
To what extent are you satisfied or dissatisfied with:
  The time you have to spend with your children?
  The emotional relationship between you and your children?
  The communication between you and your children?

Satisfaction with social life (very satisfied–very dissatisfied)
To what extent are you satisfied or dissatisfied with:
  The number of friends you have?
  The relationship you have with your friends?
  The communication between you and your friends?
  The relationship you have with your relatives?

Satisfaction with living environment (very satisfied–very dissatisfied)
To what extent are you satisfied or dissatisfied with:
  The district you live in?
  The neighbours you have?
  Your residence?
  Your quality of life?

Consideration of health (excellent–bad)
How would you describe your health?