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Job strain and major risk factors for coronary heart disease among employed males and females in a Swedish study on work, lipids and fibrinogen

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Objectives The aim of this study was to analyze the relationship of job strain (high psychological job demands and low decision latitude) to hypertension, serum lipids, and plasma fibrinogen.
Methods The study population consisted of employed persons between the ages of 15 and 64 years in the counties of Stockholm, Västernorrland, and Jämtland, Sweden. The data collection was carried out during 1992–1998. A total of 10 382 subjects participated in a medical examination and completed a questionnaire.
Results No strong associations were found between job strain and plasma fibrinogen. The males reporting job strain had lower levels of total cholesterol and high-density lipoprotein cholesterol than the other males. Similar tendencies were found for the females. The females, but not the males, with job strain had an increased prevalence of hypertension when compared with the subjects with relaxed psychosocial work characteristics. In the subgroups of younger males and females an adverse association between job strain and the ratio between low-density and high-density lipoprotein cholesterol was noted.
Conclusions The results do not support the hypothesis that job strain has an adverse impact on serum total cholesterol and plasma fibrinogen levels. They suggest that an increased risk of coronary heart disease in association with job strain, if causal, is mediated by other factors, possibly partly by hypertension and low levels of high-density lipoprotein cholesterol.

Key words cholesterol, fibrinogen, high-density lipoprotein cholesterol, hypertension, work stress.

In Sweden, considerable differences have been found in the incidence of myocardial infarction among socioeconomic and occupational groups (1–3). These differences are, to some extent, probably due to differences in life-style and living conditions, but other factors, including psychosocial factors, may also be important. Several studies have indicated that the psychosocial conditions of the work environment, especially the combination of high psychological demands and low decision latitude (job strain), is associated with an increased risk of myocardial infarction (4–18). A few studies have been negative (19–21), and the extent to which this

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association is causal is still unresolved. Furthermore, there is limited knowledge about the associations between job strain and biological risk factors for coronary heart disease.

Occasional and permanent increases in blood pressure and heart rate have been observed among subjects in occupations with job strain (22–27). However, previous studies do not give a fully consistent picture (23, 28). Only a few studies have investigated the association between job strain and blood lipids and fibrinogen. Siegrist and his co-workers (29) found that stressful job conditions may be associated with an unfavorable low-density lipoprotein (LDL) to high-density lipoprotein (HDL) balance. In a recent Swedish study of a rural male population the results indicated that control over the work situation had a positive influence on the LDL : HDL ratio (30). Wamala et al (31) found an adverse lipid profile among Swedish middle-aged women with low decision latitude at work. In the Whitehall study, an association between low decision latitude and plasma fibrinogen was observed (32), and similar findings were made in cross-sectional studies (33, 34). However, this association was not seen in a Japanese population when the results were adjusted for socioeconomic status (35). Furthermore, in a population of Danish workers, no association between job strain and fibrinogen remained when the results were adjusted for confounding factors (36). Only weak associations between job demands and decision latitude with blood pressure, total cholesterol, and fibrinogen were found among young adults in the CARDIA study (37, 38). No consistent associations between job characteristics and total cholesterol and HDL cholesterol were found among Taiwanese white-collar workers (34). Other studies have also failed to show an association between job strain and total cholesterol (25, 36).

Longitudinal studies on large cohorts of working men and women, with detailed information on exposure conditions and potential confounding factors, may help to increase the understanding of the possible mechanisms through which job strain may influence the risk of coronary heart disease. The WOLF (work, lipids and fibrinogen) study was initiated with the main objective of investigating the relationship between psychosocial work conditions, in particular job strain, biological risk factors for coronary heart disease, and, ultimately, coronary heart disease incidence and mortality. It is a multicenter study involving the participation of research institutions and occupational health service units in three Swedish counties (Stockholm, Västernorrland, and Jämtland). Previous studies on the Stockholm part of the material have approached different aspects of the psychosocial work environment, such as effort-reward imbalance and unfair treatment at work (39–41).

Possible effects of job strain on cardiovascular risk may be mediated either by effects on life-style (physical activity, smoking, eating habits) or by direct physiological effects that may raise blood pressure and certain serum lipids and also accelerate the formation of clots. In the present study, our aim was to describe the total study population of the WOLF study and to present baseline data regarding associations between job strain, blood pressure, blood lipids, and plasma fibrinogen while adjusting statistically for possible effects of life-style in order to focus on possible direct physiological effects.

Subjects and methods

A total of 36 occupational health service units in the counties of Stockholm, Västernorrland, and Jämtland were invited to take part in the study, and, of these, 33 accepted the invitation. The study population consisted of employees at approximately 60 companies served by these 36 occupational health service units, representing a number of different branches and a wide variety of occupations. The dominating branches were the pharmaceutical industry, transportation, public administration, telecommunications, sales work, teaching, mechanical industry, construction work, and bank employees. According to the Nordic version of the International Classification of Occupations, 159 occupations on the three-digit level were represented in the study (42). It was not feasible to include all employees of the 60 companies in the study, but all those employed at certain workplaces (eg, laboratory, department, institution, garage, and sales organization) were asked to participate. The selection of these workplaces was basically decided on practical grounds from the point of view of the occupational health services. For example, employees at workplaces where a health examination had recently been carried out were not reexamined. Subjects who were on more-or-less permanent leave from the workplace (eg, stationed abroad or on leave of absence) were not included in the study population.

The data collection in the county of Stockholm was carried out during 1992–1995, while the data collection in Västernorrland and Jämtland (Norrland) was performed in 1996–1998.

A clinical examination was carried out as a targeted health screening at the occupational health service unit. This examination involved measurements of height, weight, waist and hip circumference, and blood pressure. Blood samples were collected for determining blood lipids and plasma fibrinogen. All the subjects were asked to abstain from eating and drinking (with the exception of water) during the 9 hours preceding the clinical examination. Blood pressure was measured on the right arm with the subject in the supine position after a 5-minute rest. Measurements were made twice in a standardized way by specially trained nurses, with a 1-minute intermission. The mean of the two measurements was used as the recorded blood pressure. The pressure was read to the nearest 2 mm Hg (0.26 kPa). Hypertension was defined as a diastolic blood pressure of ≥90 mm Hg (≥11.97 kPa) or a systolic blood pressure of ≥140 mm Hg (≥18.62 kPa) or treatment for hypertension.

Total cholesterol, as well as HDL cholesterol, was measured enzymatically, HDL cholesterol after precipitation with phosphotungstic acid and magnesium chloride. Fibrinogen in plasma was determined by a spectophotometric test. All the analyses of blood lipids and plasma fibrinogen were carried out at the same laboratory (CALAB Medical Laboratories AB, Stockholm, Sweden). The laboratory is accredited by the Swedish Board for Accreditation and Conforming Assessment.

Hypercholesterolemia was defined as a total cholesterol level of >6.4 mmol/l. With regard to HDL cholesterol, cut-off points of 1.0 mmol/l for the males and 1.2 mmol/l for the females were used according to established criteria. The corresponding cut-off points for the LDL : HDL ratio were 4.0 for the males and 3.0 for the females. The plasma fibrinogen level was considered to be increased if it was greater than 3.60 g/l for the males and 3.84 g/l for the females. These limits corresponded to the 90th percentile for the distributions of each gender in the study population.

The occupational health service unit gave an extensive questionnaire to each subject for completion at home. The questionnaire included a large number of questions covering sociodemographic factors, occupation and work environment, life-style factors, disease history, and hereditary factors.

Job strain was measured according to a Swedish modification of a questionnaire developed by Robert Karasek (15). Psychological job demands were measured using five items with four response alternatives each, forming a four-point ordinal scale. An index of psychological job demands was formed by the sum of scores for these items, with 5 as the minimum and 20 as the maximum score for the index. In a corresponding way, decision latitude was measured by an index based on six items, with 6 as the minimum and 24 as the maximum. (See the appendix.) Decision latitude and psychological job demands were dichotomized into "high" and "low", using the median score as the cut-off point (18 for decision latitude and 13 for job demands). In the analysis, those with "low" decision latitude were compared with those with "high" decision latitude, and those with "high" job demands were compared with those with "low" job demands. Job strain was defined as the combination of high job demands and low decision latitude. In the analyses of job strain, a dichotomy was used, contrasting those with job strain to those without. Analyses were also made comparing subjects with job strain with subjects who had relaxed work conditions (ie, high decision latitude and low job demands).

Socioeconomic group was defined on the basis of information on occupation and education in accordance with a system used in Sweden (43). For the purpose of this report, the subjects were categorized as blue-collar workers or white-collar workers. They were categorized according to whether or not they reported current smoking. Those who reported exercising never or seldom were considered to be physically inactive. Overweight was defined as a body mass index (BMI) of >25, using information about weight and height (kg/m^2) from the clinical examination. A fat intake index was constructed on the basis of several questions, mainly covering the consumption of dairy products. This index ranged between zero and five, and those with an index value of at least three were classified as having high fat intake.

Of all the invited employees, a total of 10 413 subjects both responded to the questionnaire and took part in the clinical examination, corresponding to a participation rate of 82%. Altogether 10 382 subjects were between 15 and 64 years of age, and thus were included in our analysis. Of these subjects, 7146 (69%) were male and 3236 (31%) were female.

The number of subjects is shown in table 1, stratified by gender, age, and socioeconomic group. Twelve subjects could not be classified with regard to socioeconomic group and were not included in the table. In all, 3854 of the males (54%) were classified as blue-collar workers, while the corresponding number was 678 (21%) for the females. For both genders the proportion of blue-collar workers was higher in Norrland than in Stockholm.

The characteristics of the WOLF participants are given in table 2. About 22% of the males and 28% of the females were classified as exposed to job strain. Altogether 21% of the males and 27% of the females in the total study population were current smokers. Physical inactivity during leisure time, high consumption of fat, overweight (BMI >25), hypertension, and elevated total cholesterol were more common among the males than among the females. Overweight and hypertension were more prevalent among both the males and females in Norrland than among their counterparts in Stockholm. For HDL cholesterol, the LDL : HDL ratio, and plasma fibrinogen, different cut-off points were used for the males and females. Low HDL cholesterol (<1.0 respectively <1.2 mmol/l) was measured for 13% of the males and 10% of the females. A high LDL : HDL ratio was

Table 1. Proportion of blue-collar workers in the WOLF study population by gender, age, and geographic area.

Age (years)	Stockholm						Norrland						Total population					
	Males			Females			Males			Females			Males			Females		
	All subjects	Blue-collar workers		All subjects	Blue-collar workers		All subjects	Blue-collar workers		All subjects	Blue-collar workers		All subjects	Blue-collar workers		All subjects	Blue-collar workers	
	(N)	N	%	(N)	N	%	(N)	N	%	(N)	N	%	(N)	N	%	(N)	N	%
15–24	173	135	78	148	78	53	79	64	81	15	6	40	252	199	79	163	84	52
25–34	810	331	41	606	120	20	810	602	74	136	44	32	1620	933	58	742	164	22
35–44	848	294	35	639	83	13	1044	720	69	228	74	32	1892	1014	54	867	157	18
45–54	959	337	35	773	113	15	1285	770	60	271	71	26	2244	1107	49	1044	184	18
55–64	426	186	44	285	49	17	702	415	59	133	40	30	1128	601	53	418	89	21
Total	3216 (missing 6)	1283	40	2451 (missing 1)	443	18	3920 (missing 4)	2571	66	783 (missing 1)	235	30	7136 (missing 10)	3854	54	3234 (missing 2)	678	21

Table 2. Prevalence (%) of the baseline characteristics in the Stockholm, Norrland, and total WOLF study population. (BMI = body mass index, HDL = high-density lipoprotein, LDL = low-density lipoprotein)

Characteristic	Stockholm		Norrland		Total	
	Males (N=3222)	Females (N=2452)	Males (N=3924)	Females (N=784)	Males (N=7146)	Females (N=3236)
Job strain	21	27	23	30	22	28
Relaxed work	18	15	16	13	17	14
Smoking	24	27	18	24	21	27
Smoking >10 cigarettes/day	13	16	8	10	11	14
Physically inactive	25	21	28	20	27	21
BMI >25	48	30	62	45	56	33
High fat intake	19	8	20	12	19	9
Hypertension (≥140 mm Hg, ≥90 mm Hg or treatment [a])	18	13	26	21	23	15
Hypercholesterolemia (>6.4 mmol/l)	19	13	23	19	21	14
HDL (<1.0 respectively <1.2 mmol/l)	13	10	13	11	13	10
LDL : HDL ratio (≥4.0 respectively ≥3.0)	13	11	13	14	13	12
Fibrinogen (≥3.60 respectively ≥3.84 g/l)	11	10	9	10	10	10

[a] 1 mm Hg ≈ 0.133 kPa.

found for 13% of the males (ratio ≥4) and 12% of the females (ratio ≥3).

Statistical methods

The associations between the psychosocial factors of the work environment and the biological risk factors for coronary heart disease were studied by means of prevalence ratios (PR) together with 95% confidence intervals (95% CI). Stratified analyses were carried out using the Mantel-Haenszel procedure (44), adjusting for age only and for age, socioeconomic group, smoking, physical inactivity, fat consumption, and BMI. The test-based 95% confidence intervals were computed in accordance with the methods suggested by Miettinen (45). All the analyses were performed using the SAS computer program, version 8.02 (46).

Results

Table 3 shows the results for the associations between psychosocial work conditions and hypertension, plasma fibrinogen, and blood lipids among the males in the total study population. Low decision latitude was associated with low HDL cholesterol, but not with an increased LDL : HDL ratio, after adjustment for confounding factors. An inverse association between job strain and total cholesterol was found when the reference group consisted of all those without job strain. This result was also found when the males with job strain were compared with the males that had relaxed work conditions (ie, high decision latitude and low job demands). In the same way as for low decision latitude, job strain was also associated with low HDL cholesterol levels, but not with an increased LDL : HDL ratio, when compared with males with relaxed work conditions.

Table 3. Decision latitude, psychological job demands, and job strain in relation to biological risk factors for coronary heart disease among the males 15 to 64 years of age in the WOLF study population. (PR = pvalence ratio, 95% CI = 95% confidence interval, HDL = high- density lipoprotein, LDL = low-density lipoprotein)

Risk factor	Low decision latitude [a]		High job demands [b]		Job strain versus other [c]		Job strain versus relaxed [d]	
	PR	95% CI	PR	95% CI	PR	95% CI	PR	95% CI
Hypertension (≥140 mmHg systolic, ≥90 mmHg diastolic, or treatment [e])								
Adjustment for age	1.1	1.0–1.2	0.9	0.8–1.0	1.0	0.9–1.1	1.0	0.9–1.2
All [f]	1.1	1.0–1.2	0.9	0.8–1.0	1.0	0.9–1.1	1.0	0.8–1.1
Elevated plasma fibrinogen (≥3.60 g/l)								
Adjustment for age	0.9	0.8–1.1	1.0	0.8–1.1	1.0	0.8–1.2	0.9	0.7–1.2
All [f]	0.9	0.7–1.0	1.0	0.9–1.2	1.0	0.8–1.2	0.9	0.7–1.2
Hypercholesterolemia (>6.4 mmol/l)								
Adjustment for age	0.9	0.8–1.0	0.9	0.9–1.0	0.9	0.8–1.0	0.8	0.7–0.9
All [f]	0.9	0.8–1.0	0.9	0.8–1.0	0.8	0.7–1.0	0.8	0.6–0.9
Decreased HDL cholesterol (<1.0 mmol/l)								
Adjustment for age	1.3	1.2–1.5	0.9	0.8–1.0	1.1	0.9–1.2	1.3	1.0–1.6
All [f]	1.2	1.1–1.4	1.0	0.8–1.1	1.0	0.9–1.2	1.3	1.0–1.6
Elevated LDL : HDL ratio (≥4.0)								
Adjustment for age	1.0	0.9–1.2	1.0	0.9–1.1	1.0	0.8–1.1	1.1	0.9–1.3
All [f]	1.0	0.9–1.2	1.0	0.9–1.1	0.9	0.8–1.1	1.0	0.8–1.3

[a] High decision latitude was used as the reference category.
[b] Low job demands was used as the reference category.
[c] The subjects with the combination of low decision latitude and high job demands (job strain) were compared with the subjects with any other combination of decision latitude and job demands.
[d] The subjects with the combination of low decision latitude and high job demands (job strain) were compared with the subjects with the combination of high decision latitude and low job demands.
[e] 1 mm Hg ≈ 0.133 kPa.
[f] PR adjusted for age, socioeconomic group, smoking, physical activity, fat consumption, and body mass index.

Among the females, low decision latitude was associated with an increased prevalence of hypertension after adjustment for the covariates. Tendencies towards a greater prevalence of elevated plasma fibrinogen and decreased HDL cholesterol were also found for the females with low decision latitude. Females with job strain showed an increased prevalence of hypertension when compared with females in relaxed jobs (table 4).

Similar analyses as those described in tables 3 and 4 were carried out for the following three age groups: 15–44 years, 45–54 years, and 55–64 years. Tables 5 and 6 show the results for the males and females in the youngest age group. With regard to hypertension, plasma fibrinogen, and total cholesterol, there were, in general, no substantial differences between the age-specific and the overall results among the males. However, the association between low decision latitude and low HDL cholesterol levels was more pronounced for the males below 55 years of age than for the older males (PR 1.3, 95% CI 1.0–1.6; PR 1.3, 95% CI 1.1–1.7; and PR 0.9, 95% CI 0.6–1.4 for males 15–44, 45–54 and 55–64 years old, respectively). Among the females the associations between low decision latitude and total cholesterol, HDL cholesterol level, and the LDL : HDL ratio was stronger for the younger (≤44 years of age) than for the older females. Both the males and females aged 44 years and younger showed stronger associations between job strain and low HDL cholesterol levels and LDL : HDL ratio, compared with persons aged 45 years or older. An especially high prevalence of elevated LDL : HDL ratio was found for the young males exposed to job strain in Stockholm (PR 2.3, 95 % CI 1.1–4.6).

Discussion

Overall, we found no strong associations between decision latitude, psychological job demands, and job strain with hypertension, plasma fibrinogen or the LDL : HDL ratio among the males of our study; however, low decision latitude and job strain were related to an increased prevalence of low HDL cholesterol. The males who reported job strain had low total cholesterol levels to a greater extent than the other males. For the females, low decision latitude and job strain were associated with an increased prevalence of hypertension. An increased prevalence of low HDL cholesterol was also suggested for the females in jobs with low decision latitude, similar to that seen among the males, but the confidence interval was wider. These associations to low HDL cholesterol were stronger among the younger subjects of both genders.

Table 4. Decision latitude, psychological job demands, and job strain in relation to biological risk factors for coronary heart disease among the females 15 to 64 years of age in the WOLF study population. (PR = prevalence ratio, 95% CI = 95% confidence interval, HDL = high-density lipoprotein, LDL = low-density lipoprotein)

Risk factor	Low decision latitude [a]		High job demands [b]		Job strain versus other [c]		Job strain versus relaxed [d]	
	PR	95% CI	PR	95% CI	PR	95% CI	PR	95% CI
Hypertension (≥140 mm Hg systolic, ≥90 mm Hg diastolic, or treatment [e])								
Adjustment for age	1.4	1.2–1.6	0.9	0.8–1.1	1.0	0.8–1.2	1.3	1.0–1.8
All [f]	1.3	1.1–1.5	0.9	0.8–1.1	0.9	0.8–1.1	1.3	1.0–1.8
Elevated plasma fibrinogen (≥3.84 g/l)								
Adjustment for age	1.2	1.0–1.5	1.0	0.8–1.2	1.1	0.9–1.4	1.1	0.8–1.6
All [f]	1.2	0.9–1.5	1.0	0.8–1.2	1.1	0.9–1.4	1.2	0.8–1.7
Hypercholesterolemia (>6.4 mmol/l)								
Adjustment for age	1.2	1.0–1.4	0.9	0.8–1.1	1.0	0.9–1.2	1.1	0.8–1.4
All [f]	1.1	0.9–1.4	0.9	0.7–1.1	1.0	0.8–1.2	1.0	0.7–1.4
Decreased HDL cholesterol (<1.2 mmol/l)								
Adjustment for age	1.3	1.1–1.6	0.9	0.7–1.1	1.2	1.0–1.5	1.1	0.8–1.6
All [f]	1.2	0.9–1.5	0.9	0.7–1.1	1.1	0.9–1.4	1.0	0.7–1.5
Elevated LDL : HDL ratio (≥3.0)								
Adjustment for age	1.1	0.9–1.3	1.0	0.8–1.2	1.1	0.9–1.4	1.0	0.8–1.3
All [f]	1.0	0.8–1.3	0.9	0.8–1.1	1.1	0.9–1.3	0.9	0.7–1.2

[a] High decision latitude was used as the reference category
[b] Low job demands was used as the reference category.
[c] The subjects with the combination of low decision latitude and high job demands (job strain) were compared with the subjects with any other combination of decision latitude and job demands.
[d] The subjects with the combination of low decision latitude and high job demands (job strain) were compared with the subjects with the combination of high decision latitude and low job demands.
[e] 1 mm Hg ≈ 0.133 kPa.
[f] PR adjusted for age, socioeconomic group, smoking, physical activity, fat consumption, and body mass index.

Table 5. Decision latitude, psychological job demands, and job strain in relation to biological risk factors for coronary heart disease among the males 15 to 44 years of age in the WOLF study population. (PR = prevalence ratio, 95% CI = 95% confidence interval, HDL = high- density lipoprotein, LDL = low-density lipoprotein)

Risk factor	Low decision latitude [a]		High job demands [b]		Job strain versus other [c]		Job strain versus relaxed [d]	
	PR	95% CI	PR	95% CI	PR	95% CI	PR	95% CI
Hypertension (≥140 mmHg systolic, ≥90 mmHg diastolic, or treatment [e])								
Adjustment for age	1.3	1.1–1.6	0.9	0.7–1.0	1.0	0.8–1.2	1.2	0.9–1.6
All [f]	1.2	1.0–1.5	0.9	0.8–1.1	1.0	0.8–1.2	1.2	0.9–1.6
Elevated plasma fibrinogen (≥3.60 g/l)								
Adjustment for age	1.0	0.7–1.3	0.9	0.7–1.2	0.8	0.5–1.1	1.0	0.6–1.6
All [f]	1.0	0.8–1.4	0.9	0.6–1.2	0.8	0.5–1.1	0.9	0.5–1.6
Hypercholesterolemia (>6.4 mmol/l)								
Adjustment for age	1.0	0.8–1.1	0.8	0.7–1.0	0.9	0.7–1.1	0.7	0.6–1.0
All [f]	0.9	0.7–1.1	0.8	0.7–1.0	0.8	0.7–1.0	0.7	0.5–0.9
Decreased HDL cholesterol (<1.0 mmol/l)								
Adjustment for age	1.4	1.2–1.7	0.9	0.7–1.0	1.0	0.9–1.3	1.4	1.0–1.9
All [f]	1.3	1.0–1.6	1.0	0.8–1.2	1.1	0.9–1.3	1.4	1.1–2.0
Elevated LDL : HDL ratio (≥4.0)								
Adjustment for age	1.1	0.9–1.4	1.0	0.8–1.2	1.0	0.8–1.3	1.3	0.9–1.8
All [f]	1.0	0.7–1.2	1.1	0.9–1.4	1.0	0.8–1.2	1.2	0.8–1.7

[a] High decision latitude was used as the reference category
[b] Low job demands was used as the reference category.
[c] The subjects with the combination of low decision latitude and high job demands (job strain) were compared with the subjects with any other combination of decision latitude and job demands.
[d] The subjects with the combination of low decision latitude and high job demands (job strain) were compared with the subjects with the combination of high decision latitude and low job demands.
[e] 1 mm Hg ≈ 0.133 kPa.
[f] PR adjusted for age, socioeconomic group, smoking, physical activity, fat consumption, and body mass index.

Table 6. Decision latitude, psychological job demands, and job strain in relation to biological risk factors for coronary heart disease among the females 15 to 44 years of age in the WOLF study population. (PR = prevalence ratio, 95% CI = 95% confidence interval, HDL = high-density lipoprotein, LDL = low-density lipoprotein)

Risk factor	Low decision latitude [a]		High job demands [b]		Job strain versus other [c]		Job strain versus relaxed [d]	
	PR	95% CI	PR	95% CI	PR	95% CI	PR	95% CI
Hypertension (≥140 mmHg systolic,≥ 90 mmHg diastolic, or treatment [e])								
Adjustment for age	1.3	0.8–2.0	1.0	0.7–1.5	0.9	0.6–1.5	1.8	0.8–4.2
All [f]	1.1	0.7–1.7	1.0	0.6–1.6	0.8	0.5–1.3	2.0	0.8–5.0
Elevated plasma fibrinogen (≥3.84 g/l)								
Adjustment for age	1.4	1.0–1.9	1.1	0.8–1.5	1.3	0.9–1.8	1.4	0.8–2.5
All [f]	1.4	0.9–2.1	1.0	0.7–1.5	1.2	0.8–1.8	1.5	0.7–2.9
Hypercholesterolemia (>6.4 mmol/l)								
Adjustment for age	1.4	1.0–2.1	0.8	0.6–1.2	1.3	0.9–1.8	1.0	0.6–1.8
All [f]	1.6	1.0–2.4	0.8	0.6–1.3	1.3	0.8–2.0	1.2	0.6–2.4
Decreased HDL cholesterol (<1.2 mmol/l)								
Adjustment for age	1.5	1.1–2.1	0.9	0.7–1.2	1.3	1.0–1.8	1.3	0.9–2.1
All [f]	1.3	0.9–1.9	0.9	0.7–1.2	1.2	0.9–1.6	1.2	0.7–2.1
Elevated LDL : HDL ratio (≥3.0)								
Adjustment for age	1.5	1.1–2.1	1.0	0.7–1.4	1.5	1.1–2.1	1.4	0.9–2.3
All [f]	1.5	1.1–2.2	0.9	0.7–1.3	1.4	1.0–2.0	1.3	0.7–2.3

[a] High decision latitude was used as the reference category
[b] Low job demands was used as the reference category.
[c] The subjects with the combination of low decision latitude and high job demands (job strain) were compared with the subjects with any other combination of decision latitude and job demands.
[d] The subjects with the combination of low decision latitude and high job demands (job strain) were compared with the subjects with the combination of high decision latitude and low job demands.
[e] 1 mm Hg ≈ 0.133 kPa.
[f] PR adjusted for age, socioeconomic group, smoking, physical activity, fat consumption, and body mass index.

Many of the studied associations between psychosocial work conditions (especially job demands) and biological risk factors for coronary heart disease were close to the null value in this study. It is worth noting that the corresponding confidence intervals were narrow in general; this finding strengthens the interpretation of the association as truly being close to the null.

The outcome factors were originally measured on a continuous scale, and it may be argued that important information is lost when such factors are dichotomized. We have done the corresponding analyses with continuous outcomes, and the results were very similar to those presented here.

Since this is a cross-sectional study, the time relation between exposure and outcome cannot be determined. Therefore, interpretations in causal terms are more difficult. Thus a bias may have been introduced if the outcome had an influence on the probability of exposure. For example, it cannot be ruled out that the subjects with high blood pressure tended to seek certain types of jobs, possibly less stressful. In this situation a real influence on blood pressure from a stressful work environment may have been underestimated or may have even passed unobserved. This type of selection bias may explain, though probably only to a very limited extent, our somewhat unexpected results with regard to job strain and total cholesterol among the males.

The overall participation rate was 82% in our study. There were, in particular, three health care units with low participation rates. We excluded these units and made analyses restricted to subjects belonging to the remaining health care units, corresponding to a participation rate of 86%. The results were similar to those regarding all the subjects. Thus it seems unlikely that nonparticipation seriously biased our results.

The concepts "psychological job demands" and "decision latitude" are theoretically considered to be "objective" characteristics of the work environment. However, there are currently no established methods for measuring these work characteristics in an "objective" fashion. The common way of measuring is, as in this study, by asking the worker questions about work conditions. One problem with this method is that the worker's report may not only be influenced by the work environment per se, but also by individual characteristics of the worker, such as sensitivity to work stress, ability to cope with stressful conditions at work, propensity to complain about work conditions, and general satisfaction with the work situation, thus causing misclassification of exposure. The effect of this misclassification depends on whether or not it is related to the outcome, in this study blood pressure, blood lipids, and plasma fibrinogen. If it is unrelated to the outcome, a nondifferential misclassification of exposure is introduced, and this misclassification may contribute to masking true associations between work environment factors and outcomes in this study. To the extent that awareness of these outcomes exaggerates the reporting of adverse psychosocial work environment exposure, a differential misclassification of exposure would be indicated, and the prevalence ratios would be biased away from the null. Low HDL cholesterol has usually not been considered for medical treatment by general practitioners. This practice leads us to believe that it is highly unlikely that an awareness of the HDL cholesterol level would contribute to this type of misclassification and explain the results found in this study with regard to HDL cholesterol.

It has been proposed that measuring subjective job strain with questions like the ones used by us may not be sensitive to capturing job strain among white-collar workers (47). If so, and if there is a true relationship between job strain and coronary heart disease among both blue- and white-collar workers, our results would be an underestimate of the true association. However, we did not see any major differences between blue-collar and white-collar workers among the males when we did additional analyses stratified by socioeconomic status. Among the females, some differences in the estimated prevalence ratios were noted between the blue-collar and white-collar workers, with a tendency towards higher prevalence ratios regarding blood lipids among blue-collar females compared with white-collar females, when exposed to high job demands and job strain.

In some previous studies attempts have been made to measure the psychosocial work environment in a more "objective" measurement procedure. This procedure has mostly been based on population-based averages for occupation, gender, and age-specific subgroups of the population. In such studies, a significant association has been observed between job strain and ambulatory blood pressure (23), as well as between low decision latitude and plasma fibrinogen (32, 33), particularly among women.

It is well known that, if blood pressure is measured on only one occasion, less representative levels may be obtained. There may be important fluctuations in the blood pressure level over the day, and these fluctuations are not captured by a single measurement. It is therefore often a better alternative to measure ambulatory blood pressure over a 24-hour period; however, for practical reasons it was not possible in our study. Associations between job strain and ambulatory blood pressure measured over 24 hours have been found in previous studies (22–24, 26). We used specially trained nurses for the blood pressure measurements in order to reduce measurement error. It seems reasonable to assume that any misclassification of blood pressure, if present, was unrelated to the exposure in this study. This possible nondifferential misclassification would then result in a bias of the association towards the null value. This possibility may have contributed to the lack of clear associations between the psychosocial work environment factors and hypertension in this study, particularly among the males.

Blood lipids and plasma fibrinogen were analyzed in the same laboratory. Any misclassification of these factors due to errors in the analyses would thus probably be unrelated to the exposure and result in a bias of the prevalence ratios towards the null.

Our results show an association of low decision latitude and job strain with low HDL cholesterol in males, and this association was further enhanced among younger males. A similar tendency was found for the females, however, with rather broad confidence intervals. These findings are not likely to be due to selection bias or to a misclassification of exposure or blood lipids. After adjustment for several confounding factors, these results remained fairly unchanged. The prevalence ratios were on the order of 1.2–1.3, and it is still possible that remaining uncontrolled confounding caused the increased prevalence ratios. For example, we had only crude information on dietary habits. Alcohol consumption is known to be related to HDL cholesterol, and may also be related to psychosocial work conditions. However, further adjustment for alcohol consumption did not change the result in this study. Whether the potential association between decision latitude and HDL cholesterol level is due to an independent effect of adverse psychosocial conditions on the production of HDL is not known. There are indications in the literature that the proportion of HDL in total cholesterol is affected when subjects are exposed to chronic adverse psychosocial conditions. In a population study of middle-aged women, Wamala et al (31) observed that the total:HDL cholesterol ratio had a linear relationship with decision latitude (an unfavorable ratio being associated with low decision latitude). Similar observations were made for male workers by Siegrist et al (48). Furthermore, in a study of the effects of job intervention aiming at improved psychosocial conditions (improved decision latitude and social support), a significantly improved LDL : HDL ratio was observed, despite nonsignificant observed effects of the program on diet, smoking habits, and physical activity. No similar effect was observed in a reference group (49). The most likely explanation for the change in the intervention group is that stress reduction had taken place and that the reduction had affected the lipids. An adverse association between job strain and the LDL : HDL ratio was noted for the males in Stockholm and for the younger females in our study.

Somewhat surprisingly, we found an inverse association between job strain and total cholesterol among the males. We cannot rule out the possibility that residual confounding partly contributed to our results. The decrease in total cholesterol can also, in part, be due to the low HDL levels measured for these males. Overall, no associations between job characteristics and total serum cholesterol were found for the females in our study. Previous studies have shown inconsistent results regarding associations between job strain and total cholesterol (25, 29, 34, 36, 37).

In conclusion, our results provide some support for the hypothesis that occupational stress in the form of low decision latitude or job strain may have an adverse impact on HDL cholesterol in both males and females and on hypertension at least in females. Our results also indicate that psychosocial work characteristics do not influence the risk of myocardial infarction through high total cholesterol or plasma fibrinogen levels.

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References

1. Rosengren A, Wedel H, Wilhelmsen L. Coronary heart disease and mortality in middle aged men from different occupational classes in Sweden. BMJ 1988;297:1497–500.
2. Hammar N, Alfredsson L, Smedberg M, Ahlbom A. Differences in the incidence of myocardial infarction among occupational groups. Scand J Work Environ Health 1992; 18:178–85.
3. Alfredsson L, Hammar N, Gillström P. Increasing differences in myocardial infarction incidence between socio-economic groups in Stockholm. Nutr Metab Cardiovasc Dis 1995;5:99–104.
4. Karasek RA, Baker D, Marxer F, Ahlbom A, Theorell T. Job decision latitude, job demands, and cardiovascular disease: a prospective study of Swedish men. Am J Public Health. 1981;71:694–705.
5. Alfredsson L, Theorell T. Job characteristics of occupations and myocardial infarction risk — effect of possible confounding factors. Soc Sci Med 1983;17:1497–503.
6. La Croix A, Haynes S. Occupational exposure to high demand/low control work and coronary heart disease in the Framingham cohort. Am J Epidemiol 1984;120:481.
7. Haan M. Job strain and cardiovascular disease: a ten-year prospective study. Am J Epidemiol 1985;122:532.
8. Alfredsson L, Spetz CL, Theorell T. Type of occupation and near-future hospitalization for myocardial infarction and some other diagnoses. Int J Epidemiol 1985;14:378–88.
9. Karasek RA, Theorell T, Schwartz J, Schnall P, Pieper C, Michels J. Job characteristics in relation to the prevalence of myocardial infarction in the US HES and HANES. Am J Public Health 1988;78:910–8.
10. Johnson JV, Hall EM. Job strain, work place social support, and cardiovascular disease: a cross-sectional study of a random sample of the Swedish working population. Am J Public Health 1988;78:1336–42.
11. Johnson JV, Hall EM, Theorell T. Combined effect of job strain and social isolation on cardiovascular disease morbidity and mortality in a random sample of the Swedish male working population. Scand J Work Environ Health 1989; 15:271–9.
12. Alterman T, Shekelle RB, Vernon SW, Burau KD. Decision latitude, psychological demand, job strain, and coronary heart disease in the Western Electric Study. Am J Epidemiol 1994; 139:620–7.
13. Johnson JV, Stewart W, Hall EM, Fredlund P, Theorell T. Long-term psychosocial work environment and cardiovascular mortality among Swedish men. Am J Public Health 1996; 86:324–31.
14. Hammar N, Alfredsson L, Johnson JV. Job strain, social support at work, and incidence of myocardial infarction. Occup Environ Med 1998;55:548–53.
15. Theorell T, Tsutsumi A, Hallquist J, Reuterwall C, Hogstedt C, Freedlund P, et al. Decision latitude, job strain and myocardial infarction: a study of working men in Stockholm: the SHEEP Study Group. Am J Public Health 1998;88:382–8.
16. Peter R, Siegrist J. Psychosocial work environment and the risk of coronary heart disease. Int Arch Occup Environ Health 2000;73:41–45
17. Sacker A, Bartley MJ, Frith D, Fitzpatrick RM, Marmot MG. The relationship between job strain and coronary heart disease: evidence from an English sample of the working male population. Psychol Med 2001;31:279–90.
18. Yoshimasu K, the Fukuoka Heart Study Group. Relation of type A behavior pattern and job-related psychosocial factors to nonfatal myocardial infarction: a case-control study of Japanese male workers and women. Psychosom Med 2001; 63:797–804.
19. Reed DM, La Croix AZ, Karasek RA, Miller D, McLean CA. Occupational strain and the incidence of coronary heart disease. Am J Epidemiol 1989;129:495–502.
20. Hlatky MA, Lam CL, Lee KL, Clapp-Channing NE, Williams RB, Pryor DB, et al. Job strain and the prevalence and outcome of coronary artery disease. Circulation 1995;92: 327–33.
21. Steenland K, Johnson J, Nowlin S. A follow-up study of job strain and heart disease among males in the NHANES I population. Am J Ind Med 1997;31:256–60.
22. Theorell T, de Faire U, Johnson J, Hall E, Perski A, Stewart W. Job strain and ambulatory blood pressure profiles. Scand J Work Environ Health 1991;17:380–5.
23. Schnall PL, Landsbergis PA, Baker D. Job strain and cardiovascular disease. Ann Rev Public Health 1994;15:381–411.
24. Schnall PL, Schwartz JE, Landsbergis PA, Warren K, Pickering TG. A longitudinal study of job strain and ambulatory blood pressure: results from a three-year follow-up. Psychosom Med 1998;60:697–706.

25. Kawakami N, Haratani T, Araki S. Job strain and arterial blood pressure, serum cholesterol, and smoking as risk factors for coronary heart disease in Japan. Int Arch Occup Environ Health 1998;71:429–32.
26. Fauvel JP, Quelin P, Ducher M, Rakotomalala H, Laville M. Perceived job stress but not individual cardiovascular reactivity to stress is related to higher blood pressure at work. Hypertension 2001;38:71–5.
27. Pickering TG. Mental stress as a causal factor in the development of hypertension and cardiovascular disease. Curr Hypertens Rep 2001;3:249–54.
28. Tsutsumi A, Kayaba K, Tsutsumi K, Igarashi M. Association between job strain and prevalence of hypertension: a cross sectional analysis in a Japanese working population with a wide range of occupations: the Jichi Medical School cohort study. Occup Environ Med. 2001;58:367–73.
29. Siegrist J, Matschinger H, Cremer P, Seidel D. Atherogenic risk in men suffering from occupational stress. Atherosclerosis 1988;69:211–8.
30. Thelin A, Stjernström E-L, Holmberg S. Blood lipid levels in a rural male population. J Cardiovasc Risk 2001;8:165–74.
31. Wamala SP, Wolk A, Schenk-Gustafsson K, Orth-Gomer K. Lipid profile and socio-economic status in healthy middle aged women in Sweden. J Epidemiol Community Health 1997;51:400–7.
32. Brunner E, Davey Smith G, Marmot M, Canner R, Beksinska M, O´Brien J. Childhood social circumstances and psychosocial and behavioral factors as determinants of plasma fibrinogen. Lancet 1996;347:1008–13.
33. Tsutsumi A, Theorell T, Hallqvist J, Reuterwall C, de Faire U. Association between job characteristics and plasma fibrinogen in a normal working population: a cross sectional analysis in referents of the SHEEP Study: Stockholm Heart Epidemiology Program. J Epidemiol Community Health 1999;53:348–54.
34. Su CT. Association between job strain status and cardiovascular risk in a population of Taiwanese white-collar workers. Jpn Circ J 2001;65:509–513.
35. Ishizaki M, Martikainen P, Nakagawa H, Marmot MG, The Japan Work Stress and Health Cohort Study Group. Socioeconomic status, workplace characteristics and plasma fibrinogen level of Japanese male employees. Scand J Work Environ Health 2001;27:287–91.
36. Netterstrøm B, Kristensen TS, Damsgaard MT, Olsen O, Sjøl A. Job strain and cardiovascular risk factors: a cross sectional study of employed Danish men and women. Br J Ind Med 1991;48:684–9.
37. Greenlund KJ, Liu K, Knox S, McCreat H, Dyer AR, Gardin J. Psychosocial work characteristics and cardiovascular disease risk factors in young adults: the CARDIA study. Soc Sci Med 1995;41:717–23.
38. Folsom AR, Qamhieh HT, Flack JM, Hilner JE, Liu K, Howard BV, et al. Plasma fibrinogen: levels and correlates in young adults. The coronary artery risk development in young adults (CARDIA) study. Am J Epidemiol 1993;138:1023–36.
39. Peter R, Alfredsson L, Hammar N, Siegrist J, Theorell T, Westerholm P. High effort, low reward, and cardiovascular risk factors in employed Swedish men and women: baseline results from the WOLF Study. J Epidemiol Community Health 1998;52:540–7.
40. Peter R, Alfredsson L, Knutsson A, Siegrist J, Westerholm P. Does a stressful psychosocial work environment mediate the effects of shift work on cardiovascular risk factors? Scand J Work Environ Health 1999;25:376–81.
41. Theorell T, Alfredsson L, Westerholm P, Falck B. Coping with unfair treatment at work — what is the relationship between coping and hypertension in middle-aged men and women? An epidemiological study of working men and women in Stockholm (the WOLF Study). Psychother Psychosom 2000;69:86–94.
42. Nordisk yrkesklassificering. Svensk grundstandard [Nordic classification of occupations]. Stockholm: Liber förlag, 1983.
43. Statistics Sweden. Swedish socioeconomic classification. Stockholm: Statistics Sweden, 1984. Reports on statistical co-ordination, no 1982:4.
44. Mantel N, Haenszel W. Statistical aspects of the analysis of data from retrospective studies of disease. J Natl Cancer Inst 1959;22:719–48.
45. Miettinen OS. Estimability and estimation in case-referent studies. Am J Epidemiol 1976;103:226–35.
46. SAS Institute Inc. The SAS System, release 8.02. Cary (NC): SAS Institute Inc, 1999–2001.
47. Theorell T, Karasek RA. Current issues relating to psychosocial job strain and cardiovascular disease research. J Occup Health Psychol 1996;1:9–26.
48. Siegrist J, Peter R, Cremer P, Seidel D. Chronic work stress is associated with atherogenic lipids and elevated fibrinogen in middle-aged men. J Intern Med 1997;242:149–56.
49. Orth-Gomér K, Moser V, Theorell T, Fredlund P. Lipid lowering through work stress reduction. Int J Behav Med 1994;1:204–14.

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Appendix

Questions used in the job strain index

Demands	Often	Sometimes	Seldom	Never/ almost never
1. Do you have to work very fast?				
2. Do you have to work very intensively?				
3. Does your work demand too much effort?				
4. Do you have enough time to do everything?				
5. Does your work often involve conflicting demands?				

Decision Latitude

	Often	Sometimes	Seldom	Never/ almost never
6. Do you have the possibility of learning new things through your work?				
7. Does your work demand a high level of skill or expertise?				
8. Does your job require you to take the initiative?				
9. Do you have to do the same thing over and over again?				
10. Do you have a choice in deciding HOW you do your work?				
11. Do you have a choice in deciding WHAT you do at work?				