European Heart Journal (2010) **31**, 1737–1744
doi:10.1093/eurheartj/ehq124

Overtime work and incident coronary heart disease: the Whitehall II prospective cohort study

Marianna Virtanen[1]*, Jane E. Ferrie[2], Archana Singh-Manoux[2,3,4], Martin J. Shipley[2], Jussi Vahtera[1,5], Michael G. Marmot[2], and Mika Kivimäki[1,2,6]

[1]Finnish Institute of Occupational Health, Centre of Expertise for Work Organizations, Topeliuksenkatu 41 aA, FIN-00250 Helsinki, Finland; [2]Department of Epidemiology and Public Health, University College London, 1-19 Torrington Place, London WC1E 6BT, UK; [3]INSERM U687, AP-HP, Paris, France; [4]Centre de Gérontologie, Hôpital Ste Périne, AP-HP, Paris, France; [5]University of Turku, Turku University Hospital, Turku, Finland; and [6]Department of Behavioral Sciences, Finnish Institute of Occupational Health and University of Helsinki, Helsinki, Finland

Received 19 November 2009; revised 8 March 2010; accepted 23 March 2010; online publish-ahead-of-print 11 May 2010

See page 1672 for the editorial comment on this article (doi:10.1093/eurheartj/ehq116)

Aims To examine the association between overtime work and incident coronary heart disease (CHD) among middle-aged employees.

Methods and results Six thousand and fourteen British civil servants (4262 men and 1752 women), aged 39–61 years who were free from CHD and worked full time at baseline (1991–1994), were followed until 2002–2004, an average of 11 years. The outcome measure was incident fatal CHD, clinically verified incident non-fatal myocardial infarction (MI), or definite angina (a total of 369 events). Cox proportional hazard models adjusted for sociodemographic characteristics showed that 3–4 h overtime work per day was associated with 1.60-fold (95% CI 1.15–2.23) increased risk of incident CHD compared with employees with no overtime work. Adjustment for all 21 cardiovascular risk factors measured made little difference to these estimates (HR 1.56, 95% CI 1.11–2.19). This association was replicated in multivariate analysis with only fatal cardiovascular disease and incident non-fatal MI as the outcome (HR 1.67, 95% CI 1.02–2.76).

Conclusion Overtime work is related to increased risk of incident CHD independently of conventional risk factors. These findings suggest that overtime work adversely affects coronary health.

Keywords Working hours • Stress • CHD • Myocardial infarction • Angina • Middle-aged • Prospective

Introduction

Overtime work is common in developed countries and has increased steadily in recent years.[1] A survey from the OECD shows that countries exceeding most the OECD average were USA, South Korea, Greece, Mexico, Australia, and Japan.[2] Employees in the UK also had working hours above the average in the 15 member countries of the European Union.[2] A growing body of evidence suggests that working overtime may be associated with adverse health outcomes, such as hypertension, subjective health complaints, sleep problems, and depression.[1,3–8]

Studies on the relationship between overtime work and coronary heart disease (CHD) are scarce, and we are not aware of previous prospective studies on this issue. One study in California, USA used census data collected between 1949 and 1951 and reported that the highest standardized mortality ratio for CHD was among employees in occupations with long average working hours.[9] A Swedish study used a similar approach and found an association between overtime work and hospitalization for myocardial infarction (MI) among women,[10] but the inverse among men. The other studies on this topic have been case–control studies.[11–14] The major problem in case–control studies is the retrospective assessment of working hours, i.e. it is possible that the diseases itself, here CHD, influences the patient's work behaviour and perception or recall of working hours prior to the onset of illness.

The aim of the present study is to investigate the effect of overtime work on incident CHD, followed up over a 11-year period in a large-scale, prospective occupational cohort of British civil servants (the Whitehall II Study).[15] We take into account several

* Corresponding author. Tel: +358 30 4742702, Fax: +358 9 2413496, Email: marianna.virtanen@ttl.fi

factors that may act as confounders or mediators of this association, such as sex, age, and occupational grade, as well as several biological, behavioural, psychosocial, and psychological risk factors for CHD, including work characteristics and type A behaviour pattern. For comparison, we examine the association between overtime work and all-cause mortality.

Methods

Study sample and design

The Whitehall II study sample recruitment (Phase 1) took place between late 1985 and early 1988 among all office staff, aged 35–55, from 20 London based Civil Service departments.[15] The response rate was 73% (6895 men and 3413 women). Since Phase 1 there have been eight further data collection phases (1989–1990, 1991–1994, 1995–1996, 1997–1999, 2001, 2002–2004, 2006, and 2007–2009), with study phases alternating between a questionnaire-only phase and one including questionnaire and a clinical examination. Informed consent was gained from all participants. The University College London Medical School Committee on the Ethics of Human Research approved the protocol.

The question on working hours was introduced to the study for the first time at Phase 3 (1991–1994) which is the baseline for the analyses reported here. Of the 8637 participants at that phase, 7684 (89%) were employed and responded to the question on working hours. Of them, 397 (5%) worked part time (less than 7 h/day) and were excluded from the analysis, leaving a sample of 7287 participants. Out of these, data were missing on at least one of the covariates for 1126 participants and a further 147 had prevalent CHD at baseline and were also excluded. Thus, the final sample comprised 6014 participants (4262 men and 1752 women) aged 39–61 years who were followed until Phase 7 (2002–2004) which is the most recent phase for which clinical examination data are available for the Whitehall II study participants.

Measures

We determined working hours at baseline with the following question: 'On an average weekday, approximately how many hours do you spend on the following activities (if applicable): Work (daytime and work brought home)?' Response alternatives ranged from 1 to 12 h. We formulated the following categorical measure of overtime work: no overtime work (7–8 working hours/day); 1 h of overtime work a day (9 h/day); 2 h of overtime work (10 h/day); 3–4 h of overtime work (11–12 h/day).

We assessed the occurrence of CHD events between Phases 3 (1991–1994) and 7 (2002–2004), a mean follow-up of 11.2 (SD 2.7) years. Prevalent cases, determined by using a procedure similar to that for incident CHD, were excluded from the analysis. Participants were flagged by the British National Health Service (NHS) Central Registry, who notified us of the date and cause of all deaths, classified as coronary if ICD-9 (*International Classification of Diseases*, 9th edition) codes 410–414 or ICD-10 (*International Classification of Diseases*, 10th edition) codes I20–I25 were present on the death certificate. Non-fatal CHD included first non-fatal MI or first definite angina. Non-fatal MI was defined following MONICA criteria[16] based on study electrocardiograms, hospital acute ECGs, and cardiac enzymes. Incident angina was defined on the basis of clinical records and nitrate medication use, excluding cases based solely on self-reported data[17] without clinical verification and participants with definite angina at baseline. Classification was carried out independently by two trained coders, with adjudication in the event of disagreement.

Covariates included socio-demographic measures derived from the survey questionnaire; age, sex, marital status, and socioeconomic position indicated by British civil service occupational grade.[15] Employment grade in the Whitehall II study is a comprehensive marker of socioeconomic position and is related to salary, social status, and level of responsibility at work. The civil service identifies 12 non-industrial grades that, in order of increasing salary, comprise clerical assistant, clerical officer, executive officer, higher executive officer, senior executive officer, and seven 'unified grades'. Other professional and technical staff were assigned to these grades on the basis of salary. For the analysis, unified grades 1–6 were combined into one group and the bottom two clerical grades into another, producing six categories; Category 1 represents the highest status jobs and Category 6 the lowest. In 1995, the range of annual salary was £4000 to £10 999 in the two lowest grades, £5500 to £26 000 for the two intermediate grades, and £28 975 to £150 000 for the two highest grades.

Conventional risk factors for CHD[18–20] assessed at Phase 3 included diabetes, systolic and diastolic blood pressure, serum HDL and LDL cholesterol, triglycerides, and smoking status. We also included alcohol consumption,[21] exercise level,[22] daily fruit and vegetable intake,[23] body mass index,[24] sleeping hours,[25] psychological distress,[26,27] type A behaviour pattern,[28–30] job demands,[31] decision latitude at work,[31] and sickness absence[32] as potential risk factors. The following measures were assessed during a clinical examination which included a 2 h 75 g oral glucose tolerance test: diabetes (defined by a fasting glucose $\geq$7.0 mmol/L or a 2 h post-load glucose $\geq$11.1 mmol/L, or reported diabetes or use of diabetic medication); hyperglycaemia in non-diabetic participants, classified as impaired fasting glucose (fasting glucose between 5.6 and 6.9 mmol/L) and impaired glucose tolerance (2 h post-load glucose between 7.8 and 11.0 mmol/L); systolic and diastolic blood pressure (measured twice while seated after a 5 min rest using the Hawksley random-zero sphygmomanometer); serum HDL and LDL cholesterol and triglycerides from fasting status; and weight and height from which the body mass index (kg/m^2) was calculated. The following measures were based on responses to the questionnaire: smoking status (never, ex-, and current smokers including occasional smokers); alcohol consumption (units/week classified into three categories: none; $>$0 to 14 (women)/21 (men) units; more than 14/21 units),[33] exercise level ($\geq$1.5 or $<$1.5 h of moderate or vigorous exercise/week);[34] daily fruit and vegetable intake (yes/no);[34] psychological distress (yes/no, using the 30-item General Health Questionnaire, GHQ-30);[35,36] depressive symptoms (yes/no, a subscale from the GHQ-30);[35,36] sleeping hours (less than 7 h, 7–8 h, more than 8 h);[25] sickness absence (the number of sick days taken in the past year categorized as 0, 1–7, and $>$7 days); job demands and decision latitude at work (for both measures, scores were divided into tertiles);[37] and type A behaviour pattern (assessed at Phase 1 by the Framingham Type A scale, scores divided into tertiles).[29]

Statistical methods

We examined the association of overtime work with baseline socio-demographic characteristics and CHD risk factors using a χ^2 test for heterogeneity. For the continuous risk factor measures, the heterogeneity was assessed using univariate analysis of variance. We used Cox proportional hazard models with follow-up period as the time scale, to examine the association of overtime work with incident CHD disease and all-cause mortality among participants free from CHD at baseline. The time-dependent interaction term between working time and the logarithm of the follow-up period for both outcomes

was non-significant confirming that the proportional hazards assumption was not violated ($P = 0.41$ and 0.35, respectively). Those with no overtime work formed the reference category used to calculate the hazard ratios and their 95% confidence intervals of CHD among those working 1, 2, and 3–4 h overtime per day. The models were serially adjusted for covariates in order to examine the effect of covariates on the association. The analyses were repeated using a restricted definition of the outcome variable: only fatal CHD and non-fatal MI. No interaction between sex and hours of overtime work in relation to CHD was detected ($P = 0.18$ for total CHD; $P = 0.18$ for fatal CHD or non-fatal MI as the outcome), so men and women were combined in the analysis. Interactions between occupational grade and overtime work, job demands and overtime work, and decision latitude and overtime work were also tested to assess whether the health effect of overtime work is dependent on socioeconomic position or psychosocial working conditions. In order to provide a point of comparison, we also examined associations with all-cause mortality. As the exposure (overtime work) consisted of three pairwise comparisons (1, 2, and 3–4 h overtime vs. no overtime), Bonferroni corrected *P*-values were calculated, in addition to uncorrected *P*-values, to reduce the risk of type 1 errors. Bonferroni correction is a conservative statistical adjustment to adjust for multiple comparisons. This correction was also applied when testing the associations between overtime and the covariates. All *P*-values are two-tailed, and *P*-values below 0.05 were considered to indicate statistical significance. We used SAS version 9.1 (SAS, Cary, NC, USA) for statistical analyses.

Results

Of the participants, 3256 (54%) did not usually work overtime, 1247 (21%) worked approximately one, 894 (15%) two, and 617 (10%) three or four extra hours a day. *Table 1* presents associations between baseline covariates and overtime working hours. Participants working overtime were slightly younger than participants not working overtime. Men, married, or cohabitating participants and those in higher occupational grades worked overtime more often than women, non-married/co-habited, or lower-grade participants. Absence of pre-existing diabetes, smoking history, and alcohol use exceeding recommended limits were also associated with overtime work. More of those working overtime reported daily fruit and vegetable consumption and more exercise, but shorter sleeping hours and less sickness absence days. They also reported higher prevalence of psychological distress and higher scores on measures of type A behaviour, job demands, and decision latitude at work than individuals not working overtime. Overtime work was associated with lower HDL cholesterol levels compared with employees with no overtime work. After Bonferroni correction of the *P*-values, the significant heterogeneity in baseline characteristics between worktime groups (*Table 1*) remained largely unchanged. The only exceptions were the differences in age and sleeping hours which became non-significant after adjusting for multiple testing (corrected values: $P = 0.08$ for age and $P = 0.15$ for sleeping hours).

Table 2 shows the association of overtime with incident CHD. Altogether there were 67543.9 person-years of follow-up during which 369 new events of CHD occurred, resulting in a rate of 5.46 events per 1000 person-years. In the model adjusted for sociodemographic factors (Model A), working 3 or 4 h (but not 1 or 2 h) of overtime was associated with incident CHD (HR 1.60, 95% CI 1.15–2.23, $P = 0.005$), compared with no overtime work. The Bonferroni corrected *P*-value for the excess CHD risk in this overtime category was $P = 0.015$ and the association changed little after further adjustment for all potential CHD risk factors (Models B to E). The largest reduction in effect size (16%) was found after adjustment for health behaviours (Model C). Of these, smoking and body mass index were related to incident CHD. An 11% effect size reduction was found after adjustment for type A behaviour pattern (Model E). The hazard ratio for incident CHD for scores in the top tertile of type A behaviour was 1.46 (95% CI 1.09–1.95, $P = 0.011$).

We repeated the analyses with the outcome defined as fatal CHD and new non-fatal MI, but excluding definite angina pectoris (*Table 3*). In the model adjusted for socio-demographic characteristics, working 3–4 h of overtime (but not 1 or 2 h) was associated with incident fatal CHD or non-fatal MI (HR 1.90, 95% CI 1.17–3.06, $P = 0.009$) when compared with employees with no overtime work (Model A). The Bonferroni corrected *P*-value for this hazard ratio was $P = 0.027$. Again, the largest reduction in the hazard ratio was found after adjustment for health behaviours (19%, Model C) and type A behaviour pattern (12%, Model E). Of these covariates, smoking, alcohol use (lower risk with high alcohol use when compared with no use), and body mass index were independently associated with the outcome, and the hazard ratio for scores in the top tertile of type A behaviour pattern was HR 1.43 (95% CI 0.93–2.20, $P = 0.10$).

In order to examine the effect of depressive symptoms on the association between long working hours and CHD, we re-ran Model E using the depression subscale of the GHQ[38] and leaving out psychological distress as a covariate. We found no significant difference in the results (3–4 h overtime work was associated with incident CHD including definite angina, HR 1.56, 95% CI 1.11–2.20; $P = 0.010$ with incident fatal CHD, non-fatal MI or definite angina, HR 1.71, 95% CI 1.04–2.81 with incident fatal CHD, non-fatal MI or definite angina, $P = 0.036$).

To examine whether the association between long working hours and CHD was dependent on socioeconomic position or work stress factors, we tested interaction effects. No interaction was found between occupational grade or job demands and working hours (*P*-values 0.50 and 0.41 for coronary death, incident non-fatal MI, or definite angina pectoris; *P*-values 0.43 and 0.73 for coronary death or incident non-fatal MI). A significant interaction was found between decision latitude and overtime work in predicting coronary death, incident non-fatal MI, or definite angina pectoris ($P = 0.025$). Based on Model E adjustments, the HR for overtime work of 3–4 h was 1.78 (95% CI 1.10–2.89, $P = 0.020$) in the low-decision latitude group (two lowest tertiles, $n = 3415$) and 1.26 (95% CI 0.77–2.04, $P = 0.36$) in the high-decision latitude group (highest tertile, $n = 2599$). However, this interaction was lost in the analysis confined to coronary deaths and incident non-fatal MIs only ($P = 0.46$).

Finally, we examined all-cause mortality as an outcome. In the model adjusted for age, sex, marital status, and occupational grade, employees working 1 h overtime had a HR of 1.11 (95% CI 0.75–1.63, $P = 0.60$), those working two extra hours a day had a HR of 1.27 (0.83–1.94, $P = 0.27$), and those working

Table 1 Characteristics of the participants by daily overtime hours at baseline: the Whitehall II study

Characteristics	All, *n* (%)	Overtime hours, *n* (%)/Mean (SD)				*P*-value*
		No Overtime	1 h	2 h	3–4 h	
Age, years	48.7 (5.7)	49.0 (5.8)	48.5 (5.6)	48.5 (5.4)	48.3 (5.5)	0.004
Sex						
Male	4262 (70.9)	2081 (63.9)	965 (77.4)	685 (76.6)	531 (86.1)	<0.0001
Female	1752 (29.1)	1175 (36.1)	282 (22.6)	209 (23.4)	86 (13.9)	
Marital status						
Married/cohabitating	4610 (76.7)	2356 (72.4)	974 (78.1)	727 (81.3)	553 (89.6)	<0.0001
Non-married/non-cohabitating	1404 (23.4)	900 (27.6)	273 (21.9)	167 (18.7)	64 (10.4)	
Occupational grade level						
1 highest	1056 (17.6)	223 (6.9)	291 (23.3)	289 (32.3)	253 (41.0)	<0.0001
2	1353 (22.5)	577 (17.7)	372 (29.8)	257 (28.8)	147 (23.8)	
3	880 (14.6)	505 (15.5)	205 (16.4)	98 (11.0)	72 (11.7)	
4	1048 (17.4)	686 (21.1)	170 (13.6)	122 (13.7)	70 (11.4)	
5	815 (13.6)	571 (17.5)	132 (10.6)	68 (7.6)	44 (7.1)	
6 lowest	862 (14.3)	694 (21.3)	77 (6.2)	60 (6.7)	31 (5.0)	
Diabetes						
No	5278 (87.8)	2812 (86.4)	1108 (88.9)	796 (89.0)	562 (91.1)	<0.0001
Impaired fasting glucose	136 (2.3)	61 (1.9)	33 (2.7)	28 (3.1)	14 (2.3)	
Impaired glucose tolerance	459 (7.7)	292 (9.0)	77 (6.2)	55 (6.2)	35 (5.7)	
Yes	141 (2.3)	91 (2.8)	29 (2.3)	15 (1.7)	6 (1.0)	
Smoking						
Never	3092 (51.4)	1730 (53.1)	629 (50.4)	436 (48.8)	297 (48.1)	0.002
Ex	2108 (35.1)	1073 (33.0)	478 (38.3)	324 (36.2)	233 (37.8)	
Current	814 (13.5)	453 (13.9)	140 (11.2)	134 (15.0)	87 (14.1)	
Alcohol use (units/week)						
0	1085 (18.0)	717 (22.0)	158 (12.7)	125 (14.0)	85 (13.8)	<0.0001
>0≤14/21 (women/men)	3958 (65.8)	2073 (63.7)	871 (69.9)	605 (67.7)	409 (66.3)	
>14/21 (women/men)	971 (16.2)	466 (14.3)	218 (17.5)	164 (18.3)	123 (19.9)	
Daily fruit and vegetable consumption						
Yes	3691 (61.4)	1964 (60.3)	767 (61.5)	565 (63.2)	395 (64.0)	0.20
No	2323 (38.6)	1292 (39.7)	480 (38.5)	329 (36.8)	222 (36.0)	
Moderate/vigorous exercise (h/week)						
<1.5	2254 (37.5)	1334 (41.0)	412 (33.0)	315 (35.2)	193 (31.3)	<0.0001
≥1.5	3760 (62.5)	1922 (59.0)	835 (67.0)	579 (64.8)	424 (68.7)	
Sleeping hours/night						
<7	1587 (26.4)	825 (25.3)	306 (24.5)	262 (29.3)	194 (31.4)	0.007
7–8	4284 (71.2)	2348 (72.1)	911 (73.1)	611 (68.3)	414 (67.1)	
>8	143 (2.4)	83 (2.6)	30 (2.4)	21 (2.4)	9 (1.5)	
Psychological distress						
No	4680 (77.8)	2621 (80.5)	932 (74.7)	667 (74.6)	460 (74.6)	<0.0001
Yes	1334 (22.2)	635 (19.5)	315 (25.3)	227 (25.4)	157 (25.5)	
Type A behaviour pattern						
Low	1833 (30.5)	1256 (38.6)	323 (25.9)	157 (17.6)	97 (15.7)	<0.0001
Moderate	2169 (36.1)	1234 (37.9)	446 (35.8)	291 (32.6)	198 (32.1)	
High	2012 (33.5)	766 (23.5)	478 (38.3)	446 (49.9)	322 (52.2)	

Continued

Table 1 *Continued*

Characteristics	All, *n* (%)	Overtime hours, *n* (%)/Mean (SD)				*P*-value*
		No Overtime	1 h	2 h	3–4 h	
Job demands						
Low	1242 (20.7)	974 (29.9)	137 (11.0)	80 (9.0)	51 (8.3)	<0.0001
Moderate	2751 (45.7)	1650 (50.7)	552 (44.3)	341 (38.1)	208 (33.7)	
High	2021 (33.6)	632 (19.4)	558 (44.8)	473 (52.9)	358 (58.0)	
Decision latitude at work						
Low	1528 (25.4)	1096 (33.7)	214 (17.2)	137 (15.3)	81 (13.1)	<0.0001
Moderate	1887 (31.4)	1149 (35.3)	379 (30.4)	217 (24.3)	142 (23.0)	
High	2599 (43.2)	1011 (31.1)	654 (52.5)	540 (60.4)	394 (63.9)	
Sickness absence days (past year)						
0	2017 (33.5)	899 (27.6)	470 (37.7)	375 (42.0)	273 (44.3)	<0.0001
1–7	2857 (47.5)	1589 (48.8)	595 (47.7)	403 (45.1)	270 (43.8)	
>7	1140 (19.0)	768 (23.6)	182 (14.6)	116 (13.0)	74 (12.0)	
Body mass index (kg/m^2)	25.1 (3.6)	25.1 (3.7)	25.1 (3.5)	25.3 (3.8)	25.2 (3.2)	0.48
Systolic blood pressure (mmHg)	120.0 (13.3)	120.1 (13.5)	120.3 (12.9)	119.8 (13.2)	119.7 (12.8)	0.74
Diastolic blood pressure (mmHg)	79.5 (9.3)	79.4 (9.4)	79.6 (9.2)	79.6 (9.2)	79.9 (9.0)	0.47
LDL cholesterol (mmol/L)	4.37 (1.03)	4.37 (1.05)	4.33 (1.00)	4.38 (1.01)	4.42 (1.02)	0.25
HDL cholesterol (mmol/L)	1.44 (0.41)	1.45 (0.41)	1.43 (0.40)	1.44 (0.41)	1.38 (0.37)	<0.001
Triglycerides (mmol/L)	1.35 (0.74)	1.36 (0.77)	1.33 (0.71)	1.33 (0.71)	1.38 (0.71)	0.39

**P*-value for the association between baseline characteristic and overtime work.

3–4 h overtime a day had a HR of 1.35 (0.82–2.21, $P = 0.24$) when compared with employees not working overtime.

Discussion

We examined the association between overtime work and incident CHD in a cohort of British civil servants, followed up for an average of 11 years. We found that 3–4 h of overtime work per day was associated with a 1.56-fold risk of CHD, after accounting for the effects of demographic factors and several known risk factors for CHD. Similar association was found with an outcome comprising only coronary death and non-fatal MI. No significant association was found between overtime work and all-cause mortality, but the effects were in the expected direction. The specific strength of our study was a prospective study design with a relatively long follow-up period.

We found some evidence of associations of overtime work with smoking history and lower concentration of HDL cholesterol, both well-established risk factors for CHD.[18–20] Although these risk factors might be potential mechanisms explaining the association between overtime work and CHD, adjustment for them had no major effect on the association found in the present study. Thus, differences in these risk factors do not seem to be strong mediators of the observed relationship.

In their case–control study of Japanese men, Sokejima and Kagamimori[13] suggested that the relationship between extended working hours and acute MI may be explained by changes in the activity of the autonomic nervous system; through increases in sympathetic nervous activity and increased blood pressure levels; and through reduced parasympathetic nervous system which is also a risk factor for CHD. Earlier studies on these mechanisms show mixed results,[3] and our baseline assessment does not support hypertension as being on the pathway between overtime work and cardiovascular disease. However, ambulatory blood pressure monitoring might be the best way of assessing whether masked or 'hidden' hypertension[39] is a possible mediator. Work-related stress has been shown to be associated with hidden hypertension,[39] and there is also some evidence showing overtime work to be related to elevated ambulatory blood pressure.[40]

Our results show working overtime to be related to type A behaviour pattern, psychological distress—a correlate for depression and anxiety symptoms—and some suggestion of an association with short sleeping hours. Negative emotions, such as depression and anxiety, and reduced sleeping hours, have been found to be independent predictors of CHD.[25–27] However, adjustment for these factors had little effect on the association between overtime and CHD. In turn, we found that the adjustment for type A behaviour pattern attenuated the hazard ratios by 11–12%, suggesting that part of the association may be explained by such behaviours. Type A behaviour pattern is viewed to represent a specific adverse behavioural style in response to environmental stress and can be a risk factor for CHD.[28–30] Type A behaviour is also characterized by a chronic, incessant struggle to achieve more and more in less and less time, and is also believed to be characterized by aggressiveness and irritability.[28]

Table 2 Association between exposure to overtime work at baseline and incident coronary heart disease, as indicated by coronary death, incident non-fatal myocardial infarction, or incident definite angina pectoris: the Whitehall II study

Exposure: overtime work/day	Fatal CHD, non-fatal myocardial infarction, or definite angina pectoris													
	No. of events	No. of Participants	Person-years	Rate/1000 person-years	Model A, HR (95% CI)[a]	*P*-value	Model B, HR (95% CI)[b]	*P*-value	Model C, HR (95% CI)[c]	*P*-value	Model D, HR (95% CI)[d]	*P*-value	Model E, HR (95% CI)[e]	*P*-value
All	369	6014	67543.9	5.46										
No overtime	189	3256	36331.7	5.20	1.00	Ref.	1.00	Ref.	1.00	Ref.	1.00	Ref.	1.00	Ref.
1 h	69	1247	14185.4	4.86	1.01 (0.76–1.34)	0.94	1.06 (0.79–1.40)	0.71	1.04 (0.78–1.39)	0.78	1.06 (0.79–1.41)	0.71	1.04 (0.78–1.38)	0.81
2 h	60	894	10115.8	5.93	1.28 (0.95–1.74)	0.11	1.32 (0.98–1.79)	0.07	1.24 (0.92–1.69)	0.16	1.29 (0.95–1.76)	0.11	1.23 (0.90–1.69)	0.19
3–4 h	51	617	6911.0	7.38	1.60 (1.15–2.23)	0.005	1.67 (1.20–2.32)	0.002	1.56 (1.12–2.17)	0.009	1.63 (1.16–2.28)	0.005	1.56 (1.11–2.19)	0.011

HR, hazard ratio; CI, confidence interval.
[a]Model A: adjusted for age, sex, marital status, and occupational grade. Likelihood ratio (df = 11) for the overall model 134.1, $P < 0.0001$.
[b]Model B: as Model A and additionally adjusted for diabetes, systolic and diastolic blood pressure, LDL and HDL cholesterol, and triglycerides. Likelihood ratio (df = 19) for the overall model 248.3, $P < 0.0001$.
[c]Model C: as Model B and additionally adjusted for smoking, alcohol use, fruit and vegetable consumption, exercise level, body mass index, and sleeping hours. Likelihood ratio (df = 28) for the overall model 283.1, $P < 0.0001$.
[d]Model D: as Model C and additionally adjusted for sickness absence, psychological distress, job demands, and decision latitude at work. Likelihood ratio (df = 35) for the overall model 293.7, $P < 0.0001$.
[e] Model E: as Model D and additionally adjusted for type A behaviour pattern. Likelihood ratio (df = 37) for the overall model 300.3, $P < 0.0001$.

Table 3 Association between exposure to overtime work at baseline and incident coronary heart disease, as indicated by coronary death or incident non-fatal myocardial infarction: the Whitehall II study

Exposure: overtime work/day	Fatal CHD or non-fatal myocardial infarction													
	No. of events	No. of Participants	Person-years	Rate/1000 person-years	Model A, HR (95% CI)[a]	*P*-value	Model B, HR (95% CI)[b]	*P*-value	Model C, HR (95% CI)[c]	*P*-value	Model D, HR (95% CI)[d]	*P*-value	Model E, HR (95% CI)[e]	*P*-value
All	159	6014	68893.0	2.31										
No overtime	81	3256	37015.1	2.19	1.00	Ref.	1.00	Ref.	1.00	Ref.	1.00	Ref.	1.00	Ref.
1 h	27	1247	14456.5	1.87	0.95 (0.61–1.49)	0.84	1.01 (0.65–1.58)	0.97	0.99 (0.63–1.55)	0.96	0.96 (0.61–1.52)	0.87	0.93 (0.59–1.47)	0.75
2 h	27	894	10310.7	2.62	1.46 (0.93–2.30)	0.10	1.51 (0.96–2.38)	0.07	1.39 (0.88–2.18)	0.16	1.34 (0.84–2.13)	0.22	1.26 (0.79–2.02)	0.33
3–4 h	24	617	7110.7	3.38	1.90 (1.17–3.06)	0.009	1.98 (1.22–3.20)	0.005	1.79 (1.11–2.90)	0.018	1.76 (1.07–2.88)	0.026	1.67 (1.02–2.76)	0.043

[a]Model A: adjusted for age, sex, marital status, and occupational grade. Likelihood ratio (df = 11) for the overall model 75.1, $P < 0.0001$.
[b]Model B: as Model A and additionally adjusted for diabetes, systolic and diastolic blood pressure, LDL and HDL cholesterol, and triglycerides. Likelihood ratio (df = 19) for the overall model 169.1, $P < 0.0001$.
[c]Model C: as Model B and additionally adjusted for smoking, alcohol use, fruit and vegetable consumption, exercise level, body mass index, and sleeping hours. Likelihood ratio (df = 28) for the overall model 201.9, $P < 0.0001$.
[d]Model D: as Model C and additionally adjusted for sickness absence, psychological distress, job demands, and decision latitude at work. Likelihood ratio (df = 35) for the overall model 208.1, $P < 0.0001$.
[e]Model E: as Model D and additionally adjusted for type A behaviour pattern. Likelihood ratio (df = 37) for the overall model 210.8, $P < 0.0001$.

Several other factors may underlie the association between overtime work and CHD. For example, even though the association was not explained by adjustment for sleeping hours in our analysis, insufficient time for recovery in spite of increased need,[41] or difficulties in unwinding after work are possible mechanisms.[42] Employees who work overtime may also be likely to work while ill, i.e. be reluctant to be absent from work despite illness. Such sickness presenteeism has been found to be associated with increased risk of MI in male British civil servants in the Whitehall II study.[43] Although overtime workers in our study were more likely to be in higher occupational grades which suggest better resources e.g. for health care, overtime work may also be a part of a lifestyle in which symptoms of ill health are ignored and medical care not sought.[44]

There is a large body of research on work stress and CHD,[31,45] but it is not known whether work stress affects the association between long working hours and CHD. We tested interactions between long working hours and job demands, but found none. In contrast, there was some indication that decision latitude at work may modify the effect of long working hours on CHD. The excess risk of CHD was smaller for employees with high decision latitude than for those with lower decision latitude. However, this interaction was not significant when the angina pectoris cases were excluded from the outcome. Further research is therefore needed to determine whether factors, such as high decision latitude or working long hours through choice, would reduce the excess risk of CHD associated with overtime working.

Our findings should be interpreted within the context of the study limitations. First, the possibility of residual confounding by other, unmeasured or imprecisely measured predictors of coronary events can never be entirely ruled out in observational studies. A second limitation is related to modelling potential confounders as time-independent covariates; we did not assess the possible impact of changes in these factors on the risk of CHD events. Third, it is not clear whether the number of working hours reported by participants at baseline was stable over the follow-up. This could be a potential source of misclassification of our exposure measure. Thus, we examined data on working hours from a questionnaire administered to participants 5 years after the baseline questionnaire. This version of the question had been modified and requested weekly working hours rather than daily working hours. Three thousand four hundred and forty-one participants (57%) were still in employment at this follow-up phase. Of those who worked one or more hours of overtime per day at baseline, 33% worked a maximum of 40 h' workweek at follow-up, 18% worked 41–45 h, and 49% worked more than 45 h per week. Thus in the Whitehall II data, working overtime appears to be a relatively stable characteristic.

Fourth, diagnosis-based depressive and anxiety disorders, potential risk factors for CHD were not examined and could therefore potentially confound our results.[46] The association between working hours and CHD did not change when either depressive symptoms alone or the GHQ-30 total score were entered into the model. The GHQ-30 covers symptoms of depression and anxiety, as well as insomnia and social impairment. It is a well established and validated screening questionnaire for psychiatric disorder.[35,47,48] Fifth, our study was not well powered for subgroup analyses. Interaction effects should therefore be interpreted cautiously and replicated in studies with larger sample sizes. Finally, although our cohort of civil servants included several occupational grades, it did not include blue collar workers. Thus, it remains unclear whether our findings are generalizable to blue-collar workers and employees in the private sector.

In conclusion, data from a large occupational cohort indicates that overtime work is associated with increased risk of CHD independently of sociodemographic characteristics, conventional coronary risk factors, sleep deprivation, psychological distress, work characteristics, and type A behaviour. Further research should examine whether interventions designed to reduce overtime work would alter the risk of CHD.

Funding

The Whitehall II study has been supported by grants from the Medical Research Council; British Heart Foundation; Health and Safety Executive; Department of Health; National Heart Lung and Blood Institute (HL36310), US, NIH: National Institute on Aging (AG13196 and AG34454), US, NIH; Agency for Health Care Policy Research (HS06516); the John D and Catherine T MacArthur Foundation Research Networks on Successful Midlife Development and Socioeconomic Status and Health; and the BUPA Foundation, UK.

M.K. and J.V. are supported by the Academy of Finland (Projects no. #124271, #124322, #129262, and #132944), M.K. is additionally supported by the BUPA Foundation Specialist research grant, A.S.-M. is supported by a 'EURYI' award from the European Science Foundation, M.J.S. is supported by the British Heart Foundation, and M.G.M. is supported by a MRC Research Professorship.

Conflict of interest: none declared.

References

1. Caruso CC, Hitchcock EM, Dick RB, Russo JM, Schmit JM. *Overtime and Extended Work Shifts: Recent Findings on Illnesses, Injuries, and Health Behaviors*. Cincinnati: National Institute for Occupational Safety and Health; 2004.
2. OECD Employment Outlook. *Recent Labour Market Developments and Prospects Special Focus on: Clocking in (and out): Several Facets of Working Time*. OECD; 2004.
3. van der Hulst M. Long workhours and health. *Scand J Work Environ Health* 2003; **29**:171–188.
4. Shields M. Long working hours and health. *Health Rep* 1999;**11**:33–48.
5. Kageyama T, Nishikido N, Kobayashi T, Kurokawa Y, Kaneko T, Kabuto M. Long commuting time, extensive overtime, and sympathodominant state assessed in terms of short-term heart rate variability among white-collar workers in Tokyo megalopolis. *Ind Health* 1998;**36**:209–217.
6. Yang H, Schnall PL, Jauregui M, Su T-C, Baker D. Work hours and self-reported hypertension among working people in California. *Hypertension* 2006;**48**: 744–750.
7. Sekine M, Chandola T, Martikainen P, Marmot M, Kagamimori S. Work and family characteristics as determinants of socioeconomic and sex inequalities in sleep: The Japanese Civil Servants Study. *Sleep* 2006;**29**:206–216.
8. Virtanen M, Singh-Manoux A, Ferrie JE, Gimeno D, Marmot MG, Elovainio M, Jokela M, Vahtera J, Kivimäki M. Long working hours and cognitive function: the Whitehall II study. *Am J Epidemiol* 2009;**169**:596–605.
9. Buell P, Breslow L. Mortality from coronary heart disease in California men who work long hours. *J Chron Dis* 1960;**11**:615–626.
10. Alfredsson L, Spetz C-L, Theorell T. Type of occupation and near-future hospitalization for myocardial infarction and some other diagnoses. *Int J Epidemiol* 1985; **14**:378–388.
11. Russek HI, Zohman BL. Relative significance of heredity, diet and occupational stress in coronary heart disease of young adults. *Am J Med Sci* 1958;**325**:266–275.
12. Theorell T, Rahe RH. Behavior and life satisfaction characteristics of Swedish subjects with myocardial infarction. *J Chron Dis* 1972;**25**:139–147.
13. Sokejima S, Kagamimori S. Working hours as a risk factor for acute myocardial infarction in Japan: case-control study. *BMJ* 1998;**317**:775–780.

14. Liu Y, Tanaka H, The Fukuoka Heart Study Group. Overtime work, insufficient sleep, and risk of non-fatal acute myocardial infarction in Japanese men. *Occup Environ Med* 2002;**59**:447–451.
15. Marmot M, Brunner E. Cohort profile: The Whitehall II Study. *Int J Epidemiol* 2005; **34**:251–256.
16. Tunstall-Pedoe H, Kuulasmaa K, Amouyel P, Arveiler D, Rajakangas AM, Pajak A, for the WHO MONICA Project. Myocardial infarction and coronary deaths in the World Health Organization MONICA Project. Registration procedures, event rates, and case-fatality rates in 38 populations from 21 countries in four continents. *Circulation* 1994;**90**:583–612.
17. Rose GA, Blackburn H, Gillum RF, Prineas RJ. *Cardiovascular Survey Methods*. Geneva: WHO; 1982.
18. Greenland P, Knoll MD, Stamler J, Neaton JD, Dyer AR, Garside DB, Wilson PW. Major risk factors as antecedents of fatal and nonfatal coronary heart disease events. *JAMA* 2003;**290**:891–897.
19. Hozawa A, Folsom AR, Sharrett AR, Chambless LE. Absolute and attributable risks of cardiovascular disease incidence in relation to optimal and borderline risk factors: comparison of African American with white subjects—Atherosclerosis Risk in Communities Study. *Arch Intern Med* 2007;**167**:573–579.
20. Yusuf S, Reddy S, Ounpuu S, Anand S. Global burden of cardiovascular diseases: part I: general considerations, the epidemiologic transition, risk factors, and impact of urbanization. *Circulation* 2001;**104**:2746–2753.
21. Marmot MG. Alcohol and coronary heart disease. *Int J Epidemiol* 2001;**30**: 724–729.
22. Wannamethee SG, Shaper AG. Physical activity in the prevention of cardiovascular disease: an epidemiological perspective. *Sports Med* 2001;**31**:101–104.
23. Dauchet L, Amouyel P, Hercberg S, Dallongeville J. Fruit and vegetable consumption and risk of coronary heart disease: a meta-analysis of cohort studies. *J Nutr* 2006;**136**:2588–2593.
24. Bogers RB, Bemelmans WJ, Hoogenveen RT, Boshuizen HC, Woodward M, Knekt P, van Dam RM, Hu FB, Visscher TL, Menotti A, Thorpe RJ Jr, Jamrozik K, Calling S, Strand BH, Shipley MJ, for the BMI-CHD Collaboration Investigators. Association of overweight with increased risk of coronary heart disease partly independent of blood pressure and cholesterol levels: a meta-analysis of 21 cohort studies including more than 300 000 persons. *Arch Intern Med* 2007;**167**:1720–1728.
25. Ferrie JE, Shipley MJ, Cappuccio FP, Brunner E, Miller MA, Kumari M, Marmot MG. A prospective study of change in sleep duration: associations with mortality in the Whitehall II cohort. *Sleep* 2007;**30**:1659–1666.
26. Lanas F, Avezum A, Bautista LE, Diaz R, Luna M, Islam S, Yusuf S, INTERHEART Investigators in Latin America. Risk factors for acute myocardial infarction in Latin America: the INTERHEART Latin American study. *Circulation* 2007;**115**: 1067–1074.
27. Nicholson A, Kuper H, Hemingway H. Depression as an aetiologic and prognostic factor in coronary heart disease: a meta-analysis of 6362 events among 146 538 participants in 54 observational studies. *Eur Heart J* 2006;**27**:2763–2774.
28. Friedman M, Rosenman RH. Type A behavior pattern: its association with coronary heart disease. *Ann Clin Res* 1971;**3**:300–312.
29. Haynes SG, Feinleib M, Levine S, Scotch N, Kannel WB. The relationship of psychosocial factors to coronary heart disease in the Framingham study: 2. Prevalence of coronary heart disease. *Am J Epidemiol* 1978;**107**:384–402.
30. Razzini C, Bianchi F, Leo R, Fortuna E, Siracusano A, Romeo F. Correlations between personality factors and coronary artery disease: from type A behaviour pattern to type D personality. *J Cardiovasc Med* 2008;**9**:761–768.
31. Kivimäki M, Virtanen M, Elovainio M, Kouvonen A, Väänänen A, Vahtera J. Work stress in the etiology of coronary heart disease—a meta-analysis. *Scand J Work Environ Health* 2006;**32**:431–442.
32. Kivimäki M, Head J, Ferrie JE, Shipley MJ, Vahtera J, Marmot MG. Sickness absence as a global measure of health: evidence from mortality in the Whitehall II prospective cohort study. *BMJ* 2003;**327**:364.
33. White I, Altmann DR, Nanchahal K. Mortality in England and Wales attributable to any drinking, drinking above sensible limits and drinking above lowest risk level. *Addiction* 2004;**99**:749–756.
34. Nabi H, Kivimäki M, De Vogli R, Marmot MG, Singh-Manoux A. Positive and negative affect and risk of coronary heart disease: Whitehall II prospective cohort study. *BMJ* 2008;**337**:32–36.
35. Goldberg DP. *The Detection of Psychiatric Illness by Questionnaire*. London, UK: Oxford University Press; 1972.
36. Nabi H, Singh-Manoux A, Shipley M, Gimeno D, Marmot MG, Kivimäki M. Do psychological factors affect inflammation and incident coronary heart disease: the Whitehall II Study. *Arterioscler Thromb Vasc Biol* 2008;**28**:1398–1406.
37. Karasek R, Theorell T. *Healthy Work: Stress, Productivity, and the Reconstruction of Working Life*. New York: Basic Books; 1990.
38. Martikainen P, Adda J, Ferrie JE, Davey Smith G, Marmot M. Effects of income and wealth on GHQ depression and poor self rated health in white collar women and men in the Whitehall II study. *J Epidemiol Community Health* 2003;**57**:718–723.
39. Landsbergis PA, Schnall PL, Belkic KL, Schwartz JE, Baker D, Pickering TG. Work conditions and masked (hidden) hypertension—insights into the global epidemic of hypertension. *Scand J Work Environ Health* 2008;**6**:41–51.
40. Hayashi T, Kobayashi Y, Yamaoka K, Yano E. Effect of overtime work on 24 h ambulatory blood pressure. *J Occup Environ Med* 1996;**38**:1007–1011.
41. Jansen N, Kant I, van Amelsvoort L, Nijhuis F, van den Brandt P. Need for recovery from work: evaluating short-term effects of working hours, patterns and schedules. *Ergonomics* 2003;**46**:664–680.
42. Rissler A. Stress reactions at work and after work during a period of quantitative overload. *Ergonomics* 1977;**20**:13–16.
43. Kivimäki M, Head J, Ferrie JE, Hemingway H, Shipley MJ, Vahtera J, Marmot MG. Working while ill as a risk factor for serious coronary events: the Whitehall II Study. *Am J Public Health* 2005;**95**:98–102.
44. Kristensen TS. Sickness absence and work strain among Danish slaughterhouse workers: an analysis of absence from work regarded as coping behaviour. *Soc Sci Med* 1991;**32**:15–27.
45. Eller NH, Netterstrøm B, Gyntelberg F, Kristensen TS, Nielsen F, Steptoe A, Theorell T. Work-related psychosocial factors and the development of ischemic heart disease: a systematic review. *Cardiol Rev* 2009;**17**:83–97.
46. Steptoe A, Whitehead DL. Depression, stress, and coronary heart disease: the need for more complex models. *Heart* 2005;**91**:419–420.
47. McDowell I, Newell C. *Measuring Health: A Guide to Rating Scales and Questionnaires*. New York, USA: Oxford University Press; 1987.
48. Stansfeld SA, Marmot M. Social class and minor psychiatric disorder in British Civil Servants: a validated screening survey using the General Health Questionnaire. *Psychol Med* 1992;**22**:739–749.