The influence of low job control on ambulatory blood pressure and perceived stress over the working day in men and women from the Whitehall II cohort

Andrew Steptoe[a] and Gonneke Willemsen[b]

Objective **Work stress contributes to risk of coronary heart disease and hypertension. This study tested the influence of job control on ambulatory blood pressure, and ratings of perceived stress and happiness in men and women systematically sampled by socio-economic status from the Whitehall II epidemiological cohort.**

Participants **A total of 227 men and women aged 47–59 years sampled from higher, intermediate and lower employment grades.**

Outcome measures **Ambulatory blood pressure and ratings of stress, perceived control and happiness.**

Methods **Participants completed standard measures of job demands and job control, and undertook ambulatory monitoring with measures of blood pressure and subjective state every 20 min from early in the working day until going to bed.**

Results **Systolic and diastolic blood pressure were greater in participants reporting low rather than high job control (means 125.7/81.5 versus 122.4/78.6 mmHg, $P < 0.05$), independently of gender, employment grade, body mass index, age, smoking status, and physical activity. Differences persisted into the evening after work. Job demands and job strain (high demand/low control) were not associated with blood pressure. Participants reporting low job control experienced stress more frequently over the working day than did those with high job control. Higher socio-economic status participants and women were more stressed by low job control than were men and people of lower socio-economic status.**

Conclusions **Job control plays an important role in modulating cardiovascular and affective responses over the working day, and these responses may contribute to increased cardiovascular disease risk.** ***J Hypertens*** **22:915–920 © 2004 Lippincott Williams & Wilkins.**

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Keywords: ambulatory blood pressure, cardiovascular disease, gender, job stress, perceived control, socio-economic status

[a]Department of Epidemiology and Public Health, University College London, UK and [b]Department of Psychology, Free University, Amsterdam, The Netherlands.

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Correspondence and requests for reprints to Andrew Steptoe, Psychobiology Group, Department of Epidemiology and Public Health, University College London, 1–19 Torrington Place, London WC1E 6BT, UK.
Tel: +44 (0) 20 7679 1804; fax: +44 (0) 20 7916 8542;
e-mail: a.steptoe@ucl.ac.uk

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Introduction

There is substantial evidence that factors in the work environment contribute to risk of coronary heart disease and hypertension [1]. The job strain (demand/control) model has highlighted the impact of low job control on cardiovascular disease and other outcomes [2,3]. A number of studies have demonstrated that ambulatory blood pressure at work is raised in individuals who report low job control, high demands, or a combination of two [3,4]. Elevated blood pressure (BP) over the working day may be indicative of chronic neuroendocrine and autonomic activation, and be one of the mechanisms through which work-related factors increase risk of cardiovascular disease.

However, job control varies with occupational prestige and socio-economic status (SES), since low status jobs are typically rated both by their occupants and by external observers as relatively uncontrollable [5]. Coronary heart disease and to a lesser extent hypertension are more prevalent in lower socioeconomic groups [6,7]. Consequently, some of the association between low job control and ambulatory blood pressure at work may be secondary to SES. It is also possible that low job control and job strain have different effects on the ambulatory blood pressure of people varying in SES. Landsbergis *et al.* [8] reported a *post hoc* analysis of healthy men recruited at eight New York City work sites, showing that high job strain had a greater effect on ambulatory blood pressure in lower SES participants as defined by occupation. By contrast, Brisson *et al.* [9] found that the combination of high job strain and high SES (indexed by educational attainment) was associated with raised BP in a sample of women with children. Neither of these studies involved purposive sampling across the socio-economic gradient. In the present analysis, we

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utilized data from a study involving members of the Whitehall II epidemiological cohort, in which participants were systematically recruited from higher, intermediate and lower employment grades [10]. We measured job control with a questionnaire that has been shown in the full Whitehall II cohort to predict coronary heart disease independently of gender, age, socio-economic position, and standard risk factors [5]. We hypothesized that low job control would be associated with elevated BP over the working day independently of age, body mass, smoking status and an estimate of concurrent physical activity. In addition to job control, the associations of job demands and job strain with ambulatory blood pressure were assessed.

The second aim of the study was to investigate the subjective experiences through the day that are associated with high and low job control. Analyses of ambulatory blood pressure readings and concurrent subjective experience suggest that ratings of perceived control are inversely associated with BP on a moment to moment basis [11,12]. It is therefore possible that low job control is associated with frequent minor stressors over the day that in turn elicit transient BP elevations. Conversely, happiness may be associated with greater job control and lower BP [13]. We analysed subjective ratings accompanying each BP reading, and compared ratings of stress, perceived control, and happiness in high and low job control groups. We hypothesized that individuals reporting low job control would experience greater stress, lower perceived control and less happiness over the working day.

Methods

Participants

Participants in this study were 227 volunteers (121 men and 106 women) drawn from the Whitehall II epidemiological cohort [14]. They were recruited on the following criteria: aged 45–59 years, white Caucasian day workers based in the London area, not planning to retire for at least 3 years, no history of CHD, no previous diagnosis or treatment for hypertension, and willingness to take part in laboratory testing (not described here) as well as ambulatory monitoring. Premenopausal women were not eligible, since menopausal status has effects on ambulatory blood pressure [15]. Employment grade was used as the marker of SES. Employment grade is strongly associated with income and educational attainment, and has been shown in the British civil service to relate to cardiovascular disease risk [16]. Participants were sampled systematically from higher (administrative and professional), intermediate (senior and higher executive officer), and lower (clerical, office support) employment grades. Data relating ambulatory blood pressure directly with SES have been published elsewhere [10].

Job stress measures

Job demands and job control were measured with the scale previously used in the Whitehall cohort [5]. The demand scale consisted of four items (e.g. 'Do you have to work very intensively?'), and the control scale of nine items (e.g. 'I can decide when to take a break'), each of which was rated on a 4-point scale ranging from 0 (*often*) to 3 (*never/almost never*). Scores were converted to a scale from 0–100, where 100 indicates maximum demands or maximum control. The Cronbach α for the scales in this study were 0.70 and 0.73 for demands and control, respectively.

Ambulatory monitoring procedures

Ambulatory blood pressure monitoring was carried out using the SpaceLabs 90217 monitor (Redmond, Washington, USA). The monitor was fitted between 0730 and 0930 h on a working day (depending on work schedules) at the participant's place of work or in the laboratory at University College London, and was worn for the remainder of the day and evening. BP was measured at 20-min intervals, and each reading was accompanied by a diary entry in which the participant recorded location, activity over the past 5 min (lying, sitting, standing or walking), a measure of current specific activities (e.g. desk work, preparing food), verbal interactions, and any eating, drinking, smoking or medication taken since the last reading. In addition, ratings were obtained with each reading of stress, control, and happiness, on a 5-point scale where 1 = *low* to 5 = *high*.

Data analysis

The ambulatory records of seven participants were lost before downloading from monitors. The BP readings were reviewed and outliers were excluded using the criteria described by Berardi *et al.* [17]. The number of eligible readings averaged 34.3 ± 5.7, but ranged widely between individuals. We therefore averaged data into four periods: morning (0750–1050 h), midday (1100–1400 h), afternoon (1400–1700 h), and evening (1700–2230 h). The mean number of readings in these four periods was 4.61 ± 0.98, 7.27 ± 1.1, 8.17 ± 1.4, and 14.1 ± 4.2, respectively. We only included individuals in the analyses who had at least two readings from each time period, so as to ensure that robust findings were obtained. A total of 198 individuals were included in the final analyses. The participants with complete data did not differ from the 22 with missing data in terms of gender distribution, employment grade, or age. There were no differences across employment grades in the number of readings contributing to each time period, or in the time of starting monitoring in the morning.

Scores on the ratings of stress, control and happiness were skewed towards low stress, high control, and high happiness. We therefore calculated the number of read-

ings in each time period for which the participant experienced moderate to high stress (3–5), moderate to low control (1–3) and high happiness ratings (4 or 5). These counts were divided by the total number of ratings in each time period to derive the percentage of occasions that the individual reported high stress, low control and high happiness.

Systolic and diastolic BP and ratings of stress, perceived control and happiness were analysed in two ways. First, the grand mean across the complete recording period was analysed with employment grade, gender, and either job demands, control or job strain (divided by median split) as between-subject factors. Physical activity is a strong determinant of BP [18]. We have previously demonstrated that activity ratings are systematically associated with activity assessed objectively using accelerometers [10], so these were included as covariates in BP analyses, while age, body mass index and smoking status were included as covariates in analyses of all variables. Secondly, repeated measures analysis of variance was carried out to assess changes with time of day. The Greenhouse–Geisser correction was applied where appropriate, and adjusted P values are presented. Data are presented as means ± standard deviation, adjusted for covariates.

Results

Table 1 summarizes the characteristics of the high and low job control groups. The proportion of men was somewhat greater in the high than low job control groups, but the effect was not significant ($P = 0.66$). The groups did not differ in age, body mass index, waist/hip ratio, proportion of smokers, or proportion of women taking hormone replacement treatment. Low job control was more frequently reported in participants from lower employment grades ($P < 0.001$), and the high job control group was better education ($P = 0.033$). Ratings of job demands did not differ between high and low job control groups.

Blood pressure

The average systolic pressure was significantly higher in the low control group (mean 125.7 ± 12.1 mmHg) compared with the high job control group (122.4 ± 11.5 mmHg, $P = 0.047$). Levels were higher in the morning in lower employment grade participants, as described previously [10], but this did not interact with job control. Systolic pressure was higher in men than women ($P < 0.001$), but there was no interaction between gender and job control. In the analysis across the day, the differences between job control groups were significant in the morning and evening ($P < 0.05$), but not at midday or in the afternoon (Fig. 1).

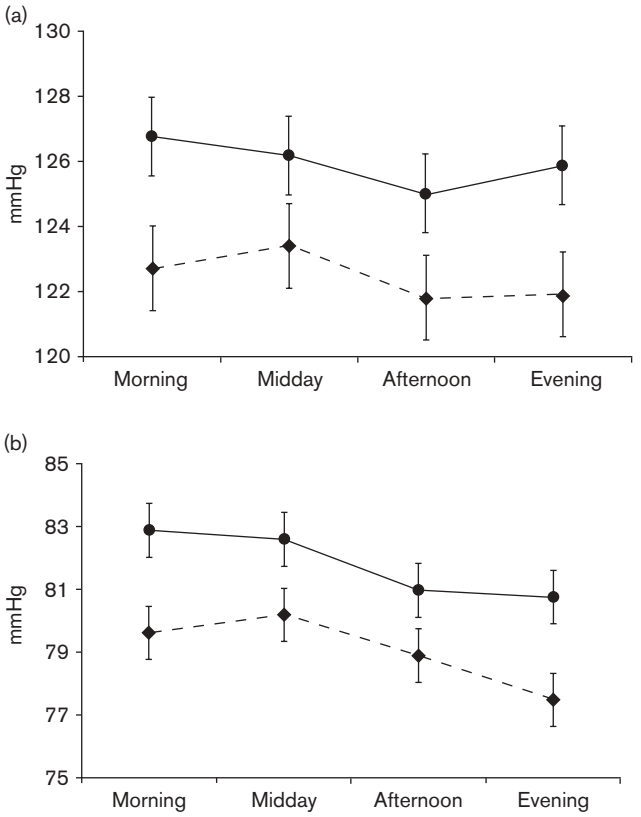
There was no association between job demands and systolic pressure. The adjusted means were 122.3 ± 9.8 and 124.4 ± 13.0 mmHg for the high and low demand groups, and there was no interaction between job demands and time of day. Job strain was also unrelated to ambulatory systolic pressure. Adjusted means were 124.9 ± 11.0 and 123.4 ± 12.6 mmHg in the high and low job strain groups ($P = 0.38$).

A similar pattern of results emerged for diastolic blood pressure. Diastolic pressure was higher in the low job control (adjusted mean 81.5 ± 7.3 mmHg) compared with the high job control group (78.6 ± 7.3 mmHg, $P = 0.007$). This effect did not vary with gender or employment grade. Diastolic blood pressure diminished between the early part of the day and the evening ($P < 0.001$, Fig. 1), but *post hoc* analyses confirmed significant effects of job control in all four time periods ($P = 0.041$ to 0.002).

Table 1 Characteristics of the high and low job control groups. Means ± standard deviation and *n* (%)

	High job control ($n = 98$)	Low job control ($n = 100$)
Gender		
Men	59	47
Women	39	53
Age	52.5 ± 2.8	52.0 ± 2.8
Grade of employment		
Higher	51 (52.0)	28 (28.0)
Intermediate	29 (29.6)	36 (36.0)
Lower	18 (18.4)	36 (36.0)
Educational attainment		
Basic education	34 (36.2)	41 (47.1)
High school graduation	18 (19.1)	22 (25.3)
Degree, etc.	42 (44.7)	24 (27.6)
Body mass index	25.6 ± 3.7	25.2 ± 3.7
Waist/hip ratio	0.86 ± 0.10	0.84 ± 0.10
Current smokers	7 (7.1)	9 (9.0)
Hormone replacement therapy (women)	11 (28.2)	13 (24.5)
Job demands	64.6 ± 18.2	65.2 ± 19.2
Job control	79.2 ± 6.5	54.1 ± 11.2

Fig. 1



(a) Mean systolic blood pressure and (b) diastolic pressure, in the morning, midday, afternoon and evening periods in high (dotted line) and low (solid line) job control groups, adjusted for gender, employment grade, age, body mass index, smoking status and physical activity. Error bars are standard errors of the mean (SEM).

Diastolic pressure did not vary either with job demands or job strain. The mean levels in the high and low job demand groups were 78.5 ± 6.2 and 80.0 ± 8.0 mmHg ($P = 0.36$), while the mean values for high and low job strain groups were 80.3 ± 6.9 and 79.9 ± 7.7 mmHg respectively ($P = 0.72$).

Perceived control ratings

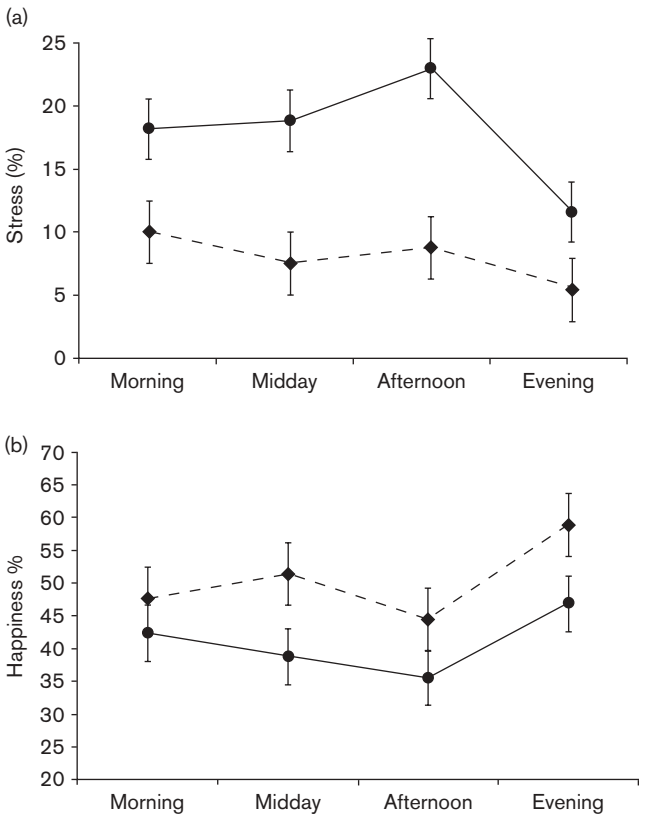
More BP readings were associated with low perceived control in the low job control group (26.8%) than in the high job control group (12.3%). There were no differences in perceived control ratings between men and women, or between the three employment grade groups. However, low perceived control was more commonly reported in the afternoon (24.3%) than in the morning (18.7%) or mid-day (18.9%), and was least frequently reported in the evening (15.7%, $P < 0.001$). This pattern did not vary with job control, employment grade, or gender.

Perceived control ratings over the day were not related to job demands. The proportion of BP readings associated with low perceived control averaged 19.7 ± 24.5 and $17.7 \pm 26.5\%$ in the high and low job demand groups. By contrast, there was a significant difference in perceived control between high and low job strain groups ($P = 0.016$). This mirrored the pattern observed for the job control grouping, since 23.4% of BP readings were associated with low perceived control in the high job strain group, compared with 14.4% in the low job strain group.

Perceived stress ratings

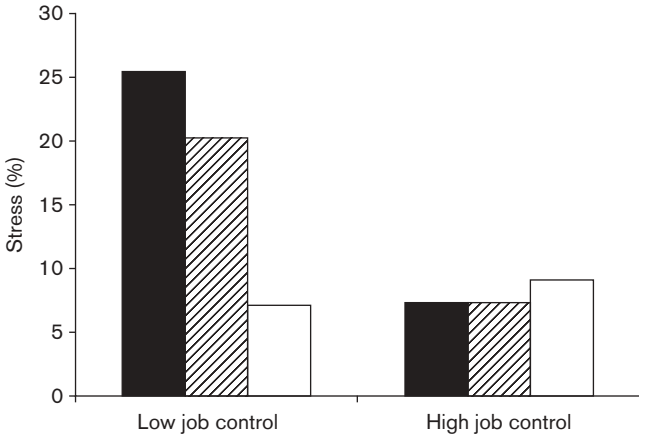
Individuals in the low job control group reported stress on 18.3% of occasions, compared with 7.8% in the high job control group ($P < 0.001$), as shown in Figure 2. The highest stress was recorded in the afternoon and lowest in the evening ($P < 0.001$). The difference between job control groups was significant at all times of day ($P < 0.01$), but diminished in the evening. In addition, there was an interaction between job control and employment grade ($P = 0.017$), illustrated in Figure 3. Higher employment grade participants who reported low job control experienced greater stress over

Fig. 2



Proportion of blood pressure readings associated with (a) moderate to high stress and (b) high happiness ratings, in high (dotted line) and low (solid line) job control groups over the day. Error bars are standard errors of the mean SEM.

Fig. 3



Proportion of blood pressure readings associated with moderate to high stress in high and low job control groups. Solid bars, higher employment grade; hatched bars, intermediate employment grade; open bars, lower employment grade.

the working day than did those in the lower employment grade. Women were more stressed by the experience of low job control than were men ($P = 0.036$); the proportion of high stress ratings averaged 22.8% in women and 12.9% in men reporting low job control, compared with 6.9 and 9.2% in women and men reporting high job control.

Stress ratings did not differ in the high and low job demand groups (adjusted means 16.9 and 9.6%). Significant effects were observed for job strain, and these mirrored the pattern for job control illustrated in Figure 2.

Happiness ratings

Happiness did not vary with job control, job demands, job strain, gender, or employment grade, with $46.7 \pm 37.5\%$ of BP readings being associated with high happiness ratings. Happiness was highest on average in the evenings, and lowest in the afternoon ($P < 0.001$, Fig. 2), but this pattern did not interact with job control, job demands, job strain, gender, or employment grade.

Discussion

Ambulatory systolic and diastolic blood pressure was greater throughout the working day in men and women reporting low job control, and this pattern was not affected by gender or SES. Job demands and job strain had little association with BP. These results are partly consistent with previous research in which ambulatory measures have been related to low job control [19], but most studies have demonstrated associations between ambulatory blood pressure and job strain, rather than assessing job control as a separate variable [3]. The reason for the discrepancy may relate to the pattern of job demands and job control observed in the Whitehall II cohort of British civil servants. Marmot *et al.* [14] have shown that job control is inversely associated with grade of employment in the Whitehall II cohort. However, high job demands are also more prevalent in the higher status participants, and do not co-segregate demographically with low job control. This is not the case in many studies of job strain, in which low status jobs are characterized by low control and high demands. In this cohort, low job control may be the particularly toxic component of work stress, and associations of BP with job strain will be diluted by the effects of job demands.

The differences in BP between high and low job control groups averaged 3.3/2.9 mmHg over the day and evening. These differences are not large, and unlikely to be of clinical significance. However, heightened BP may be indicative of moderate stress-induced neuroendocrine and sympathetic nervous system activation. Recent studies indicate that stress-related elevations in BP are positively associated with hemostatic responses [20] and inflammatory cytokine release [21]. The BP differences may therefore be markers of biological responses that have direct significance for cardiovascular disease risk.

We found no evidence for an interaction between job characteristics and SES in relation to BP as found by others [8,9]. Independently of job factors, systolic blood pressure was higher in the morning in the lower employment grade participants, as described previously [10]. It is evident from Figure 1 that the impact of low job control carried over into the evening period outside work.

Some insight into the factors sustaining these BP differences can be gained from the analyses of subjective ratings. People experiencing low job control reported more frequent episodes of perceived low control over the day than did the high job control group. Previous studies have demonstrated that BP is greater during periods of low compared with high perceived control [11,22]. If episodes of low perceived control are more frequent in people reporting low job control, this may contribute to the global elevation in ambulatory blood pressure. Low job control was also associated with more stress over the day (Fig. 2), and this may also stimulate elevations in BP [23]. As might be expected, stress was more frequent in the daytime than the evening, while participants reported being happier in the evening. The absence of significant difference in happiness ratings would suggest that people reporting low job control do not simply have a negative affectivity reporting bias.

Potentially important interactions were observed between job control and SES in relation to perceived stress. As shown in Figure 3, the greater experience of stress over the working day in people reporting low job control was confined to higher and intermediate employment grade groups, and the stress ratings of the lower grade group did not vary with job control. Low SES is associated with diminished general sense of control as well as low job control, due possibly to greater exposure to chronic uncontrollable stressors [24]. Experience at work may therefore conform to more general expectations of life in low SES groups, who may consequently be well adapted to low control situations. But higher SES groups are accustomed to greater degrees of control over their life circumstances, and may therefore find lack of control at work particularly aversive and stressful.

This study was carried out in middle-aged white men and women living and working in an urban environment, and results may not generalize to other groups. Ambulatory blood pressure was monitored over a single working day, and repeated measures would be valuable to assess the stability of findings [25]. We excluded hypertensives from these analyses. It is possible that some hypertensives had already suffered the adverse consequences of work stress [4], so our evaluation may have underestimated the impact of work stress on BP. No recordings were obtained at night, so it is not known whether basal levels or the rise in BP on waking up are associated with job control. Participants in studies of this kind may modify their behaviour during ambulatory monitoring, perhaps avoiding situations that they consider demanding or embarrassing [26]. People with higher job control may have greater opportunities to select less stressful work duties on the day of monitoring, and this could contribute to the pattern of results. Nevertheless, the findings suggest that job control plays an important role in modulating cardiovascular and affective responses over the working day. These responses may help explain how work characteristics are linked with cardiovascular disease risk.

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