Job Characteristics, Occupational Status, and Ambulatory Cardiovascular Activity in Women

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ABSTRACT

Background: *Prior research concerning the effects of occupational status and work stress on ambulatory blood pressure (AmBP) has seldom included women, and available results are equivocal. Moreover, the concurrent effects of occupational status and job characteristics have rarely been investigated. Some research is consistent with the idea that stressful job characteristics are especially detrimental to health in low-status workers, creating a cumulative physiological burden.* ***Purpose:*** *To examine the independent and joint effects of occupational status and perceived demands, control, and social support at work on AmBP and heart rate (HR) in women.* ***Methods:*** *One hundred eight women (M age = 41.07 years) wore an AmBP monitor for 2 days and completed a self-report assessment of job control, demands, and support (i.e., Karesek et al.'s Job Content Questionnaire).* ***Results:*** *After controlling for numerous potential confounds, occupational status and job characteristics accounted for 18% and 22% of the inter-individual variability in ambulatory systolic blood pressure (SBP) and HR, respectively. Occupational status independently predicted ambulatory cardiovascular activity and interacted with job characteristics, particularly in relation to SBP.* ***Conclusions:*** *Inasmuch as ambulatory SBP and HR predict future cardiovascular morbidity and mortality, women with both lower status occupations and stressful job circumstances could be at disproportionately high cardiovascular risk.*

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INTRODUCTION

Karasek (1) and Karasek and Theorell (2) proposed the job strain model to explain how psychosocial aspects of the work environment affect health and well-being. This framework maintains that jobs involving high levels of psychological demands (i.e., rapid pace and high volume of work) and low control (i.e., inadequate power to make decisions and opportunity to use one's skills) produce deleterious health effects. Of the two components, some research suggests that low job control is more toxic (e.g., 3–7; see 8 for a review), although a recent study found stronger effects for job demands (9). Johnson and colleagues (10,11) extended the job strain model by demonstrating that a lack of social support at work further increases health risks. Although several updates and alternatives been proposed (12), the job strain model remains a useful and dominant perspective in research concerning work characteristics and health.

Substantial research indicates that job strain precedes health problems, most frequently cardiovascular morbidity and mortality (13,14). In part, job strain may influence cardiovascular health by altering autonomic nervous system activity. Consistent with this assertion, prior research shows that men with high-strain jobs experience elevated ambulatory blood pressure (AmBP) (15–18). The limited research examining job strain and AmBP in women has yielded inconsistent results, with some studies finding an association (e.g., 19,20) and others identifying no association (e.g., 15,18). Given the conflicting findings, further research concerning job strain and AmBP in women is needed.

Occupational status is also an important predictor of cardiovascular morbidity and mortality (6,7,21–24). The relationship typically is inverse and linear, such that individuals with lower status occupations evidence greater health risks than their counterparts with higher status jobs. However, an interesting departure from this trend has been identified by several prior studies, in which higher rates of coronary heart disease (CHD) morbidity (25,26) and greater atherosclerotic burden (22) were observed in women with clerical jobs (i.e., middle status), relative to women with either blue collar (i.e., low status) or white collar (i.e., high status) jobs.

Like job characteristics, occupational status might influence cardiovascular outcomes through effects on autonomic nervous system activity. However, the few studies that have tested this hypothesis have produced conflicting results. Blumenthal et al. (19) found a *positive* association between occupational status and AmBP in untreated hypertensive individuals. In another study, the combination of a high-effort coping style and high-status job predicted elevated AmBP in women (27). The authors suggested that this pattern of results could reflect range restriction created by studying a high socioeconomic status sample. Similarly, in Blumenthal et al.'s study (19), the range of AmBP may have been restricted in the hypertensive sample. Matthews et al. (28) found no difference in AmBP be-

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tween men and women with professional versus technical/clerical jobs but did find a difference for ambulatory heart rate (AmHR). Finally, a recent study of British civil servants from the Whitehall II cohort identified elevated ambulatory systolic blood pressure (SBP) and AmHR in men and women employed in low-status positions (i.e., clerical or office workers) relative to middle- or high-status positions but only for readings taken during morning hours (29). Given the conflicting evidence to date, further research is needed to clarify the nature of the association between occupational status and AmBP, preferably in studies including participants with a range of occupational status and blood pressure levels.

Although low occupational status and work stress often co-occur (30,31), their joint effects on cardiovascular outcomes have rarely been tested. Nonetheless, some research suggests that the effects of job characteristics on cardiovascular morbidity and mortality are more salient in lower status workers than in higher status groups (e.g., 5,32,33). Furthermore, job strain showed a stronger association with AmBP in men with lower status jobs than in those with white collar jobs (34). Individuals with low-status jobs and high work stress may experience a double psychological and physiological burden, which could create synergistic health effects. However, contradictory findings were identified in the Western Electric Study (35), in which job control had a greater protective effect in white collar than in blue collar workers. Two other studies found no interactive effect of job strain and occupation class on CHD risk (7,9).

In summary, prior work indicates the utility of concurrently examining occupational status and job characteristics in relation to cardiovascular outcomes, and further research concerning women is needed. Toward this goal, in this study we investigated the independent and interactive effects of occupational status and job demands, control, and support on AmBP and AmHR in women working in white collar, clerical, and blue collar occupations. The study expands on prior research by including women with a range of occupations, thereby avoiding the potential influence of range restriction. Furthermore, our study is the first, to our knowledge, to examine the interactive effects of occupational status and the Karasek job strain parameters on AmBP in women. Women wore an AmBP monitor during 2 working days and completed diary entries assessing confounding influences on cardiovascular activity. Consistent with most prior research, we predicted that women with low-status occupations and more stressful job situations would evidence higher levels of AmBP and heart rate (HR), when compared with women working in higher status occupations or those reporting less stressful work environments. Furthermore, on the basis of the premise that having a low-status occupation and high work stress would produce synergistic effects, we also predicted that the effects of job characteristics would be heightened in women with low-status occupations compared with women in higher status occupations.

METHOD

Participants

Participants were 114 women recruited from a small midwestern university town (Kent, OH) and surrounding communities. Participants self-referred for the study in response to flyers, university e-mail announcements, or newspaper advertisements stating that healthy women were needed for a study of blood pressure and social experiences. Some participants learned about the study through word of mouth. Eligibility was assessed via phone interview. Participation was limited to women working at least 35 hr/week during daytime or evening hours and who were married or living as if married. These exclusionary criteria were adopted so that participants would be exposed to a variety of social interactions and environmental demands throughout the monitoring period. Additional eligibility criteria included self-reported absence of cardiovascular diseases (CVDs) and no use of medication with autonomic or other cardiovascular effects. Participants were paid \$60 (n = 65) or \$75 (n = 42) for completing the experiment. (The incentive payment was increased to expedite enrollment.) One participant was excluded because she failed to complete the assessment of job characteristics, and 5 participants were excluded because they provided no usable AmBP or diary data, generally consequential to equipment failure.

Procedure

Ambulatory monitoring took place during 2 consecutive working days, on Mondays through Thursdays. Participants reported to the laboratory on the first morning and received a detailed explanation of the study protocol. After obtaining written informed consent, a trained technician attached the AmBP monitor and provided the participant with a handheld computer. The technician then explained the use of the AmBP monitor and the handheld computer, obtained test readings, and allowed the participant to complete practice diary entries. Participants were given a battery of questionnaires to be returned on the 2nd day of monitoring. Participants wore the monitor throughout the period of wakefulness the 1st day, removed it approximately 1 hr before bed, and returned to the laboratory the following morning for the initiation of a 2nd day of monitoring. The monitor was set to take automatic readings of SBP, diastolic blood pressure (DBP), and HR at 45-min intervals (randomly varying from 40 to 50 min), to operate in dynamic inflation mode (i.e., to inflate to 30 mmHg higher than the previous reading), and to perform one retry if an erroneous reading was taken (e.g., as a result of arm movement or insufficient inflation pressure). Participants were kept blind to their readings. Participants were instructed to complete a diary entry on the handheld computer immediately following each cuff inflation. On the average, 30.5 readings (SD = 10.28) were provided. Variable numbers of readings across participants were due to a combination of factors, including participant noncompliance (e.g., removing the monitor prior to the proscribed time); monitor retries; equipment failure (e.g., inability to download some of the monitor or electronic diary data or unusable data); and varying work, sleep, and wake times.

Measures

Occupational status. Participants noted their job title and were grouped according to employment in blue-collar (n = 18; e.g., bakery worker; parking attendant, janitorial worker, campus police) administrative support/clerical (n = 50; e.g., secretary, administrative assistant, accounting clerk, receptionist, data entry), or white collar (n = 40; e.g., associate professor, assistant dean, lecturer, school psychologist, accountant) occupations, based on the Duncan socioeconomic index (SEI) (36). Specifically, white collar workers comprised women with Duncan SEI codes within the category "executive, administrative, and managerial occupations"; clerical workers had Duncan SEI codes within the category "technical, sales, and administrative support," subcategory "administrative support occupations, including clerical"; and blue collar workers had Duncan SEI codes within the category "service occupations." If occupational status was not apparent from the job title, the experimenter sought further information about responsibilities and work content until status could be assigned.

Job characteristics. Psychological work demands, decisional latitude, and support were assessed with Karasek et al.'s (37) Job Content Questionnaire. The Psychological Demands scale consists of nine items that measure work quantity, intellectual demands, and time constraints. *Decisional Latitude* refers to the degree to which the respondent can make decisions at work, express creativity, and use and develop skills. Social Support at work is assessed with 11 items—5 describing supervisor support and 6 related to coworker support.[1] Substantial prior research has demonstrated the reliability and validity of the Job Content Questionnaire scales. In this sample, internal consistency was calculated at $\alpha = .67$ for Psychological Demands, $\alpha = .81$ for Decisional Latitude, and $\alpha = .85$ for Social Support at work. Henceforth, these scales are referred to as Demands, Control, and Support.

Health-related covariates. Weight and height were self-reported, and body mass index (BMI) was calculated (weight in kg/height in m^2). Smoking status was evaluated with one item asking if the participant regularly smokes at least one cigarette per day. Participants self-reported their menopausal status and whether they were using hormone replacement therapy (HRT) or hormonal birth control (BCP).

Diary. Participants completed a 39-item diary entry after each AmBP measurement. Most items were derived from the Diary of Ambulatory Behavioral States (38). For this study, we examined extraneous cardiovascular influences, including posture, physical activity, temperature, talking during the time of cuff inflation, and exercise and substances ingested between readings.[2]

[1]One participant did not complete the Supervisor Support scale. To avoid loss of data, the mean for the coworker support items was multiplied by 11 and used to represent total work support.

[2]The diary also included information about momentary psychosocial experiences, including mood, task demands, and social interaction. Consistent with prior research (28), women with lower status occupations tended to report more negative psychosocial experiences. However, these variables were weakly predictive of cardiovascular outcomes and therefore are not presented here.

Equipment

AmBP monitor. The Accutracker DX ambulatory monitor (Suntech Medical Instruments, Raleigh, NC) was used to assess AmBP and AmHR. The Accutracker DX uses a noninvasive, auscultatory technique and has been shown to accurately assess cardiovascular changes during simulated ambulatory assessments with mental and physical stressors (39).

Palmtop computer. Participants were provided with a battery-operated handheld computer (Palm Inc., Santa Clara, CA), containing a diary programmed using the Experience Sampling Program (developed and distributed by Lisa Feldman-Barrett, http://www2.bc.edu/~barretli/esp). Questions were presented in a fixed order on a liquid crystal display, and participants responded by tapping the touch-sensitive screen with a stylus. Each entry was automatically time stamped. Diary data were downloaded to an IBM-compatible computer after each day of monitoring.

Data Analysis

Consistent with criteria set forth by Marler et al. (40), blood pressure and HR readings were considered artifactual and were deleted if (a) SBP was < 70 or > 250, (b) DBP was < 45 or > 150, (c) HR was < 40 or > 200, or (d) SBP/DBP $< [1.065 + (.00125 \times \text{DBP})]$ or > 3. To ensure that all analyses were based on the same data, if one reading was deleted for an entry, all cardiovascular parameters were deleted. Using these decision rules, approximately 17% of the readings were omitted for each person, on average. Erroneous values were typically accompanied by Accutracker error messages, indicating problems such as microphone difficulties or arm movements. An average of 25.25 entries remained for each participant (SD = 10.52) after artifactual data were deleted.

Primary analyses were conducted through hierarchical linear modeling (HLM 5.04) (41,42), a procedure for examining outcomes measured on repeated occasions, which does not require equal numbers or increments of measurements across participants. SBP, DBP, and HR served as dependent variables in separate analyses. HLM proceeds at multiple levels. Here, Level 1 analyses modeled a distinct regression equation for each participant based on time-varying covariates (e.g., posture, exercise, substances). At Level 2, between-subjects covariates (e.g., age, BMI) and predictors (i.e., occupation, job characteristics) were used to predict systematic variability in the person-specific parameters. Covariates were centered about the grand mean, and time-varying covariates were treated as fixed, to reduce model complexity and because the effects of these variables were not expected to vary randomly. Maximum likelihood methods were used to obtain the model solutions.

Initial analyses were performed to identify covariates. Next, we tested models containing only the job environment components, to examine their main effects on the outcomes and the amount of variance accounted for by these effects. We then tested models containing occupational status, job characteristics, and their interactions. Previous research has identified distinct influences of the individual parameters of the job strain

TABLE 1

Results of the One-Way Analyses of Variance Examining Differences in the Work Environment Variables Among the Occupation Groups

	Blue-Collar[a]		*Clerical*[b]		*White-Collar*[c]		*Total Sample*[d]		
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*F*(2, 105)
Demand	22.83_a	3.50	25.54_b	4.17	$24.45_{a,b}$	3.18	24.69	3.81	3.61*
Control	27.43_a	4.57	28.70_a	3.60	34.88_b	3.71	30.78	4.95	37.57**
Support	27.57_a	3.92	31.59_b	5.58	33.88_c	4.98	31.77	5.51	9.48**

Note. Means with different subscripts differ according to Fisher's Least Significance Difference Test at $p < .05$.
[a]$n = 18$. [b]$n = 50$. [c]$n = 40$. [d]$N = 108$.
*$p < .05$. **$p < .01$.

model. Furthermore, power in this study was not sufficient to estimate models containing all main effects and two-, three-, and four-way interactions forming the full factorial model for the effects of occupation, job strain, and isostrain. We therefore examined the distinct effects of Demands, Control, and Support. These variables were centered about the grand mean (i.e., $M = 0$) to reduce multicollinearity with interaction terms (43). Occupation was expressed with two dummy codes that compared the clerical and white collar groups, respectively, to the blue collar group (coded 0). Because of this coding scheme, in the full model the job characteristic terms represent the simple main effects for the blue collar group. Interaction effects were created by multiplying the occupational status dummy codes with each job parameter.

RESULTS

Participant Characteristics and Health-Related Covariates

The mean age of the women was 41.07 years ($SD = 9.18$) and, consistent with the area demographics, the majority (86.9%, $n = 93$) was White. Of the remainder, 11 women were African American, 2 were Latina, 1 was Asian American, and 1 woman did not specify her race/ethnicity. The average BMI for the sample was 27.12 ($SD = 5.96$). Thirteen percent of the sample reported smoking regularly (14 women), 31% (33 women) were postmenopausal, 7.4% (8 women) were taking HRT, and 13% (14) were taking BCP.

Participant Characteristics and Health-Related Variables According to Job Characteristics and Occupation

One-way analyses of variance (ANOVAs) and chi-square tests showed that the occupation groups did not differ according to age, ethnicity, smoking status, menopausal status, or use of HRT or BCP (all *p*s > .35). The occupation groups differed in body mass, $F(2, 105) = 4.09, p < .05$. Women with blue collar jobs ($M = 30.68, SD = 6.14$) had higher BMIs than women in clerical ($M = 26.46, SD = 4.91$) or white collar jobs ($M = 26.34, SD = 6.60$). Correlation coefficients revealed no associations between the job scales and age (*p*s > .15). Control and Support were significantly, inversely related to BMI (*r*s = –.19 and –.34, respectively), and Demands were related marginally to BMI ($r = -.17, p < .10$). The job scales were not related to ethnicity, smoking status, menopausal status, or use of HRT or BCP (all *p*s > .18).

Association Between Occupational Status and Job Characteristics

Occupation group differences on the job scales were tested through one-way ANOVAs. As shown in Table 1, the occupation groups differed on all parameters. Follow-up tests revealed that the clerical group reported higher Demands when compared with the blue collar group. The white collar group reported higher Control than either the blue collar or clerical groups. Finally, all groups differed according to work support, with the white collar group reporting the highest support and the blue collar group reporting the lowest support.

Covariates of HLM Models for Ambulatory Cardiovascular Activity

Initial HLM models were run to select time-varying covariates. Covariates that predicted one or more of the cardiovascular outcomes at $p \leq .10$ in individual models were included in all analyses; specifically, posture (two dummy codes: sitting vs. lying down and standing, respectively), physical activity (three dummy codes: none vs. some, moderate, and strenuous), temperature comfort (two dummy codes: too hot and too cold), talking at the time of cuff inflation, and exercise and consumption of substances (caffeine, food, drugs) between readings. Consumption of alcohol did not predict any of the outcomes. In addition to the Level 1 covariates, age, smoking status, BMI, menopausal status, use of BCP, and use of HRT were examined as possible covariates at Level 2.[3] Each of these variables predicted

[3]We did not include ethnicity in the covariates analyses because the vast majority of participants were White and because neither occupation status nor the job characteristics were related to ethnicity ($p > .25$). Furthermore, 1 participant did not report her ethnicity. However, there was a tendency for women with African American/Black ethnicity to show higher ambulatory SBPs ($p < .10$) when compared with women of other ethnicities (but not DBPs or HRs, $p > .4$). To ensure that this trend did not bias the results, we ran the primary SBP model controlling for ethnicity and found that the results were not substantively different from the uncontrolled analysis.

TABLE 2
Effects of Time-Invariant and Time-Varying Covariates on Ambulatory Cardiovascular Activity

	Systolic Blood Pressure			*Diastolic Blood Pressure*			*Heart Rate*		
Variable	*Coefficient*	*SE*	*t*	*Coefficient*	*SE*	*t*	*Coefficient*	*SE*	*t*
Intercept	132.11	1.58	83.58****	78.23	0.77	101.45****	82.56	1.00	82.72****
Age (1-year increase)[a]	0.07	0.19	0.70	0.23	0.09	2.55**	–0.12	0.13	–0.91
Body mass index (kg/m^2)[a]	0.64	0.26	2.49**	0.61	0.14	4.38****	0.28	0.18	1.62
Current smoker[a]	–4.56	4.09	–1.12	–2.43	2.52	–0.96	2.53	2.84	0.89
Postmenopausal[a]	3.82	4.28	0.89	2.68	1.93	1.39	1.65	2.53	0.65
Taking HRT[a]	–9.74	6.15	–1.58	–5.43	2.88	–1.88	–3.40	2.81	–1.21
Taking BCP[a]	–0.14	4.36	–0.03	–0.53	2.30	–0.23	0.46	3.01	0.15
Caffeine[b]	–2.95	1.24	–2.38**	–0.25	0.70	–0.35	–0.29	0.80	–0.36
Food[b]	2.48	0.99	2.50**	0.49	0.58	0.84	0.71	0.64	1.12
Drugs[b]	–3.39	2.64	–1.27	1.22	1.71	0.71	1.22	1.82	0.67
Exercise[b]	–0.95	2.61	–0.37	0.72	1.22	0.59	2.82	1.61	1.75*
Talking[c]	0.20	0.83	0.25	0.93	0.52	1.78*	0.09	0.54	0.16
Too cold[c]	0.47	1.87	0.25	–0.76	1.15	–0.66	–2.35	1.13	–2.08**
Too hot[c]	1.50	1.95	0.77	0.05	1.10	0.04	4.55	1.20	3.79****
Posture[c]									
Lying down vs. sitting	0.10	2.27	0.04	–3.21	1.62	–1.98**	–1.56	1.37	–1.14
Standing vs. sitting	2.15	1.13	1.90*	1.89	0.60	3.14***	4.82	0.80	6.01****
Physical activity[c]									
Some vs. no activity	1.01	1.10	0.92	0.58	0.58	0.99	1.34	0.74	1.81*
Moderate vs. no activity	–0.76	1.56	–0.49	0.20	0.98	0.20	4.63	1.23	3.77****
Strenuous vs. no activity	4.52	4.80	0.94	4.20	3.04	1.38	7.62	3.80	2.01**

Note. Estimates are unstandardized partial regression coefficients and standard errors. All covariates were centered about the sample mean prior to entry and were entered simultaneously. $N = 108$. HRT = hormone replacement therapy; BCP = birth control pills.

[a]Covariate entered at Level 2. [b]Between readings. [c]At time of cuff inflation.

*$p < .10$. **$p < .05$. ***$p < .01$. ****$p < .0001$.

one or more of the cardiovascular outcomes in preliminary analyses, and therefore all were included as between- subjects covariates. Table 2 shows the results of the analyses that regressed the cardiovascular outcomes on all selected covariates, simultaneously. Chi-square tests indicated substantial remaining interindividual variability for each ambulatory cardiovascular outcome after controlling for the covariates (all *ps* $< .0001$), suggesting the utility of examining further predictors.

Job Characteristics and Ambulatory Cardiovascular Activity

Initial models examined the main effects of job characteristics on AmBP and HR. After controlling for covariates, the job characteristics accounted for 4.6% of the interindividual variability in SBP, $\chi^2(3, N = 108) = 4.47$, $p > .10$. An examination of individual effects showed that Support predicted SBP, $\gamma = –0.67$, $SE = 0.32$, $t(98) = –2.09$, $p < .05$, but the effects of Demands, $\gamma = 0.15$, $SE = 0.43$, $t(98) = 0.36$, and Control, $\gamma = 0.41$, $SE = 0.38$, $t(98) = 1.09$, were nonsignificant. The job characteristics explained 3.4% of the interindividual variance for DBP, $\chi^2(3, N = 108) = 2.93$, $p > .10$, and none of the individual job parameter effects were statistically significant, with $\gamma = 0.07$, $SE = 0.32$, $t(98) = 0.32$ for Demands; $\gamma = 0.24$, $SE = 0.18$, $t(98) = 1.35$ for Control; and $\gamma = –0.23$, $SE = 0.16$, $t(98) = 1.42$ for Support. The analysis for HR showed that the job scales explained 10.2%, a significant amount, of the variability in HR between participants, $\chi^2(3, N = 108) = 10.37$, $p < .05$. Demands, $\gamma = 0.56$, $SE = 0.25$, $t(98) = 2.28$, and Support, $\gamma = –0.36$, $SE = 0.17$, $t(98) = –2.12$, were statistically significant predictors ($p < .05$), and Control, $\gamma = 0.33$, $SE = 0.19$, $t(98) = 1.76$, $p < .10$, was a marginally significant predictor of this outcome.

Occupational Status, Job Characteristics, and Ambulatory Cardiovascular Activity

Table 3 displays the results of the analyses that contained all occupational status and job characteristics main effects and all two-way interaction terms. After controlling for the covariates, the occupation and job variables accounted for 18% of the variability between participants in SBP, $\chi^2(11, N = 108) = 19.38$, $p = .05$. Consistent with predictions, the clerical and white collar groups evidenced lower AmBP levels when compared with the blue collar group. The effects for Demands, Control, and Support were all significant for the blue collar group, in the expected direction. Furthermore, all interaction effects were statistically significant, which indicates that these effects differed for the clerical and white collar groups, relative to the blue collar group. Figure 1 depicts the interaction between Demands and occupational status in predicting SBP. Increasing Demand was associated with augmented SBP levels in the blue collar group but had little effect on SBP in the clerical or white collar groups. As shown in Figure 2,

TABLE 3
HLM Analyses Examining the Effects of Occupational Status, the Psychosocial Work Environment Scales, and Their Interactions, on Ambulatory Cardiovascular Activity

	Systolic Blood Pressure			*Diastolic Blood Pressure*			*Heart Rate*		
Variable	*Coefficient*	*SE*	*t*	*Coefficient*	*SE*	*t*	*Coefficient*	*SE*	*t*
Intercept	147.33	2.83	52.00***	80.58	3.04	26.538***	88.19	3.30	26.75***
Clerical (vs. blue collar)	–15.53	4.21	–3.69***	–3.11	3.34	–0.93	–3.49	3.94	–0.89
White collar (vs. blue collar)	–12.88	4.39	–2.93***	–1.81	3.68	–0.49	–10.80	3.77	–2.86***
Demands	3.14	0.95	3.33***	0.07	0.56	0.13	1.22	0.63	1.94*
Control	–1.98	0.71	–2.78***	–0.41	0.30	–1.36	–0.18	0.44	–0.42
Support	2.19	0.59	3.69***	0.35	0.49	0.71	0.09	0.56	0.17
Demands × Clerical (vs. blue collar)	–2.91	1.22	–2.39***	0.10	0.65	0.15	–0.57	0.83	–0.67
Demands × White Collar (vs. blue collar)	–2.48	1.27	–1.95**	0.25	0.69	0.36	–0.72	0.72	–1.00
Control × Clerical (vs. blue collar)	3.24	1.07	3.02***	0.82	0.50	1.65	1.29	0.72	1.79*
Control × White Collar (vs. blue collar)	2.13	1.08	1.97**	0.57	0.52	1.10	0.95	0.57	1.68*
Support × Clerical (vs. blue collar)	–2.70	0.71	–3.78***	–0.63	0.54	–1.16	–0.55	0.64	–0.85
Support × White Collar (vs. blue collar)	–3.29	0.77	–4.25***	–0.48	0.56	–0.86	–0.11	0.60	–0.19

Note. Blue collar is the comparison group, so that the intercept represents the average level of the outcome for the blue collar group, the occupation dummy codes examine the difference between the clerical, or white collar, and blue collar groups, and the Demands, Control, and Support terms represent simple main effects for the blue collar group. The interaction terms compare the effects of the job characteristics for the clerical or white collar group, with those for the blue collar group. HLM = hierarchical linear modeling.
$^*p < .10$. $^{**}p < .05$. $^{***}p < .01$.

Control was inversely associated with SBP levels in blue collar workers, whereas Control had a slight augmenting effect on SBP levels in the clerical group and very little effect in the white collar group. As shown in Figure 3, increasing work Support had an augmenting effect on SBP in the blue collar group; higher Support was associated with lower SBPs in the white collar group and, to a lesser extent, in the clerical group.

The model examining the joint effects of job characteristics and occupation accounted for only 8% of the between-subjects variability in DBP, $\chi^2(11, N = 108) = 8.36, p > .10$, after controlling for covariates. As shown in Table 3, none of the individual effects were statistically significant.

The aggregate occupation and job characteristics model accounted for 22% of the inter individual variance in AmHR levels, $\chi^2(11, N = 108) = 25.08, p > .01$, after controlling for covariates. Examination of individual effects, shown in Table 3, indicated that white collar workers displayed significantly lower AmHRs when compared with blue collar workers. The effect of Demand was marginally significant for the blue collar group, with higher Demand predicting higher HR. The interactions

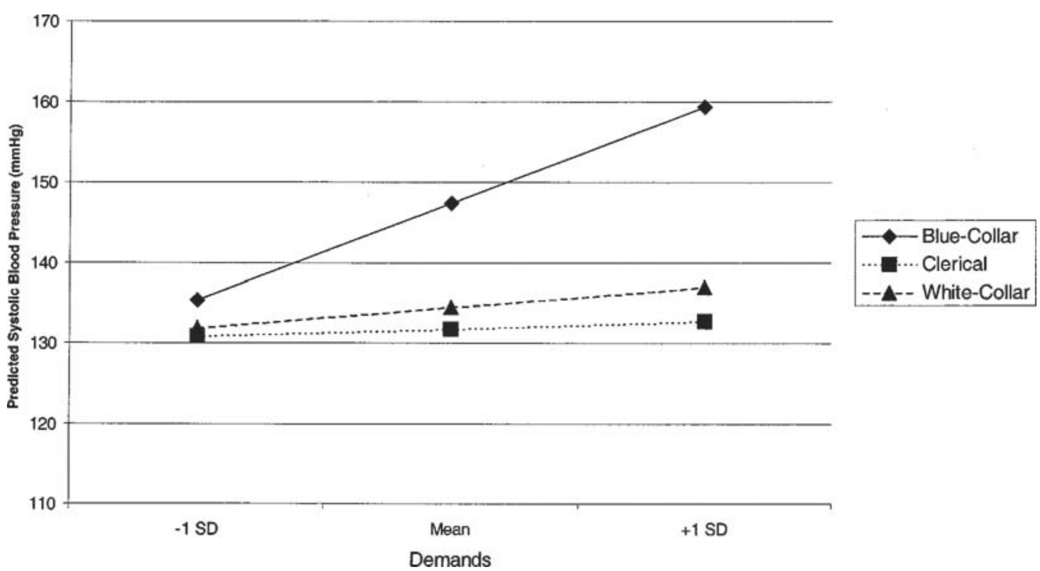

FIGURE 1 Average ambulatory systolic blood pressure (SBP) according to occupational status and perceived job demands. SBP estimates are adjusted for all covariates included in the model. Demand is depicted at the sample mean, and at 1 *SD* above and below the sample mean, for illustrative purposes.

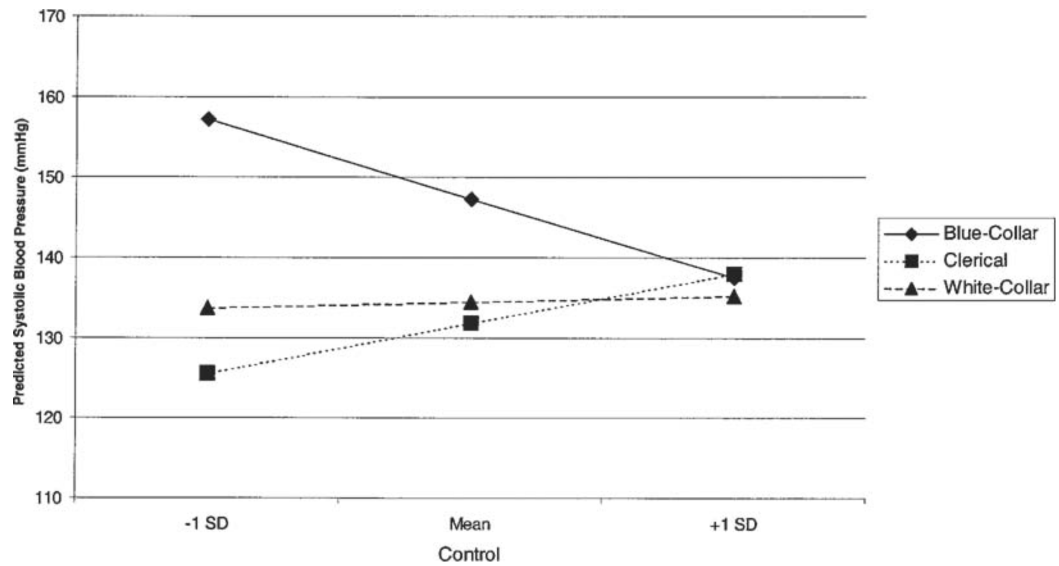

FIGURE 2 Average ambulatory systolic blood pressure (SBP) according to occupational status and perceived job control. SBP estimates are adjusted for all covariates included in the model. Control is depicted at the sample mean, and at 1 *SD* above and below the sample mean, for illustrative purposes.

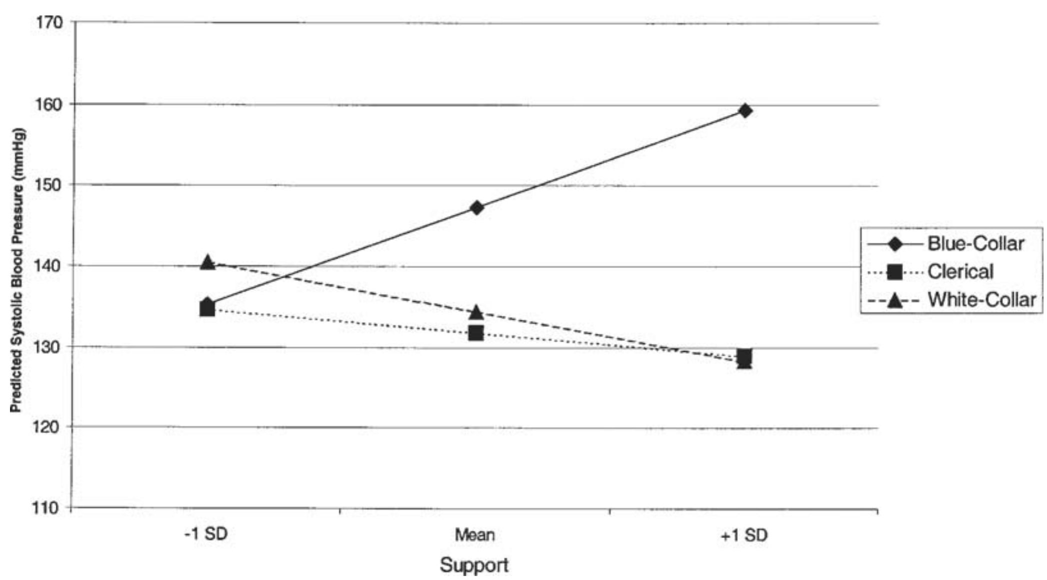

FIGURE 3 Average ambulatory systolic blood pressure (SBP) according to occupational status and work support. SBP estimates are adjusted for all covariates included in the model. Support is depicted at the sample mean, and at 1 *SD* above and below the sample mean, for illustrative purposes.

comparing the effects of Control for the blue collar versus clerical and white collar workers were both marginally significant. Control had little effect on HR in the blue collar group and was positively associated with HR in the other groups.

Do the Effects of Work Environment and Occupational Status Vary According to Location?

Secondary HLM analyses included a time-varying, dummy-coded variable specifying location at the time of cuff inflation as work versus elsewhere (generally, home). When included in the covariates-only models, location was marginally predictive of SBP, $\gamma = 2.09$, $SE = 1.12$, $t(107) = 1.89$, $p < .10$, and SBP tended to be lower at work. Location did not predict DBP, $\gamma = 0.70$, $SE = 0.55$, $t(107) = 1.26$, or HR, $\gamma = 1.00$, $SE = 0.70$, $t(107) = 1.42$. We then examined whether the effects of job characteristics differed according to location. In no case did Demands, Control, or Support interact with location to predict AmBP or HR (all ps > .25), and results of these analyses were not substantively different from those that did not include location. Finally, we tested models that included all occupation and job characteristic effects predicting average AmBP or HR (i.e., intercepts) and predicting the slope for the association between location and ambulatory cardiovascular activity. We did not test the three-way interactions among occupation, job characteristics, and location, because of inadequate sample size. In these models, neither location (both ps

> .60) nor the interaction of location with occupation or job characteristics (all *p*s > .15) predicted SBP or DBP. Furthermore, the results of these analyses did not differ from those that did not account for location. Location also did not predict AmHR levels ($p >$ .15). However, the effect of location on HR differed for blue collar and clerical participants ($p < .01$). On average, blue collar workers had AmHRs that were 2.88 beats per minute (bpm) lower when measured somewhere other than work, whereas clerical workers' AmHRs were 3.4 bpm higher when somewhere other than work. The occupation and Occupation × Job Characteristic interaction effects for HR were not substantively different from those in the model that did not include location.

Could Results Reflect a Blood-Pressure-Related Sampling Bias?

Given the relatively high blood pressures observed in this study, and because we did not restrict entry based on resting blood pressure, one might argue that observed effects could reflect a sampling bias resulting in the disproportionate presence of untreated hypertension in low-occupation or highly stressed workers. To eliminate this possibility, we examined occupation and job strain in relation to the average of a series of sitting and standing blood pressure readings taken on the morning of each monitoring day from 103 of the participants. The occupation groups differed marginally according to SBP, $F(2, 100) = 2.43$, $p < .10$, but did not differ according to DBP, $F(2, 100) = 1.57$. Higher job control was marginally, inversely associated with SBP ($r = -.16$) and significantly related to DBP ($r = -.28$), but no other job strain effects were observed. When we repeated the full-model AmBP analyses controlling for the average laboratory SBP and DBP values, the pattern of observed results was quite similar to that from the uncontrolled analyses, with the exception that the effects of Control for the blue collar group, and the interaction comparing the effect of Control in blue collar versus clerical workers, were no longer significant (with *p*s = .12 and .13, respectively). One woman in the blue collar group was found to have particularly high SBP (i.e., average sitting and standing SBPs across both days = 193 mmHg). To ensure that her data did not disproportionately influence the results, we also repeated the analyses excluding this participant and found that the statistical findings were unchanged from the original analyses. Notably, the average ambulatory SBP for this participant throughout the 2 days was 136 mmHg, and it is therefore possible that her clinic BP measures were inaccurate. Furthermore, when this participant was excluded from the analysis, the ANOVA testing the difference in clinic SBP for the occupation groups was nonsignificant, $F(2, 99) = 0.90$.

DISCUSSION

In combination, measures of occupational status and job characteristics predicted ambulatory cardiovascular activity in women, accounting for 18% of the interindividual variance in SBP and 22% of the interindividual variance in HR. These effects emerged after controlling for numerous potential confounds, including BMI and smoking status, as well as momentary fluctuations in posture and physical activity. Consistent with prior research suggesting an occupational gradient in cardiovascular risk for women (e.g., 6,7,22), having a lower status occupation predicted higher ambulatory cardiovascular activity. Furthermore, these effects were large in this sample, with white collar and clerical workers having average SBPs that were nearly 13 and 16 mmHg lower and HRs that were nearly 11 and 3.5 bpm lower, respectively, when compared with blue collar workers. Some previous studies did not find the expected inverse association between occupational status and AmBP (5,27,28), and one study found an inverse association during morning hours only (29). It is possible that these results were influenced by a restriction of range in BP (5) or occupation (27–29). We consistently observed very little difference in AmBP between the upper and middle-status occupation groups. As in a prior study (28), women with white collar occupations did appear to have lower HRs than women in clerical positions, and a secondary analysis revealed that this was a statistically significant difference, $\gamma = 4.93$, $SE = 2.50$, $t(98) = 1.97$, $p < .05$. It is important to note that the effects of occupation emerged in models that controlled for job characteristics. Marmot et al. (6) suggested that work control may explain much of the occupation gradient in cardiovascular health. However, as Wamala et al. (7) noted, job control may be more closely confounded with social status in men than in women. Women in low-status jobs are likely to many face occupational obstacles beyond poor job control, as we discuss next.

When examined independent of occupation, job characteristics were weak predictors of AmBP. These findings are consistent with other prior studies that have identified no effect of job strain on AmBP in women (15,18), although other studies have found an association (e.g., 19). It is important to note that previous studies have typically used a categorical assessment of job strain, in which demands and control were dichotomized and combined, consistent with the model advanced by Karasek and Theorell (2). In contrast, we examined continuous individual parameters, and therefore our results cannot be considered directly comparative. However, exploratory analyses found that multiplicative interaction effects representing job strain (Demands × Control) and isostrain (Demands × Control × Support) also did not predict AmBP.[4] There are a number of reasons that the job

[4]Based on reviewer recommendations, we explored the effects of "job strain" (i.e., the Demands × Control interaction effect [2]) and "isostrain" (i.e., the three-way interaction of Demands, Control, and Support [10]) on ambulatory BP and HR. Prior to creating multiplicative interaction terms, all scales were converted to *z* scores and recoded so that a higher score would represent a more stressful job situation. Because all possible two-way interaction terms must be examined to test a three-way interaction, these analyses also included effects for the interactions of demands by support and control by support. Stepwise analyses were performed, in which we first added the main effects of Demands, Control, and Support to the regression equation that contained covariates, then added the two-way interaction terms (Control × Demands, Control × Support, Support × Demands) and examined both the change in variance accounted for, and the individual interaction effects, and finally added the three-way interaction effect and examined the change in variance and significance of the term. Neither the two-way interaction effects nor the three-way interaction added

strain model could be less relevant to explaining AmBP, and possibly other cardiovascular outcomes, in women than in men. In women, the impact of increasing demands might not be buffered in the presence of higher control, in part because their level of control is lower than that of men in comparable jobs (e.g., 44–46). In addition, women still complete the majority of domestic work even in dual-earner households (47,48), and the effects of high demands at work and at home could be synergistic (46,49). Indeed, a prior study showed that in combination, work and family responsibilities had a larger impact on ambulatory BP than did either factor alone (but this effect emerged only for women with a university degree; 50). Because we did not administer a comparable assessment of home stress, we cannot test the combined effects of home and work stress in our study.[5]

Interaction effects emerged between occupational status and job strain in predicting ambulatory SBP, and the job strain parameters did significantly affect AmBP in the blue collar group. Hence, in line with our predictions, the effects of stressful work environments were especially salient in the low-status occupation group. Specifically, for blue collar workers, a 1 *SD* increase in demands, or a 1 *SD* decrease in control, would predict a 12-mmHg or 10-mmHg increase in SBP, respectively. The finding that job characteristics have stronger effects in lower status workers is consistent with some (e.g., 5,32,35), but not all (e.g., 7,9), prior research. However, to our knowledge, ours is the first study that examined the interactive effects of occupational status and the Karasek job strain parameters on women's AmBP. It seems intuitive that low occupational status and stressful work characteristics would exhibit synergistic effects, because individuals with low-status jobs may have a number of work stressors beyond the characteristics examined here, including gender discrimination, physical aspects of the working environment, lower salary, and poorer benefits. Asymmetry between personal efforts (psychological and physical demands) and rewards (salary, esteem, and job security) is thought to increase risk for CHD according to another prominent model of work strain, the effort–reward imbalance model (51). Moreover, especially for women, low status is likely to transcend the work environment to home and other contexts. Thus, women in low-status jobs may experience repeated stressors from multiple sources, which, when occurring in combination with work stress, could produce a cumulative physiological burden, thereby fostering detrimental health outcomes, consistent with the allostatic load hypothesis (e.g., 52). Conversely, if available, resources such as control could buffer the effects of other stressors present in individuals with low social status (as suggested by Figure 2) although, as observed in this study, status and resources are often confounded (see 53 for a related review and discussion).

Not only did blue collar workers show the greatest augmentation of SBP with higher demands and lower control, but they also failed to benefit from work support and, in fact, evidenced a positive association between SBP and work support. The reasons for this directional effect are unclear, and they contrast with those from a prior study showing that low work support was most detrimental for cardiovascular morbidity and mortality in blue collar workers (5). However, that study concerned a different endpoint and involved a sample of Swedish men, and therefore the results are not directly comparable. Perhaps female blue collar workers increased their productivity in response to the perception of a supportive environment, resulting in greater cardiac demand. Productivity in at least some members of this group is likely to have a physical component, although these effects should have been accounted for through statistical control for posture and activity. It is also important to note that blue collar workers had lower levels of support when compared with the other participants; indeed, all but 3 had work support scores below the sample mean. Overall, the results suggest that examining either occupational status or work environment in isolation may underestimate associated risk; researchers may gain more information about cardiovascular outcomes by examining the concurrent impact of these variables.

To place our findings in a clinical context, a growing body of research suggests that AmBP measures are superior to casual measures as predictors of cardiovascular morbidity and mortality (54,55). In this study, occupation predicted both SBP and HR, and job characteristics predicted SBP and HR in blue collar workers, but there were no effects for DBP. DBP has long been thought to have the greatest prognostic value for cardiovascular morbidity and mortality, but more recent evidence suggests the significance of SBP, particularly in conjunction with aging. The latest report from the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of Blood Pressure (in 2003) states that, in persons over 50, having a SBP over 140 mmHg is a more important cardiovascular risk factor than elevated DBP (56). Furthermore, a recent meta-analysis of 61 prospective studies suggested that each increment of 20 mmHg for SBP above 115 mmHg predicts a twofold increased risk for cardiovascular mortality for individuals aged 40 through 69 (57). Other research provides evidence of the relationship among job strain, AmBP, and structural changes in the heart signaling sustained exposure to elevated blood press (i.e., increased left ventricular mass [58]), further demonstrating the particular deleterious implications of these findings for the low-status workers.

significantly to model fit for SBP, DBP, or HR (all *p*s > .27). An examination of individual interaction terms showed a significant effect of Demands × Support in predicting SBP, $\gamma = 2.37$, $SE = 1.21$, $t(95) = 1.96$, $p < .05$, indicating that people with high demands and low support have higher AmBPs. However, this effect became nonsignificant when isostrain was included in the model. Demands × Support, $\gamma = -4.21$, $SE = 2.51$, $t(94) = -1.68$, and Support × Control, $\gamma = -4.26$, $SE = 2.67$, $t(94) = -1.66$, were marginally significant predictors of HR ($p < .10$), but only after isostrain was added to the model. Notably, these effects were in the opposite direction than one might predict from the job strain model. These analyses are available from Linda C. Gallo on request. Power was not sufficient to accurately estimate models containing the job characteristic and occupation main effects and their two-, three-, and four-way interaction terms.

[5]Participants did specify the number of children under 18 living in the home. Because prior research has shown an association between number of children and AmBP in women (50), we repeated the analyses controlling for this variable; results were not altered.

Finally, although the prognostic meaning of elevated HR has not been definitively established, some research suggests that higher HR predicts cardiovascular mortality in middle-aged or elderly normotensive individuals (59,60).

It is also notable that many women in this study had clinic SBP values in the normal range but ambulatory SBP values in the hypertensive range. Specifically, among the 103 women for whom clinic readings were available, approximately 39% of blue collar workers, 28% of clerical workers, and 21% of white collar workers had unadjusted ambulatory SBPs but not clinic SBPs, greater than or equal to 140 mmHg (the cutoff for a hypertension diagnosis [56]). Participants were less likely to show a discrepancy for DBP, with 6% of blue collar workers, 11% of clerical workers, and 5% of white collar workers having ambulatory but not clinic DBPs > 90 mmHg. The likelihood of incongruity between clinic and ambulatory SBP suggests the importance of more widespread utilization of workplace blood pressure surveillance (61)—particularly in higher risk workers, such as those with lower status or highly stressful jobs.

These results should be interpreted in light of several limitations. First, because the data are cross-sectional, we cannot be certain of the direction of the association between job strain and AmBP. However, job strain was assessed at the beginning of the experiment, and participants were kept blind to their readings. Hence, we can be reasonably sure that having higher AmBP did not influence work perceptions. Second, we used a convenience sample, obtained through volunteer recruitment procedures, and we therefore cannot ensure that the resulting sample is representative. The sample is also relatively small, particularly for the blue collar group, and effect sizes presented here should be viewed tentatively. The sample is also ethnically homogeneous, potentially limiting the generalizability of the results. Research incorporating more diverse, and larger samples, preferably using a probability sampling technique, would increase confidence in these findings. Future studies should also incorporate both men and women in order to consider potential gender differences in the observed associations. Including participants with a range of blood pressure levels is a strength of this research inasmuch it minimizes range restriction, but it would be beneficial to repeat these methods in a larger sample with occupation groups matched for blood pressure. However, because occupation and hypertension status are inherently confounded, this goal would be difficult to accomplish without potentially introducing another systematic bias (e.g., a group of particularly "healthy" blue collar workers).

A limitation of these findings is that we did not administer a comparable assessment of home stress (i.e., demands, control, and support). This could be especially important for women, who maintain disproportionate obligations (i.e., child care, housework) outside of the workplace (e.g., 62,63). Future research might explore the concurrent effects of social status, work stress, and home stress by assessing these characteristics in a more detailed manner and evaluating AmBP across both work and nonwork days. Our study also assessed only limited aspects of work environment; other factors are clearly important. For example, a recent study showed that both job strain and an imbalance between efforts and rewards exhibited additive effects in predicting CVD risk (64), and another study found that both models were about equally predictive of CVD mortality when examined within the same working cohort (65). Thus, an expanded evaluation of the psychosocial work environment would be an important extension of this research. Additional research has shown that work hours are a primary predictor of CVD risk, with shift work creating a 40% increase in risk (66). Furthermore, irregular or shift-based working hours may be more common in lower status occupations. In this study, all participants worked day or evening shifts, but we did not collect detailed information concerning work hours. Future research might evaluate degree to which working hours contribute to, or modify, the observed associations.

Finally, a limitation to our diary procedure should be noted. Specifically, we did not assess cigarette smoking between readings, separate from other drugs. Participants were told by research assistants to include nicotine in the "drug" category; however, we were unable to control specifically for momentary nicotine consumption. Because smoking status was not related to occupation or job stress, we do not feel that this had a substantial effect on the results.

In summary, this study contributes to prior research by examining the concurrent impact of occupational status and work environment on AmBP in women. Women working in low-status occupations evidenced higher ambulatory cardiovascular activity compared with women in higher status jobs. Furthermore, women in lower status occupations were especially vulnerable to the effects of high job demands and low control, and they did not benefit from work support. Inasmuch as ambulatory SBP and HR are predictive of future cardiovascular morbidity and mortality, this study adds to findings suggesting that women with lower status occupations and greater work stress are at risk for future cardiovascular health problems.

REFERENCES

(1) Karasek R: Job demands, job decision latitude, and mental strain: Implications for job redesign. *Administrative Science Quarterly.* 1979*, 24:*285–308.

(2) Karasek R, Theorell T: *Healthy Work, Stress, Productivity and the Reconstruction of Working Life*. New York: Basic Books, 1990.

(3) Bosma H, Peter R, Siegrist J, Marmot M: Two alternative job stress models and the risk of coronary heart disease. *American Journal of Public Health.* 1998, *88:*68–74.

(4) Hammar N, Alfredsson L, Johnson JV: Job strain, social support at work, and incidence of myocardial infarction. *Occupational and Environmental Medicine.* 1998, *55:*548–553.

(5) Johnson JV, Hall EM, Theorell T: Combined effects of job strain and social isolation on cardiovascular disease morbidity and mortality in a random sample of the Swedish male working population. *Scandinavian Journal of Work Environment and Health.* 1989, *15:*271–279.

(6) Marmot MG, Bosma H, Hemingway H, Brunner E, Stansfeld S: Contribution of job control and other risk factors to social variations in coronary heart disease incidence. *The Lancet.* 1997, *350:*235–239.

(7) Wamala SP, Mittleman MA, Horsten M, Schenck-Gustafsson K, Orth-Gomér K: Job stress and the occupational gradient in coronary heart disease risk in women: The Stockholm Female Coronary Risk Study. *Social Science & Medicine.* 2000, *51:*481–489.

(8) Schnall PL, Landsbergis PA, Baker D: Job strain and cardiovascular disease. *Annual Review of Public Health.* 1994, *15:*381–411.

(9) Kuper H, Marmot M: Job strain, job demands, decision latitude, and risk of coronary heart disease within the Whitehall II study. *Journal of Epidemiology and Community Health.* 2003, *57:*147–153.

(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 populations. *American Journal of Public Health.* 1988, *78:*1336–1342.

(11) Johnson JV, Stewart W, Hall EM, Fredlund P, Theorell T: Long term psychosocial work environment and cardiovascular mortality among Swedish men. *American Journal of Public Health.* 1996, *86:*324–331.

(12) Marmot M, Theorell T, Siegrist J: Work and coronary heart disease. In Stansfeld SA (ed), *Stress and the Heart: Psychosocial Pathways to Coronary Heart Disease*. London: BMJ Books, 2002, 50–71.

(13) Hemingway H, Marmot M: Evidence based cardiology: Psychosocial factors in the aetiology and prognosis of coronary heart disease: Systematic review of prospective cohort studies. *British Medical Journal.* 1999, *318:*1460–1467.

(14) Belkic K, Landsbergis PA, Schnall P, et al.: Psychosocial factors: Review of the empirical data among men. In Schnall P, Belkic K, Landsbergis PA, Baker D (eds), *The Workplace and Cardiovascular Disease. Occupational Medicine: State of the Art Reviews.* Philadelphia: Hanley and Belfus, 2000, 24–46.

(15) Light KC, Turner JR, Hinderliter AL: Job strain and ambulatory work blood pressure in healthy young men and women. *Hypertension.* 1992, *20:*214–218.

(16) Schnall PL, Schwartz JE, Landsbergis PA, Warren K, Pickering TG: Relation between job strain, alcohol, and ambulatory blood pressure. *Hypertension.* 1992, *19:*488–494.

(17) 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. *Psychosomatic Medicine.* 1998, *60:*697–706.

(18) Steptoe A, Cropley M, Griffith J, Joekes K: The influence of abdominal obesity and chronic work stress on ambulatory blood pressure in men and women. *International Journal of Obesity and Related Metabolic Disorders.* 1999, *23:*1184–1191.

(19) Blumenthal JA, Thyrum ET, Siegel WC: Contribution of job strain, job status and marital status to laboratory and ambulatory blood pressure in patients with mild hypertension. *Journal of Psychosomatic Research.* 1995, *39:*133–144.

(20) Laflamme N, Brisson C, Moisan J, et al.: Job strain and ambulatory blood pressure among female white-collar workers. *Scandinavian Journal of Work, Environment and Health.* 1998, *24:*334–343.

(21) Buring JE, Evans DA, Fiore M, Rosner B, Hennekens CH: Occupation and risk of death from coronary heart disease. *Journal of the American Medical Association.* 1987, *258:*791–792.

(22) Gallo LC, Troxel W, Matthews KA, et al.: Occupation and subclinical cardiovascular disease in postmenopausal women: Are clerical workers at greater risk? *Health Psychology.* 2003, *22:*19–29.

(23) Marmot MG, Shipley MJ, Rose G: Inequalities in death—specific explanations of a general pattern? *The Lancet.* 1984, *1:*1003–1006.

(24) Rosengren A, Wedel H, Wilhelmsen L: Coronary heart disease and mortality in middle aged men from different occupational classes in Sweden. *British Medical Journal.* 1988, *297:*1497–1500.

(25) Haynes SG, Feinleib M: Women, work and coronary heart disease: Prospective findings from the Framingham Heart Study. *American Journal of Public Health.* 1980, *70:*133–141.

(26) House JS, Strecher V, Metzner HL, Robbins CA: Occupational stress and health among men and women in the Tecumseh Community Health Study. *Journal of Health and Social Behavior.* 1986, *27:*62–77.

(27) Light KC, Brownley KA, Turner JR, et al.: Job status and high-effort coping influence work blood pressure in women and Blacks. *Hypertension.* 1995, *25:*554–559.

(28) Matthews KA, Raikkonen K, Everson SA, et al.: Do the daily experiences of healthy men and women vary according to occupational prestige and work strain? *Psychosomatic Medicine.* 2000, *62:*346–353.

(29) Steptoe A, Kuntz-Ebrecht S, Owen N, et al.: Socioeconomic status and stress-related biological responses over the working day. *Psychosomatic Medicine.* 2003, *65:*461–470.

(30) Marmot M, Theorell T: Social class and cardiovascular disease: The contribution of work. *International Journal of Health Services.* 1988, *18:*659–674.

(31) Stansfeld SA, Head J, Marmot MG: Explaining social class differences in depression and well- being. *Social Psychiatry and Psychiatric Epidemiology.* 1998, *33:*1–9.

(32) Hallqvist J, Diderichsen F, Theorell T, Reuterwall C, Ahlbom A: Is the effect of job strain on myocardial infarction due to interaction between high psychological demands and low decision latitude? Results from Stockholm Heart Epidemiology Program (SHEEP). *Social Science and Medicine.* 1998, *46:*1405–1415.

(33) Steenland K, Johnson J, Nowlin S: A follow-up study of job strain and heart disease among males in the NHANES1 population. *American Journal of Industrial Medicine.* 1997, *31:*256–260.

(34) Landsbergis PA, Schnall PL, Pickering TG, Warren K, Schwartz JE: Lower socioeconomic status among men in relation to the association between job strain and blood pressure. *Scandinavian Journal of Work Environment and Health.* 2003, *29:*206–215.

(35) Alterman T, Shekelle RB, Vernon SW, Burau KD: Decision latitude, psychological demand, job strain, and coronary heart disease in the Western Electric Study. *American Journal of Epidemiolgy.* 1994*, 139:*620–627.

(36) Duncan OD: *Notes on Social Measurement: Historical and Critical*. New York: Russell Sage Foundation, 1984.

(37) Karasek R, Brisson C, Kawakami H, et al.: The Job Content Questionnaire (JCQ): An instrument for internationally comparative assessments of psychosocial job characteristics. *Journal of Occupational Health Psychology.* 1998, *3:*322–355.

(38) Kamarck TW, Shiffman SM, Smithline L, et al.: Effects of task strain, social conflict, and emotional activation on ambulatory cardiovascular activity: Daily life consequences of recurring

stress in a multiethnic adult sample. *Health Psychology.* 1998, *17:*17– 29.

(39) Goodie JL, Kamarck TW: Use of the Accutracker DX to assess behavioral influences on ambulatory cardiovascular activity: A preliminary investigation. *Blood Pressure Monitoring.* 1996, *1:*135–140.

(40) Marler MR, Jacob RG, Lehoczky JP, Shapiro AP: The statistical analysis of treatment effects in 24-hour ambulatory blood pressure recordings. *Statistics in Medicine.* 1988, *xx:*697–716.

(41) Bryk AS, Raudenbush SW: *Hierarchical Linear Models: Applications and Data Analysis Methods*. Newbury Park, CA: Sage, 1992.

(42) Raudenbush S, Bryk A, Cheong YF, Congdon R: *HLM 5: Hierarchical Linear and Nonlinear Modeling*. Lincolnwood, IL: Scientific Software International, 2000.

(43) Aiken LS, West SG: *Multiple Regressions: Testing and Interpreting Interactions*. Newbury Park, CA: Sage, 1991.

(44) Evans O, Steptoe A: The contribution of gender-role orientation, work factors and home stressors to psychological well-being and sickness absence in male- and female-dominated occupational groups. *Social Science and Medicine.* 2002, *54:*481–492.

(45) Hall EM: Gender, work control, and stress: A theoretical discussion and an empirical test. *International Journal of the Health Services.* 1989, *19:*725–745.

(46) Hall EM: Double exposure: The combined impact of the home and work environments on psychosomatic strain in Swedish women and men. *International Journal of the Health Services.* 1992, *22:*232–260.

(47) Hunt K, Annandale E: Relocating gender and morbidity: Examining men's and women's health in contemporary Western societies. *Social Science and Medicine.* 1999, *48:*1–5.

(48) Light KC: Stress in employed women: A woman's work is never done if she's a working mom. *Psychosomatic Medicine.* 1997, *59:*360–361.

(49) Krantz G, Ostergren PO: Double exposure. The combined impact of domestic responsibilities and job strain on common symptoms in employed Swedish women. *European Journal of Public Health.* 2001, *11:*413–419.

(50) Brisson C, Laflamme N, Moisan J, et al.: Effect of family responsibilities and job strain on ambulatory blood pressure among white-collar women. *Psychosomatic Medicine.* 1999, *61:*205–213.

(51) Siegrist J: A theory of occupational stress. In *Stress in the Work Place: Past, Present and Future.* London: Whurr, 2001, 52–66.

(52) McEwen BS, Seeman T: Protective and damaging effects of mediators of stress: Elaborating and testing the concepts of allostasis and allostatic load. *Annals of the New York Academy of Sciences.* 1999, *896:*30–47.

(53) Gallo LC, Matthews KA: Understanding the association between socioeconomic status and physical health: Do negative emotions play a role? *Psychological Bulletin.* 2003, *129:*10–51.

(54) Staessen JA, Thijs L, Fagard R, et al.: Predicting cardiovascular risk using conventional vs. ambulatory blood pressure in older patients with systolic hypertension. *Journal of the American Medical Association.* 1999, *282:*539–546.

(55) Verdecchia P: Prognostic value of ambulatory blood pressure: Current evidence and clinical implications. *Hypertension.* 2000, *35:*844–851.

(56) Chobanian AV, Bakris GL, Black HR, et al.: Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure, National Heart, Lung, and Blood Institute; National High Blood Pressure Education Program Coordinating Committee. Seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. *Hypertension*. 2003, *42:*1206–1252.

(57) Lewington S, Clarke R, Qizilbash N, Peto R, Collins R: Prospective studies collaboration: Age- specific relevance of usual blood pressure to vascular mortality. A meta-analysis of individual data for one million adults in 61 prospective studies. *The Lancet.* 2002, *360:*1903–1913.

(58) Schnall PL, Schwartz JE, Landsbergis P, et al.: The relationship between job strain, alcohol, and ambulatory blood pressure. *Hypertension.* 1992, *19:*488–494.

(59) Aronow WS, Ahn C, Mercando AD, Epstein S: Association of average heart rate on 24-hour ambulatory electrocardiograms with incidence of new coronary events at 48-month follow-up in 1,311 patients (mean age 81 years) with heart disease and sinus rhythm. *American Journal of Cardiology.* 1996, *78:*1175–1176.

(60) Palatini P, Julius S: Heart rate and the cardiovascular risk. *Journal of Hypertension.* 1997, *15:*3–17.

(61) Belkic K, Schnall P, Landsbergis P, et al.: Hypertension at the workplace: An occult disease? The need for work site surveillance. In Theorell T (ed), *Everyday Biological Stress Mechanisms: Advances in Psychosomatic Medicine.* Basel, Switzerland: Karger, 2001, 116–138.

(62) Lundberg U: Influence of paid and unpaid work on psychophysiological stress responses of men and women. *Journal of Occupational Health Psychology.* 1996, *1:*117–130.

(63) Lundberg U, Frankenhaeuser M: Stress and workload of men and women in high-ranking positions. *Journal of Occupational Health Psychology.* 1999, *4:*1422–1451.

(64) Peter R, Siegrist J, Hallqvist J, et al.: Psychosocial work environment and myocardial infarction: Improving risk estimation by combining two complementary job stress models in the SHEEP Study. *Journal of Epidemiology and Community Health.* 2002, *56:*294–300.

(65) Kivimaki M, Leino-Arjas P, Luukkonen R, et al.: Work stress and risk of cardiovascular mortality: Prospective cohort study of industrial employees. *British Medical Journal.* 2002, *325:*857.

(66) Boggild H, Knutsson A: Shift work, risk factors and cardiovascular disease. Scandinavian *Journal of Work, Environment & Health.* 1999, *25:*85–99.