Life-Course Exposure to Job Strain and Ambulatory Blood Pressure in Men

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This 1985–1995 study was designed to assess the association between blood pressure (measured by using an ambulatory monitor) and history of exposure to job strain. Items from the Job Content Questionnaire were completed by 213 employed men, aged 30–60 years at entry into the Work Site Blood Pressure Study in New York City, New York, for each previous job they had held. The systolic blood pressure of men employed for ≥25 years who were exposed to job strain for 50% of their work life was 4.8 mmHg (95% confidence interval: –3.7, 13.4) higher at work and 7.9 mmHg (95% confidence interval: 0.8, 15.0) higher at home than that of men with no past exposure, independent of current exposure. Evidence was inconsistent for the hypothesis of rapid induction of/recovery from the effects of job strain on blood pressure, and there was little effect of past job strain on diastolic blood pressure. These findings provide some support for the hypothesis of an effect of cumulative burden of exposure to job strain on systolic blood pressure.

blood pressure; blood pressure monitoring, ambulatory; employment; hypertension; social class; stress; work

Abbreviations: AmBP, ambulatory blood pressure; JCQ, Job Content Questionnaire; WHQ, Work History Questionnaire.

Job strain, defined as the combination of high psychological job demands and low job decision latitude or low job control, has been shown to be a risk factor for cardiovascular disease and for blood pressure elevation when blood pressure is measured with an ambulatory monitor (1, 2). The systolic and diastolic ambulatory blood pressure (AmBP) of men who experience job strain is about 6–8 mmHg and 3–5 mmHg higher, respectively, than in men who do not (1, 2).

However, these values are likely underestimates of the effect of job strain since, in most studies, job strain is measured at only one point in time (1, 2). It is hypothesized that chronic biologic arousal due to *sustained* job strain contributes to the development of essential hypertension (1, 3). Use of current exposure as a surrogate for lifetime exposure is inaccurate, in part because people often gain skills with time and age, may be promoted, may select out of "high-strain" jobs, or may experience changing job characteristics even within the same job title. Many employees with

a lengthy history of job strain thus might be currently classified as having no job strain because of recent promotions or other job changes—with a resulting bias toward the null hypothesis.

We also have little knowledge of the temporal association between job strain and blood pressure elevation. Are decades of exposure required to raise blood pressure, or is the induction period short? After removal of exposure, does blood pressure return to baseline ("recovery"), or is the process of elevation irreversible? If reductions are possible, how quickly do they occur?

To our knowledge, there have been no intervention studies of job strain and blood pressure. However, recent findings from the prospective Work Site Blood Pressure Study (4–7) provide some indication of induction time and effect sizes. Relative to men not experiencing job strain at either time 1 (entry into the study) or time 2 (3 years later) (n = 138), those exposed at both time 1 and time 2 (n = 15), that is, experi-

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TABLE 1. Numbers of eligible subjects entering the Work Site Blood Pressure Study in New York City, New York, and participation in the work history substudy, 1985–1995

Time at entry	Year at entry	Men (no.)	Women (no.)
Work Site Blood Pressure Study			
Time 1	1985–1988	283	25
Time 2	1988–1991	7	54
Time 3	1991–1995	6	97
Total		296	176
Work history substudy (1991–1995)			
Eligible subjects participating at time 3		222	161
Work history substudy subjects for whom data were complete (1991–1995)			
Time 1	1985–1988	201	20
Time 2	1988–1991	6	44
Time 3	1991–1995	6	93
Eligible subjects with complete data		213	157

* All eligible subjects except four women completed the Work History Questionnaire. The questionnaires of nine men were incomplete because of administration errors.

encing "chronic exposure," had substantially higher systolic (11–12 mmHg) and diastolic (6–9 mmHg) AmBP at both time 1 and time 2 (7). These effects were greater than the cross-sectional effects at either time (6–7 mmHg systolic, 2–5 mmHg diastolic).

Prospectively, subjects reporting job strain at time 1 but no job strain at time 2 ($n = 25$) exhibited significant decreases in AmBP at work (5.3 mmHg systolic, 3.2 mmHg diastolic) and at home (4.7 mmHg systolic, 3.3 mmHg diastolic) (7), suggesting that recovery from the effects of job strain can occur in a short period of time, that is, less than 3 years. However, there was no significant AmBP change in the group whose exposure changed from no job strain at time 1 to job strain at time 2, suggesting that the induction period may be longer than 0–3 years. Contrary to the cumulative burden hypothesis, no significant change was found in the AmBP of the 15 men facing chronic job strain exposure over 3 years. This finding may have been due to their high AmBP at entry into the study and a possible "saturation" effect (7).

Therefore, we planned to test the following two hypotheses by analyzing measures of historical exposure:

1. H1: An effect of *cumulative burden* of exposure to job strain. Support would be provided by associations between AmBP at entry into the study, independent of job strain at entry, and measures of lifetime exposure to job strain prior to entering the study.

2. H2: *Rapid (<5 years) induction/recovery periods* regarding the effect of job strain. Support would be provided by associations between AmBP at entry into the study, independent of job strain at entry, and recent exposure that are stronger than associations in the distant past. The hypothesis of a short and complete recovery period is incompatible with an effect of cumulative exposure.

MATERIALS AND METHODS

Study sample

The Work Site Blood Pressure Study is a prospective study that has enrolled 472 initially healthy, full-time employees from a wide variety of white-collar and blue-collar jobs at 10 New York City work sites (4–7). Data are currently available from the first three rounds of data collection (table 1). The current analysis (1985–1995) was restricted to male subjects.

Sample selection procedures are described in detail elsewhere (4, 7). Briefly, a sphygmomanometer and the American Heart Association protocol were used to conduct casual blood pressure screenings, including three sitting readings, of potential subjects at their work sites (8). At least 75 percent of the employees in a department had to participate in the screening for the employees from that department to be eligible for the study.

After 3,216 men were screened at the first eight work sites, subjects were eligible to be selected for the initial case-control study (before funding became available for the cohort study) if they were aged 30–60 years, were employed for >30 hours per week, were able to read English, had a body mass index (kg/m^2) of <32.5, had no second job of ≥15 hours per week, and had been at their current work site for at least 3 years before being approached for this study and, if applicable, before being diagnosed as having high blood pressure (4). Potential subjects were excluded if they had a history of coronary, cerebrovascular, or peripheral vascular disease; electrocardiographic evidence of myocardial infarction, ischemia, or atrial fibrillation; funduscopic changes; evidence of any secondary cause of hypertension; a screening systolic blood pressure of >160 mmHg; or a screening diastolic blood pressure of >105 mmHg.

After these criteria were applied, 1,674 men were found to be eligible for the study—474 cases (screening diastolic

blood pressure of >85 mmHg or taking medication for hypertension) and 1,200 controls. To increase the statistical power of the initial case-control study, cases were oversampled at an average ratio of two cases to three controls. Eligible cases were further defined as subjects whose mean casual diastolic blood pressure was >85 mmHg at *both* initial screening and recruitment (4–6 weeks later) or who were taking medication for hypertension. Those who had a diastolic blood pressure of ≤85 mmHg on both occasions and were not taking antihypertensive medication were eligible to serve as controls. A total of 84 cases and 186 controls were enrolled in the initial case-control study. After the addition of 13 subjects whose diastolic blood pressure "crossed over" the 85-mmHg threshold between screening and recruitment, 283 male subjects were eligible for cross-sectional analyses of blood pressure at time 1. An additional seven men were recruited at time 2 and six men at time 3 (6–7 years after the start of the cohort study) from the ninth and 10th work sites as they entered the study (table 1).

Ambulatory monitoring

At each round of data collection, subjects wore a Spacelabs (Redmond, Washington) AmBP monitor for 24 hours during a normal workday (4, 7) (model 5200 at time 1, sites 1–7; model 90202 at time 1, site 8, and at time 2, all sites; model 90207 at time 3, all sites). Men currently taking antihypertensive medication were titrated off medication and were then monitored for 3 weeks before wearing the AmBP monitor. Medicated subjects were eligible only if they were able to have their medication stopped for at least 3 weeks before wearing the AmBP monitor and still maintain a diastolic blood pressure of <105 mmHg. Few potential subjects were excluded for this reason. The timer on the monitor was set to take readings at 15-minute intervals during the day and at 30- to 60-minute intervals during the subject's normal hours of sleep. Each time the monitor inflated and recorded blood pressure during waking hours, the subject was asked to remain as motionless as possible and then to record in a diary his or her activity, location (i.e., work, home, sleep), position (i.e., standing, sitting, reclining), and mood. The diary information was used to compute the proportion of readings in the standing position (a proxy measure of physical activity) and to calculate average AmBPs for each location category. When fewer than five readings were obtained at work, at home, or during sleep, the corresponding average was treated as missing data (9).

Medical examination

Subjects also received a medical examination, which included a full history, a physical examination, 24-hour urine collection, assessment of alcohol intake, and current smoking history. Height and weight were determined at the physical examination, and body mass index was calculated according to the following formula: weight (kg)/height (m)^2.

General psychosocial questionnaire

At each round of data collection, subjects completed a questionnaire packet, which included the Job Content Questionnaire (JCQ), a widely used, well-validated instrument (10–12). The following three JCQ scales were used:

1. *Job decision latitude* was considered the sum of two equally weighted subscales: 1) skill utilization (keep learning new things, can develop skills, job requires skill, job involves task variety, job is repetitive (reverse scored), job requires creativity) and 2) decision authority (have freedom to make decisions, can choose how to perform the work, have a lot of say on the job).

2. *Psychological job demands* was defined by five items (excessive work, conflicting demands, insufficient time to do the work, work fast, work hard). Internal consistency reliability (Cronbach's alpha) was 0.74 for job demands and 0.83 for job-decision latitude. Three-year test-retest reliability was $r = 0.64$ for both of these scales.

3. *Job-related physical exertion* was measured by a single item (job requires lots of physical effort). Three-year test-retest reliability was $r = 0.67$.

In addition, the following three non-JCQ measures were analyzed:

1. *Demographic items* included sex, race/ethnicity, age, and education.

2. The *Jenkins Activity Survey* (13) was administered to evaluate Type A behavior, and subjects were classified as Type A if they scored above 0. Three-year test-retest reliability was 0.70 (kappa).

3. *Alcohol and smoking behavior* was assessed by questionnaire, with responses reviewed by a nurse. Alcohol consumption was based on two questions representing frequency and quantity (14). Regular drinking was defined as binge drinking or drinking ≥4–6 days per week. Three-year test-retest reliability was 0.40 (phi coefficient). Current smoking was based on one question ("do you smoke cigarettes?" (yes/no)). Three-year test-retest reliability was 0.69 (kappa).

Modeling of job strain exposure at study entry

The interaction between psychological job demands and job-decision latitude, which defines job strain, was modeled by using the previously reported "quadrant" term (4, 5, 12, 15). The dichotomous job-strain variable was defined as job-decision latitude of <37 as well as job demands of >32 (their respective sample medians for males). Despite the relative stability of both continuous subscales, job strain was quite unstable over 3 years (kappa = 0.27).

Sample for the work history substudy

All men participating in the third round of data collection agreed to complete the Work History Questionnaire (WHQ) (table 1). Because of administration errors, the WHQs of nine men enrolled at time 1 were incomplete, leaving 213 men for whom work history data were complete. These 213 men reported a total of 1,040 previous jobs, an average of 4.9 per man.

WHQ

The WHQ, a structured interview developed by the first author, initially included six questions on job demands, job-decision latitude, and workplace social support based on the JCQ (10, 11). The questions were asked for each previous full-time job held by study subjects.

Reliability. Internal consistency of the three two-item scales was high for job demands (work very hard, perform an excessive amount of work) (Cronbach's alpha = 0.81) but only borderline for job-decision latitude (a lot of say about what happened on the job, a high level of skill) (alpha = 0.62) and workplace social support (a helpful supervisor, helpful coworkers) (alpha = 0.62).

Validity. The WHQ has moderate validity for assessing previous job characteristics, as measured by correlations with JCQ scales for the same job ($r = 0.44–0.57$), a weak association with systolic blood pressure, and expected patterns of intercorrelation and change over time. In contrast, the WHQ is a poor predictor of diastolic blood pressure, and dichotomous job-strain variables constructed from WHQ scales are not in close agreement with job strain based on the JCQ (16, 17). Thus, while some evidence exists for the construct validity of the WHQ job-demands and job-decision-latitude scales in assessing past job characteristics, evidence for predictive validity is limited to systolic AmBP. Evidence for the construct validity of the WHQ social support scale is more limited; thus, social support was excluded from this analysis.

Data analysis

For each year of work life before entry into the study, a job-strain variable was constructed, defined by job demands of >5 ("agree" with at least one of two job-demands items) and decision latitude of <6 ("disagree" with at least one of two decision-latitude items). Then, various measures of historical exposure were constructed to test the two study hypotheses:

1. H1: *Cumulative burden.* Number of years and proportion of work life exposed to job strain.

2. H2: *Induction and recovery periods.* As recommended (18, p. 298; 19, p. 302; 20), exposure was examined within discrete 5-year exposure windows: 1–5, 6–10, 11–15, 16–20, 21–25, and ≥26 years prior to entry into the study. To replicate this study's prospective analysis (7), the 1- to 3-year exposure window was also examined. Within each window, exposure was defined as a continuous variable (years of exposure). The numbers of men available for analysis in each time window were 213 (past 1–5 years), 202 (6–10 years), 159 (11–15 years), 126 (16–20 years), and 89 (21–25 years). Subjects unemployed during half or more of an exposure period were assigned a missing value for that entire period. In addition, to prevent confounding by exposure in other time windows, we adjusted for exposure in all windows concurrently (18, p. 299; 19, p. 302), an analysis limited to the 85 subjects employed for ≥25 years before entry into the study and for whom data for all time periods were complete.

Exposure measures were examined for their association with work and home AmBP at entry into the study by using multiple linear regression controlling for age (years), education (years), race/ethnicity (Caucasian vs. other), body mass index, current smoking status (yes/no), regular alcohol consumption (yes/no), AmBP readings during winter months (yes/no), proportion of AmBP readings in the standing position, and work site. Analyses of systolic AmBP also controlled for a quadratic term of age. In an additional step, job strain at entry into the study (measured by the full JCQ) was added to the regression model to assess the effect of past exposure independent of current exposure.

Analyses of AmBP during sleep are not presented in this paper because of the small number of men who had valid sleep AmBP measurements ($n = 169$ out of 213 subjects) and thus limited power to detect associations. Several potential confounders revealed near-zero associations with AmBP (job physical exertion ($r = 0.00–0.02$), Type A behavior ($r = 0.00–0.06$), and 24-hour urine sodium excretion ($r = –0.01$ to $–0.04$)) and therefore were not included in regression models.

RESULTS

The 213 men for whom complete work history data were available averaged 43.1 years of age (range, 30–60 years) and 22.6 years of work life (range, 6–43 years) when they entered the cohort study. Of the 283 eligible men entering the cohort study at time 1, 201 participated at time 3 and had complete work history data (table 1). The remaining 82 time 1 men not participating in the work history substudy were older; were more likely to be smokers and drinkers; had higher AmBP; and had a lower educational level, job-decision latitude, and job demands (table 2). However, of the 201 men participating in the work history substudy, those who experienced job strain (full JCQ) had a systolic AmBP 5.5 mmHg higher and a diastolic AmBP 4.4 mmHg higher at work than did men who did not experience job strain, similar to the cross-sectional associations for the full sample of 283 men (6.3–7.8 mmHg systolic, 2.6–5.0 mmHg diastolic) (7). Thus, little evidence exists that sample selection would bias associations between job strain and AmBP.

Some support was provided for hypothesis H1, that cumulative burden of job-strain exposure is associated with systolic AmBP (tables 3 and 4), but only for men with at least 25 years of previous employment. In the group employed for ≥25 years, the AmBP of men exposed to job strain for 50 percent of their work life was 4.8 (95 percent confidence interval: –3.7, 13.4) mmHg higher at work and 7.9 (95 percent confidence interval: 0.8, 15.0) mmHg higher at home than that of men with no prior job strain, independent of job strain at entry into the study.

Inconsistent support was provided for hypothesis H2, that induction and recovery periods for the effect of job strain are relatively rapid. A combination of substantial effects of recent (3- and 5-year) exposure, independent of exposure at entry into the study, and very weak associations with distant past exposure was observed, as hypothesized, but only in the long-term employment group (tables 3 and 4). Among the long-term employed, in the past 1- to 5-year time window,

TABLE 2. Descriptive statistics for 213 male employees aged 30–60 years from 10 work sites in New York City, New York, who participated in the work history substudy of the Work Site Blood Pressure Study, 1985–1995

Variable	Work history substudy sample (*n* = 213)	Work history sample initially enrolled at time 1* (*n* = 201)	Time 1–eligible men not participating	
			Time 3* (*n* = 82)	*p* value†
Age (years)	43.1	43.2	46.9	0.002
Body mass index (kg/m²)	25.7	25.8	25.7	NS‡
24-hour urine sodium (mEq§/24 hours)	149.7	149.9	145.7	NS
Education (no. of years)	14.7	14.6	13.7	0.008
Job-decision latitude¶	36.3	36.4	34.5	0.012
Job demands¶	32.2	32.2	30.7	0.074
Job physical exertion¶	1.88	1.84	1.86	NS
Work systolic AmBP§ (mmHg)	130.0	130.0	134.1	0.018
Work diastolic AmBP (mmHg)	82.5	82.2	84.4	0.05
Home systolic AmBP (mmHg)	126.5	126.3	129.7	0.057
Home diastolic AmBP (mmHg)	78.7	78.4	81.7	0.003
Race/ethnicity: Caucasian (%)	81.2	83.6	84.1	NS
Regular alcohol drinker (%)	18.8	18.9	28.0	0.09
Current smoker (%)	15.6	15.0	30.5	0.003
Job strain# (%)	23.0	23.4	17.1	NS

* Time 1, entry into the cohort study; time 3, 6–7 years after the start of the cohort study.

† *p* value of the difference in group means (*t* test) or group proportions (chi-square test) between the work history sample enrolled at time 1 (*n* = 201) and the sample not participating (*n* = 82). Because of missing data, *N* = 283 for all comparisons except for work blood pressure (*n* = 282), home blood pressure (*n* = 277), urine sodium (*n* = 277), and current smoker (*n* = 282).

‡ NS, not significant: *p* > 0.15.

§ mEq, milliequivalent; AmBP, ambulatory blood pressure.

¶ Measures of self-reported characteristics from the Job Content Questionnaire (10–12).

Variable defined as job decision latitude <37 as well as job demands >32 (their respective sample medians for males) from the Job Content Questionnaire (10–12).

each year of job strain was associated with a 2.30 (95 percent confidence interval: –0.33, 4.93) mmHg higher work and a 2.99 (95 percent confidence interval: 0.80, 5.17) mmHg higher home systolic blood pressure. The substantial effects in this time window remained after adjustment for possible confounding by exposure in other time windows (restricted to men employed for ≥25 years). However, these effects of recent exposure were not observed when the complete sample of 213 men was examined.

DISCUSSION

Our data provide some support for the hypothesis of an effect of cumulative exposure to job strain. Proportion of work life exposed to job strain was substantially associated with systolic AmBP at entry into the cohort study, independent of job strain at entry, although only among men who had at least 25 years of past employment. The correlation between years of exposure in adjacent time periods was greater in the sample restricted to men employed for ≥25

years. Thus, the long-term employed in this sample may have experienced not only greater duration of exposure but also greater stability of exposure, contributing to the cumulative effect.

Consistent support was not provided for the hypothesis of rapid induction of/recovery from the effect of job strain on AmBP. As hypothesized, stronger effects were observed for recent compared with distant time windows. However, substantial effects of recent exposure were observed in only the long-term-employment group, suggesting an induction period of more than 5 years for younger subjects. Little effect of past exposure was found after adjustment for other time windows and current job strain, supporting the hypothesis of relatively rapid recovery. However, this finding might also have resulted in part from collinearity between exposures (number of years of job strain) in adjacent time windows for men employed for ≥25 years: 0–5 years with a 6- to 10-year window (*r* = 0.79), 6–10 years with a 11- to 15-year window (*r* = 0.75), 11–15 years with a 16- to 20-year window (*r* = 0.57), and 16–20 years with a 21- to 25-year

TABLE 3.   Association between measures of life-course exposure to job strain and ambulatory blood pressure‡ among 213§ male employees aged 30–60 years from nine work sites in New York City, New York, 1985–1995

Effect of job strain	Work ambulatory blood pressure (n = 212)				Home ambulatory blood pressure (n = 199)				
	No.	Diastolic	95% CI¶	Systolic	95% CI	No.	Diastolic	95% CI	Systolic	95% CI
At entry into the study (JCQ¶)#,‡‡	212	3.8**	1.3, 6.3	4.8*	0.5, 9.1	199	3.9**	1.3, 6.5	5.7**	1.5, 9.9
Past job strain (WHQ¶)§§										
Per year exposed: total work life¶¶	212	−0.11	−0.30, 0.08	−0.02	−0.35, 0.31	199	−0.05	−0.25, 0.15	0.12	−0.19, 0.44
For 50% vs. 0% of work life exposed##	212	−1.4	−3.5, 0.7	−0.9	−4.6, 2.7	199	−0.9	−3.0, 1.3	−0.4	−3.9, 3.1
Restricted to ≥10 years of employment	200	−1.2	−3.3, 0.9	−1.0	−4.7, 2.8	190	−0.7	−2.9, 1.5	−0.3	−3.9, 3.4
Restricted to ≥15 years of employment	157	−2.6†	−5.3, 0.1	−1.2	−6.2, 3.8	150	−1.1	−3.8, 1.5	0.4	−4.0, 4.9
Restricted to ≥20 years of employment	125	0.0	−3.7, 3.8	1.6	−5.1, 8.4	121	1.4	−2.2, 5.0	3.5	−2.4, 9.5
Restricted to ≥25 years of employment	87	−0.1	−4.8, 4.6	4.8	−3.7, 13.4	83	0.8	−3.7, 5.2	7.9*	0.8, 15.0
Exposure windows unadjusted for each other (per year exposed)¶¶										
In the past 3 years	212	−0.12	−1.34, 1.10	0.82	−1.31, 2.95	199	−0.22	−1.48, 1.03	0.76	−1.28, 2.80
In the past 5 years	212	−0.12	−0.86, 0.63	0.34	−0.97, 1.65	199	−0.10	−0.88, 0.68	0.43	−0.83, 1.69
In the past 6–10 years	200	−0.38	−1.05, 0.30	−0.31	−1.53, 0.91	190	−0.38	−1.09, 0.33	−0.13	−1.31, 1.04
In the past 11–15 years	157	−0.94*	−1.71, −0.16	−0.40	−1.82, 1.03	150	−0.65	−1.42, 0.12	−0.63	−1.88, 0.63
In the past 16–20 years	125	−0.60	−1.88, 0.68	0.41	−1.04, 1.87	121	0.31	−0.48, 1.09	0.70	−0.59, 2.00
In the past 21–25 years	87	−0.28	−1.30, 0.74	0.12	−1.75, 1.99	83	0.04	−0.93, 1.01	0.70	−0.90, 2.31
In the past ≥26 years	85	0.01	−0.61, 0.72	0.12	−1.14, 1.38	81	0.30	−0.33, 0.93	0.60	−0.46, 1.66

   * $p < 0.05$, ** $p < 0.01$: significance of ambulatory blood pressure difference between exposed and nonexposed groups.

   † $p < 0.10$: significance of ambulatory blood pressure difference between exposed and nonexposed groups.

   ‡ Adjusted for age, race/ethnicity, education, body mass index, alcohol consumption, smoking, winter season, standing position, work site, and job strain at entry into the study.

   § One man with fewer than five ambulatory blood pressure readings at work and 14 men with fewer than five ambulatory blood pressure readings at home were excluded from the analysis.

   ¶ CI, confidence interval; JCQ, Job Content Questionnaire; WHQ, Work History Questionnaire.

   # The blood pressure values reflect the difference between men with and without exposure to job strain when they entered the study.

   ‡‡ Job strain is defined as job decision latitude <37 as well as job demands >32 (their respective sample medians for males) from the JCQ (10–12).

   §§ Job strain is defined as two-item job decision latitude <6 ("disagree" with at least one of two decision latitude items) as well as job demands >5 ("agree" with at least one of two job demands items) from the WHQ (17).

   ¶¶ The blood pressure values reflect the effect of 1 year of exposure within the specified time period, e.g., the difference between men with 1 year vs. 0 years of exposure or 4 years vs. 5 years of exposure.

   ## The blood pressure values reflect the difference between men for whom 50% vs. 0% of their work life was exposed to job strain.

window ($r = 0.80$). Therefore, it may be difficult to observe the independent effects of different time windows in this sample, and adjustment for confounding may represent overadjustment.

The effect on systolic AmBP of cumulative past exposure combined with current exposure is substantial. A man who, for 50 percent of his 25 years of employment, was exposed to job strain as well as experienced current job strain would have a 10.2-mmHg higher work and a 14.6-mmHg higher home systolic AmBP relative to a man with no current or past exposure (summary of independent effects from the same regression model). This effect is roughly twice the difference between Blacks and Whites in this sample, and it is larger than the estimated effect of aging 30 years or gaining 40 pounds (18 kg) of weight (7). These effects are also clinically significant. An elevation of 8–10 mmHg in systolic blood pressure is associated with a 20–25 percent increased risk of coronary heart disease mortality and a 34–43 percent increased risk of stroke mortality (21).

Evidence for the construct validity of the WHQ (16, 17) makes it unlikely that greater measurement error explains the weaker effects of distant past exposure. However, such a hypothesis cannot be ruled out. Support for the cumulative-burden hypothesis was weakened by the lack of an association between most measures of past job strain and diastolic AmBP. The WHQ scales had predictive validity for systolic but not diastolic AmBP. The limited predictive validity of the WHQ, coupled with the borderline reliability of the two-item WHQ decision-latitude scale and the lack of agreement between dichotomous job-strain variables constructed from WHQ and JCQ scales, suggests that even larger estimates of effect might be observed if the full set of JCQ items were used to assess previous jobs.

The Work Site Blood Pressure Study was designed to minimize potential selection bias that might artificially inflate associations. To reduce the likelihood that hypertensives might select into high-strain jobs, cases were required to be at their work site at least 3 years before diagnosis. In addition, no association was found between case-control status (or mean AmBP) and personality/psychological measures such as anxiety, hostility, anger, or Type A behavior that might influence job selection (4, 22). In fact, in

TABLE 4. Association between measures of life-course exposure to job strain and ambulatory blood pressure‡ for only those men aged 30–60 years employed for ≥25 years§ at nine work sites in New York City, New York, 1985–1995

Effect of job strain	Work ambulatory blood pressure (*n* = 87)					Home ambulatory blood pressure (*n* = 83)				
	No.	Diastolic	95% CI¶	Systolic	95% CI	No.	Diastolic	95% CI	Systolic	95% CI
At entry into the study (JCQ¶)#,‡‡	87	5.0*	0.4, 9.5	6.4	−1.9, 14.7	83	4.2	−0.1, 8.5	8.4*	1.3, 15.4
Past job strain (WHQ¶)§§										
Per year exposed: total work life¶¶	87	−0.01	−0.30, 0.27	0.29	−0.23, 0.80	83	0.04	−0.23, 0.31	0.49*	0.06, 0.92
In the past 3 years	87	1.84	−0.64, 4.31	3.79†	−0.70, 8.28	83	0.56	−1.83, 2.94	4.63*	0.89, 8.37
In the past 5 years	87	0.99	−0.47, 2.44	2.30†	−0.33, 4.93	83	0.43	−0.98, 1.84	2.99*	0.80, 5.17
In the past 6–10 years	87	−0.17	−1.78, 1.43	1.96	−0.97, 4.90	83	−0.52	−2.03, 1.00	2.41†	−0.03, 4.85
In the past 11–15 years	87	−0.93	−2.45, 0.59	1.21	−1.59, 4.01	83	−0.71	−2.16, 0.74	1.58	−0.79, 3.95
In the past 16–20 years	87	0.01	−1.07, 1.08	0.85	−1.06, 2.76	83	0.10	−0.93, 1.12	1.33	−0.31, 2.96
In the past 21–25 years	87	−0.27	−1.29, 0.76	0.16	−1.68, 2.01	83	0.07	−0.91, 1.04	0.79	−0.85, 2.33
Exposure windows adjusted for each other (per year exposed)¶¶										
In the past 5 years	85	3.20†	−0.00, 6.41	3.37	−2.66, 9.39	81	3.12†	−0.07, 6.31	4.72†	−0.31, 9.74
In the past 6–10 years	85	−2.96	−7.90, 1.99	−1.85	−11.15, 7.45	81	−3.97	−8.86, 0.93	−2.99	−10.70, 4.72
In the past 11–15 years	85	−0.37	−3.63, 2.88	0.80	−5.33, 6.93	81	0.85	−2.34, 4.03	1.28	−3.74, 6.29
In the past 16–20 years	85	1.01	−0.91, 2.92	1.45	−2.19, 5.10	81	0.22	−1.64, 2.07	1.34	−1.62, 4.30
In the past 21–25 years	85	−0.86	−2.46, 0.73	−0.96	−4.01, 2.09	81	−0.20	−1.76, 1.36	−0.44	−2.96, 2.08

* $p < 0.05$: significance of ambulatory blood pressure difference between exposed and nonexposed groups.

† $p < 0.10$: significance of ambulatory blood pressure difference between exposed and nonexposed groups.

‡ Adjusted for age, race/ethnicity, education, body mass index, alcohol consumption, smoking, winter season, standing position, work site, and job strain at entry into the study.

§ Because of missing data, complete data for all time periods within the past 25 years were available for 85 men.

¶ CI, confidence interval; JCQ, Job Content Questionnaire; WHQ, Work History Questionnaire.

The blood pressure values reflect the difference between men with and without exposure to job strain when they entered the study.

‡‡ Job strain is defined as job decision latitude <37 as well as job demands >32 (their respective sample medians for males) from the JCQ (10–12).

§§ Job strain is defined as two-item job decision latitude <6 ("disagree" with at least one of two decision latitude items) as well as job demands >5 ("agree" with at least one of two job demands items) from the WHQ (17).

¶¶ The blood pressure values reflect the effect of 1 year of exposure within the specified time period, e.g., the difference between men with 1 year vs. 0 years of exposure or 4 years vs. 5 years of exposure.

national studies (23), as in the current study (16), the opposite pattern is observed—people tend to select out of high-strain jobs over time.

On the other hand, restrictions to the range of variation in exposure and outcome due to study design might have reduced the statistical power available to detect main effects of job strain. Blue-collar and high-strain jobs were probably underrepresented in this sample, and non-English speakers (e.g., those working in "sweatshops") were excluded. Participants whose screening blood pressure was >160/105 mmHg were also excluded because of ethical reasons (the risks of stopping antihypertensive medication while wearing the ambulatory monitor) and the hypothesis that stress mechanisms (e.g., sympathetic hyperactivity) have little additional effect at these levels since structural changes in the arterial wall result in permanent elevations in blood pressure (24). Finally, potential subjects who had cardiovascular disease were excluded because blood pressure is typically lower following a heart attack or stroke (25), and those with documented target organ damage might select out of high-strain jobs.

The validity of our findings was enhanced by use of the state-of-the-art technique of AmBP monitoring, which is more reliable and valid than recording blood pressure in a clinic setting (26). Reliability was improved through absence of observer bias and an increased number of readings. Validity was improved by measuring blood pressure during a person's normal daily activities. AmBP is also more highly correlated with target organ damage and cardiovascular disease than are casual (clinic) blood pressure measurements (26).

Work history questions were based on the JCQ (10–12), a widely used instrument to assess job strain (1, 2). The JCQ does not ask about perceptions of stress, rather about objective job characteristics. Expert ratings have been highly correlated ($r > 0.6$) with self-reported measures of job-decision latitude (27–29). National US surveys show high proportions of between-occupation variance in self-reported job-decision latitude and valid patterns of response (30).

However, the potential remains for self-reported exposure to overestimate associations, particularly for psychological job demands, an inherently more subjective measure than decision latitude. Subjects entering the study at time 1 or time 2 and completing the WHQ at time 3 were aware of earlier AmBP levels, but little evidence exists that cases exaggerated their job demands. Job demands were not associated with case-control status (4) nor with mean diastolic blood pressure at time 1, only with work systolic blood pressure (6).

Did cases exaggerate their responsibility and authority levels (decision latitude) because of the prevailing popular belief in "executive stress"? If so, then cases would have underreported job strain, and associations between job strain and AmBP would have been underestimated. Finally, we found no association between case-control status (or mean AmBP) and personality/psychological measures that might have influenced reporting (4, 22).

To our knowledge, the Work Site Blood Pressure Study is the only prospective study of job strain and AmBP of greater than 1 year in duration. Ten years of follow-up have just been completed on a sample of men and women, which will provide further data to assess the hypotheses of cumulative burden and of induction and recovery time.

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