

Relation Between Job Strain, Alcohol, and Ambulatory Blood Pressure

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“Job strain” (defined as high psychological demands and low decision latitude on the job) has been previously reported to be associated with increased risk of hypertension and increased left ventricular mass index (LVMI) in a case-control study of healthy employed men, aged 30–60 years, without evidence of coronary heart disease. We hypothesized that job strain would be associated with increased ambulatory blood pressure (AmBP). A total of 264 men at eight work sites wore an AmBP monitor for 24 hours on a working day. In an analysis of covariance model, job strain was associated with an increase in systolic AmBP of 6.8 mm Hg ($p=0.002$) and diastolic AmBP of 2.8 mm Hg at work ($p=0.03$) after adjusting for age, race, body mass index, Type A behavior, alcohol behavior, smoking, work site, 24-hour urine sodium, education, and physical demand level of the job. Alcohol use also had a significant effect on AmBP. However, among subjects not in high-strain jobs, alcohol had no apparent effect on AmBP at work. Instead, alcohol use and job strain interacted such that workers in high-strain jobs who drank regularly had significantly higher systolic AmBP at work ($p=0.007$). Among the other risk factors, only age, body mass index, and smoking had significant effects on AmBP. Job strain also had significant effects on AmBP at home and during sleep as well as on LVMI. A large body of previous research that suggests job strain is a risk factor for the development of coronary heart disease may now be partially explained as the consequence of elevation of blood pressure and structural changes in the heart. (*Hypertension* 1992;19:488–494)

KEY WORDS • alcohol • blood pressure, ambulatory • occupations • epidemiology • stress, psychological • essential hypertension

We recently reported¹ the results of a case-control study of employed men in which “job strain” (defined as high psychological demands and low decision latitude on the job) was found to be associated with an increased risk of hypertension after controlling for most other known risk factors. Although our research used traditional methods of casual blood pressure measurement conducted at the work site to define hypertension status, we were concerned about the known low reliability of this method due to error in measurement and high biological variability between measurements. As an alternative, we also measured blood pressure using ambulatory blood pressure (AmBP) monitors. AmBP monitors have solved several of the problems associated with casual blood pressure measurements. AmBP monitors can generate blood pressure estimates that are more reliable than casual blood pressure measurement due to the absence of observer error and the increased number of readings. In addition, AmBP monitor estimates of

blood pressure may be a more valid reflection of an individual’s true blood pressure due to the ability of this method to sample blood pressure during a subject’s usual activities.^{2,3}

Job strain in this research is modeled as an interactive variable in which jobs characterized by high levels of psychological work demands (working fast and hard) and low levels of control over the work process (little authority and low skill level) are considered stressful (see Figure 1). Job strain has been our principal independent variable because it previously has been shown to be predictive of an increased risk of coronary heart disease as well as psychological symptoms such as exhaustion and depression.^{4–6}

In our initial research design we hypothesized that job strain would be associated with both an increased risk of having hypertension as well as increased ambulatory blood pressure, thereby helping to explain earlier reported associations between job strain and coronary heart disease. This article reports our findings regarding the relation of job strain, alcohol, and other known risk factors to AmBP measured on a working day.

Methods

The present study is a case-control study of working men conducted at eight New York City work sites each employing at least 150 men. These sites were a newspaper typography department, a federal health agency, a stock brokerage firm, a liquor marketer, a private hos-

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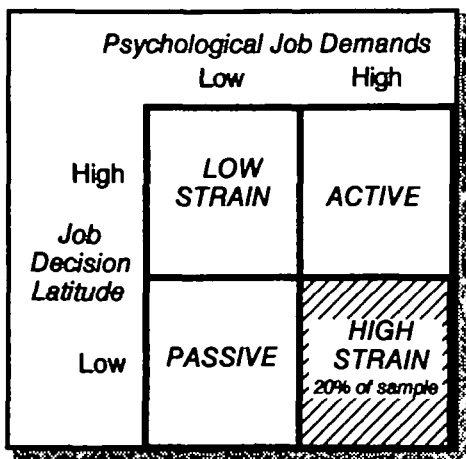


FIGURE 1. Schematic model of "job strain" hypothesis.

pital, a sanitation collection and repair facility, a department store warehouse, and the headquarters for a large insurance company. At least 75% of the employees in a department had to participate in the screening for the employees from that department to be eligible for the study. All employed men at these work sites underwent an initial blood pressure screening procedure that was conducted by trained staff and that included three readings of blood pressure with the subject in a sitting position (using the American Heart Association [AHA] protocol⁷) and a brief evaluation of medical and demographic variables.

From this screened sample, subjects were eligible to be selected for the study if they were between 30 and 60 years old, were employed more than 30 hours per week, were able to read English, had a body mass index (BMI) (kg/m^2) less than 32.5, had no second job of 15 or more 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. Due to incomplete application of the BMI inclusion/exclusion criteria, only a subset of those subjects whose BMI at screening was greater than 30 and less than 32.5 was considered eligible for recruitment. 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; or a systolic blood pressure (SBP) greater than 160 mm Hg or diastolic blood pressure (DBP) greater than 105 mm Hg at the time the screening was performed. (Upper limits for blood pressure eligibility at the first site, our pilot study, were applied at recruitment and not at screening.) Subjects with previously diagnosed hypertension who were being given antihypertensive treatment were eligible only if they could have their medication stopped for at least 3 weeks before wearing the AmBP monitor and were still able to maintain a DBP below 105 mm Hg. A total of 1,629 men were found eligible for the study after the first screening.

Blood Pressure Criterion for Selection of Subjects

Based on the average of the last two (of three) casual blood pressure measurements taken during the work

site screening, subjects meeting the above eligibility criteria and having none of the exclusion criteria were divided into two groups: those having DBP greater than 85 mm Hg or who were taking antihypertensive medication for hypertension were potential case subjects, and those whose DBP was 85 mm Hg or less were potential control subjects. At the time of recruitment, 4–6 weeks after the initial screening, casual blood pressures were again measured at the work site using the same AHA protocol. Potential case subjects willing to participate in the study whose DBP exceeded 85 mm Hg were defined as case subjects, and potential control subjects willing to participate whose DBP was 85 mm Hg or less were defined as control subjects. Subjects whose blood pressure crossed over at the recruitment visit (initial screening DBP greater than 85 mm Hg and recruitment visit DBP 85 mm Hg or less or initial screening DBP 85 mm Hg or less and recruitment visit greater than 85 mm Hg) were not invited to participate.

A total of 88 case subjects agreed to participate in the study and completed the AmBP protocol, and 176 control subjects completed the protocol. The combined group of case subjects and control subjects totaling 264 subjects constituted the case-control sample.

Procedures

Subjects wore an AmBP monitor (Spacelabs 5200) for 24 hours during a normal work day, using procedures described previously.⁸ The monitor was attached while the subject was at work and calibrated by comparing five successive systolic and diastolic readings against simultaneously determined auscultatory readings, taken by a trained observer with a mercury column, in which both had to be within 5 mm Hg to be acceptable. The timer on the monitor was set to take readings at 15-minute intervals during the day and 30-minute intervals during normal hours of sleep, and the subject was instructed to proceed through a normal workday. Each subject was asked to remain as motionless as possible each time the monitor took a reading during waking hours and then to record his activity, location, position, and mood in a diary. Those case subjects who were taking medication for hypertension were titrated off treatment under careful medical supervision after their recruitment visit and wore the ambulatory monitor after they had stopped their medication for a 3-week period. The diary information (i.e., whether subjects reported being at work, at home, or asleep) was used to calculate average ambulatory blood pressures for each location category.

Subjects were also given a routine medical examination, which included a full history, a physical examination, assessment of alcohol intake, current smoking history, and exercise habits. Height and weight were determined at the physical examination, and BMI was calculated according to the formula $\text{weight}(\text{kg})/\text{height}(\text{m})^2$. Blood testing (including lipid profile and plasma renin activity), a 24-hour urine collection for electrolyte excretion including sodium and creatinine clearance, an electrocardiogram, and an M-mode echocardiogram under two-dimensional guidance performed according to standard procedures⁹ were carried out at the Hypertension Center at Cornell University Medical College.

		Psychological Job Demands	
		Low (<32)	High (\geq 32)
Job Decision Latitude	High (>37)	SBP = 129 DBP = 83 (N = 56) LOW STRAIN	SBP = 132 DBP = 83 (N = 60) ACTIVE
	Low (\leq 37)	SBP = 129 DBP = 82 (N = 93) PASSIVE	SBP = 137 DBP = 85 (N = 55) HIGH STRAIN

FIGURE 2. Schematic shows systolic (SBP) and diastolic (DBP) ambulatory blood pressure by "job strain" quadrant, controlling for age, body mass index, body mass index stratum, race, work site, education, 24-hour urine sodium, smoking, alcohol, Type A behavior, and physical exertion. N=264.

Subjects completed a questionnaire packet that included the Job Content Questionnaire (JCQ) to evaluate job strain. The JCQ is a 42-item questionnaire developed by Dr. Robert Karasek and is based, in part, on questions drawn from the US Department of Labor/University of Michigan Quality of Employment Surveys.¹⁰ Two scales were used to define job strain: job decision latitude and psychological job demands. Decision latitude was defined as the sum of two subscales each given equal weight: 1) skill discretion, measured by six items (keep learning new things, can develop skills, job requires skill, has task variety, is repetitious, requires creativity), and 2) decision authority, measured by three items (have freedom to make decisions, can choose how to perform work, have a lot of say on the job). The second scale is psychological job demands, defined by five items (excessive work, conflicting demands, insufficient time to do work, work fast, work hard). All questions were scored on a Likert scale of 1 to 4, and both decision latitude and psychological job demands were constructed to have a range of 12 to 48. Scale reliability was acceptable for both decision latitude (Cronbach's $\alpha=0.82$) and demands ($\alpha=0.74$).

Previous research⁵ in a nationally representative working male population indicated that about 20% of the men have jobs simultaneously high in demands and low in control. Cut points for psychological work load and decision latitude were selected so that 20% of our study sample would also be classified as having "high strain" jobs. Jobs were classified as high strain if subjects scored both 37 or below for decision latitude and 32 or above for psychological job demands. In addition, the jobs of persons located in the three other quadrants defined by these cut points were labeled active, passive, and low strain as shown in Figure 2 (e.g., active jobs were those in which subjects scored both 37 or above for decision latitude and 32 or above for psychological job demands).

The Jenkins Activity Survey was administered to evaluate Type A behavior, and subjects were classified as Type A if they scored above 0. A demographic questionnaire elicited information on years of education, individual and family income, marital status, religion, race, age, and employment history. Age was trichotomized into 10-year intervals (30–40, 41–50, and 51–60) and treated as a categorical variable. Education was dichotomized at 13 years or more versus 12 years or less. Alcohol behavior was assessed by interview at the medical examination. Subjects were classified either as nondrinkers if they reported they drink not at all or occasionally or as drinkers if they reported daily consumption (at least five or more times per week) or binge drinking. Smoking status was ascertained by interview, and subjects were classified as smokers if they currently smoke. Race was classified as either Caucasian or other. Finally, physical activity on the job was evaluated by a single item from the JCQ ("job requires lots of physical effort") with four possible response options.

There are very little missing data in this study. Those subjects missing data on either the outcome measure or job strain, the focal predictor, were excluded from the analyses of that outcome; the modal category (mean) has been substituted for missing data on all categorical (continuous) variables.

Statistical Analyses

Bivariate relations of job strain and the other independent variables with AmBP were first examined. Analysis of covariance (ANCOVA) was used to model the relation between job strain and AmBP after controlling for other known risk factors (age, BMI, 24-hour urine sodium excretion, Type A behavior, alcohol, level of education, race, and smoking status) or variables potentially confounding the job strain and blood pressure relation (physical exertion level of the job and work site). Education was included in this analysis as a control variable because of the known potential impact of low socioeconomic status and/or low education on blood pressure. A stratum variable was computed for BMI greater versus less than 30 to account for any effects of our incomplete sampling of those with BMI above 30. The covariates were entered first with main effects (job strain, alcohol, smoking, education, and site) assessed after adjusting for the covariates.

After testing the job strain hypothesis, we explored whether the effects of job strain on work AmBP varies as a function of other predictors. For this exploratory analysis, all two-way interaction terms of job strain with the statistically significant covariates were created. This set of interaction terms was added to the ANCOVA model. To protect against the increased risk of a type I error associated with multiple tests, individual interaction terms were examined only if the global change-in- R^2 test was statistically significant at the $p<0.10$ level. If this test was significant, then the most significant interaction term (with $p<0.05$) was included in the model. The process was iteratively repeated on the remaining interaction terms to test for additional interaction effects. The use of $p<0.10$ for global tests is designed to balance the desire for control over the risk of a type I error in the experiment with the reduced power of global significance tests.

This study was designed as a case-control study, with stratified sampling of case patients and control subjects. Assuming the models being estimated are correctly specified, we found that stratified sampling does not affect the validity of unstandardized estimates of the effect of job strain on blood pressure or hypothesis tests of these effects. In fact, the design should increase the power to test the research hypotheses by increasing the sample variance of the independent variable. (Stratified sampling does, however, influence the validity of population-specific parameters such as correlation coefficients and R^2 .) Nevertheless, it is desirable to assess whether the results might be attributable to the study design. Three strategies were used to address this concern. First, to control for any biases that could arise from estimating a misspecified model on a stratified sample, the ANCOVA was repeated after weighting the sample to reflect the expected distribution if case subjects and control subjects had been recruited proportionally to their actual distribution at each site (see "Appendix" for details). Second, to rule out the possibility that the observed effects of job strain are due only to between-strata differences and do not operate within strata, pooled within-strata estimates were obtained by reestimating the ANCOVA model, controlling for case/control status. For this analysis, we expected the significance of the predictors to diminish but the magnitude of the within-strata effects to be relatively unchanged. Finally, we examined whether the relation of job strain and the statistically significant covariates to AmBP differs for case subjects and control subjects. After the same exploratory procedure described in the preceding paragraph, we created interaction terms of case subject status with all statistically significant terms in the model, including job strain interaction terms. A global test, using $p < 0.10$, of this set of interaction terms was conducted, and individual interactions were examined only if the global test was statistically significant.

Results

The descriptive statistics for the sample meeting selection and exclusion criteria and completing the entire protocol ($N=264$) are shown in Table 1. The average age of the sample was 44.3 years, and the average BMI was 25.8. Twenty-three percent of our sample consumed alcohol on a regular basis. Subject's AmBP was highest at work, followed by at home, and then asleep.

One purpose of the present study was to compare analyses of AmBP with our previously published parallel analysis of hypertension.¹ Accordingly, we reexamined the effect of job strain on hypertension and left ventricular mass index (LVMI) now that we have added an eighth site to our study (see Table 2). After controlling for the effects of age, BMI, BMI stratum, Type A behavior, 24-hour sodium excretion, physical activity level of the job, education level, smoking status, alcohol intake, and work site, job strain is a significant predictor of case-control status (estimated odds ratio, OR=2.7; $p=0.015$). After excluding those subjects receiving anti-hypertensive medication, 203 subjects had technically satisfactory echocardiograms. Using an ANCOVA model, we showed that the relation of job strain to LVMI was 9.7 g/m^2 ($F=3.37$; $p=0.001$) after controlling

TABLE 1. Descriptive Statistics for Case-Control Study Sample

Variable	Mean	SD
Age (yr)	44.3	8.7
Body mass index (kg/m^2)	25.8	2.8
24-Hour urine sodium	149.2	63.0
Regular drinkers (%)	23	
Education (yr)	14.4	2.5
Type A behavior (%)	40	
Physical exertion level	1.9	0.8
Caucasian race (%)	84	
Current smokers (%)	19	
Job strain (%)	21	
Screening SBP (mm Hg)	123.7	13.6
Screening DBP (mm Hg)	80.0	10.1
Average work AmSBP (mm Hg)	131.6	14.0
Average work AmDBP (mm Hg)	83.0	8.6
Average home AmSBP (mm Hg)	127.9	14.1
Average home AmDBP (mm Hg)	79.5	8.6
Average sleep AmSBP (mm Hg)	113.7	13.8
Average sleep AmDBP (mm Hg)	68.0	9.3

$N=264$. SBP, systolic blood pressure; DBP, diastolic blood pressure; AmSBP, ambulatory SBP; AmDBP, ambulatory DBP.

for the same variables as above. This relation with LVMI was consistent across the three 10-year age groups.

Our job strain model predicts (see Figure 1) that blood pressure will be elevated in the high-strain quadrant of the model. ANCOVA (high strain versus the three other quadrants combined) supports the job strain hypothesis. The effect of job strain on systolic AmBP at work is 6.8 mm Hg ($F=10.3$; $p=0.002$) after controlling for age, BMI, BMI stratum, work site, level of education, smoking, alcohol, Type A behavior, race, physical exertion level on the job, and 24-hour urine sodium (see Table 3). The effect of job strain on diastolic AmBP at work of 2.8 mm Hg ($F=5.0$; $p=0.03$) is also statistically significant. Figure 2 presents the systolic and diastolic AmBP results by quadrant of the job strain model. It is worth noting that the three non-high-strain quadrants are similar to each other in AmBP.

Job strain has the same magnitude of effect on systolic AmBP during at home and asleep hours as it does for working hours, demonstrating a strong effect of job strain on 24-hour AmBP (see Table 4). We also examined the effect of job strain as well as other

TABLE 2. Effect of Job Strain on Hypertension Case Status and Left Ventricular Mass Index

Effect	Odds ratio	Effect size (g/m^2)	χ^2	F	p Value*
Case status ($N=264$)					
Job strain	2.7	...	5.90	...	0.015
Left ventricular mass index ($N=203$)					
Job strain	...	9.7	...	3.37	0.001

Controlling for age, body mass index, body mass index stratum, 24-hour urine sodium, work site, Type A behavior, race, education, alcohol, smoking, and physical exertion level on job.

*Two-tailed probability levels.

TABLE 3. Effect of Job Strain, Alcohol, Smoking, and Education on Average Ambulatory Blood Pressure at Work

Effect	Effect size	F	p Value*
Average work systolic AmBP			
Job strain	+6.8	10.3	0.002
Alcohol	+3.9	3.5	0.06
Smoking	+4.0	3.2	0.08
Education	+0.5	0.0	0.84
Average work diastolic AmBP			
Job strain	+2.8	5.0	0.03
Alcohol	+2.9	5.9	0.02
Smoking	+0.5	0.2	0.70
Education	-0.2	0.0	0.90

Analysis of covariance ($N=264$), controlling for age, body mass index, body mass index stratum, 24-hour urine sodium, work site, Type A behavior, race, and physical exertion level on job. AmBP, ambulatory blood pressure. Effect sizes are adjusted for other main effects.

*Two-tailed probability levels.

independent variables on work minus home differences in AmBP. Although the average systolic and diastolic AmBPs were about 3.5 mm Hg higher at work compared with home, no variable was found to be related to this difference.

As expected, age and BMI have large and substantive effects on all measures of AmBP. Regular alcohol consumption has an effect on both systolic and diastolic AmBP at work of about 3.6 mm Hg ($p=0.06$) and 2.8 mm Hg ($p=0.02$), respectively. Cigarette smoking has a main effect on systolic AmBP of 4 mm Hg at work (NS), 5.2 mm Hg at home ($F=5.5$; $p=0.02$), and 3.9 mm Hg while asleep (NS). The effects of smoking on diastolic AmBP are consistently positive but small and nonsignificant. However, in our study population, Type A behavior and education level were not associated with a significant increase in any measure of blood pressure after controlling for the other known risk factors.

We next turn to the issue of whether job strain may interact with the other significant predictors of AmBP at work. The global test for the set of job strain interactions was highly significant for work systolic AmBP ($p=0.009$) and not significant for diastolic AmBP. The most significant interaction term for systolic AmBP was

TABLE 4. Effect of Job Strain on Work, Home, and Sleep Ambulatory Blood Pressure

Effect	Work	Home	Sleep
Systolic ambulatory blood pressure (mm Hg)			
Job strain	6.8	6.5	6.2
F	10.3	8.9	7.6
p Value*	0.002	0.003	0.006
Diastolic ambulatory blood pressure (mm Hg)			
Job strain	2.8	2.4	1.7
F	5.0	3.8	1.5
p Value*	0.03	0.05	0.23

Analysis of covariance ($N=264$), controlling for age, body mass index, body mass index stratum, 24-hour urine sodium, work site, alcohol, smoking, Type A behavior, race, education, and physical exertion level on job.

*Two-tailed probability levels.

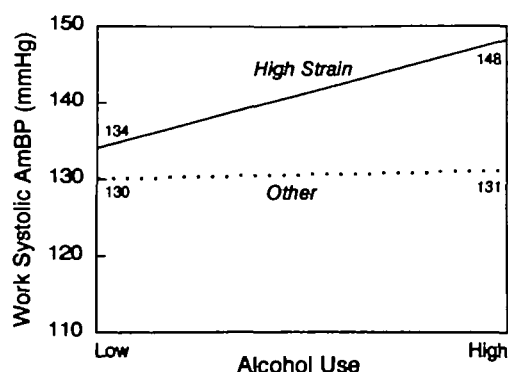


FIGURE 3. Line graph shows effect of "job strain" on systolic ambulatory blood pressure (AmBP) at work by alcohol use, controlling for age, body mass index, body mass index stratum, race, work site, education, 24-hour urine sodium, smoking, Type A behavior, and physical exertion. $N=264$.

job strain with alcohol ($F=7.4$, $p=0.007$). As shown in Figure 3, workers not in high-strain jobs exhibit no relation between alcohol consumption and systolic AmBP at work, whereas those in high-strain jobs exhibit a very substantial relation. Viewed from the opposite perspective, there is a weak, presumably insignificant, 4-mm Hg effect of job strain on systolic AmBP for low alcohol consumption and a large effect (17 mm Hg) for regular consumption of alcohol. It is important to note that, although this interaction suggests that either job strain moderates the effect of alcohol on systolic AmBP or alcohol moderates the effect of job strain on systolic AmBP, there is no evidence that the effect of job strain is mediated through alcohol consumption, e.g., that increased alcohol use is a response to job strain. In fact, the proportion of heavy alcohol consumers is the same for those in high-strain jobs (23%) as those in other jobs.

The global test of the remaining job strain interaction terms is again significant, and the most significant term is the interaction with age ($F=3.7$; $df=2$; $p=0.026$). With each successive age cohort, job strain is associated with a greater increase in systolic AmBP at work (see Figure 4). The difference between those in high-strain versus other jobs is 15 mm Hg greater in the oldest age cohort than in the youngest age cohort. Just as those not in high-strain jobs showed no relation between alcohol and systolic AmBP at work, they also show virtually no relation between age and systolic AmBP at work.

To investigate the possible influence of our stratified recruitment scheme for case subjects and control subjects, we weighted the sample to approximate what would have been achieved if case subjects and control subjects had been sampled proportionately at each site (see "Appendix"). The ANCOVA results for this reweighted analysis did not differ substantially from the results presented above, supporting the conclusion that our sampling scheme has not biased the relation between job strain and AmBP in our target population. (We reestimated the "unweighted" ANCOVA model, adding a dummy variable for whether the subject was a case subject in our case-control study, and found that this reduced the effect size of job strain on AmBP by 25%. The overall pattern of relations between job strain

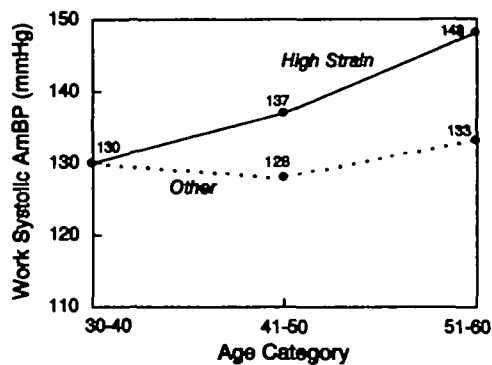


FIGURE 4. Line graph shows effect of "job strain" on systolic ambulatory blood pressure (AmBP) at work stratified by age, controlling for body mass index, body mass index stratum, race, work site, education, 24-hour urine sodium, smoking, alcohol, Type A behavior, and physical exertion. $N=264$.

and AmBP was unchanged, and the systolic AmBP findings were still statistically significant. We decided to present the results for the entire group regardless of hypertension status in the model since we believe hypertension status to be an intervening variable between job strain and AmBP and therefore inappropriate to control when testing the overall effects of job strain. Finally, our global test of whether the effects of job strain and the other significant predictors (including the two-way interaction effects of job strain with alcohol and age) were the same for case subjects and control subjects was not significant ($p>0.10$) for both systolic and diastolic AmBP at work.)

Discussion

These results are consistent with our earlier reported findings.¹⁻³ Once again we find that AmBP is highest during working hours. Job strain adds an important dimension to our understanding of the impact of work on blood pressure. We find that exposure to job strain is associated with an increase in work-time AmBP of almost 7 mm Hg systolic and 3 mm Hg diastolic after controlling for other known risk factors for hypertension. Furthermore, only those jobs characterized by a combination of high demands and low control (see Figure 2) are associated with an increase in blood pressure. This latter finding strengthens our argument that it is the combination of high work demands and low control that constitutes the risk factor and suggests there may be a threshold effect as well. In addition, our finding that job strain is associated with similar magnitude increases in at home and asleep AmBP supports our hypothesis that job strain results in a generalized and persistent arousal beyond the immediate situation that initially provokes it (not merely transient elevated AmBP at work). However, it remains to be determined how long this effect persists when individuals are removed from the work situation, e.g., on weekends, vacations, or after job changes.

We also find that job strain has a greater effect on blood pressure with increasing age. Somewhat surprising, however, is the finding that exposure to job strain has little or no effect on AmBP in our 30-40-year-old subjects. This may be interpreted as consistent with an

"incubation" effect of job strain on AmBP. Perhaps age functions in this population as a proxy variable for exposure to chronic stressors such as job strain. A somewhat less likely alternative explanation is the possibility that older people are more sensitive to job strain. We are currently conducting a prospective study to replicate the above findings and to examine the possibility that younger subjects with high-strain jobs will show different rates of increase in blood pressure over time than older subjects in similar jobs.

We found a strong interaction effect of job strain and alcohol on systolic AmBP at work. Alcohol has been reported to have adverse effects on blood pressure in a number of studies,¹¹⁻¹⁴ but we know of no other research reporting an interaction effect of alcohol with an occupational risk factor. Taken together, these findings that alcohol use and age are only related to AmBP among those in high-strain jobs is intriguing. Although speculative, it suggests the possibility that high-strain work is a vulnerability factor, substantially altering an individual's susceptibility to other traditional risk factors.

The effect of cigarette smoking on systolic AmBP is consistent with that reported by a number of previous researchers.^{15,16} We looked for but did not observe an interaction of job strain and smoking on AmBP.

Several potential threats to the internal validity of these findings, e.g., selection bias, have been discussed in our earlier publication detailing our case-control study results.¹ We have not controlled in this analysis for position. Position is more relevant to AmBP than casual blood pressure measurements since AmBP is taken in a number of positions, whereas our casual blood pressure measurements were all taken while the subject was seated. It is possible that individuals in high-strain jobs may be more likely to stand, which would raise their readings. To properly control for position, a substantially more complex analysis is required, which will be reported in a future article. On the other hand, it seems unlikely that controlling for position will substantially alter the relation of job strain to at home and asleep AmBP.

These findings require replication in a prospective research design, which we are presently conducting. Women and larger numbers of minority workers need to be studied as well. Further research is also necessary to explore the best form of the job strain variable, including its objective-subjective dimensions, the persistence of its effects, and the nature of the relation among job strain, blood pressure, and increased echocardiographically determined LVMI noted above. Based on the large effects we observed on all measures of blood pressure as well as on LVMI, job strain would appear to be an important risk factor for hypertension among healthy working men.

Appendix

The present case-control study recruited eligible case subjects with casual DBP between 85 and 105 mm Hg, and control subjects were randomly selected in a ratio of about 3 control subjects to 2 case subjects at each site (4:1 at the eighth site). To investigate whether this sampling scheme impacts the estimated relation between job strain and AmBP, we repeated the analysis after weighting case subjects and control subjects to their actual proportion at each work site. In other words, we have reweighted the subsample from each site to reflect the

distribution of case subjects and control subjects in the screening sample of that site.

Each case group at each site is weighted as follows: total subjects studied divided by total eligible subjects, or n/N , divided by case subjects studied divided by total eligible cases, or a/A , which equals nA/Na , where n is the actual total number of case subjects and control subjects entered into the study at each site, N is the total number of eligible case subjects and control subjects at each site, A is eligible case subjects at each site, and a is actual case subjects enrolled at each site.

The weighting for controls is nB/Nb , where n is the actual total number of case subjects and control subjects entered into the study at each site, N is the total number of eligible case subjects and control subjects at each site, B is eligible control subjects at each site, and b is actual control subjects enrolled at each site.

Since b/B is usually a smaller number than a/A , this weighting scheme gives more weight to each control subject and less weight to each case subject at all but two sites. For example, at the federal health agency, case subjects are given a weight of 0.495 based on a ratio of $23 \times 37 / 172 \times 10$, where 23 is the total number of case subjects and control subjects studied, 37 is the number of eligible case subjects, 172 is the total number of eligible case subjects and control subjects, and 10 is the actual number of case subjects. The respective weight for control subjects at this site is 1.389. The sum of the weights across all subjects at a given site equals the number of subjects studied at that site; that is, the weighted and unweighted sample sizes are equal.

The weights assigned to case group and control group at each site are:

Site	Control group	Case group
Typographers	1.238	0.854
Federal health agency	1.389	0.495
Stock brokerage firm	1.008	0.982
Liquor marketer	1.358	0.487
Private hospital	0.864	1.818
Sanitation collection center	1.147	0.747
Department store warehouse	1.243	0.612
Insurance company	0.859	1.660

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