

Increases in Job Strain Are Associated With Incident Hypertension in the CARDIA Study

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ABSTRACT

Background: Job strain, defined as high job demands and low decision latitude, has been associated with increased blood pressure levels in some studies, but most of these studies have been cross-sectional. **Purpose:** We sought to determine whether changes in job strain during young adulthood were associated with the development of hypertension, using the Coronary Artery Risk Development in Young Adults cohort. **Methods:** A total of 3,200 employed, initially normotensive participants, aged 20 to 32 in 1987–1988, were followed for 8 years; the Job Content Questionnaire was completed twice: initially and 8 years later. Hypertension at follow-up was defined as systolic blood pressure (SBP) of 160 or higher and diastolic blood pressure of 95 mmHg or higher, or reporting being on antihypertensive medication. **Results:** Job strain (based on job demands above the median and decision latitude below the median of the sample) was associated with hypertension incidence ($p < .05$) for the entire cohort and among White women and men. Adjustment for baseline SBP, education, body mass index (BMI), change in BMI, and age did not alter these relations. The ratio of increasing demands relative to decreasing decision latitude was also associated with greater incidence of hypertension in the entire cohort in the multivariate model (odds ratio = 2.06, 95% confidence interval = 1.01–4.26). **Conclusions:** An increase in job strain is associated with incident hypertension, particularly among Whites.

(Ann Behav Med 2004, 28(1):4–9)

This article was presented in part at the meeting of the American Psychosomatic Society, March 2000. This research was supported by Contracts N01–HC–48047, N01–HC–48048, N01–HC–48049, N01–HC–48050, and N01–HC–95100 from the National Heart, Lung, and Blood Institute, Bethesda, Maryland.

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INTRODUCTION

Job strain, defined as a demanding and stressful work environment with little latitude, flexibility, or options for coping with these demands, is associated with increased blood pressure (BP) in some (1–3), but not all (4–9), studies. However, differences in how the measures of job strain have been formulated have occurred across studies. The Job Content Questionnaire (JCQ), developed by Karasek (10), is the most widely used scale to measure job strain. Many studies use median splits on the scale to define higher job demands and lower decision latitude and then use these to create a high-demands/low-latitude group with high job strain (1–3,6). Other studies have used the JCQ to create other formulations of job strain, such as a demands–latitude ratio (11,12), whereas some studies use other scales entirely (13).

Another consideration is that job strain may change over time, and it is possible that change or chronicity of job strain may be important in the development of elevated BP. Only three previous studies have assessed job strain changes over time in relation to BP. Theorell and colleagues (11) found that periods of increase in both the demands–latitude ratio and job demands were related to increases in workplace systolic BP (SBP) over 1 year. Schnall et al. (3) found that decreases in job strain over a 3-year follow-up were associated with decreases in ambulatory BP, whereas individuals with high job strain at both time points had higher ambulatory BP but no significant increases. Similarly, a 5-year longitudinal study (13) examined BP change among Australian government employees with minimal average job strain change and found that persistently high job strain was not associated with BP change. However, this latter study neither assessed job strain change specifically nor used the JCQ to assess job strain. In addition, none of the previously mentioned studies addressed whether job strain was associated with hypertension, and none of them included analyses by ethnicity.

Most studies that have found relations between job strain and BP have been conducted with individuals in middle to older

adulthood (1–3). We evaluated in a biethnic cohort of young adults whether incident hypertension was associated with changes in job strain, chronic high job strain, or both, across an 8-year period. Our primary hypotheses were (a) chronic high job strain is associated with increased incidence of hypertension, relative to continuous low job strain levels; (b) decrease in job strain over the 8-year follow-up period is related to lower rates of incident hypertension; and (c) increase in job strain is related to an increased risk of hypertension.

METHOD

Participants

The Coronary Artery Risk Development in Young Adults (CARDIA) study was designed to determine the precursors of cardiovascular risk factors in young adults and to determine the relations between behavioral factors and changes in cardiovascular risk factors over time. The study design and baseline characteristics of the participants have been previously reported (14). The CARDIA participants were initially recruited in 1985 and 1986 from Birmingham, Alabama; Chicago, Illinois; Minneapolis, Minnesota; and Oakland, California. A total of 5,115 young adults between the ages of 18 and 30 years were recruited, approximately balanced at each center for age (18–24 and 25–30 years), sex, ethnicity (African American and White), and educational level (high school graduate or less and beyond high school). Because of competing demands for psychosocial assessments, and because CARDIA was not designed to be a study of job stress, job strain was measured in 1987–1988 (the Year 2 examination) and again in 1995–1996 (the Year 10 examination). For the purposes of this analysis, the Year 2 examination was considered the baseline examination.

Exclusionary criteria were not attending both Year 2 and Year 10 examinations ($n = 1,337$), nonemployment ($n = 1,316$), taking antihypertensive medications at the Year 2 examination ($n = 37$) or undiagnosed hypertension (SBP ≥ 160 /diastolic BP [DBP] ≥ 95 ; $n = 1$), pregnancy at the examination ($n = 109$), and sex change between examinations ($n = 2$). Of the eligible participants, the following did not complete the job strain measures at both examinations, primarily because the measures were not completed at Year 2 when first introduced into the protocol: 19 White men, 93 White women, 52 African American men, and 140 African American women. These exclusions left 3,200 participants for analysis, including 847 White men, 908 White women, 596 African American men, and 849 African American women. The study was approved by the institutional review board for each of the four testing centers, and participants gave written informed consent.

Data Collection

Job characteristics and job strain were measured using the JCQ as described previously (15) at both the Year 2 and Year 10 examinations. Blood pressure was measured three times after a 5-min rest, using a random-zero sphygmomanometer. The first and fifth Korotkoff sounds were recorded; the average of the last two readings was used as the resting BP. Participants were also questioned regarding the use of medications for hypertension.

Hypertension was defined in two ways, both including individuals on antihypertensive medications at follow-up. The primary definition was 160 or higher for SBP and 95 mmHg or higher for DBP, or use of antihypertensive medications, with the analyses presented later in this article using this definition; the other was 140/90 mmHg or higher, or use of antihypertensive medications. Unless otherwise noted, the analyses for the latter yielded the same results as the primary analyses.

Covariates potentially related to BP change or hypertension, measured as described previously at either examination (14–16), were initially included in the analyses. These included baseline age, baseline body mass index (BMI; calculated as weight in kg/height in m²), baseline alcohol intake (in ml/day), baseline SBP, family history of high BP (as reported at the follow-up examination), baseline cigarette smoking status (present smoker, never smoker, or past smoker), examination site, education level at follow-up (in years), and change in BMI.

Statistical Analysis

We used the GLM procedure (SAS, Triangle Park, NC) for analyses assessing race and sex differences in baseline variables. A p value of .05 was considered significant. Because there is no gold standard for assessing job strain, we examined the association between job strain and hypertension in several ways. First, we created a high job strain category, categorizing participants as above or below the median for their same-sex/race group distribution of the two subscales of the JCQ, thereby defining individuals with high job demands and low decision latitude at both baseline and follow-up. We again used the GLM procedure for these analyses (because of the presence of zeros in some cells). For the final analyses, we used logistic regression. Raw change scores (using continuous data) for the individual subscales were entered with two types of multiplicative interaction term of the change in the two scales. In the first, the interaction term was determined with the raw scores for the two scales; for the second, the decision latitude scale was inverted, so both scales were in the same direction (greater change being an adverse outcome). Finally, we conducted analyses using change scores for the ratio of job demands to decision latitude (again using continuous data). Initial models indicated that some covariates were not significant in predicting hypertension and hence were not included in final analyses. These covariates were family history of high BP, cigarette smoking status, change in smoking status, change in education, and alcohol intake; education for analysis of change in decision latitude and job demands; and education and change in BMI for analyses of change in ratio of job demand to decision latitude. We conducted secondary analyses excluding participants who were homemakers, and among those who did not use antihypertensive medication, we conducted linear regression models with regard to the job strain measures and change in BP across the 8 years.

RESULTS

Baseline and Follow-Up Characteristics

Relative to those excluded from our analysis, participants included in the analysis were more likely to be White and female

($ps < .0001$), had slightly more average years of education at study entry (13.97 ± 2.20 years vs. 13.33 ± 2.10 years, $p < .0001$), and had slightly higher SBP levels at study entry (110.1 ± 10.76 vs. 110.01 ± 11.0 mmHg, $p < .01$). However, there were no significant differences in either job demands or decision latitude between participants included in the analysis and excluded participants who attended the initial examination in which job characteristics were assessed (data not shown).

As in other CARDIA reports (14,16), Whites had more years of education than African Americans, African American men had the highest levels of SBP and DBP at baseline and follow-up, and BMI levels were highest among African American women (see Table 1). Although Whites reported higher job demands than African Americans at both time points, no significant changes in job demands were noted in either group during the 8-year follow-up. In addition, Whites had more decision latitude than African Americans at both time points ($ps < .001$ for both gender groups), but all groups showed increases in decision latitude ($ps < .001$). Rates of incident hypertension at follow-up were higher among African Americans than Whites.

Baseline job demands were associated with higher education at follow-up ($r = .09$) and lower SBP ($r = -.04$), and change in job demands was not associated with any covariates. Baseline decision latitude was associated with higher education at follow-up ($r = .19$), lower BMI and change in BMI ($rs = -.07$ to $-.08$), and age ($r = .11$). Change in decision latitude was associ-

ated with less education ($r = -.06$), change in BMI ($r = -.04$), and age ($r = .05$). Family history of hypertension was not associated with any job strain measures.

Hypertension and Job Strain

It was previously reported that there was no relation between different formulations of job strain and BP at Year 2 in CARDIA participants (15). In unadjusted cross-sectional analyses of job strain (defined by median splits) at follow-up, in the individual race/gender groups, among White men only, high job strain was associated with a higher prevalence of hypertension than was low job strain (3.1% vs. 0.6%, $p < .005$).

For the entire cohort, individuals who changed from low job strain to high job strain over the 8-year follow-up had higher rates of hypertension ($n = 20$ of 406, or 4.93%) at Year 8 than either individuals who were low at both time points ($n = 54$ of 2,045, or 2.64%) or individuals who went from high to low job strain ($n = 8$ of 495, or 1.62%); individuals with high job strain at both time points were intermediate ($n = 7$ of 254, or 2.8%). An identical pattern was seen among the White men and women and African American men, although the relationships were statistically significant only among the Whites. Adjustment for significant covariates (education, age, BMI, change in BMI, and baseline SBP) did not alter these relationships (data not shown).

We explored the relationship of other formulations of job strain to incident hypertension including job demands and deci-

TABLE 1
Characteristics and Race/Sex Differences of the Study Sample: The CARDIA Study, 1987–1995

	African American Men ^a	African American Women ^b	White Men ^c	White Women ^d	<i>p</i>		
					Race	Sex	Race/Sex Interaction
Age at baseline, years	26.4 (3.7)	26.6 (3.9)	27.6 (3.4)	27.6 (3.4)	< .0001	.44	.86
Education at follow-up (years)	13.9 (2.2)	14.0 (2.1)	15.6 (2.7)	15.6 (2.5)	< .0001	.37	.67
BMI at baseline (kg/m ²)	25.8 (4.7)	26.6 (6.7)	24.9 (3.7)	23.6 (4.8)	< .0001	.12	< .0001
BMI at follow-up (kg/m ²)	28.2 (5.8)	29.7 (7.6)	26.7 (4.5)	25.5 (6.2)	< .0001	.33	< .0001
SBP at baseline (mmHg)	113.3 (10.2)	105.3 (9.6)	111.3 (9.4)	102.0 (9.1)	< .0001	< .0001	.18
SBP at follow-up (mmHg)	116.0 (11.9)	110.0 (14.2)	111.3 (10.5)	103.2 (9.9)	< .0001	< .0001	.002
DBP at baseline (mmHg)	70.6 (9.7)	66.7 (9.1)	69.2 (8.6)	64.5 (8.6)	< .0001	< .0001	.06
DBP at follow-up (mmHg)	76.7 (10.2)	72.9 (10.4)	73.4 (8.8)	67.6 (8.7)	< .0001	< .0001	.01
% hypertensives at follow-up (<i>n</i>)	4.5 (27)	4.8 (41)	1.1 (9)	1.3 (12)			
Job decision latitude at baseline	34.2 (6.2)	34.1 (6.3)	37.0 (6.5)	36.2 (6.5)	< .0001	.03	.17
Job decision latitude at follow-up	36.3 (5.8)	35.7 (6.4)	39.0 (5.9)	38.1 (5.8)	< .0001	.0009	.48
Job demands at baseline	30.7 (5.9)	31.6(6.5)	32.3 (6.0)	32.8 (6.4)	< .0001	.002	.51
Job demands at follow-up	30.2 (5.9)	31.3 (6.5)	32.2 (6.2)	32.9 (6.4)	< .0001	< .0001	.38
% job strain—low at both exams (<i>n</i>)	63.3 (378)	59.8 (510)	67.6 (573)	64.4 (584)			
% job strain—change from low to high (<i>n</i>)	12.2 (72)	14.5 (123)	11.5 (97)	12.5 (114)			
% job strain—change from high to low (<i>n</i>)	16.8 (100)	16.9 (141)	13.6 (115)	15.2 (139)			
% job strain—high at both exams (<i>n</i>)	7.7 (46)	8.8 (75)	7.3 (62)	7.9 (71)			

Note. Values are means (standard deviations) unless otherwise indicated. Job decision latitude and psychological demands are continuous variables, job strain formulated using median splits (see text). CARDIA = Coronary Artery Risk Development in Young Adults; BMI = body mass index; SBP = systolic blood pressure; DBP = diastolic blood pressure.

^a $n = 596$. ^b $n = 849$. ^c $n = 847$. ^d $n = 908$.

sion latitude at baseline as covariates. The multiplicative interaction terms of change in job demands and change in decision latitude were included in models using change of each of the individual factors. In all cases, the interaction terms were not significant in the models predicting hypertension.

Relationships of change in the decision latitude and job demands and their ratio with hypertension incidence are shown in Tables 2 and 3. An increase in job demands was related to incident hypertension in adjusted models, regardless of the definition of hypertension. Increases in the ratio were associated with increases in risk of hypertension at follow-up (but not with hyper-

tension defined as >140/90 or participants who were on medications). Small numbers prevented an analysis of the interaction of sex and race. Analyses excluding homemakers ($n=662$) showed a similar if not stronger pattern: an increase in job demands (odds ratio [OR] = 1.07, 95% confidence interval [CI]: 1.02–1.12) and increases in the ratio (OR = 2.53, 95% CI = 1.18–5.40) were related to incident hypertension in adjusted models.

Change in decision latitude ($p < .002$) and change in the ratio of job demands and decision latitude ($p < .02$) were associated with increased SBP across 8 years in the full model including all covariates but excluding participants on antihypertensive medications. Job strain measures were not related to 8-year change in DBP.

TABLE 2

Adjusted Odds Ratios and 95% Confidence Intervals for Incident Hypertension for 8-Year Change in Decision Latitude and Job Demands: The CARDIA Study, 1987–1995

Variable	Odds Ratio	Confidence Interval
Change in decision latitude	1.02	0.98, 1.06
Change in job demands	1.05	1.01, 1.09
Baseline decision latitude	1.01	0.96, 1.06
Baseline job demands	1.04	0.99, 1.09
BMI (per kg/m ²)	1.06	1.02, 1.09
Change in BMI (per kg/m ²)	0.93	0.86, 1.00
Baseline systolic blood pressure (per mmHg)	1.11	1.09, 1.14
Age (per year)	1.16	1.08, 1.25
Center—Birmingham	2.03	1.08, 3.89
Center—Chicago	1.14	0.54, 2.39
Center—Minneapolis	0.76	0.36, 1.63
Race (African American vs. White)	2.27	1.28, 4.01
Sex (men vs. women)	2.33	1.37, 3.97
Family history of hypertension	2.73	1.40, 5.35

Note. CARDIA = Coronary Artery Risk Development in Young Adults; BMI = body mass index.

TABLE 3

Adjusted Odds Ratios and 95% Confidence Intervals for Incident Hypertension for 8-Year Change in Ratio of Job Demands and Decision Latitude: The CARDIA Study, 1987–1995

Variable	Odds Ratio	Confidence Interval
Change in ratio	2.06	1.01, 4.26
Baseline ratio	1.27	0.47, 3.44
BMI (per kg/m ²)	1.04	1.01, 1.07
Baseline systolic blood pressure (per mmHg)	1.12	1.09, 1.14
Age (per year)	1.17	1.09, 1.26
Center—Birmingham	1.96	1.04, 3.69
Center—Chicago	1.13	0.54, 2.36
Center—Minneapolis	0.72	0.34, 1.53
Race (African American vs. White)	2.02	1.17, 3.51
Sex (men vs. women)	2.41	1.42, 4.10
Family history of hypertension	2.85	1.45, 5.59

Note. CARDIA = Coronary Artery Risk Development in Young Adults; BMI = body mass index.

DISCUSSION

This study provides evidence that an increase in job strain is associated with incident hypertension. In this cohort of young adults, who had a low incidence of hypertension, individuals with an increase in job strain over the 8-year follow-up period had higher rates of hypertension when job strain was formulated either as being in the high job demands/low decision latitude based on median splits, or by change in the job demands/decision latitude ratio. In this study's initial categorical analysis, when analyses were broken down by race/sex groups, the results were statistically significant among Whites, with a similar nonsignificant pattern among African American men. The lack of a positive relation between job strain and BP among African Americans is consistent with other studies (6,17).

In our analysis, only multiplicative interaction terms of the two job strain factors (decision latitude and psychological demands) were not significantly related to incident hypertension. This result is similar to that of Landsbergis et al. (18), who found that all formulations of job strain derived from the JCQ were related to SBP in a cross-sectional analysis, with the exception being the multiplicative interaction term. Other studies using the multiplicative term have also found no relation with BP, although these studies did not find relations between BP and job strain using other definitions either (7,19).

Our results indicate that, contrary to our other initial hypotheses, chronic high job strain was not related to incident hypertension, and decreases in job strain were not related to a lower incidence of hypertension. It is not clear how increases in job strain can increase hypertension risk whereas chronic job strain does not. Sympathetic nervous system hyperactivity is commonly assumed to mediate the relation between job strain and hypertension (18,20); one potential explanation is that there may be a sensitization process during chronic job strain whereby chronic increases in sympathetic nervous system activity could lead to downregulation of adrenergic receptors (21).

The results of this study can be contrasted against previous CARDIA analyses examining the relationships of hypertension or BP with psychosocial risk factors. First, the previous cross-sectional analysis found no relationships between job strain and BP at Year 2, regardless of the formulation of job strain (15). The young age of the cohort, and the small variance in BP levels in that initial analysis, may have contributed to a

lack of findings at that time. Many CARDIA participants may have been working at jobs that were temporary or leading up to the work they were doing at the follow-up examination. On average, psychological demands at work were not increased over the 8-year follow-up, but decision latitude improved over time, indicating that job conditions generally improved for the cohort. However, individuals for whom job conditions worsened over time (in either overall job strain or increased job demands) were more likely to develop hypertension. Changes in job strain may therefore be important to assess, particularly in younger cohorts.

In our analysis, the most consistent finding for a relationship between categorical job strain and hypertension was found among Whites; however, this result must be regarded as preliminary, given the small number of cases of hypertension among Whites and the nonsignificant trend for African American men to show a pattern similar to that of Whites. In addition, change in job strain was a less powerful predictor of hypertension than most other risk factors, including race, sex, geographical location, and family history of hypertension. In another CARDIA analysis, depressive symptoms predicted hypertension, primarily because of their association in African Americans (16). The reasons for the ethnic differences between the two analyses are not clear. In one study of 152 working women (almost evenly divided by ethnicity), job strain was highly correlated with depressive symptoms as measured by the Beck Depression Inventory (20), and the relationship was not affected by entering race-ethnicity as a covariate. Perhaps more important, unemployment was strongly related to depressive symptoms (22–24) and, in CARDIA, depressive symptoms predicted unemployment 5 years later (25). The different effects for depression relative to job strain by ethnicity may be due to the exclusion of individuals not working at the follow-up examination in our analysis. The potential confounding in studies of job strain due to eliminating unemployed individuals may be important to consider in future studies. Finally, job strain may be less salient in African Americans because of other sources of stress in their lives that mask the effect of job strain. This pattern is similar to the apparent one for the stress consequences on other health outcomes, for example, effect of poverty on infant mortality, or stressful life events on psychological distress being stronger for African Americans than Whites (26–27).

These results add to evidence linking job strain to hypertension. Much of the available evidence for psychosocial factors as predictors of hypertension comes from studies of depression and anxiety (16,28–30) and of anger and anger expression (31–34). These factors differ from job strain in that depression, anxiety, and anger all are emotional responses to the environment, whereas self-reported job strain can be construed as assessing “stress,” that is, the perceived impact of situations related to environmental factors.

One limitation of this analysis is that individuals on antihypertensive medications completed the JCQ with full knowledge of their hypertensive status. There is a possibility that this knowledge influenced their reporting of their job situation; this problem has been a criticism of previous studies in the area of psychosocial factors and hypertension (31,35). However, the secondary analyses also showed that change in the ratio of job de-

mands to decision latitude was related to increased SBP over the 8 years, supporting the likelihood that the bias was small. Given that individuals in the United States change jobs more frequently than they did in the past (36), it may be difficult to perform a true prospective study of job strain, other than in subpopulations where job status is stable. This problem may be an ongoing issue in the area of job characteristics as they affect disease. Finally, as indicated earlier, the small number of hypertension cases limits the power of the analysis in specific race/sex groups.

In summary, increases in job strain are associated with greater hypertension incidence, particularly among White young adults. This finding is robust in that it is consistent across formulations of job strain as measured by the JCQ. True prospective studies with job strain may be difficult because of changes in job status over time.

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