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A Follow-up Study of Job Strain and Heart Disease Among Males in the NHANES1 Population

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Several studies have associated heart disease with job strain, defined as low job control and high job demands. We have studied incident heart disease (519 cases) and job strain among 3,575 males in NHANES1 survey who were currently employed at baseline in the early 1970s, and followed through 1987. Scores for job control and job demands were assigned to each subject based on current occupation at baseline. Controlling for conventional risk factors, we found no excess risk for those with the highest strain (lowest control and highest demands, rate ratio 1.08). Those with highest job control did have significantly decreased risk (rate ratio 0.71, 95% CI 0.54–0.93). In blue-collar workers (58% of subjects) there was a significant inverse trend in risk with increasing job demands. Control for level of physical activity did not change this finding. A combination of high control and demand was protective among blue-collar workers (odds ratio 0.69, 0.48–0.99). Our findings suggest that class-specific analyses are needed in studying job stress, and that "active" blue–collar workers with high control and high demand are protected against heart disease. The "job demand" variable may measure whether work is challenging rather than fast-paced. Our findings are limited by the use of assigned job scores based on job title. Am. J. Ind. Med. 31:256–259, 1997. © *1997 Wiley-Liss, Inc.*†

KEY WORDS: job strain; job stress; heart disease; NHANES1

INTRODUCTION

In 1979 Karasek and colleagues developed a two-dimensional model of job strain based on low control ("decision latitude") and high demands, and suggested that increased job strain might be associated with heart disease. This hypothesis has been tested with prospective studies in several populations. Among the larger prospective studies, there have been positive findings in Sweden [Johnson et al. 1989; Karasek et al. 1981; Alfredsson et al., 1985], a negative finding in Hawaii [Reed et al., 1989], and positive finding for job control but not for job demands in a study done in Illinois [Alterman et al., 1994]. A recent U.S. study with both a cross-sectional and longitudinal design found no association between job strain and either prevalent coronary artery disease or subsequent cardiovascular mortality or morbidity [Hltatky et al., 1995]. There have been positive findings from Swedish case-control studies [Alfredsson et al., 1982, Hammar et al., 1994], and several cross-sectional studies. Most of these studies have been reviewed recently [Schnall et al., 1994]. When the two components of strain have been analyzed separately, findings have been more consistent for an association between heart disease and low job control than between heart disease and high job demands. Indeed, there is some evidence that high demands coupled with high control are protective.

Many of the Swedish studies lacked data on cardiovascular risk factors, while the Hawaii and Illinois studies did control for the principal risk factors. Many studies have used scores for job control and job demand taken from surveys of workers in different occupations, and then assigned these scores to all workers in a given occupational category in the population under study. Schwartz et al. [1988] refined this

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procedure somewhat by adjusting U.S. survey scores within an occupation for demographic factors such as age and education. Of particular concern in all these studies is adequate control for socioeconomic status, which may be correlated both with heart disease and with job control and job demands.

The mechanism by which job strain may affect the cardiovascular system is not clear, but there is some evidence that jobs with higher strain may increase catecholamines and cortisol, and increase ambulatory blood pressure at work [Frankenhauser, 1989; Schnall et al., 1990].

To further study this issue, we have considered the relation between indices of job strain and heart disease in the follow-up data from the NHANES1 population, a large representative sample of the U.S. population. This population was originally studied at baseline in 1971–1975, and then followed for morbidity and mortality through 1987. Our study was restricted to men: approximately 90% of the women in the NHANES1 population had jobs for which no scores for job strain existed (primarily ‘‘Housewife’’).

MATERIALS AND METHODS

The National Health and Nutrition Survey I (NHANES1) was conducted from 1971–1975 and involved the collection of interview and medical exam data on 23,808 subjects, ranging in age from 1 to 74 [NCHS, 1979]. Follow-up information for disease incidence was obtained by obtaining hospital records through 1987 for 14,407 participants, who were 25-74 years of age when they were examined in NHANES1 [NCHS, 1987]. Death certificates were also collected for those who died through 1987.

Our study was restricted to males ($n = 5{,}811$), because of the lack of job strain scores for most women. We first eliminated those with heart disease at baseline by eliminating those reporting a history of heart failure, heart attack, or taking pills for heart disease ($n = 609$). Analyses were then restricted to 3,575 men who were currently working at baseline interview who also had jobs for which scores for demand and control were available (97% of those eliminated at this step were not currently working; only a few had jobs which could not be scored). Cases were defined as any incident heart disease (9th Revision ICD Codes 410–414) on either hospital discharge records or death certificates ($n = 519$). The date of diagnosis was taken from hospital discharge when possible. For those with heart disease identified only from death certificate (23%), the date of death was used for date of diagnosis.

A multivariate model was built which included variables known a priori to be associated with heart disease, including age at baseline, systolic blood pressure, cholesterol, body mass index (kilograms/meters^2), smoking (current, former, never), and diabetes at baseline. All these variables did in fact predict heart disease in our data. Education was used to control for potential confounding by socioeconomic status. Education was used rather than income; these two variables were highly correlated but education had a slightly better fit to the data, based on the log likelihood. Other variables tested but which did not predict heart disease included self-reported physical exercise, alcohol consumption, marital status, and blood pressure medication.

All variables were taken from the NHANES1 baseline data, with the exception of smoking. While smoking data were available for only about one-half of the subjects at baseline, most of those missing baseline smoking data had complete smoking histories collected during interviews conducted in 1982–1984. From these data we ascertained smoking status at baseline. For those who still had missing smoking data (6%), a separate category was created so as not to lose these individuals from the analysis.

Analyses were conducted using Cox regression via SAS PHREG [SAS 1991]. Although these data were collected using a multistage cluster sampling procedure so as to be able to make estimates for the U.S. population, we have ignored design effects in calculating rate ratios and their standard errors, treating the data as if it were a simple random sample from a hypothetical general population (a reasonable assumption for the purposes of estimating etiologic effects).

Job scores were provided by current occupation (1970 U.S. census coding) by Carl Pieper (personal communication), and were adjusted within occupation for age, education, geographical region of residence, race, marital status, urban vs. rural residence, and employment status (public vs. private sector, self-employment) [Schwartz et al., 1988]. Two principal scores were analyzed: job control (decision authority and decision latitude) and job demand. Analysis was conducted for quartiles of job scores and tests for trend were conducted by using job scores as continuous variables. Quartile cutpoints for job control were 84.5, 78.1, and 69.1; for job demands they were 33.7, 33.4, and 28.7. In addition, a combination of low job control and high job demand variables indicating a high strain subgroup was analyzed (17% of the population), as well as a combination of high job control and high job demands (34% of the population) (a possibly protective combination), using as cutpoints the median values for these variables.

The scores for each occupation were derived from Quality of Employment Surveys, sponsored by the U.S. Department of Labor and conducted by the University of Michigan Institute for Survey Research in 1969, 1972, and 1977 (with sample size of 993, 985, and 968 males, respectively). Job control is a weighted sum of a six-item scale, including four questions about ‘‘decision latitude’’ or ‘‘skill discretion’’ (whether a job allows learning new things,

TABLE I. Correlations (p-values) between Job Control and Job Demand Scores and Other Variables for Controls (Cases Excluded)

	Job control	Job demand	Systolic BP	BMI	Education	Income	Cholesterol	Age
Job control	1.00	.45	−.09	.02	.37	.21	.06	−.03
		.0001	.0001	.11	.0001	.0001	.0008	.09
Job demand	.45	1.00	−.21	.02	.30	.25	−.06	−.48
	.0001		.0001	.15	.0001	.0001	.001	.0001

requires a high level of skill, requires creativity, is not repetitious), and two questions about decision authority (allows freedom over how work is done, and allows one to make decision on one's own). Job demands is a sum of a five-item scale based on questions about how hard the work is, the pace of the job, if it involves excessive demands, if there is too little time to do the work, and if the job involves conflicting demands.

Separate analyses were also conducted for blue-collar workers (58% of the population). Using 1970 census codes, blue collar was defined as working in occupations with codes 400–989, while codes lower than 400 were considered white collar. Separate analyses were also conducted for cases who got heart disease under age 65.

Although not presented, we conducted additional analyses, including in the model only variables for age and exposure, on the grounds that some covariates in the model (e.g., blood pressure) might act as intermediate variables, and also to investigate to what degree estimates of exposure effect might change without control of potential confounders.

RESULTS

Table I presents correlations between job control and job demand scores and the other variables in the model. Job control and job demand were strongly and positively correlated. Both were in turn positively correlated with education and income, and negatively correlated with systolic blood pressure. Correlations were weaker between either job score and cholesterol and body-mass index. Job demand was negatively correlated with age, but job control showed little or no correlation. Further regression analyses of the relationship between job control and job demand found that job demand remained highly correlated with job control after adjusting for education, age, and race. This result was true for both white- and blue-collar workers.

Current smokers and blue-collar workers had significantly lower job control scores than did nonsmokers and white-collar workers, respectively, but no differences between these groups were found for job demand scores.

Despite the fact that a number of these variables were both associated with exposure and heart disease, in practice there appeared to be little important net confounding by variables other than age. Models with only age and exposure (not shown) gave exposure effect estimates similar to estimates with the full model. However, we present data here from the full model.

Table II presents results for job scores and heart disease. For job control there is a decreasing but not significant trend in heart disease risk with increasing control; the quartile with most control is significantly protected (rate ratio 0.71, 95% CI 0.54–0.93). Neither high demand–low control jobs nor high demand–high control jobs differed from other jobs.

When cases and controls were stratified by blue-collar/white-collar status, there were trends of decreasing risk with increasing job control ($p = .29$) and increasing job demand ($p = .01$) for blue collar workers. Findings for job demand were not altered by adjustment either for self-reported nonrecreational physical activity or by incorporation of job scores for physical activity (neither of which were predictive of heart disease). Blue-collar workers in high control and high demand jobs (20% of blue-collar workers) had significantly decreased risk compared to other blue-collar workers (rate ratio 0.69, 95% CI 0.48–0.99). There were no trends for white-collar workers.

DISCUSSION

Karasek et al. [1988], examined job strain in a subset ($n = 2{,}424$, males) of the NHANES1 population in a cross-sectional study of heart disease prevalence at baseline. Using a job strain definition similar to ours, they found an association between high job strain and a history of myocardial infarction, based on only 30 cases. In contrast, we have studied 3,575 males (519 cases) who were employed and free from heart disease at baseline in the early 1970s and were followed through 1987 for ischemic heart disease.

We found no increased risk of heart disease for jobs with high strain, defined as jobs with low control and high demands. Nor did we find any significant trends in risk when analyzing the separate components of job strain (job control

TABLE II. Results for Job Scores for Current Occupation*

Current occupation (519 cases)	Odds ratio (95% CI)	P-value for trend
Job control		
2nd quartile vs. first	0.80 (0.62–1.02)	
3rd quartile vs. first	0.82 (0.64–1.06)	
4th quartile vs. first	0.71 (0.54–0.93)	0.55
Job demand		
2nd quartile vs. first	0.77 (0.60–0.98)	
3rd quartile vs. first	0.94 (0.72–1.21)	
4th quartile vs. first	0.81 (0.61–1.09)	0.17
Low control and high demand**	1.08 (0.81–1.49)	
High control and high demand***	0.97 (0.78–1.20)	
Current occupation-blue collar only (313 cases)		
Job control		
2nd quartile vs. first	0.87 (0.66–1.16)	
3rd quartile vs. first	0.67 (0.48–0.93)	
4th quartile vs. first	0.69 (0.46–1.02)	0.29
Job demand		
2nd quartile vs. first	0.83 (0.62–1.12)	
3rd quartile vs. first	0.83 (0.58–1.18)	
4th quartile vs. first	0.64 (0.40–1.03)	0.01
Low control and high demand**	1.14 (0.80–1.63)	
High control and high demand***	0.69 (0.48–0.99)	
Current occupation-white collar only (206 cases)		
Job control		
2nd quartile vs. first	0.71 (0.40–1.28)	
3rd quartile vs. first	0.97 (0.57–1.65)	
4th quartile vs. first	0.74 (0.43–1.26)	0.59
Job demand		
2nd quartile vs. first	0.69 (0.45–1.06)	
3rd quartile vs. first	1.09 (0.73–1.64)	
4th quartile vs. first	0.93 (0.61–1.44)	0.43
Low control and high demand**	1.05 (0.63–1.77)	
High control and high demand***	1.19 (0.89–1.62)	

*Occupation as reported at baseline interview in 1971–75, for those then currently working. All models include age, blood pressure, education, body mass index, cholesterol, smoking, and self-reported diabetes. Blue- and white-collar quartiles used for blue- and white-collar analyses.

**Lower 50% for control and upper 50% for demands.

***Upper 50% for control and upper 50% for demands.

and job demands) and heart disease, although those with highest job control were significantly protected.

Separate analyses by blue- and white-collar status revealed no trends or significant findings among white-collar men. Among blue-collar men, those with the highest levels of job demands or job control had the lowest risks. There was a significant trend indicating that increasing job demands led to increasing protection ($p = .01$). Those with both high control and high demands were significantly protected (rate ratio 0.69). We reviewed other studies in which the components of job strain were analyzed separately, to see if others had found increased job demands protective. Alterman et al. [1994], also found a protective effect for increased job demands. Hltatky et al. [1995], found a protective effect of job demands in univariate analyses of coronary artery disease prevalence in an employed population, but did not present multivariate results for job demands.

Our findings for a protective effect of job demands (among blue-collar workers) contradicts the common view that increased job demands are thought to increase heart disease risk. There are problems in measuring job demands by imputation from job title, at a single point in time. Other investigators have noted that only a small portion of the individual variation in psychological job demands are captured by the job title group [Schwartz et al., 1988; Johnson and Stewart, 1993]. Production and performance demands frequently vary across individual work stations, workplaces, and individuals. Also, there is considerable temporal variation in psychological demands within the same individual.

We controlled for physical activity at work (either self-reported or based on job scores) to check the possibility that job demands among blue-collar workers were acting as a surrogate for increased physical activity, but control for physical activity at work did not affect findings for job demands.

The variable for job demands may be measuring something other than what was originally intended — demands for fast-paced performance. In our data, psychological demands are positively correlated with both income and education. Occupations with high demand scores may be those which require more challenging and mentally active work — components of the work process that are more health enhancing than otherwise. This speculation is reinforced by our finding of a protective effect among blue-collar workers for jobs with high demand/high control or ‘‘active jobs.’’ The original Karasek formulation predicted that high demands in the presence of high control should not cause more job strain, but rather enhance challenge, growth, and learning, although this component of the demand-control model has been relatively neglected. It is also interesting to note that a similar finding has recently been reported by Johnson and his colleagues. In a nested case-control study of cardiovascular mortality in a cohort of randomly-sampled 12,500 Swedish males [Johnson et al., 1996], those exposed to the ‘‘active’’ condition at work (high demands, high control) were found to be at lowest risk for cardiovascular disease in comparison to all other combinations of the demand-control model.

The demand-control model has provided a conceptual reference point for many studies in the last decade. The findings of our study suggest the importance of addressing two issues in future research: 1) exposure measurement should be improved, especially for the psychological demand variable, 2) class-specific analyses should be performed regularly, rather than simply adjusting for education or socioeconomic status as covariates. The protective effects of higher job control and higher job demands for blue-collar workers need further investigation.

A limitation of our study is that our exposure assessment was limited to one point in time. This might have introduced misclassification error because people may have changed jobs. Furthermore, we do not know how long study subjects worked in their jobs, and duration of exposure rather than current exposure may be related to heart disease risk. Also, we have only been able to infer scores for job strain based on job title, with the scores for specific job titles taken from one survey and applied to a different population from another survey. In the original survey from which the scores for different occupations were derived, there may have been only a few people in a given occupation, so the scores may not be very accurate.

On the other hand, our study had certain strengths. We have studied prospectively a large disease-free population, which was representative of the U.S. population. Selection bias due to ill subjects having certain types of jobs is therefore unlikely, and sample size is large enough to make reasonable inferences.

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