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OCCUPATIONAL STRAIN AND THE INCIDENCE OF CORONARY HEART DISEASE

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The hypothesis that men in high "strain" occupations have an increased risk of developing coronary heart disease was tested during an 18-year follow-up study from 1965–1983 of a cohort of 8,006 men of Japanese ancestry in Hawaii. There were no significant associations between the incidence of coronary heart disease and the individual job components of high psychologic demands and low job control or for the high strain interaction of these two characteristics. There were, in fact, trends of associations opposite to that predicted by the job strain model which were of borderline significance in multivariate analyses. Stratified analyses by level of acculturation showed similar inverse associations of job strain and coronary heart disease for the more Westernized men and no association for the more traditional men. There were also no significant associations among the various job characteristics and the major risk factors for coronary heart disease in this cohort. The disagreement of these results with those from other studies may be due to methodologic differences of using men whose usual and current occupations were the same in this study compared with using only current occupation in the other studies, the use of different methods of measuring job strain, or the possibility that men in this cohort perceive or react to occupational strain differently.

blood pressure; coronary disease; occupational diseases; stress

The concept that occupational stress increases the risk of coronary heart disease has been of interest for some time, but the epidemiologic evidence for such a causal association is inconsistent and often confusing (1–5). Part of the problem may be due to the diverse and often vaguely defined conditions which have been considered "stressful," and part may be due to the fact that occupation, per se, is a complex variable. Occupation categories can be surrogate measures for other risk factors such as physical activity, general fitness, and socioeconomic status (1, 6–7); and occupation can be linked through both social behavior and stress to health-related behavior such as cigarette smoking and alcohol and coffee consumption (8–10).

The potential influence of these different facets of occupation requires a clear specification of what job characteristics produce stress. Such specification is central to the understanding of whether jobs affect the development of coronary heart disease

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independently of other risk factors. Karasek (11) has proposed a specific two-dimensional model of job stress and coronary heart disease. The model focuses upon an interaction between high psychologic demands of an occupation (work load and work pace) and low amounts of decision-making freedom to cope with the high levels of demands. This combination is postulated to result in psychologic "strain" and subsequently increased cardiovascular disease risk.

Initial tests of this hypothesis in Swedish populations have shown the predicted association of high-strain work with indicators of coronary heart disease (12–14), and a study of two US survey populations has shown associations with the prevalence rates of myocardial infarction (15). Our study tests the hypothesis that employment in occupations characterized by high job demands and low job control is associated with the incidence of coronary heart disease over an 18-year follow-up period from 1965 to 1983. In addition, we have also examined the association between these job characteristics and the major cardiovascular disease risk factors in this cohort.

Materials and methods

The Honolulu Heart Program is a long-term prospective epidemiologic investigation of coronary heart disease and stroke among men of Japanese ancestry who were born between 1900 and 1919 and were living on Oahu Island, Hawaii, in 1965. Between 1965 and 1968, 8,006 eligible men participated in the initial examination. Details of the cohort characteristics have been described elsewhere (16).

Incident cases of coronary heart disease were identified by follow-up examinations two and six years after baseline and by morbidity and mortality surveillance through continuous monitoring of hospital discharge records, death certificates, and obituary notices in local newspapers. Diagnoses of coronary heart disease were determined by a panel of physicians after review of medical records, death certificates, and other pertinent information. For this report, only men with definite new coronary heart disease were included as incidence cases. Definite coronary heart disease included documented fatal coronary heart disease and nonfatal myocardial infarction as defined elsewhere (17).

Job characteristics

The methods used to estimate the job characteristics have been described in detail by Karasek et al. (15) and Schwartz et al. (18). The approach is "ecologic" in nature, i.e., job characteristic scores were developed for specific occupations, and all persons with that occupation were given the same scores. The source of data for estimating job characteristics consists of three nationally representative Surveys of Working Conditions, also known as the Quality of Employment Surveys, sponsored by the US Department of Labor and conducted by the Institute for Survey Research at the University of Michigan in 1969, 1972, and 1977 (18). These cross-sectional surveys ask respondents who worked in the paid civilian labor force to report on a wide range of characteristics of their jobs. Two scores were used for this study. "Decision latitude" is a scale of job control based upon 10 questions relating to skill discretion and freedom to make decisions about task performance: "(1) Keep learning new things; (2) Requires high level of skill; (3) Requires creativity; (4) Not repetitious; (5) Can develop skills; (6) Job has variety; (7) Can choose how to perform work; (8) Can make decisions on my own; (9) Have a lot of say on the job; (10) Take part in decisions that affect me" (18, p. 905). "Psychologic demands" is a scale based upon five questions about the pace and intensity of work demands: "(1) Work fast; (2) Work hard; (3) Work is excessive; (4) Not enough time to do work; (5) Face conflicting demands at work" (18, p. 905).

Job scores were originally computed for 440 occupations listed in the 1970 US Cen-

sus of Occupations (19) and later merged into 211 occupations covering 98.5 per cent of the work force (18).

The next step was to link the job scores completed for this national survey to occupations of the men in the Honolulu Heart Program cohort. During the baseline examination, the men were asked about their current and usual occupations and the number of years worked at each. All listed occupations were coded to the 1970 US Census occupation codes (19) by a trained coder and rechecked by one of the authors (D. M.). There was less than 1 per cent difference due to similar codes for some job titles. The consistency of reported occupations was also checked through occupation data obtained at follow-up examination. For this study, we included only men for whom the usual and current occupations were the same in order to avoid the complications associated with mixed influences of different jobs and the potentially stressful effects of multiple job changes. Individual occupation codes were then linked to the job characteristic data base, and each person was assigned the job characteristic scores for his occupation. Internal and external reliability checks of this method have been reported to be acceptable (18). The data base also included job characteristic scores which have been adjusted for several demographic characteristics (15), but these scores were not used since we preferred to examine the need for such adjustments based upon the characteristics of persons in the cohort rather than to use the national group values.

Analytic methods

To illustrate associations, we calculated age-adjusted 18-year incidence rates of definite coronary heart disease by quartiles of the job characteristic scores. Cox proportional hazards models with age were used to test the significance of associations.

Several approaches were used to examine the specific interaction hypothesis that men in jobs with high psychologic demands and low decision latitude have the highest risk of coronary heart disease. The first was simply to calculate two-by-two contingency tables of age-adjusted coronary heart disease incidence rates by cross-tabulation of the two scores divided into high and low groups at the median score. A "job strain" score was also developed from a multiplicative model quite similar to that proposed by Karasek et al. (15). We also used a "vector" distance score developed from a standard additive model of vector distance using the following formula:

$$Z = \frac{1}{6\sqrt{2}} \sqrt{(Z_{DL} - 3)^2 + (Z_{PD} + 3)^2}.$$

Z_{DL} and Z_{PD} are the person's standardized Z scores for decision latitude and psychologic demands obtained as five-year age group-specific Z scores. The distance of 3 standard deviations was used to include 99 per cent of the distributions. For this model, Z has the limits of 0 and 1 with strain increasing as the score approximates 1.

RESULTS

Table 1 shows the derivation of the study population. Of the 8,006 men who participated in the baseline examination, 7,550 were free of prevalent coronary heart disease, stroke, and cancer. Of these, 4,737 men reported that their usual and present occupations were the same. During the period 1965–1983, 359 of the 4,737 men developed definite coronary heart disease.

The means and standard deviations were

TABLE 1

Derivation of the study population, Hawaii, 1965–1983

No. who completed first examination	8,006
No. free of prevalent coronary heart disease, stroke, and cancer	7,550
No. for whom usual and present occupations were the same	4,737
No. with incident definite coronary heart disease	359

30.3 ± 2.6 for the psychologic demands score and 71.9 ± 8.1 for the decision latitude score. These values were similar to those reported for the national samples in the US National Health Examination Survey and the first US National Health and Nutritional Examination Survey (NHANES I) (15). A detailed comparison of major occupations indicated that in the Hawaii sample there were about three times more men with craft, construction, and clerical jobs than expected from the national samples, about half as many men with professional and managerial jobs, and less than one fourth as many with industrial-type operative and unskilled blue-collar jobs. However, if it is true that the job scores rather than the actual distribution of occupations are the important items, then this cohort is similar to other US samples (15).

Table 2 shows the age-adjusted 18-year incidence rates of definite coronary heart disease per 1,000 persons by quartiles of the psychologic demands and decision latitude scores. The hypothesis under study implies that the rates should increase with higher levels of psychologic demands and decrease with higher levels of decision latitude. There was no meaningful pattern of association of the coronary heart disease rates with any of the scores in this cohort. Cox proportional hazards models with age revealed no statistically significant associations. Models which included weights for the number of years worked at the jobs showed similar lacks of association.

Table 3 shows the age-adjusted coronary heart disease incidence rates by cross-tabulation of psychologic demands and decision latitude scores divided at the median value of each score. The study hypothesis implies that the men in the cell with high demands and low latitude would have the highest risk. Contrary to the hypothesis, these men actually had the lowest coronary heart disease incidence rates, and the men with jobs that had low demands and high latitude had the highest rates, but this trend was not statistically significant. Similar analyses weighted by number of years worked showed the same pattern.

Two other interaction models were examined as described in Materials and Methods. Table 4 shows the 18-year incidence rates of definite coronary heart disease per 1,000 persons by quartiles of scores derived from these models. The standardized job strain score is a multiplicative model similar to that developed by Karasek et al. (15). The vector distance score is from the standard additive model of vector distance. As with the cross-tabulation analysis, there was no significant association of coronary heart disease incidence with increasing job strain.

To determine whether the job scores were associated with the major risk factors for coronary heart disease in this cohort, we calculated age-adjusted mean levels of the risk factors by quartiles of the psychologic demands and decision latitude scores and the vector distance score. As shown in table

TABLE 2

Age-adjusted 18-year coronary heart disease incidence rates per 1,000 persons by quartiles of job characteristics, Hawaii, 1965–1983

Quartiles	Psychologic demands	Decision latitude
1 Low	99	91
2	75	68
3	104	108
4 High	85	91
	$\chi^{2*} = 0.11$	$\chi^{2*} = 0.21$

* χ^2, 2 df from Cox proportional hazards model with age.

TABLE 3

Age-adjusted 18-year incidence rates of definite coronary heart disease per 1,000 persons by cross-tabulation of psychologic demands and decision latitude, Hawaii, 1965–1983

	Psychologic demands		
	Low	High	Total
Decision latitude			
High	113	90	99
Low	84	76	79
Total	97	83	

5, there were no significant associations of the scores with any of the risk factors.

We also examined multivariate Cox proportional hazards models relating definite coronary heart disease to each of the job scores and interaction terms included separately with age, systolic blood pressure, physical activity, cigarette pack-years, serum cholesterol, and glucose in the model. Contrary to the hypothesis, coronary heart disease was inversely associated with the strain scores at a borderline level ($\chi^2 = 3.25$, $p = 0.07$), while there were no significant associations with the psychologic demands or the decision latitude scores.

As a final exploration, we examined the possibility that the lack of association between coronary heart disease and theoretically stressful job characteristics was due to the Japanese ethnic characteristics of the men in the cohort. Earlier studies indicated that ability to read and write the Japanese language was a good measure of acculturation in this cohort (20). Accordingly, we divided the men into two categories of ability to read and write Japanese, coded as none (none or poor) and good (fair or good) and calculated age-adjusted 18-year incidence rates of definite coronary heart disease by quartiles of the job characteristic scores (table 6). For the men who were most Westernized, as indicated by the language ability measure none, the patterns of coronary heart disease risk were the reverse of those predicted by the stress hypothesis. That is, the rates were highest among men with the lowest level of psycho-

TABLE 4

Age-adjusted 18-year incidence rates of definite coronary heart disease per 1,000 persons by quartiles of job strain scores, Hawaii, 1965–1983

Quartiles of job strain		Coronary heart disease incidence rates/1,000 persons	
		Standardized job strain score	Standardized vector distance score
1	Low strain	102	112
2		94	64
3		69	95
4	High strain	96	86
		$\chi^{2*} = 0.35$	$\chi^{2*} = 0.91$

* χ^2, 2 df from Cox proportional hazards model with age.

TABLE 5

Age-adjusted mean levels of selected coronary heart disease risk factors by quartiles of job characteristics among men free of cardiovascular disease and cancer at the initial examination, Hawaii, 1965–1983

	Quartiles			
	Low 1	2	3	High 4
	Psychologic demands			
Systolic blood pressure	134	134	132	134
Diastolic blood pressure	82	83	81	82
Serum cholesterol	217	217	218	218
Cigarettes per day	10	10	10	10
Alcohol intake (oz./month)	13	14	16	14
Body mass index	24	24	23	24
Physical activity index	32	34	34	33
	Decision latitude			
Systolic blood pressure	135	132	134	133
Diastolic blood pressure	82	82	82	82
Serum cholesterol	218	217	217	219
Cigarettes per day	11	11	11	9
Alcohol intake (oz./month)	14	16	15	14
Body mass index	24	24	24	24
Physical activity index	33	36	34	31
	Strain vector score			
Systolic blood pressure	133	132	134	135
Diastolic blood pressure	82	81	82	83
Serum cholesterol	218	216	218	219
Cigarettes per day	9	11	11	11
Alcohol intake (oz./month)	12	15	15	16
Body mass index	24	24	24	24
Physical activity index	33	35	33	33

TABLE 6

Age-adjusted 18-year incidence rates of definite coronary heart disease, by acculturation group and job characteristics, Hawaii, 1965–1983

	Japanese language ability	
	None (n = 2,959)	Good (n = 1,723)
Quartiles of psychologic demands		
1 Low	114	63
2	101	79
3	95	57
4 High	94	81
	$\chi^{2*} = 2.14$	$\chi^2 = 0.13$
Quartiles of decision latitude		
1 Low	94	87
2	78	50
3	106	88
4 High	124	58
	$\chi^2 = 3.31$	$\chi^2 = 1.26$
Quartiles of strain vector distance		
1 Low	120	94
2	66	57
3	96	91
4 High	86	91
	$\chi^2 = 4.11$	$\chi^2 = 1.08$

* χ^2, 2 df from Cox proportional hazards models with age.

logic demands, the highest level of decision latitude, and the lowest level of strain. These patterns were statistically significant for the vector distance score ($p < 0.05$) and of borderline significance for the decision latitude score ($p = 0.07$). There were no meaningful patterns of associations for the more traditional Japanese men with good language ability. Interaction terms of language ability times the job scores were not significant in Cox models. The results from multivariate analyses including the major coronary heart disease risk factors were quite similar. Similar analyses were performed among subsets of the men grouped by birthplace and socioeconomic status, but no meaningful patterns of associations were revealed. All of the above analyses were also performed for the total cohort using weights for the number of years at different occupations, and the results were similar to the those presented here.

DISCUSSION

The findings of this study reveal no association between long-term exposure to high strain job situations and the 18-year incidence of coronary heart disease in a cohort of men of Japanese ancestry living in Hawaii. Not only do our findings offer no support for the hypothesis that men in jobs with the characteristics of high-demand, low-control work have an increased risk of coronary heart disease, but they reveal a trend opposite to that predicted by the job strain model. Furthermore, there was no evidence that the high strain interaction or the individual elements of psychologic demands or job control were related to any of the major risk factors known to predict coronary heart disease in this cohort. These results differ from several previous investigations which have tested this specific hypothesis (12–15, 21, 22).

Disagreements among studies provide an opportunity to make evaluations and modifications of the hypothesis for future testing. When we compare the negative results of our study with the positive results of the others, there are at least three possible explanations for the differences: study biases, different methods, and the possibility that the effects of potential stress are specific to certain occupational situations or cultural characteristics.

Besides the obvious differences in case definition and the use of incidence versus prevalence rates, the major methodological difference among the studies is that of measuring job strain. The study of Swedish men by Karasek et al. (12) and a study in Finland (21) used questionnaire responses which measured the perceptions of the study subjects themselves to determine the job characteristics. Two other studies in Sweden (13, 14) used preexisting questions from a 1977 survey of working men to characterize 118 occupational groups which

were then applied to jobs of the study subjects. While the linkage methodology was the same, the questions on job characteristics were different.

Only one published study involving two US cross-sectional survey groups (15) and one prospective study among a subset of Framingham subjects (22) have used the same method used in this study. The results of both of these studies supported the hypothesis, although there was evidence that the association of job strain scores and coronary disease was due to association with other risk factors in the Framingham Study. Thus, while there are major differences in determination of strain exposure status, there is no pattern which suggests that the contrasting results can be explained by this problem.

There are also methodological differences which relate to the problem of study bias. All but one of the previous studies used the current occupation of the study subjects without any concern for the person's usual job or for the number of job changes. Such categories can include a bias of "occupational drift" in which healthy persons move into less stressful jobs while ill persons do not. Karasek et al. (15) have argued against some types of selection bias in their prevalence study; however, without information on occupational history, the extent of such a problem cannot be known.

The use of current occupation can also result in confusion due to the mixed effects of occupational mobility. Syme et al. (23) have reported that men who change jobs frequently have a higher risk of coronary disease than men who do not. Men in high-strain occupations (e.g., waiters, cooks, and freight handlers) can be much more occupationally mobile than those in low-strain jobs (e.g., forest rangers and epidemiologists). The use of men in this study who reported that their current and usual occupations were the same placed more emphasis upon chronic exposure to a stable set of work conditions and was less likely to be affected by occupational drift or the effects of occupational mobility. This appears to be a major concern which needs to be addressed in future studies.

The age at risk of the Hawaii cohort, aged 45–68 years at entry, is another source of difference. Several of the other studies on persons from ages 20–65 years have shown stronger associations between job strain and indicators of cardiovascular disease in younger men, with little excess risk beyond age 55 (13–15). We found no significance for an age-strain interaction term in multivariate analysis, but if such an interaction exists it could account for the lack of association of occupational strain and incident disease in this study.

The cultural and regional differences in working conditions and the workers themselves are also potential problems in studying the effects of occupational stress. This study is based upon a cohort of men of Japanese ancestry living in Hawaii. Their scores for stressful working conditions were based solely on their job titles through linkage to scores developed from national surveys. It is possible that the actual working conditions to which this cohort was exposed were not accurately represented by this method in spite of the fact that the mean values of job characteristics were similar to other US samples. It is also possible that the strain phenomenon is unique to highly industrialized or other specific types of jobs which are uncommon in Hawaii. If true, then this is a limitation on the validity of the model because if the scores are not independent of specific jobs then the whole approach of using scores is open to question.

It is also possible that these men have different needs, desires, and perceptions about job control and demands. To the extent that actual or perceived working conditions of any group differ from the US sample of employed men used to develop the job characteristics scoring system, the possibility for classification error and conflicting results increases. The different pat-

terns of results shown by the men divided into Westernized and traditional Japanese groups indicate that such cultural differences can affect the associations.

Interpretations of the findings from this study are thus limited by the use of an indirect estimate of job strain that may not reflect real perceptions of job strain in this group. While we can conclude that the results measured by this indirect method are contrary to the hypothesis, we do not know what the results would have been if we had directly questioned the study subjects about their job characteristics.

Had the findings been supportive of the hypothesis, we might have recommended widespread use of this easily applicable method for other cohorts. However, in light of the unresolved questions above, it would seem more useful in future studies to make direct measurements of perceived job conditions. In retrospect, the advice of Kasl in a review of one of the first reports on occupational strain seems most appropriate: "Perhaps the most challenging next step will be to develop new tailor-made measurement procedures which are designed to reflect closely the theoretical formulations regarding job decision latitude and job demands" (5, p. 684).

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