Lack of Predictability at Work and Risk of Acute Myocardial Infarction: An 18-Year Prospective Study of Industrial Employees

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Objectives. We examined whether the distinctive components of job control—decision authority, skill discretion, and predictability—were related to subsequent acute myocardial infarction (MI) events in a large population of initially heart disease–free industrial employees.

Methods. We prospectively examined the relation between the components of job control and acute MI among private-sector industrial employees. During an 18-year follow-up, 56 fatal and 316 nonfatal events of acute MI were documented among 7663 employees with no recorded history of cardiovascular disease at baseline (i.e., 1986).

Results. After adjustment for demographics, psychological distress, prevalent medical conditions, lifestyle risk factors, and socioeconomic characteristics, low decision autonomy ($P<.53$) and skill discretion ($P<.10$) were not significantly related to subsequent acute MI. By contrast, low predictability at work was associated with elevated risk of acute MI ($P=.02$). This association was driven by the strong effect of predictability on acute MI among employees aged 45 to 54 years.

Conclusions. Prospective evidence suggests that low predictability at work is an important component of job control, increasing long-term risk of acute MI among middle-aged employees. (*Am J Public Health.* 2008;98:2264–2271. doi: 10.2105/AJPH.2007.122382)

Cardiovascular diseases account for approximately 40% of deaths in developed countries.[1] Acute myocardial infarctions (MIs) account for nearly half of all the cardiovascular mortality.[2] According to current knowledge, acute MI is predicted by not only well-known risk factors, such as smoking and lack of physical activity, but also psychosocial factors.[3]

Most working-age adults in industrialized countries spend about one third of their waking hours at work during an average period of more than 30 years.[4] Work environments often entail various stressful characteristics.[5] Correspondingly, recent reviews proposed that adverse work-related psychosocial risk factors may contribute to poor cardiac health.[6,7]

In occupational epidemiology, the job strain model[8] has dominated research on cardiovascular risk factors. This model postulates that a combination of high work demands and low control at work (i.e., job strain), if prolonged, increases the risk of heart disease. Although some follow-up studies have supported this model,[9,10] many large-scale prospective studies with null findings also have been reported.[11–14] Poor job control may be more detrimental to heart health than high job demands,[15] but evidence on the independent predictive role of job control in coronary heart disease is scarce and mixed.[13,16,17]

Several factors may explain the conflicting findings. First, dimensions of job control, such as decision authority (i.e., decision latitude concerning one's work pace and phases, and independence from other workers while carrying out tasks) and skill discretion (i.e., the level of cognitive challenges and variety of tasks at work), could contribute differently to health outcomes.[18] Predictability on the job (i.e., the clarity of work goals and opportunity to foresee changes and problems at one's work) has been suggested to represent a further component of job control, but empirical research on this component is largely lacking.[19–21] Predictability involves relatively high stability of work and a lack of unexpected changes, which characterized the earlier industrial era which had stable production systems.[22] Predictable outcomes are less common in today's turbulent work life; thus, lack of predictability may represent a salient health hazard[23,24] and may contribute to myocardial risk.[25]

Second, research indicates that physiological stress, especially exposure to long-term environmental stressors, can cause detrimental prolonged neurohormonal reactions as well as pathological physiological changes by adversely affecting the process of atherosclerosis,[16,26,27] thereby increasing the risk of acute MI.[28,29] However, most prospective studies on stressful work environment and subsequent cardiovascular disease have used follow-up periods of less than 10 years[6,7] or have studied all-cause cardiovascular outcomes rather than mortality and morbidity resulting from acute MI.[9] Thus, potential long-term effects of work-related psychosocial factors on acute MI events have not been examined.

Third, age may play a role in the association between job strain and acute MI risk. Weaker effects have been found among older workers; plausible reasons for this are healthy worker survivor bias; retirement during follow-up may remove job strain and cause exposure misclassification (i.e., healthier older employees survive, retire, and are no longer exposed to work-related characteristics); and an increasing number of other age-related causes of acute MI.[30] Among younger employees, job strain may be associated with shorter exposures to harmful job characteristics than among middle-aged employees. Long-term prospective age-specific studies are therefore needed to determine whether current psychosocial risks of work environment predict acute MI events and whether the influence of work characteristics is stronger among middle-aged employees.

The objective of our 18-year follow-up study was to examine whether the distinctive components of job control—decision authority, skill discretion, and predictability—were related to subsequent acute MI events in a large population of initially heart disease–free industrial employees after the effects of established risk factors were taken into account. We further tested age-specific vulnerability among these employees.

METHODS

Study Population

Data for our analyses originated from the Still Working Study, a prospective cohort study assessing health and potential risk factors at baseline and data on 18-year mortality and morbidity among private-sector industrial employees within a multinational forest industry corporation, with domicile in Finland.[31]

A questionnaire on work-related psychosocial factors and health-related factors was sent to all 12173 (69% blue-collar workers) employees in Finland in winter to spring 1986. In all, 9292 employees (response rate=76%) responded to the questionnaire. Most of the white-collar employees were managers, foremen, supervisors, secretaries, technical designers, and laboratory technicians. The blue-collar employees usually worked as machine operators, maintenance workers, cleaners, or laboratory assistants.

The employees initially free from heart disease who responded to the survey, who had worked in the company for at least 24 months before the survey, and who could be identified from the database of the National Population Register Centre were included in the study cohort of 1716 female and 5947 male employees (total=7663). At the beginning of the study, the mean age was 40 years (range=18–65 years), and the average organizational tenure was 16 years (range=2–45 years).

Baseline Screening

Data on age, marital status, and gender were obtained from the National Population Register Centre, and occupational status was obtained from the employers' registers.[32] Lifestyle risk factors were measured at baseline. Smoking was measured with the question, "Do you smoke?" The response format was "Never smoked," "I used to smoke, but I have quit," and "Yes." Alcohol use was measured with the question, "How often do you drink to the point of feeling intoxicated?" The response format was "Never," "Less than once a year," "A few times a year," "Once a month," "A couple of times a month," "Once a week," "A couple of times a week," and "Daily or nearly daily." Physical activity was measured with the question, "How often do you exercise in your free time?" The response format was "Daily or almost daily," "Once a week," "A couple of times a month," "A few times a year," and "Never."

To indicate potential biomedical risk factors, information on all persons who were eligible for reimbursement of medicine because of hypertension (yes vs no) or diabetes (yes vs no) before the assessment of psychosocial factors (1964–1986) was obtained from the Drug Imbursement Register held by the Social Insurance Institution, Finland. This national registry covers all information on entitlement to reimbursed drugs relating to chronic illnesses. Employees eligible for reimbursement for the previously mentioned reasons and all those employees who had been admitted to the hospital because of cardiovascular problems (*International Classification of Diseases, Ninth Revision* [*ICD-9*][33] codes 390–449) between 1972 and 1986 (n=341) were excluded from the final study population (data derived from the Hospital Discharge Register).

We also used a 10-item scale (α=.89) to measure psychological distress (yes vs no) at baseline. The employees assessed their symptoms, such as anxiety, insomnia, and depression, during the previous weeks. Finally, we measured traditional exposures at work, such as vibration, noise, and abnormal temperature, with an 11-item checklist. The question format was "Are the following elements present in your work environment?" (1=I am not disturbed by it or not at all; 2=somewhat disturbing, 3=very disturbing or hazardous to my health). The presence of 1 or more hazards indicated physically hazardous work.[34]

Assessment of Psychosocial Risk Characteristics at Work

Job characteristics were assessed with the Occupational Stress Questionnaire.[35] Decision authority (α=.79) was measured with 5 items (e.g., "Can you plan your work by yourself?"). Skill discretion (α=.82) was measured with 5 items (e.g., "Is your work monotonous or variable?"), and predictability (α=.68) at work was assessed with 5 items (e.g., "Can you anticipate the problems and disturbances arising in your work?"). The measure of predictability specifically assesses the clarity of work goals, ability to foresee work problems, work awareness (i.e., knowledge on how one's work tasks are related to the whole work process) as a whole, and the significance of work disturbances to work process and work outcome. These characteristics were measured on a 5-point scale (1=well to 5=very little). The convergent and construct validity of the scales has been found to be good, and these variables have been shown to predict various types of health outcomes such as subjective functional capacity and medically certified sickness absence.[22,34,36–38]

To test the 3-factor structure in this cohort, we created an unrotated principal component matrix and applied a rotation matrix with a varimax criterion. The analysis confirmed the 3-factor structure: the 5 items measuring decision latitude and autonomy loaded on the first factor (decision authority; component loadings from 0.40 to 0.76), the 5 items measuring task variety and knowledge use formed the second factor (skill discretion; component loadings from 0.52 to 0.72), and the 5 items measuring the general awareness, goal clarity, and anticipation of problems composed the third factor (predictability; component loadings from 0.49 to 0.64). All cross-loadings of the items representing separate dimensions were lower than 0.39.

Ascertainment of Acute Myocardial Infarction

Participants' personal identification numbers (a unique number assigned to each Finnish citizen) were used to determine acute MI through hospitalization and mortality registers. Data on fatal acute MI were obtained from a register maintained by Statistics Finland, offering virtually complete population mortality data. The causes of death were coded according to *ICD-9* in 1987 to 1995 and according to *International Statistical Classification of Diseases, 10th Revision* (*ICD-10*),[39] in 1996 to 2004. Information on the basic cause of death was used.

Data on nonfatal acute MI were obtained from the Hospital Discharge Register maintained by the National Research and Development Centre for Welfare and Health. The register contains dates of admission and discharge and ICD codes for primary and subsidiary diagnoses collected from Finnish hospitals. Information on both primary and subsidiary diagnoses was used.

Date and cause of death or date and cause of hospital admission for all participants who died or were admitted to the hospital between January 1, 1987, and December 31, 2004, were obtained. *ICD-9* code 410 indicated death or hospital admission because of acute MI.

Statistical Analysis

The sum scales were formed by using factor analysis, and their reliability was assessed with Cronbach's α. Means and standard deviations of psychosocial characteristics were computed for each cardiovascular risk factor. We used the paired *t* test as a preliminary way of comparing the study groups (Table 1).

Associations between baseline characteristics, psychosocial work characteristics, and acute MI were assessed with Cox proportional hazards regression models (Tables 2–4). For each participant, person-days of the follow-up were calculated from January 1, 1987, until death, hospitalization because of acute MI, or December 31, 2004, whichever came first. The time-dependent interaction terms between each predictor and logarithm of the follow-up period were all nonsignificant, confirming that the proportional hazards assumption was justified (all *P* values > .70). The use of categorical job control variables (tertiles) in the models provided evidence of the linear association between the psychosocial risks and acute MI (the highest risk of acute MI was found when the level of the characteristic was low and vice versa). In the tested models, the psychosocial risks were modeled as continuous, and models were run separately for each psychosocial predictor. Adjusted hazard ratios and 95% confidence intervals (CIs) were calculated. The results provide risk estimates of mortality and morbidity caused by acute MI associated with a 1–standard deviation decrease in standardized work-related psychosocial risk measures at baseline (mean = 0; SD = 1).

At the first stage, hazard ratios and 95% confidence intervals were adjusted for age (18–44 years, 45–54 years, 55 years or older), gender, marital status (married vs not married), hypertension (yes vs no), diabetes (yes vs no), psychological distress (yes vs no), lifestyle risk factors (smoking vs nonsmoking; binge drinking twice or more per month vs less than twice per month[40]; physical exercise twice or more per week or once a week vs less than once a week), and physical work environment (hazardous vs no hazards) at baseline.

At the second stage, the psychosocial variables were additionally regressed together with educational attainment (no vocational education, vocational school or equivalent vs vocational school or college) and occupational status (blue-collar vs white-collar employee; model 2). All of these analyses also were performed separately for the 3 age groups, and

TABLE 1—Psychosocial Factors Among 7663 Employees Free of Cardiovascular Disease at Baseline, by Baseline Characteristics: Still Working Study, Finland, 1986

	Skill Discretion, Mean (SD)	*P* for Trend	Decision Authority, Mean (SD)	*P* for Trend	Predictability, Mean (SD)	*P* for Trend
Age at baseline, y		<.001		<.001		.96
18–44	3.31 (0.82)		3.57 (0.82)		3.80 (0.62)	
45–54	3.32 (0.82)		3.56 (0.86)		3.80 (0.66)	
55–64	3.51 (0.70)		3.84 (0.81)		3.81 (0.67)	
Gender		<.001		<.001		<.001
Women	2.88 (0.80)		3.32 (0.85)		3.56 (0.67)	
Men	3.45 (0.77)		3.87 (0.81)		3.87 (0.61)	
Occupational status		<.001		<.001		<.001
White collar	3.75 (0.73)		3.94 (0.66)		3.94 (0.62)	
Blue collar	3.12 (0.77)		3.41 (0.85)		3.74 (0.63)	
Educational attainment		<.001		<.001		<.001
Vocational school/college	3.92 (0.71)		4.08 (0.63)		4.04 (0.60)	
Vocational school	3.39 (0.80)		3.59 (0.77)		3.82 (0.62)	
No vocational education	3.05 (0.74)		3.40 (0.87)		3.70 (0.64)	
Marital status		<.001		<.001		<.001
Married	3.41 (0.81)		3.62 (0.82)		3.83 (0.63)	
Unmarried	3.12 (0.80)		3.48 (0.84)		3.74 (0.64)	
Smoking status		.004		.02		<.001
No	3.35 (0.80)		3.60 (0.83)		3.78 (0.64)	
Yes	3.28 (0.84)		3.55 (0.85)		3.86 (0.63)	
Alcohol use[a]		.26		.15		.23
No	3.33 (0.82)		3.58 (0.83)		3.80 (0.64)	
Yes	3.30 (0.81)		3.54 (0.82)		3.83 (0.62)	
Physical activity		<.001		.36		.007
More than once per week	3.32 (0.81)		3.58 (0.82)		3.81 (0.64)	
Once per week	3.38 (0.81)		3.60 (0.81)		3.83 (0.62)	
Less than once per week	3.28 (0.82)		3.57 (0.86)		3.77 (0.65)	
Prevalent hypertension		.29		.15		.86
No	3.32 (0.82)		3.58 (0.83)		3.80 (0.64)	
Yes	3.37 (0.75)		3.65 (0.81)		3.81 (0.62)	
Prevalent diabetes		.08		.13		.05
No	3.32 (0.81)		3.58 (0.83)		3.80 (0.64)	
Yes	3.51 (0.82)		3.74 (0.81)		3.97 (0.60)	
Psychological distress		<.001		<.001		<.001
No	3.39 (0.80)		3.64 (0.82)		3.88 (0.61)	
Yes	3.13 (0.84)		3.41 (0.84)		3.58 (0.66)	
Physical work environment		<.001		<.001		<.001
No hazards	3.47 (0.78)		3.74 (0.78)		3.86 (0.62)	
Hazardous	3.16 (0.82)		3.41 (0.85)		3.74 (0.65)	

[a]Frequency of binge drinking: no = less than twice per month; yes = twice or more per month.

TABLE 2—Cox Proportional Hazard Ratios (HRs) and 95% Confidence Intervals (CIs) for Acute Myocardial Infarction (MI), by Conventional Risk Factors: Still Working Study, Finland, January 1, 1987, to December 31, 2004

	No. (No. of Acute MIs)	HR (95% CI)	*P*
Age at baseline, y			<.001
18–44	5055 (133)	1.00	
45–54	2189 (196)	3.99 (3.12, 4.84)	
55–64	419 (43)	4.77 (3.38, 6.74)	
Gender			<.001
Women	1716 (24)	1.00	
Men	5947 (348)	4.88 (3.23, 7.39)	
Occupational status			.88
White collar	2490 (123)	1.00	
Blue collar	5173 (249)	1.02 (0.82, 1.26)	
Educational attainment			.13
Vocational school/college	3270 (167)	1.00	
Vocational school	3295 (161)	1.36 (0.98, 1.91)	
No vocational education	1098 (44)	1.25 (0.89, 1.74)	
Marital status			.51
Married	5436 (292)	1.00	
Unmarried	2227 (80)	0.92 (0.71, 1.18)	
Smoking status			<.001
No	5127 (199)	1.00	
Yes	2536 (173)	2.14 (1.74, 2.63)	
Alcohol use			.67
No	6662 (328)	1.00	
Yes	1001 (44)	0.93 (0.68, 1.28)	
Physical activity			.15
More than once per week	2745 (151)	1.00	
Once per week	2527 (124)	1.13 (0.86, 1.47)	
Less than once per week	2391 (97)	1.28 (1.00, 1.65)	
Prevalent hypertension			<.001
No	7343 (333)	1.00	
Yes	320 (39)	1.89 (1.35, 2.66)	
Prevalent diabetes			<.001
No	7607 (359)	1.00	
Yes	56 (13)	5.03 (2.88, 8.78)	
Psychological distress			.17
No	5676 (265)	1.00	
Yes	1987 (107)	0.86 (0.68, 1.07)	
Physical work environment			.83
No hazards	4020 (200)	1.00	
Hazardous	3643 (172)	1.02 (0.83, 1.26)	

Note. Models were adjusted for age and gender.

the test for age interaction was conducted after adjustment for all covariates and main effects of age and psychosocial risk.

To estimate the potential effect of subclinical cardiac problems on subsequent acute MI, we carried out subsidiary analyses after excluding the participants who died or were hospitalized because of acute MI within the 4-year follow-up after the assessment of psychosocial factors (by 1990) and observed changes in the hazard ratios (follow-up from January 1, 1990 to December, 31, 2004). The analyses were conducted with the TPHREG procedure in the SAS 9.1 statistical software package (SAS Institute Inc, Cary, NC).

RESULTS

During the mean follow-up of 17.1 (range=0–18.0) years, 56 deaths from acute MI and 316 hospital admissions because of acute MI (372 onsets of acute MI) were documented among the participants who had been free from cardiovascular disease at baseline according to the medical records. Of the persons who had an acute MI, 55% died before they were admitted to the hospital. Altogether, 706 study participants died during the follow-up. In the data, 271 of the deaths and 1115 of the hospital admissions were related to cardiovascular problems (*ICD-9* codes 390–449).

Table 1 shows the associations of covariates with studied psychosocial factors. It shows lower levels of skill discretion, decision authority, and predictability for employees with lower occupational status and for women. A higher prevalence of psychological distress was found in those with low levels of skill discretion, decision authority, and predictability. The bivariate correlation between skill discretion and decision authority was rather strong (r=0.56), but other correlations between psychosocial risks were moderate (r=0.30–0.35).

Table 2 shows age- and gender-adjusted associations of demographic, occupational, educational, behavioral, biomedical, physical, and psychological risk factors with acute MI. As anticipated, older age, male gender, smoking, low levels of physical activity, hypertension, and diabetes increased the risk of acute MI. However, blue-collar status, low educational level, frequent binge drinking, high psychological distress, and being unmarried were not associated with significantly elevated acute MI risk.

Table 3 presents the relative hazards for acute MI by levels of the components of the psychosocial work environment. Excess risks were observed for low predictability at work but not for low decision authority or low skill discretion (model 1). After additional adjustment for educational attainment and occupational status, low predictability remained

TABLE 3—Multivariate Cox Proportional Hazards Models and 95% Confidence Intervals (CIs) for Acute Myocardial Infarction (MI) at Baseline and at 4-Year Follow-Up, by Levels of Work Characteristics: Still Working Study, Finland, January 1, 1987, to December 31, 2004

Work Characteristic	Model 1,[a] Hazard Ratio (95% CI)	Model 2,[b] Hazard Ratio (95% CI)
	Population at baseline	
Skill discretion	1.10 (0.98, 1.23)	1.11 (0.98, 1.26)
Decision authority	1.04 (0.93, 1.15)	1.04 (0.93, 1.16)
Predictability	1.13 (1.02, 1.26)	1.13 (1.02, 1.26)
	Population after 4 y	
Skill discretion	1.11 (0.99, 1.25)	1.12 (0.98, 1.28)
Decision authority	1.06 (0.95, 1.18)	1.06 (0.94, 1.19)
Predictability	1.13 (1.01, 1.27)	1.13 (1.01, 1.26)

Note. At baseline, sample number was 7663 and the number of acute MIs was 372. After 4 years, the sample number was 7580 and the number of acute MIs was 337. In this population, the follow-up was 1990–2004.
[a]Adjusted for age, gender, marital status, prevalent hypertension, prevalent diabetes, psychological distress, smoking status, alcohol use, and physical activity at baseline.
[b]Additionally adjusted for occupational status and educational attainment at baseline.

TABLE 4—Age-Group Stratified Multivariate Cox Proportional Hazards Models and 95% Confidence Intervals (CIs) for Acute Myocardial Infarction (MI) at Baseline and at 4-Year Follow-Up: Still Working Study, Finland, January 1, 1987, to December 31, 2004

	Employees Aged 18–44 y	Employees Aged 45–54 y	*P*[a]
	Population at baseline		
Population (no. of acute MIs)	5055 (133)	2189 (196)	
Work characteristic, HR (95% CI)			
Skill discretion	1.11 (0.90, 1.33)	1.14 (0.95, 1.35)	.61
Decision authority	0.96 (0.79, 1.16)	1.12 (0.97, 1.31)	.23
Predictability	1.00 (0.84, 1.20)	1.24 (1.07, 1.43)	.06
	Population after 4 y		
Population (no. of acute MIs)	5025 (127)	2152 (171)	
Work characteristic, HR (95% CI)			
Skill discretion	1.11 (0.94, 1.43)	1.13 (0.93, 1.36)	.77
Decision authority	0.99 (0.82, 1.20)	1.15 (0.98, 1.35)	.32
Predictability	1.00 (0.83, 1.21)	1.25 (1.07, 1.46)	.09

Note. HR = hazard ratio. Adjusted for continuous age, gender, marital status, prevalent hypertension, prevalent diabetes, psychological distress, smoking status, alcohol use, physical activity, occupational status, and educational attainment at baseline.
[a]Test for age group interaction.

associated with an elevated risk of acute MI (model 2). The models also were tested with the fully adjusted models, including all dimensions of job control. A 1-SD decrease in standardized predictability increased the hazard ratio to 1.12 (95% CI=1.00, 1.25; *P*=.05), whereas the associations related to other dimensions were nonsignificant. When the items of decision authority and skill discretion were combined to form a measure of job control (α=0.86) without predictability, the effect on acute MI was nonsignificant (model 2: hazard ratio=1.09; 95% CI=0.96, 1.23). However, when the items representing predictability were included in the variable (α=0.84), the effect of job control became significant even after all adjustments (model 2: hazard ratio=1.14; 95% CI=1.01, 1.28).

Table 4 shows the age-specific effect of predictability on acute MI among employees who were likely to stay at work for most of the follow-up (younger than 55 years). A 1-SD decrease in predictability was associated with a 1.24-times increase in the risk of acute MI among the middle-aged cohort, although no significant association was found among younger employees (test for age interaction, *P*<.06). As expected, among employees older than 54 years, lack of predictability was not a significant determinant of acute MI (hazard ratio=1.00; 95% CI=0.69, 1.46). These results prevailed in the fully adjusted models, including all dimensions of job control.

As Tables 3 and 4 show, a stratified analysis among employees who were alive 4 years after the assessment of psychosocial work characteristics indicated similar associations between these psychosocial factors and acute MI between 1990 and 2004.

DISCUSSION

This 18-year follow-up study showed that low predictability at work was an important psychosocial risk factor for acute MI. Low predictability remained an independent predictor of acute MI after adjustment for established demographic, lifestyle, educational, occupational, physical, and biomedical risk factors. The age-stratified analyses suggested that the effect of predictability on acute MI was driven by effects seen among middle-aged employees. These findings broaden the evidence on potential pathogenic components of job control at work.

Many theories of occupational stress in the late 20th century regarded job control as a central component of stress process.[8,16] Most of the previous studies on psychosocial factors of work and cardiovascular health, often reporting equivocal results, have used decision authority and skill discretion as components of job control (decision latitude).[9–14] It is likely that several independent, but yet unrecognized, psychosocial risk factors, which cannot be regarded exclusively as elements of the traditional job control concept, may affect heart health. In line with some recent studies,[19,41] our findings indicate that contemporary organizational environments may entail specific risk features, such as unpredictable changes,[23] that may be more important risks to cardiac health than are the traditional dimensions of job control.

Inability to anticipate and foresee future changes may have become a particularly salient health risk factor in today's rapidly changing work life.[41–43] Also, our measure of predictability may be more relevant in reference to nonspecific stress-alleviating coping resources such as compensability and manageability of work environment than are more-specific task-related measures of job control. Overall, future-oriented understanding of the whole work process might make one's work more meaningful, decreasing the risk for chronic strain and its potential consequences, such as acute MI.

Low predictability influenced the risk of acute MI among middle-aged individuals. This is in agreement with the results from 2 large-scale cohort studies.[30,44] Given the better physical health and a shorter average duration of exposure to adverse work characteristics among the younger employees, the younger age cohorts may be less vulnerable to stressful characteristics of work than are the middle-aged cohorts. Among the oldest employees, the association between work characteristics and acute MI can disappear because of healthy-worker bias, retirement during follow-up, or masking of increased number of age-related risk factors. Hence the inclusion of older employees and younger employees in the cohort may have diluted the association between predictability and acute MI.

Predictability at work may affect acute MI though various processes. Potential underlying physiological mechanisms include increases in sympathetic nervous system activity that lead to cardiac instability,[45] high catecholamine excretion,[26] and glucocorticoid secretion.[28] Mental strain caused by poor predictability may elevate the risk of hypertension[44] and metabolic syndrome,[46] decrease heart rate variability,[28] reduce myocardial blood supply,[43] and stimulate platelet activation.[47] These factors have shown to be closely associated with cardiac events.[41,48–52]

Limitations

There are at least 5 limitations of this study. First, for employees with stable work characteristics, a single time measurement may provide an accurate estimate of long-term stress, but this is not necessarily the case for all employees.[53] However, the risk of inaccurate measurement of job characteristics is less probable in the sector investigated than in many other sectors because it has traditionally been rather stable with regard to psychosocial characteristics because employees are trained to do specific tasks.[31] However, environmental characteristics of some employees may have been altered during the follow-up because of organizational changes and other transitions, attenuating the associations between psychosocial explanatory variables and acute MI toward null.

Second, the main analyses included only 1 dimension of job control at a time. Because other dimensions of job control may confound the tested associations, this procedure may increase the risk of reporting false-positive results (undercontrol). However, corresponding results derived from models including all dimensions of job control confirmed that predictability at work affects subsequent acute MI even after conservative adjustments.

Third, we had no information on body mass index, dietary habits, or family history of cardiovascular disease. These factors might have partly confounded the associations. However, previous studies have shown that these types of biological, behavioral, and genetic risk factors have a rather independent role in the process of heart disease with regard to psychosocial characteristics.[9,13] It is therefore unlikely that these factors would have significantly altered the relation between the psychosocial predictors studied and myocardial end point. However, some unexplored factors such as excessive occupational exposure, low household income, and very long working hours may have contributed to cardiovascular risk and confounded the associations. Our long-term study also may have been partly hampered by the measures of health behavior assessing exclusively the frequency of nonspecified physical activity and binge drinking. Recently developed measurements of physical activity[54] and alcohol consumption[55] probably would assess the cardiovascular risk more adequately.

Fourth, undiagnosed heart disease may have affected our results. To control reversed causality by potential effects of subclinical heart disease conditions, we repeated our survival analyses within a subpopulation of employees who were alive 4 years after the assessment of psychosocial factors and did not have acute MI during that time. The results remained essentially the same. This may indicate that associations were not explained by poor subclinical heart health at baseline.

Fifth, although the study populations represented rather well the Finnish private industrial sector in terms of work tasks and overall work environment, further research is needed to determine whether our results are generalizable to other settings.

Conclusions

Our data suggest that low predictability at work are associated with an increased risk of subsequent acute MI among middle-aged industrial employees. This research adds a potentially important component to the body of evidence showing an effect of job control on a severe myocardial end point. Predictability at work should be taken into account in future research on job control and workplace interventions to reduce psychosocial adversity at work. ■

About the Authors

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Contributors

A. Väänänen was the principal author, designed the hypotheses, coordinated the project, and conducted the data analysis. A. Koskinen and M. Joensuu coordinated the project with A. Väänänen, designed and collated the data, assisted with the data analysis, and contributed to the writing of the article. M. Kivimäki and P. Jäppinen took part in the study design, contributed to the interpretation of the data, and edited the article. J. Vahtera and A. Kouvonen advised in the analyses, contributed to the drafting of the article, and helped in the interpretation and presentation of the results.

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Human Participant Protection

All study phases were approved by the ethics committee of the Finnish Institute of Occupational Health.

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