

Workplace Organization and Cardiovascular Disease Risk

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Topics

- Context to work-related stress
 - Epidemic of cardiovascular disease
 - Changing organization of work
- Theoretical models of stress
 - Historical development of stress models
 - Major theoretical models of stress
- Summary of research findings
- Implications for clinical assessment, prevention, and intervention

Epidemic of Hypertension and CVD

Worldwide CVD Epidemic

- Cardiovascular disease (CVD) is the major cause of morbidity and mortality in industrialized world.
- Dramatic increases in CVD morbidity and mortality over the last 30 years in the former Soviet Union and Eastern European countries.
- Rising prevalence rates in many developing countries.

CVD in the United States

- In the United States, CVD is the cause of 41% of all deaths.
- 250,000 - 350,000 people annually die suddenly of heart disease.
- 250,000 people lose their lives each year more slowly due to chronic CVD.
- The prevalence of hypertension remains high in the U.S. (3/4 of African-Americans and more than half of whites aged 60-74).

Traditional Medical Approach

- Focuses on:
 - individual traits, especially genetic susceptibility
 - risk behaviors (smoking, diet, sedentary lifestyle, etc.)
- Primary strategies to curtail the CVD epidemic are:
 - better management of atherogenic risk factors
 - use of medical treatments and technological advances
 - research into molecular biology of atherogenic and other cardiodegenerative processes

Limitations of Traditional Approach

- While biomedical models are highly sophisticated, our understanding of the etiology of CVD and our ability to manage the epidemic are still limited.
- Traditional risk factors are “proximate” causes; each of them has a complex set of determinants, many of which are of psychosocial origin.

Social Epidemiology Approach to Understanding CVD Etiology

- Increased recognition of importance of behavioral factors and social experiences.
- Emergence of social epidemiology as a field which examines social factors as more distal causes or modifiers of disease processes.
- Social epidemiologists have demonstrated that lower socioeconomic status is an important risk factor. However, general social conditions still do not fully explain all the variance in CHD.

Social-Historical Context of Work-related Stress and CVD

- Both CVD and hypertension appear to be of relatively recent historical origin.
- While CVD mortality in industrialized countries has declined over the past 40 years, CVD incidence has shown little or no decline over the past 20 years.
- Several individual risk factors for CVD have been identified; however, many cases of CVD do not occur in “high risk” individuals.

Organization of Work

Work Organization

- Refers to the work process and organizational practices that influence job design.
 - management style, production methods, and human resource policies
- Also includes external factors, such as the legal and economic environment and technological factors, that encourage or enable new organizational practices.

Work Organization

External Context

Economic, legal, political, technological, and demographic forces

- Economic developments (e.g., globalization)
- Regulatory, trade, and economic policies (e.g., deregulation)
- Technological innovations
- Changing worker demographics and labor supply



Organizational Context

Management structures, supervisory practices, production methods, and human resource policies

- Organizational restructuring (e.g., downsizing)
- New quality and process management initiatives (e.g., lean production, just-in-time)
- Alternative employment arrangements (e.g., contingent labor)
- Work/life/family programs and flexible work arrangements
- Changes in benefits and compensation systems

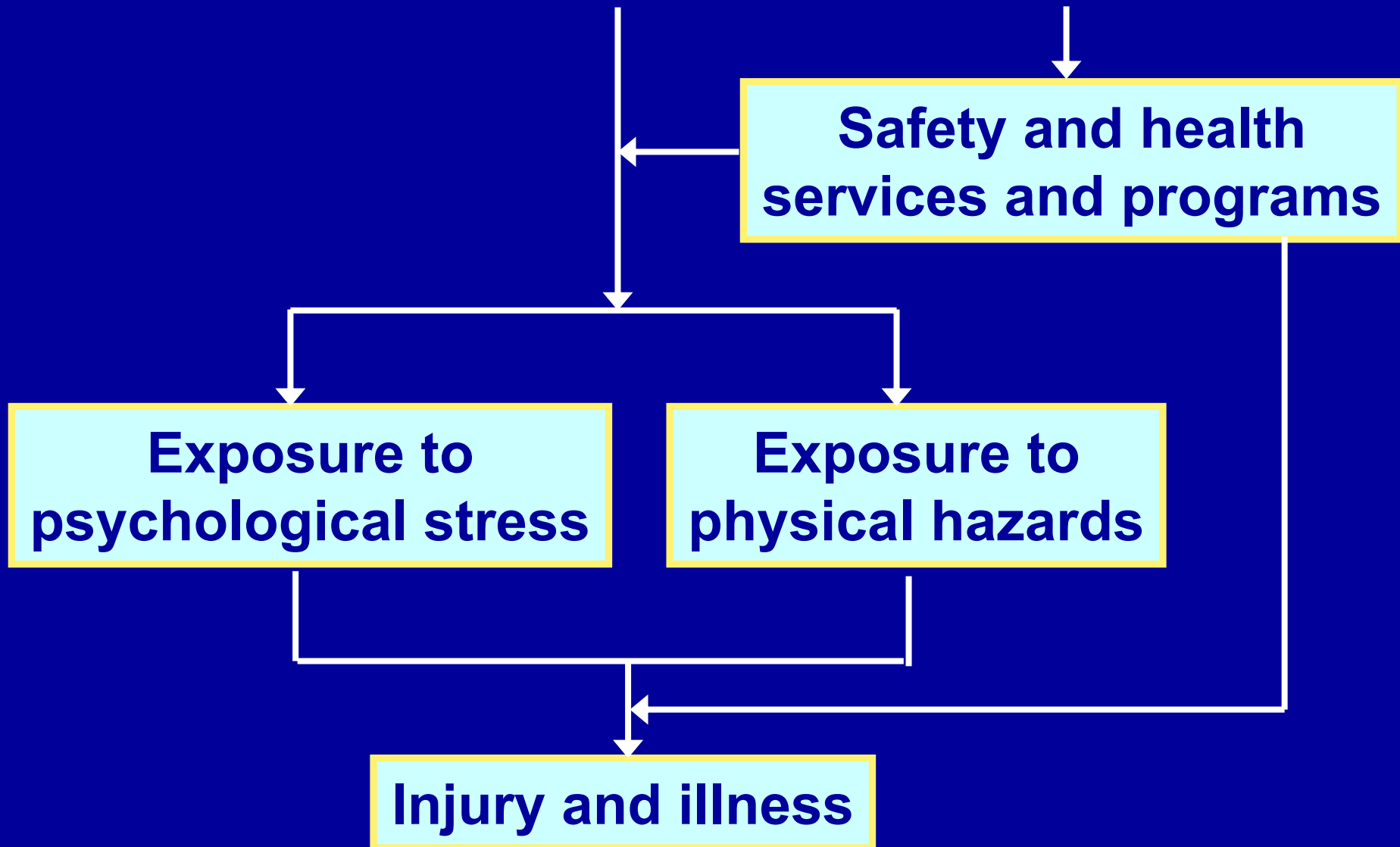


Work Context

Job characteristics

- Task attributes: temporal aspects, complexity, autonomy, psychological demands
- Social-relational aspects of work
- Career development

Organization of work can influence



Changes in the Organization of Work over the Past 200 Years

- Craftwork has been replaced by industrial processes.
- Skilled workers have been replaced by lower - skilled labor in new machine-based production.
- Taylorism reshaped workplace with it's emphasis on narrow performance and efficiency using the technique of the assembly line, at the expense of broader employee knowledge of the work process.
- White collar work, through office automation, has been shaped by principles of the assembly line.

Current Trends in Working Conditions

- Tele-working and increased use of information and communication technology
- Downsizing, outsourcing, subcontracting and globalization, with the associated change in employment patterns
- Demands for workers' flexibility, both in terms of number and function or skills
- Increasing proportion of the population working in the service sector
- Longer work weeks
 - In Europe, in 1996, 23% of those employed were working >45 hours per week.
 - In U.S., average weekly work hours increased by 3.5 to 47.1 hours from 1977 to 1997.

NIOSH Statement on the Changing Organization of Work

Revolutionary changes in the organization of work have far outpaced our knowledge about the implications of these changes for the quality of working life and for safety and health on the job. This gap in knowledge is one of the 21 priority areas for research under the National Occupational Research Agenda (NORA).

NIOSH Statement on the Changing Organization of Work

Research and development needs:

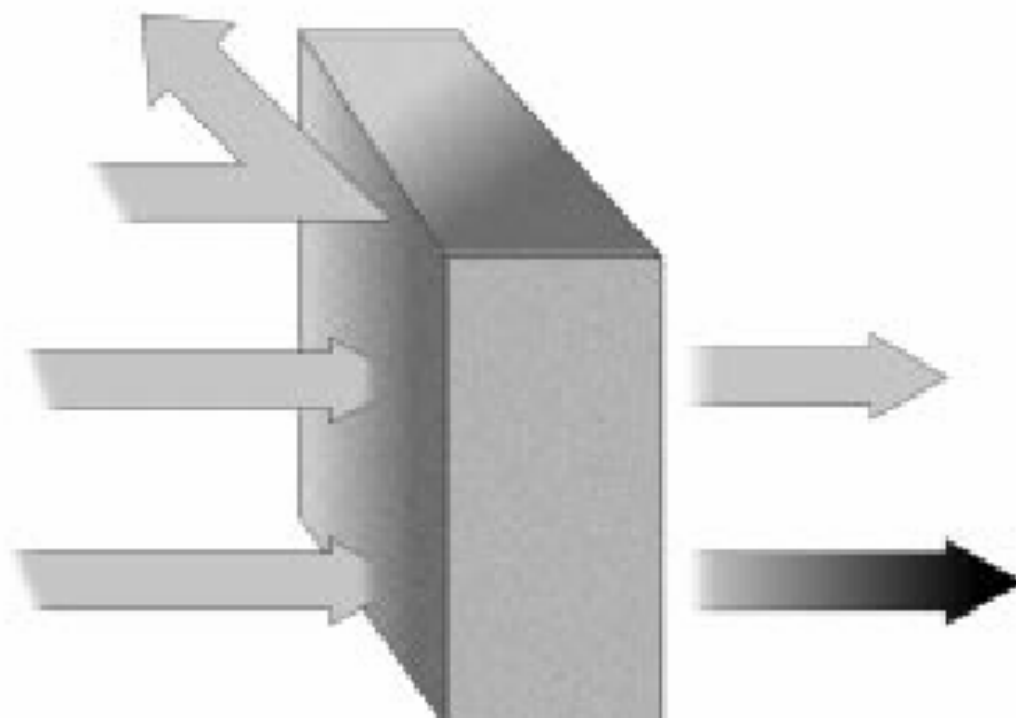
- Improved surveillance mechanisms to better track how the organization of work is changing.
- Accelerated research on safety and health implications of the changing organization of work.
- Increased research focus on organizational interventions to protect safety and health.
- Steps to formalize and nurture organization of work as a distinctive field in occupational safety and health.

Work-Related Psychosocial Stress

NIOSH Definition of Job Stress

The harmful physical and emotional responses that occur when the requirements of the job do not match the capabilities, resources, or needs of the worker. Job stress can lead to poor health and even injury.

**Stressful
Job
Conditions**
(Stressors)



**Individual and
Situational Factors**

**Risk of
Injury
and
Illness**

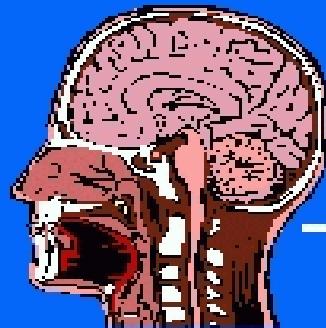
Emergence of Stress Concept

- Initial stress theories were developed to describe the reactions of organisms to acute stress in situations threatening biological survival.
 - *e.g., Walter Cannon, 1914 – fight or flight*
- Many of the initial stressors studied were uncontrollable events to the subjects.
- Focus was on response of an individual to an environmental stressor.

Walter Cannon: Homeostasis/Fight or Flight




Threatening
Event




Sympathetic branch of
Autonomic Nervous System

Adrenal Medulla
(Endocrine Gland)

Epinephrine
Norepinephrine
(Stress hormones)



↑ Heart Rate
↑ Blood Flow
↑ Respiration
↑ Muscle
Strength



Energy is Mobilized,
prepares for
vigorous
muscle
activity

Hans Selye's "General Adaptation Syndrome"

Stress is a biological response caused by all noxious stimuli (nonspecificity):



Person-Environment (P-E) Fit model

- Developed in the early 1970s by researchers at the University of Michigan,
- States that strain develops when there is a discrepancy between the motives of the person and the supplies of the environment (job), or between the demands of the job and the abilities of the person to meet those demands.

Current Leading Models and Issues in Work-Related Stress

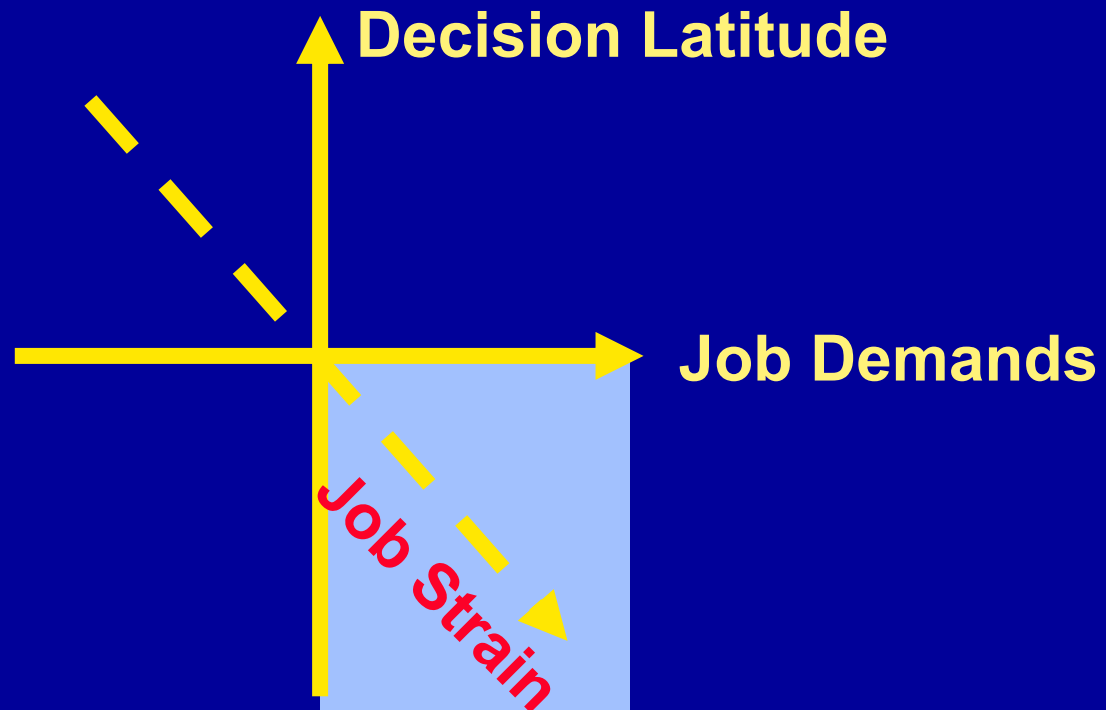
- **Job Strain** - high psychological work demands with low job decision latitude (control).
- **Effort-Reward** - mismatch between high workload (demand) and low control over long-term rewards.
- **“Threat-avoidant” vigilant work** – continuously maintaining a high level of vigilance in order to avoid disaster.
- **Long work hours and shift work**

Job Strain Model of Work Stress

- Psychosocial model that relates work organization to physiological outcomes
- Relevant to social changes in the organization of work during past century
- Validated model, well-operationalized

Job Strain (Karasek)

Combination of: HIGH psychological job demands and LOW job decision latitude



Job Content Questionnaire

Psychological Job Demands

- My job requires working very fast
- My job requires working very hard
- I am not asked to do an excessive amount of work*
- I have enough time to get the job done*
- I am free from conflicting demands that others make*

*Reverse scored

Job Content Questionnaire

Job Decision Latitude (two subscales)

- **Decision authority**
 - My job allows me to make a lot of decisions on my own
 - I have very little freedom to decide how I do my work*
 - I have a lot of say about what happens on my job

*Reverse scored

Job Content Questionnaire

Job Decision Latitude (two subscales)

- **Skill Utilization**

- My job requires that I learn new things
- My job involves a lot of repetitive work*
- My job requires me to be creative
- My job requires a high level of skill
- I get to do a variety of different things on my job
- I have an opportunity to develop my own special abilities

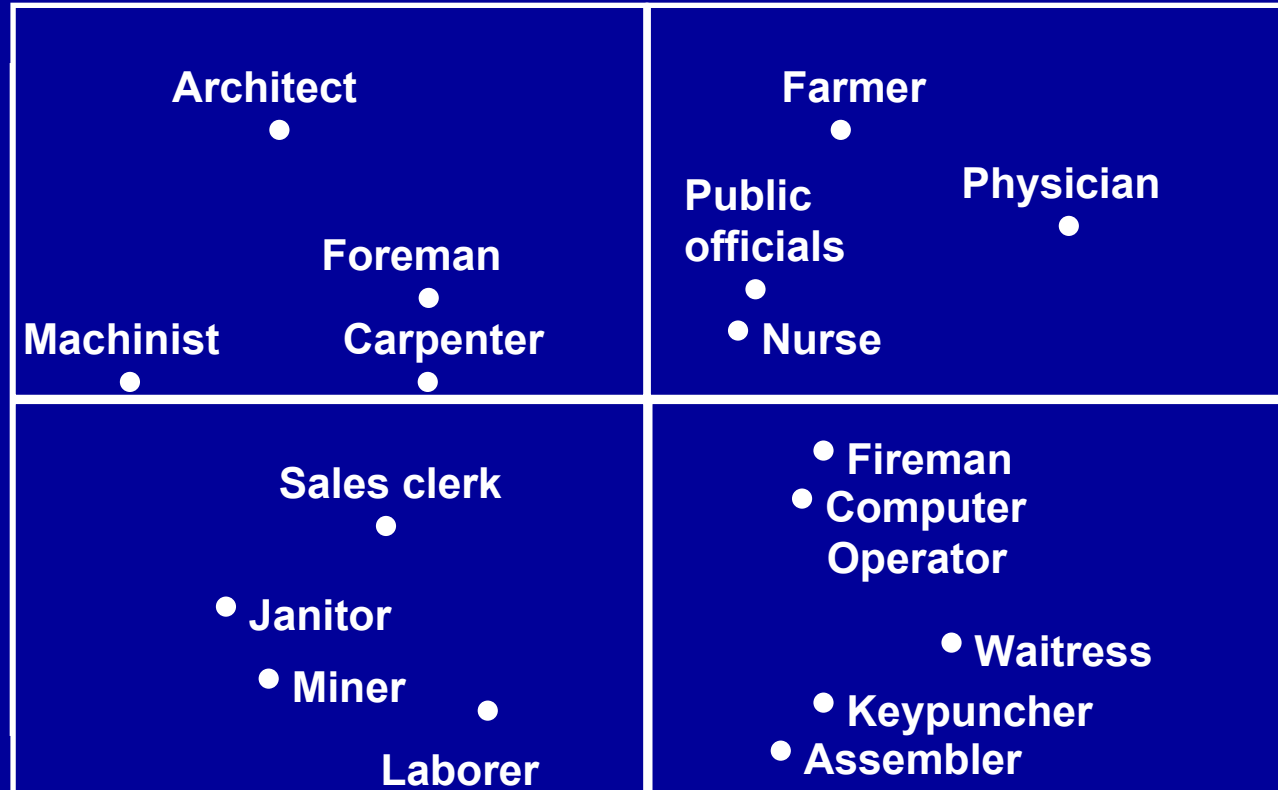
* Reverse scored

Job Demands

Low

High

High



Decision Latitude

Low

Work Stress and CVD

- Large body of epidemiological and physiological research implicates a number of workplace factors in the etiology of hypertension and CVD.
- Evidence is particularly strong with respect to exposure to high strain work and risk of hypertension and CVD.

Cardiovascular Changes Associated With Exposure to Work Stressors

- **Strongest evidence**

- ↑ workplace blood pressure (BP)
- Sustained elevations in BP
- ↑ left ventricular mass

- **Likely associations**

- Arteriosclerosis
 - Adverse metabolic responses (glucose intolerance, adverse lipid profile), ↑ fibrinogen
- Changes in heart rate (HR)
 - ↑ HR, diminished HR variability, sometimes ↓ HR

- **Possible associations**

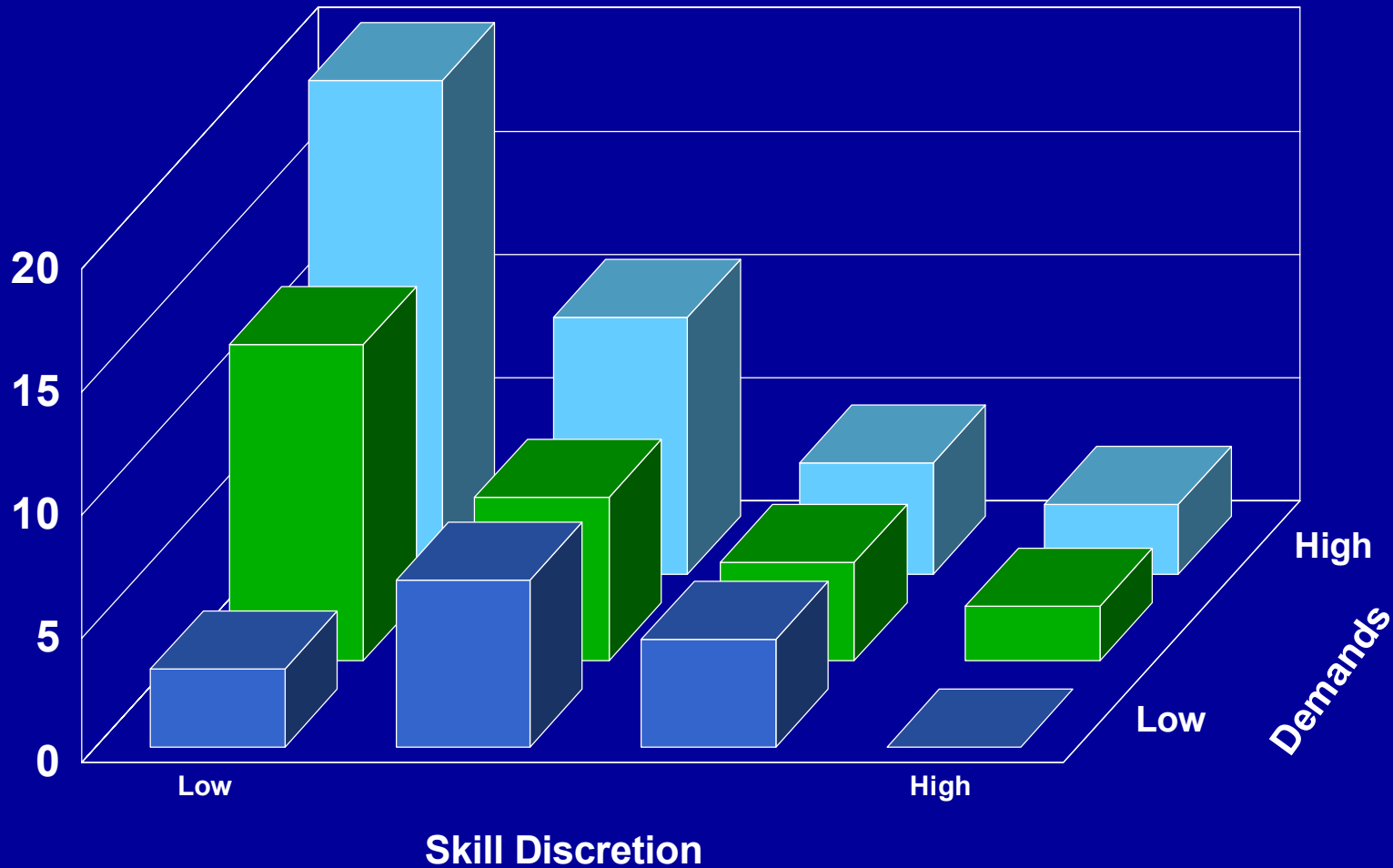
- Myocardial ischemia
- Compromise to cardiac electrical stability
- Triggering of acute cardiac events

Studies of Job Strain and Coronary Heart Disease

- **26 studies published between 1981 and 1999**
 - 16 from Sweden (many using national data bases)
 - 7 from the U.S. (2 using national data bases)
 - Also from Czech republic, Denmark, England, Finland

	<u>Significant positive associations</u>	<u>Mixed positive and null associations</u>	<u>Total # of studies</u>
Cohort studies	6	5	13
Case-control studies	2	6	9
Cross-sectional studies	4	0	5

CHD Prevalence in Swedish National Study



Karasek, Baker, et al., *AJPH* 1981

Job Strain and Risk of Myocardial Infarction

- **Study design**

- Swedish men, 45-65 y.o.
- N = 1047 cases, 1450 population controls
- Outcomes: first hospitalized and/or fatal MI

- **Result: exposure to high job strain**

- All working men: RR = 2.2 (95% CI=1.2- 4.1)
- Manual workers: RR =10.0 (95% CI=2.6- 38.4)

(Adjusted for hypertension, smoking, BMI)

Return to High Strain Work Post- MI

5-year follow-up of 79 men with first MI before age 45:

- Return to high strain work was a significant, independent predictor of IHD-related mortality.
- Predictive strength of comparable magnitude to degree of coronary atheromatosis, more powerful than left ventricular ejection fraction.
- The finding remained robust after adjustment for standard cardiac risk factors.

Theorell T, Perski A, et al. *Int J Cardiology* 1991.

Theorell T, Karasek R. *Stress Medicine* 1995.

Evidence from Prospective Studies of Job Strain and CVD

Conclusion from Review of 14 Studies*:

- The evidence, particularly among men...is strong and consistent, that an association exists between exposure to job strain and risk of CV disease.
- Since bias towards the null is present in most of these studies, the magnitude of this association appears to have been substantially underestimated.

*Is Job strain a risk factor for CVD? SJWEH April 2004 in press.

Studies of Job Strain and Blood Pressure (BP)

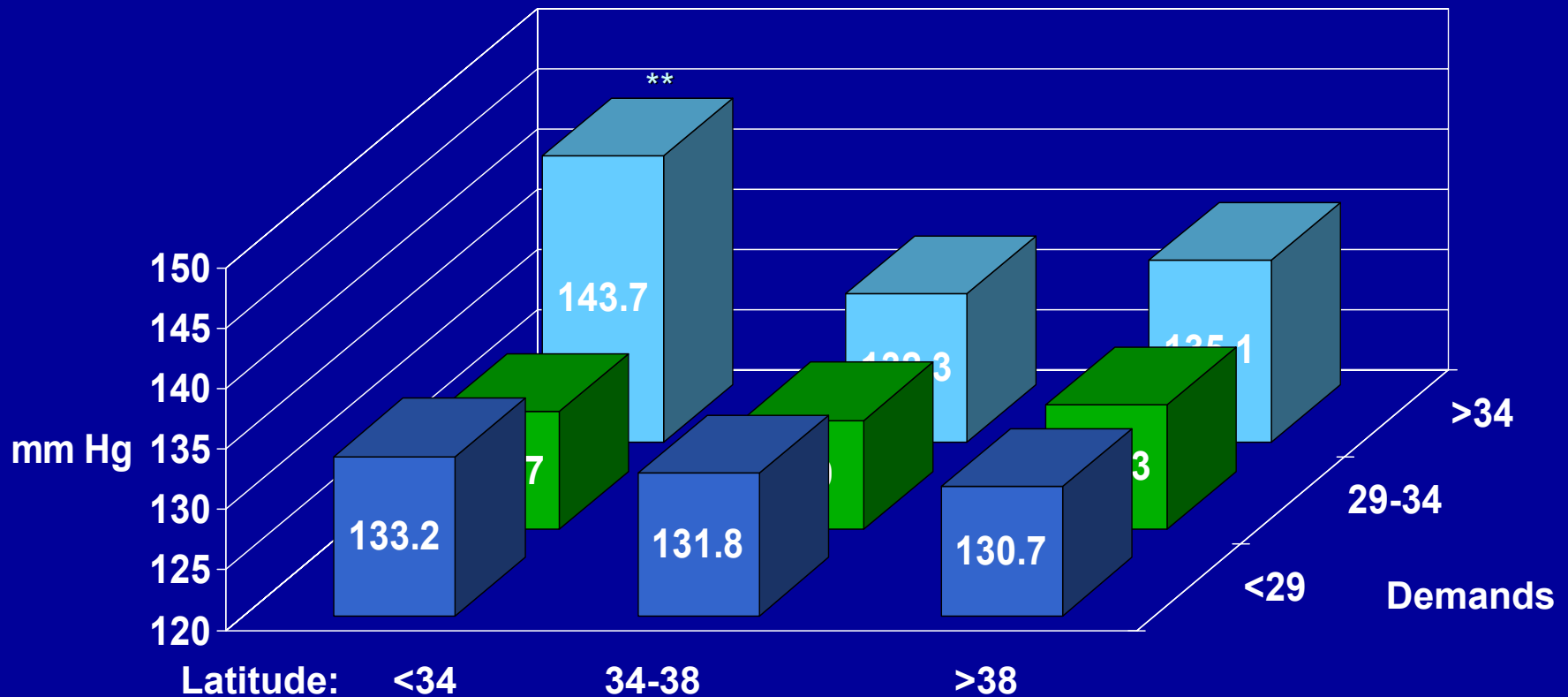
	<u>Significant positive associations</u>	<u>Mixed positive and null associations</u>	<u>Total # of studies</u>
Clinic BP	1	5	16
Ambulatory BP	6	6	14
men	4	4	12
women	1	3	6

Belkić K, et al. *Occupational Medicine: State of the Art Reviews* 2000;15:24-46.

New York City Work Site Blood Pressure Study 1985-2001

- Based at Cornell University-New York Presbyterian Hospital
- Began in 1985 as a case-control study
- 283 men initially enrolled at 8 large NYC work sites
- Became prospective study with 10 years follow-up
- 472 subjects enrolled at 10 sites (38% women)

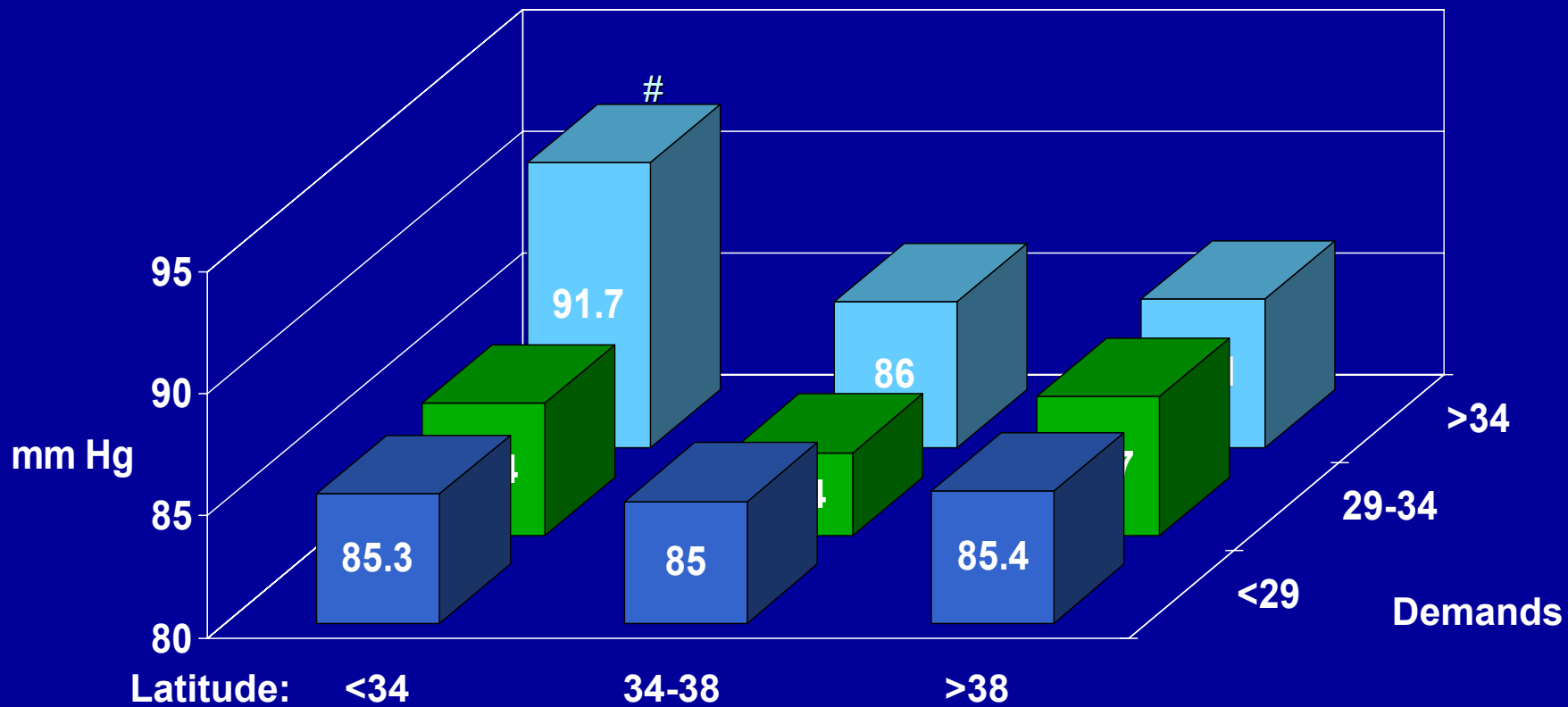
Work Ambulatory Systolic BP by Tertiles of Job Demands and Job Decision Latitude (n=208 men, Time 3)



controlling for age, body mass index, race, education, smoking, alcohol use and work site

**p<.01(vs mean of other 8 cells)

Work Ambulatory Diastolic BP by Tertiles of Job Demands and Job Decision Latitude (n=208 men, Time 3)



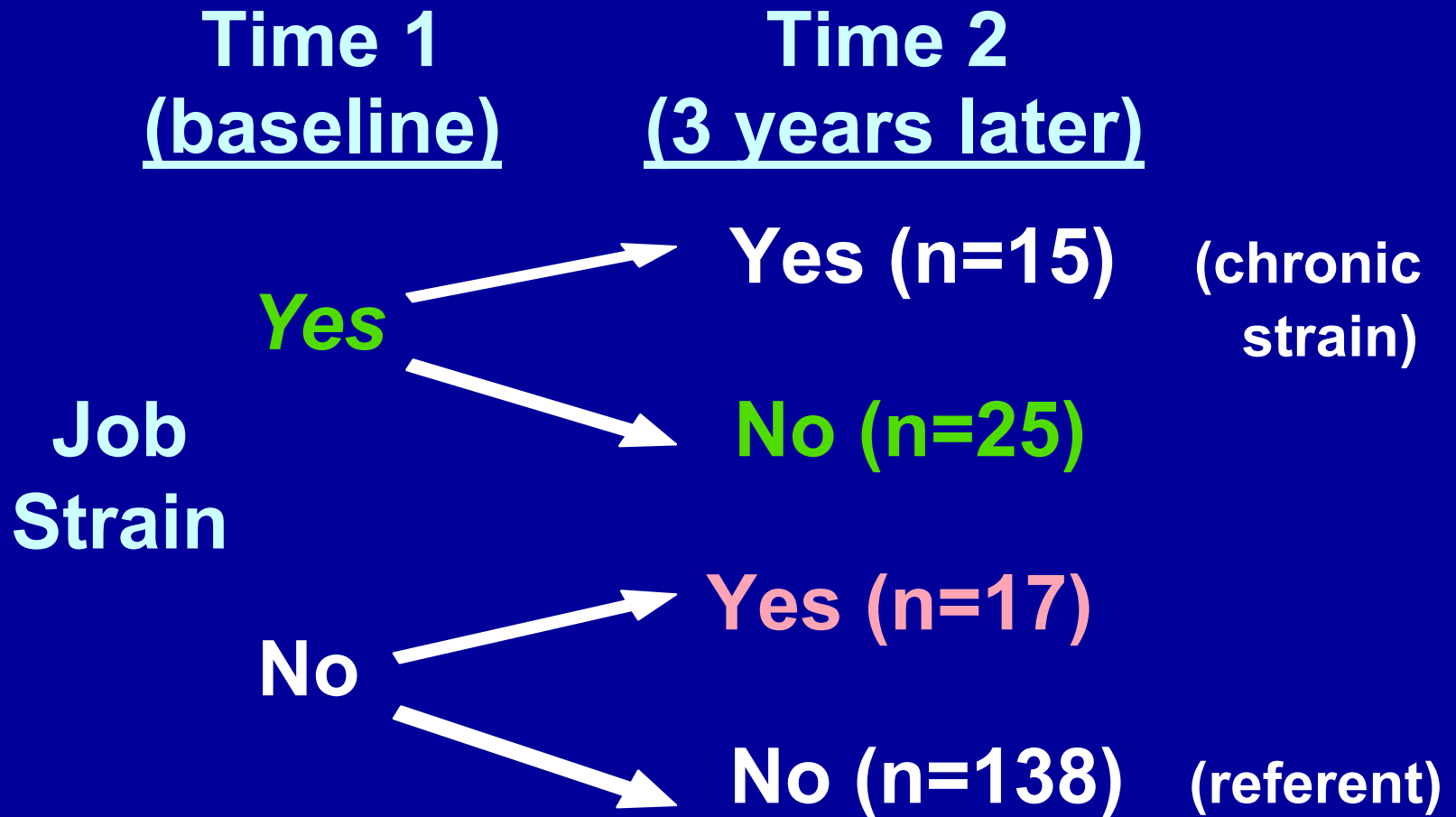
controlling for age, body mass index, race, education, smoking, alcohol use and work site

#p<.10 (vs mean of other 8 cells)

Increased LVMI with Exposure to Job Strain

LVMI increased 7.3 gm/m² in subjects with job strain compared to those without job strain (p=0.03, N=149).

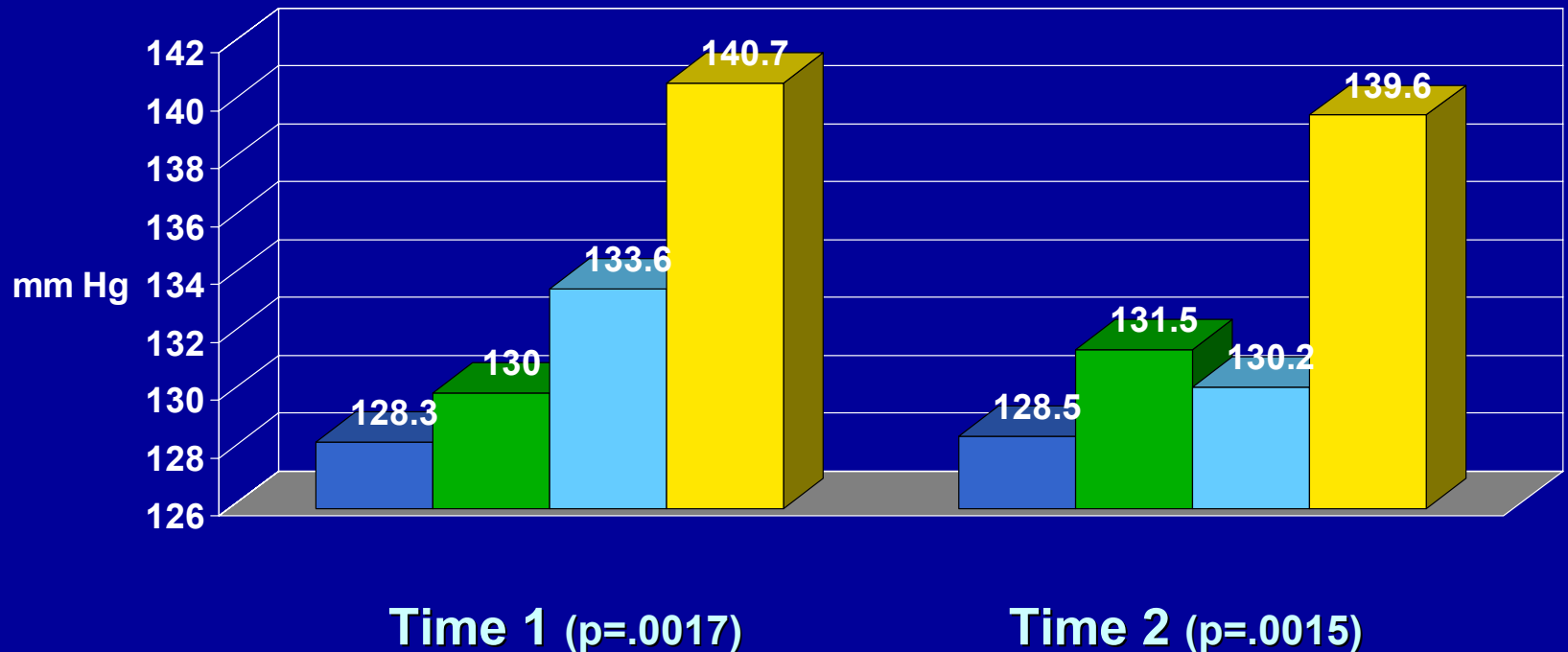
Job Strain Change Variable



Job Strain Change and Work Systolic Ambulatory BP

(n=195 men, longitudinal analyses)

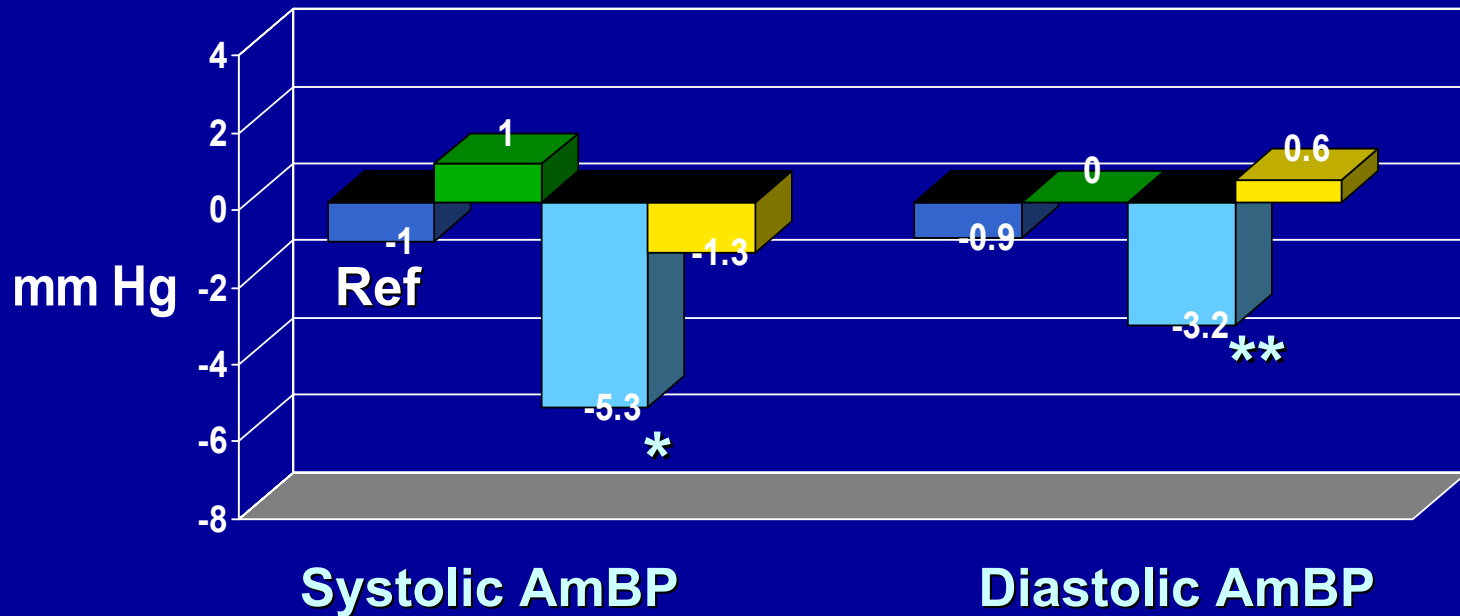
Strain-T1:	no	no	yes	yes	no	no	yes	yes
Strain-T2:	no	yes	no	yes	no	yes	no	yes



controlling for age, education, body mass index, race, smoking, alcohol use, work site

Job Strain Change and 3-yr Work AmBP Change (n=195 men, Time 1-2)

Strain-T1:	no	no	yes	yes	no	no	yes	yes
Strain-T2:	no	yes	no	yes	no	yes	no	yes



controlling for age, race, body mass index, smoking, alcohol use, work site

*p<.05, **p<.01, (vs Ref group)

Schnall et al. *Psychosomatic Medicine* 1998;60:697-706.

Historical Exposure to Job Strain and Ambulatory Blood Pressure

- 213 men aged 30-60 at entry into NYC Work Site BP study, completed Job Content Questionnaire for each past job.
- **Results**: Systolic BP of men with at least 25 years of employment and 50% of work life exposed to job strain was 5.2 mm Hg (95% CI -3.2, 13.6) higher at work and 8.2 mm Hg (95% CI 1.2, 15.3) higher at home than men with no past exposure, independent of current exposure.

Effects of Work & Job Strain on Systolic Ambulatory BP

- Work vs. non work + 5 mm Hg
- Job Strain vs. no strain + 7 mm Hg
- Repeated exposure to job strain compared to one exposure + 5 mm Hg
- Cumulative exposure prior to entering study + 5 mm Hg

Hypertension and Psychological Symptoms

- Job strain was not associated with anxiety or self-reported feelings of stress in the Cornell Worksite Study
- “Job Stress” is not a subjective perception

Job Strain and Cardiovascular Risk Factors other than Blood Pressure

(n=15 total studies)

	<u>Significant positive associations</u>	<u>Mixed positive and null associations</u>	<u>Total # of studies</u>
cigarette smoking	3	6	11
serum cholesterol or high fat intake	0	2	7
sedentary behavior	1	1	3
body mass index	1	2	5
plasma fibrinogen	2	1	4

Population Attributable Risk % for CVD due to Job Strain (based on C-S results)

<u>Study Population</u>	<u>Years</u>	<u>Study Outcome</u>	<u>% Job Strain Exposure</u>	<u>RR</u>	<u>PAR%</u>
NY City men	1985-8	High BP	21	2.8	27.4
U.S. men - HES	1960-2	MI	21.8	2.48	24.4
U.S. men - HANES	1971-5	MI	23.2	3.28	34.6
Swedish men	1976-86	CVD	20	1.9	15.3
European men & women	1996	CVD	30	1.5-2.0	13-23
Swedish men	1977-90	CVD	75 ¹	1.72	35
Danish men	1991	CVD	6 ²	2	6
Danish women	1991	CVD	16 ²	2	14

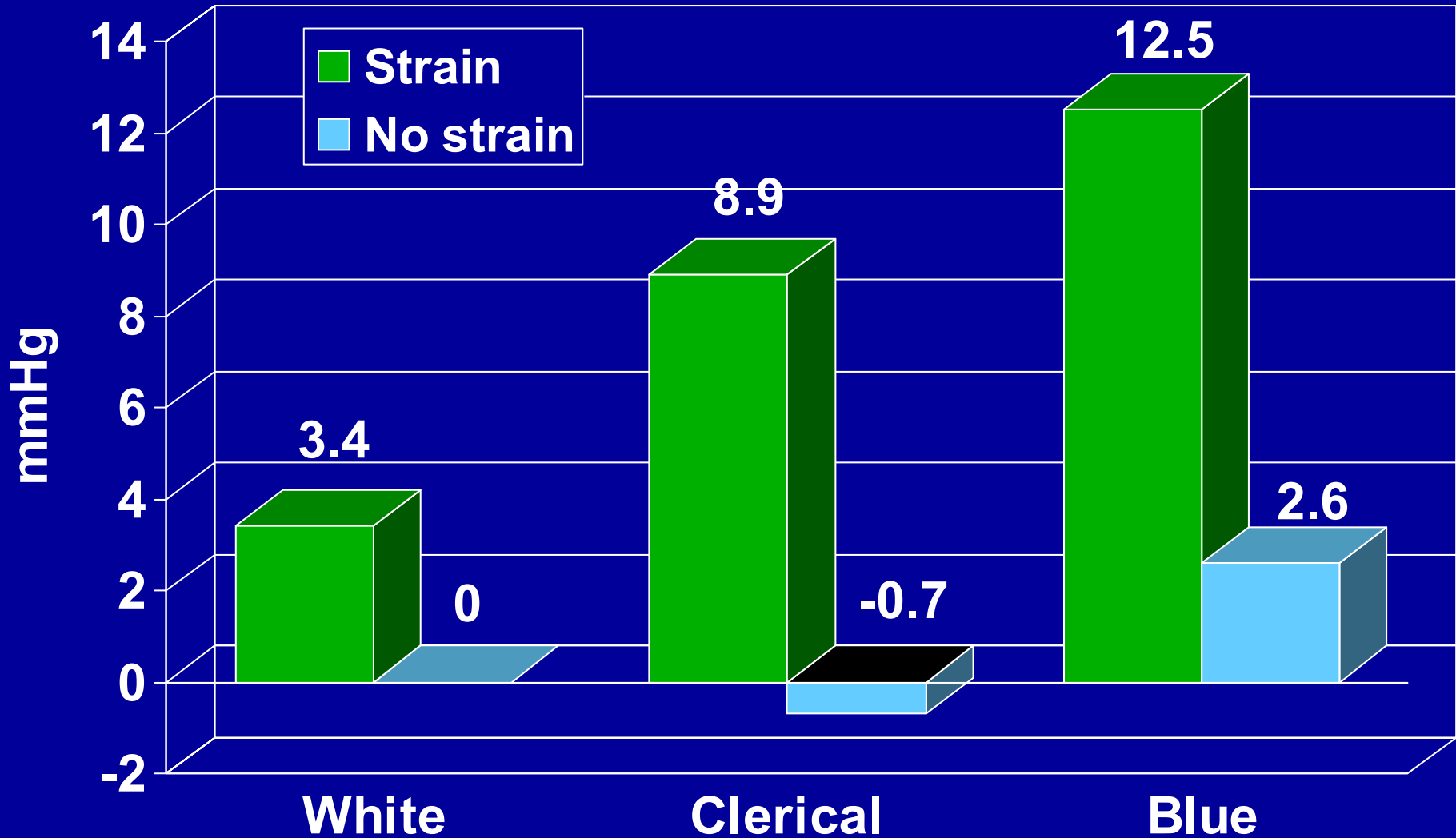
¹ exposed to medium and low work control

² exposed to monotonous high-paced work (virtually no job strain in Denmark)

Job Strain, CVD and CVD risk factors: Effect Modification

- **Stronger effects:**
 - Older Age (4 of 5 studies)
 - Lower Socioeconomic Status (8 of 14 studies)
 - Low Social Support (5 of 6 studies)
- **Similar effects for men and women:**
 - Similar effect sizes in 20 studies
 - Stronger for men in 9, while stronger for women in 9

Job Strain and Work Ambulatory Systolic BP by Occupational Status (n=283 men)



Job Strain, CVD and CVD risk factors: Methodological Issues

- **Imputation studies**
 - Positive in 8 of 12 CVD studies
 - Positive in 2 of 10 risk factor studies (+ 2 mixed)
- **Varied measures of Job Decision Latitude:**
 - Low “supervision clarity” (Framingham heart study)
 - Low income (Finnish Kuopio heart study)
- **Varied measures of Job Demands:**
 - Physical demands (Finnish factory study)
 - Low autonomy & support, responsibility, insecurity, deadlines, mental stress (Kuopio heart study)

Workplace Exposures Other than Job Strain

- Effort-Reward Imbalance
- Shift Work
- Long Work Hours
- Threat-avoidant-vigilant work (high risk groups such as bus and truck drivers)
- Physical factors (noise, heat, cold, etc.)
- Chemical factors (lead, carbon monoxide, etc.)



Effort-reward model of work stress

Johannes Siegrist and Richard Peter

Extrinsic Effort

Time pressure
Increase in workload
Interruptions
Responsibility
Piecework
Shiftwork
Noise

Intrinsic Effort

IMMERSION (Need for Control)
Need for approval
Competitiveness
Latent hostility, impatience
Inability to withdraw from work

Low Reward

Esteem Reward

Lack of respect
Inadequate support
Unfair treatment

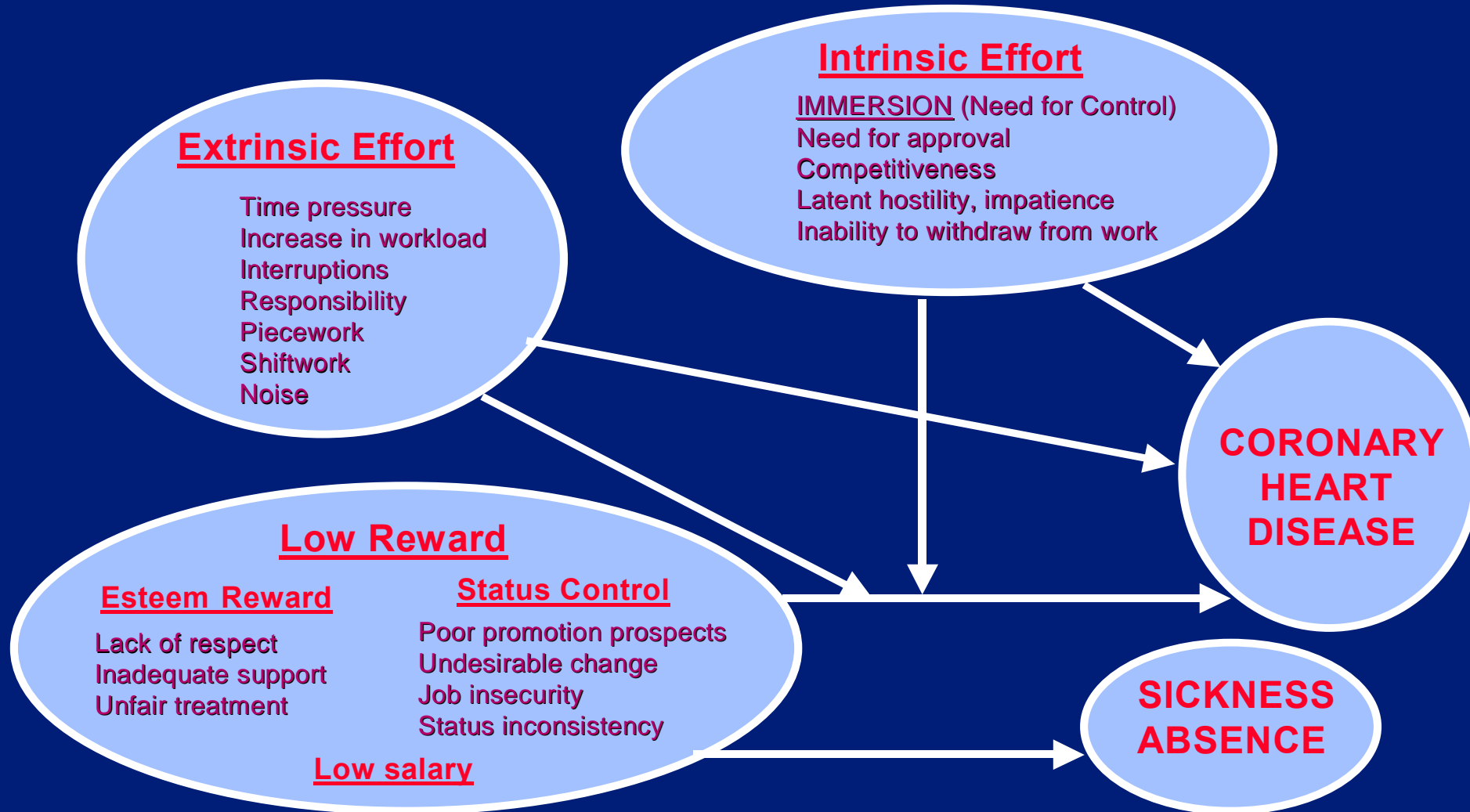
Status Control

Poor promotion prospects
Undesirable change
Job insecurity
Status inconsistency

Low salary

**CORONARY
HEART
DISEASE**

**SICKNESS
ABSENCE**



Effort-Reward Imbalance and MI

- N=2297 middle-aged Eastern Finish men
- 8.1 year follow-up
- Incident Acute Myocardial Infarction
- Exposure to: High demands, Low Resources, Low Reward
- RH=2.3 (CI=1.2-4.4)
(Adjusted for age, alcohol, smoking physical activity)

Shift Work and Risk of Acute MI

- Shift Work vs. Day work
- N=2006 cases
- N=2642 population controls

OR (95% CI)

Among those aged 45-55

- Men: 1.6 (1.1-2.4)
- Women: 3.0 (1.4-6.5)

(Adjusted for smoking, job strain, educational level)

Knutsson A, Hallqvist J, et al. *Occup Environ Med* 1999.

Long Working Hours

- Long working hours and sudden death are most likely related, but not yet well studied.
- *Karoshi* : "Sudden death from ischemic heart disease or cerebrovascular disease due mainly to physiologically demanding work conditions, such as long working hours or shift work."

Cardiovascular Changes Associated With Exposure to Work Stressors

- **Strongest evidence**

- ↑ workplace blood pressure (BP)
- Sustained elevations in BP
- ↑ left ventricular mass

- **Likely associations**

- Arteriosclerosis
 - Adverse metabolic responses (glucose intolerance, adverse lipid profile), ↑ fibrinogen
- Changes in heart rate (HR)
 - ↑ HR, diminished HR variability, sometimes ↓ HR

- **Possible associations**

- Myocardial ischemia
- Compromise to cardiac electrical stability
- Triggering of acute cardiac events

Validation of Psychosocial Approach for CVD Risk

- **Theoretical Basis**: Theoretical models predict how these factors affect the development of hypertension and CVD
- **Empirical Evidence**: Large body of research confirms the relation of workplace factors to hypertension & CVD.
- **Biological Plausibility**: Research has demonstrated mediating biological mechanisms by which work stressors are perceived & processed by the CNS, and can lead to cardio-deleterious effects.

Work Stressors and \uparrow BP (1)

I (a). The Defense Response: Acute CV Reaction

\uparrow HR, \uparrow stroke volume

\uparrow Blood flow to skeletal muscles, heart & brain

\downarrow Blood flow to kidneys, \downarrow Na excretion (\uparrow blood volume)

Overall effect = reversible \uparrow BP
(mainly systolic)

Work Stressors and \uparrow BP (2)

I (b): The Defense Response & Sustained \uparrow BP

- (i) Prolonged, repeated defense response without physical activity: No skeletal muscle vasodilatation
 - (ii) Sustained \uparrow sympathetic outflow (+ angiotensin, insulin)
→ thickening of blood vessel walls
- (i) & (ii) → **Sustained \uparrow BP** (especially diastolic)

Atherogenesis & Stress Mechanisms(1)

Early Stages:

Endothelial damage

- Animal studies of social stress
- Hypertension → ↑ shear stress at branch points

Lipoprotein incorporation into plaque-- ↑ LDL cholesterol

- Animal studies of behavioral stress
- Some human "naturalistic" studies: academic exams
- Effort-Reward imbalance (job strain data not consistent)

Atherogenesis & Stress Mechanisms(2)

Later Stages (thrombogenesis) :

↑ *Fibrinogen*, ↑ platelet aggregation, ↑ blood viscosity

- Low socioeconomic status
- Low control over work
- Effort reward imbalance

Depressed Heart Rate Variability (HRV) and Environmental Stressors:

- Heavy mental workload
- Can occur with long work hours, shift work
- Recent evidence of association with exposure to job strain or high noise levels (Van Amelsvoort 2000)

Clinical Implications

What are the clinical implications of the finding that work stressors play a role in the development of essential hypertension and CVD?

Occult Workplace Hypertension in NYC

Work Site BP Study

	Work diastolic Amb BP (mm Hg)		
	<u>>85</u>	<u>≤85</u>	<u>Total</u>
Work site casual >85 DBP Office BP's	55	24	79
Work site casual ≤85 DBP Office BP's	36	139	175

false positives = $24/79 = 0.30$ (White Coat Hypertension)

false negatives = $36/175 = 0.21 = 21\%$ of “normal population”

Occult Workplace Hypertension: Association with LVMI

- The “false negatives” had an LVMI 13g/m^2 (CI, 8-18 g/m^2) greater than those with normal waking AmBP and clinic BP's.
- Individuals with “occult hypertension” during waking life had a similar LVMI and prevalence of discrete atherosclerotic plaques compared to 64 patients with both increased clinic and AmBP (true positives). Both groups differed significantly from those with normal AmBP and normal CCBP, after adjusting for covariates.

Surveillance

“*Surveillance* at individual workplaces and *monitoring* at national and regional levels, in order to identify the extent of work-related stress health problems and to provide baselines against which to evaluate efforts at amelioration. We recommend that workplaces assess both workplace stressors and health outcomes known to result from such exposures on an annual basis.”

Return to Work

Working people are at increased risk of a repeat MI if they return to work with a job characterized by having “job strain”

Theorell, et al. *Int J. of Card* 1993

Approaches to the Prevention and Control of Stress

- **Treat the Individual**
 - Medical Treatment - hypertension, backache, depression
 - Counseling Services
 - Employee Assistance Programs - alcohol, drugs
- **Reduce Individual Vulnerability**
 - Counseling - individual, group programs
 - Training Programs - relaxation, meditation, biofeedback
 - General Support - exercise programs, recreational activities

Approaches to the Prevention and Control of Stress

- **Treat the Organization**
 - Diagnosis - attitude surveys, rap sessions
 - Develop Flexible and Responsive Management Style
 - Improve Internal Communications
- **Reduce Organizational Stress**
 - Variable Work Schedules
 - Job Restructuring - enlargement, enrichment, increased control
 - Supervisor Training and Management Development

Why Intervene at the Work Place?

- Primary intervention (i.e., aimed at workplace characteristics) will be the most effective way to prevent risk.
- Interventions located at worksite are:
 - less expensive than treatment
 - best place to lower established risk factors through behavioral techniques
 - provide cardiovascular disease prevention through work reorganization

How to Change the Organization to Prevent Job Stress

—*American Psychologist*

- Ensure that the workload is in line with workers' capabilities and resources.
- Design jobs to provide meaning, stimulation, and opportunities for workers to use their skills.
- Clearly define workers' roles and responsibilities.
- Give workers opportunities to participate in decisions and actions affecting their jobs.
- Improve communications—reduce uncertainty about career development and future employment prospects.
- Provide opportunities for social interaction among workers.
- Establish work schedules that are compatible with demands and responsibilities outside the job.

END

The UCI-STEP Project

(Surveillance, treatment & early prevention)

A comprehensive program is needed for the improvement of the psychosocial well-being and cardiovascular (as well as other) health of working people through:

- Surveillance
- Detection with referral (UCI) for evaluation & treatment of individuals with early manifestations of CVD
- Interventions at the workplace intended to reduce exposures

UCI-STEP Service Component

- A comprehensive plan of surveillance with detection of psychosocial exposures and incipient illness is provided in cooperation with interested corporations, health care providers, public agencies and labor unions
- Working people with identified problems are referred to UCI facilities for further evaluation and treatment (if necessary) by COEH and UCI Medical Center specialists

UCI-STEP Research Component

Carried out in parallel with service component to:

- Evaluate the surveillance and treatment programs
- Inform subsequent intervention and prevention programs for target populations

Observational studies of "naturally occurring" changes in the workplace can be conducted through on-going surveillance at the workplace with re-evaluation of psychosocial exposures and their relation to changes in workplace BP and other CV parameters

UCI-STEP Primary Prevention

Prevention programs will be developed:

- that focus on organizational change and changes in job characteristics
- in close collaboration with working people & management

Interventions will be informed by knowledge of the workplace accumulated over time through on-going surveillance, and implemented observational studies