Psychosocial Workplace Factors And Physiological Mechanisms Affecting The Cardiovascular System

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UCLA Work and Health

Stress Theory

- The biomedical understanding of stress began with the observation that the human body works to maintain an internal steady state (***homeostasis***) in the face of sometimes dramatic alterations in the external environment
- Research demonstrated that exposure to physical stimuli such as extremes in temperature or noise would trigger an **adaptation response** – a "hard-wired" physiological program designed to return the body's internal environment to a homeostatic equilibrium as quickly as possible

- ***Stress*** was originally defined as the give and take between the demands of the external environment and the body's efforts to maintain equilibrium (5). More recently the term ***allostatic load*** has been introduced to describe the cumulative costs to the body of these repeated and sustained adaptation efforts (5).

‘STRESS’

best understood as a ***process*** with origins in

- (1) environmental demands, which
- (2) if appraised as threatening will trigger
- (3) acute physiological reactions, that if repeated and prolonged will give rise to
- (4) biological and behavioral effects, which may lead to
- (5) long term health consequences such as chronic disease, and eventually, death.

Environmental Demands

- Although many aspects of the work environment may induce physiological adaptation responses, stress research has largely focused on threatening and challenging stimuli that promote the activation of a particular class of ***emergency reactions*** known as the "***fight or flight***" response
- These types of reactions are most likely to be triggered in work environments where high demands for performance are coupled with low levels of control over decision making (8). Researchers suggest that threats to an individual's control and/or the actual loss of that control is the key to predicting which environments will be stressful (9).
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Cognitive Appraisal

- Some researchers have suggested that environmental demands must be perceived by the individual as threatening in order to be stressful (13). However, an increasing body of research suggests that neurohormonal activation may occur even without the subjective awareness of something being 'threatening' to the individual (14). This may particularly be the case when stressful environmental conditions are a normal and routine part of an individual's experience at work.

Acute Reactions: Two distinct patterns of acute response have been identified

- ***Active Distress:*** The 'fight or flight' response is an adaptation syndrome from our hunting and gathering past that prepares us for vigorous, survival related activity (5, 6). It involves 'effortful' or active adaptation to those environmental challenges that threaten our control over valued environmental resources (9, 10). This reaction pattern involves the activation of the sympathetic adrenal medullary system by the amygdala in the brain's limbic system. Marked elevations in cathecholamine excretion (adrenaline and nor-adrenaline) are triggered with concomitant increases in testosterone, blood pressure, and heart rate.

Acute Reactions to STRESS

- If this acute reaction pattern is frequently triggered, if it is prolonged, and if return to baseline (recovery) is not rapid, then adverse pathophysiological changes are more likely to occur.

Acute Reactions to STRESS

- ***Passive Distress*:** The 'conservation-withdrawal' response is activated by environmental events or situations that involve loss or threats of loss – as in unemployment or job insecurity (9). It can also be associated with the exhaustion and emotional depletion that occurs after active efforts to adapt to environmental challenges have been unsuccessful in preventing a loss of control. This acute reaction pattern is based in the hippocampus and involves the activation of the pituitary-adrenal-cortical system with increases in cortisol, decreases in testosterone as well as increases in depressive symptoms.

Effort/Distress Model

- The Effort/Distress Model (10) suggests that the most ‘toxic’ jobs are those where both of these types of acute reactions occur simultaneously. For example, workers with high demands have high adrenaline levels, while those with low control have high levels of cortisol. Workers exposed to both high demands and low control have high levels of adrenaline and cortisol. Researchers who have developed the Effort/Distress model report that the presence of cortisol makes the cardiovascular system more vulnerable to damage from the other stress hormones (16).

The Effort-Distress Model

- **Marianne Frankenhauser and her colleagues in Sweden have confirmed the involvement of two neuroendocrine systems in the stress response**
  - **the sympathoadrenal medullary system (which secretes the catecholamines, adrenalin and noradrenalin),**
  - **and the pituitary-adrenal cortical system (which secretes corticosteroids such as cortisol).**
- **Under demanding conditions in the laboratory where the organism can exert control, i.e., in the face of controllable and predictable stressors (analogous to "active" work in the Karasek model), adrenalin levels increase, but cortisol decreases.**
- **Effort without distress is experienced.**

The Effort-Distress Model cont:

- **However, in demanding low control situations (analogous to Karasek's "high strain" jobs), where demands are perceived as excessive or threatening, both adrenalin and cortisol are elevated and effort with distress is experienced (26, 27, 57).**
- **In Frankenhauser's model, low demand-low control situations (analogous to Karasek's "passive" jobs or Seligman's concept of "learned helplessness" (1)) create feelings of depression and helplessness and elevated cortisol, although only mild elevations in catecholamines (26).**

Evidence for Effort-distress model

- Lundberg and Frankenhauser (1980) reported on a laboratory study in which healthy adults performed two tasks.
  - The first involved a one-hour monotonous vigilance task which induced effort and distress, and the second was a more enjoyable self-paced reaction time task, which required effort but did not induce distress.
  - During the monotonous vigilance task, urinary excretion of both adrenalin and cortisol increased, while during the self-paced task adrenalin increased, but cortisol levels were less than baseline (27).

Evidence for Effort-distress model

In a field study, machine-paced assembly line sawmill workers had higher catecholamine levels than self-paced workers (Frankenhauser and Gardell, 1976). In addition, the assembly line workers reported more rush and irritation during work, more psychosomatic disturbances, such as sleep disorders, gastrointestinal disorders, and general nervous symptoms than did workers with less restricted jobs, for example, maintenance and repair men (27).

More Evidence for Effort-distress model

- A field study of computer (VDT) workers, routine high-speed data entry workers had slightly higher catecholamine levels at work than a control group of typists and secretaries with fairly flexible and variable tasks including social interaction (27). The difference between groups increased in the evening at home (between 16:00 and 21:30 hours), with only the control group's levels returning to baseline. This difficulty in "unwinding" was also seen among the machine-paced sawmill workers.

- Another study in which "slow unwinding" was observed was a study of female office workers engaged in an extended period of overtime work. Adrenalin excretion was significantly elevated throughout the overtime period, both during the day and in the evening, compared to values before the overtime period. Elevated evening levels were accompanied by markedly elevated heart rate as well as feelings of irritability and fatigue (27). In another study, such slower unwinding was also observed in a sample of 15 female managers, relative to female clerical workers, or male managers (Frankenhauser et al., 1989).

Biological and behavioral effects of STRESS

- In the presence of acute or chronic stressors the body struggles to adapt. Over time this process causes the wear and tear that researchers now refer to as allostatic load (5, 6). As stress increases in frequency, intensity and duration, the efficiency in coordinating the body's adaptive responses begins to break down. Allostatic responses are no longer terminated appropriately, thereby maintaining a level of neurohormonal activation within the body long after the stress in the environment has ceased. This may explain why after exposure to years of job stress blood pressure may become permanently elevated above earlier baseline levels (18).

Allostasis

- **Allostasis, meaning literally "maintaining stability (aka as homeostasis) through change" was introduced by Sterling and Eyer * to describe how the cardiovascular system adjusts to resting and active states of the body.**
- **This notion can be applied to many physiological mediators, such as the secretion of cortisol as well as catecholamines.**
- **The concept of "allostatic load" was proposed to refer to the wear and tear that the body experiences due to repeated cycles of allostasis as well as the inefficient turning-on or shutting off of these responses (22;26).**
- **As an example of allostatic load, the persistent activation of blood pressure in dominant male cynomologus monkeys vying for position in an unstable dominance hierarchy is reported to accelerate atherosclerotic plaque formation (17).**
- **Homeostasis and allostasis provide two different explanations of hypertension – as either due to breakdown of homeostasis (internal dysregulation) or an appropriate response to chronic stressors (allostasis)**

- * Sterling and Eyer. Allostasis: A new paradigm to explain arousal pathology in Handbook of Life Stress, Cognition and Health. 1988. John Wiley and sons.

Pathophysiology from allostasis.

- *Hypertension: adaptation to sustained vigilance.*
- Roughly one-quarter of US adults are hypertensive (blood pressure >140/80 mm Hg on repeated measurement). A few cases arise from identifiably defective phenotypes (e.g., (Wilson et al., 2001), but 95% are classified as "essential" hypertension –cause unknown (Zhu et al., 2002). Prevalence is greater for African-Americans than for whites (32% vs. 23%; Carretero and Oparil, 2000a) . This difference of nearly 40% is commonly attributed to genetics, but this seems doubtful because the West African ancestors of US blacks were not hypertensive (Waldron, 1979). Furthermore, hypertension seems to be more strongly associated with various sources of social distress, rather than race *per se*.

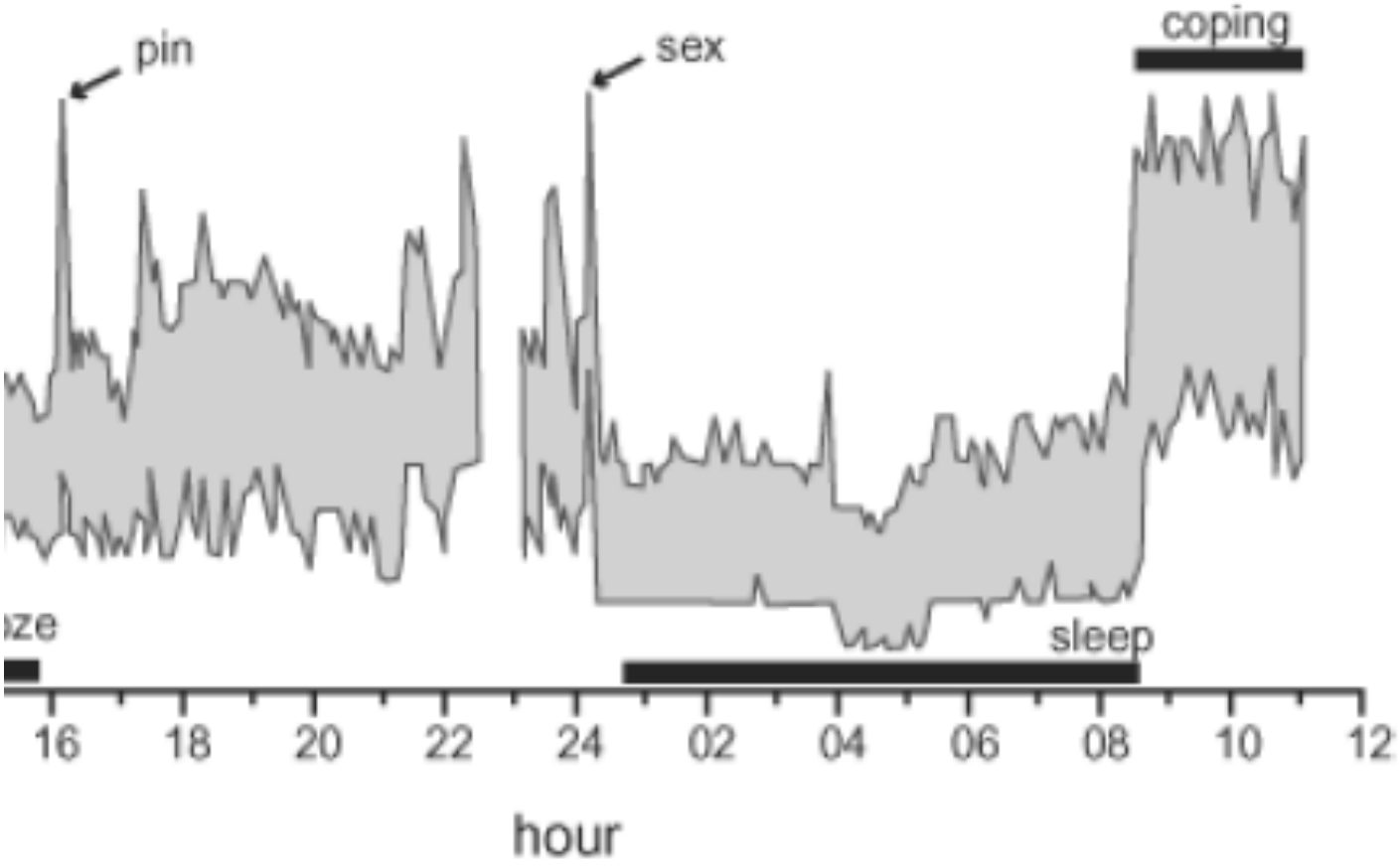


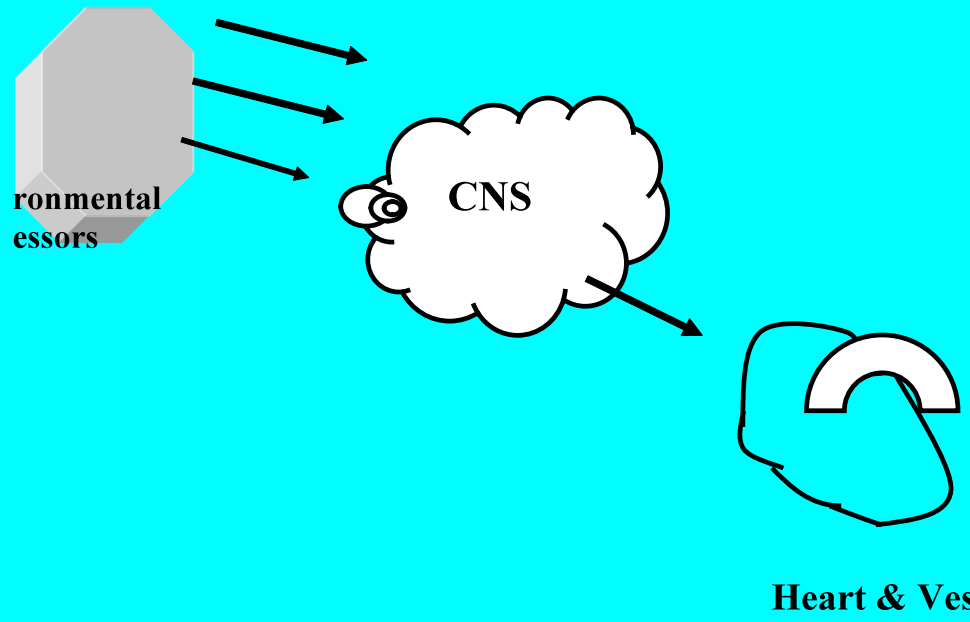
Figure 3. Arterial p
fluctuates to meet p
demand.
Pressure was plotted
adult at 5 minute int
hours. Note that pres
about equal time abo
the steady daytime l
pattern suggests, not
setpoint, but rather r
to rising and falling
trace, systolic; lower
Redrawn from Beva

- The homeostasis model cannot explain essential hypertension because it attributes all pathology to a "defect" – to something "broken". But the allostasis model suggests that there is no defect. More parsimoniously, it proposes that hypertension emerges as the concerted response of multiple neural effectors to prediction of a need for vigilance (Figure 4). When this prediction is sustained, all the effectors, both somatic and neural, adapt progressively to life at high pressure. The adaptations all seem entirely explicable from our general knowledge of signaling and regulation (Figure 5). Although the endpoint may be tragic (Figures 7, 11), every step along the path seems perfectly "appropriate".

Biological and behavioral effects

- The impact of allostatic load has been most clearly demonstrated in the cardiovascular system where chronic stress has been shown to be linked to increases in cholesterol, elevations in plasma fibrinogen, increases in heart muscle mass, disturbances in cardiac rhythm, and increases in heart rate (19). More recently researchers have examined the impact of stress-related muscle tension on the muscle skeletal system (20) and have linked the stress related modulation of the immune system to inflammatory, infectious and autoimmune disease

ECO-NEUROCARDIOLOGY:
Environment-Brain-CV System Arc



ECO-NEURO-CARDIOLOGY

”The biological paradigm by which social factors, such as work stress, are perceived and processed by the central nervous system, resulting in pathophysiological changes that increase CVD risk”

Belkic, Schnall, Landsbergis, Baker. The Workplace & Cardiovascular Health: Conclusions and thoughts for a future agenda. Occupational Medicine State of the Art Review, 2000; 15: p.313.

ECO-NEURO-CARDIOLOGY

- Renders plausible the various theoretical constructs of work stress as they relate to CVD
- Offers a framework in which to grasp how stress mechanisms give rise to various cardiovascular target organ responses
- Empirically grounded

Belkic K. The Forebrain: Central stress mechanisms and Cardiovascular Responses. Occupational Medicine State of the Art Review, 2000; 15: p. 109.

Cardiovascular Changes Associated With Exposure to Work Stressors

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

Strongest direct evidence

Cardiovascular Changes Likely Associated With Exposure to Work Stressors

- Arteriosclerosis

  Adverse metabolic responses (glucose intolerance, adverse lipid profile), ↑ fibrinogen

- Changes in heart rate (HR)

(↑ HR, diminished HR variability, sometimes ↓ HR)

Cardiovascular Changes Possibly Associated With Exposure to Work Stressors

- Myocardial ischemia

  Compromised O_2 balance in the myocardium

- Compromise to cardiac electrical stability

- Triggering of acute cardiac events

Biological Mechanisms - I

Biological Mechanisms - I
The Classical Defense Response

- Activated when called upon to actively cope with a challenge or stressor
- Prepares the organism for a physical response: ”Fight or Flight”
- Phylogenetically very old

Physiological components of the Defense Response

- Cognitive:

--Increased Alertness

--Rapid Assessment of the situation

--Rapid decision-making

- Metabolic – Energy Mobilization:

--Increased blood glucose

--Increased blood lipids

--Inhibition of anabolism

Physiological components of the Defense Response (contd.)

- Hemodynamic:

--Activation of the cardiovascular system, with blood flow directed to the heart, skeletal muscles and the brain

--Fluid and sodium retention by the kidney to maintain blood volume

--Coagulation promoted to prevent excessive bleeding with potential injury

These responses are mediated by activation of the SP nervous system, activation of sympathoadreno-medullary system (catecholamine), as well as the hypothalamic-pituitary-adrenocortical system (glucocorticoids). These, in turn, act on other hormonal systems.

The Classical Defense Response to Modern-Day Stressors?

- Many of today's stressors are likely to be chronically present rather than acute
- A physical response (fighting or running away) is rarely, if ever, called for

Key Question:

Is active coping possible and does it lead to resolution?

(Recall the Active Quadrant of the JSM)

The Gazelle versus "Civilized" Humans

- Auditory warning signal
  = hearing the predator (*Acute danger*)
- Immediate neuroendocrine & CV preparation
- Visual imperative signal
  = the predator coming close
- The gazelle's response
  = "all-out flight"
- Return to physiologic baseline

- Visual signals often predominate (*Threat often implicit, but continuous*)
- Lower grade, chronic neuroendocrine & CV preparation
- Minimal flight or fight response
- Chronic state of "visceral –vascular readiness"

Vigilance Response

- Active coping downplayed—watching and waiting
- Slowed: HR, breathing, metabolism *(energy conserved)*
- Blood vessels constrict--↓ blood flow to skeletal muscles
- Provoked by: noxious or symbolically threatening stimuli, defeat, hopelessness
- Neuroanatomically distinct from the Defense Reponse

Biological Mechanisms - II
Defeat Reaction

- During exposure to some acute stressors, particularly those that are threatening, cortisol is released.
- Animal studies reveal that when repeatedly faced with noxious events that cannot be controlled, motivation becomes undermined, resulting in passive behavior and giving-up.
- Human equivalent – learned helplessness (Seligman)

Biological Mechanisms - II
Defense and Defeat

- ”The ancient ’defense’ and ’defeat’ reactions, intended for quite different situations, are often activated by the artificial stimuli and symbolic threats inherent in today’s hectic and competitive life.” *(Folkow 1994)*
- Frequent shifts between defense and defeat
- Activation of Sympathoadrenal medullary and hypothalamic-pituitary-adrenocortical axes

How can Work Stressors lead to ↑BP & Hypertension *(1)?*

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

↑ HR, ↑ stroke volume (*the heart beats hard and fast*)

↑ Blood flow to skeletal muscles, heart & brain

↓ Blood flow to kidneys, ↓ Na excretion (↑ blood volume)

Overall effect =Reversible ↑ BP (mainly systolic)

Preparation for Fight or Flight

How can Work Stressors lead to ↑BP & Hypertension *(2)?*

I (b): <u>The Defense Response & Sustained ↑ BP</u>

(i) Prolonged, repeated defense response without physical activity: No skeletal muscle vasodilatation

(ii) Sustained ↑ sympathetic outflow (+ angiotensin, insulin) → thickening of blood vessel walls

(i) & (ii) → **Sustained ↑ BP** (especially diastolic) →

The heart beats against resistance → ↑ heart mass → further ↑ BP & ↑ risk of cardiac events

Animal Models

- In all animal models, when the acute or semichronic arousing stimulus is removed, bp falls.
- But when chronic and removed later pressure may remain elevated
- E.g, elevated BP in mouse colony falls when stranger mouse is removed (but only if less than 6 months)

How can Work Stressors lead to ↑BP & Hypertension *(3)?*

II. <u>The Defeat Reaction</u>

-- Activation of the hypothalamic-pituitary adrenocortical axis → ↑ glucocorticoids → direct pressor effects + potentiation of sympathetic effects on BP

-- Possible relation to the vigilance response → vasoconstriction

Less empirical evidence for all the links in this pathway in relation to workplace stressors

How can Work Stressors lead to ↑ BP & Hypertension *(4)?*

III. Defense + Defeat (Effort-Distress Model)

--Monotonous, vigilance task →

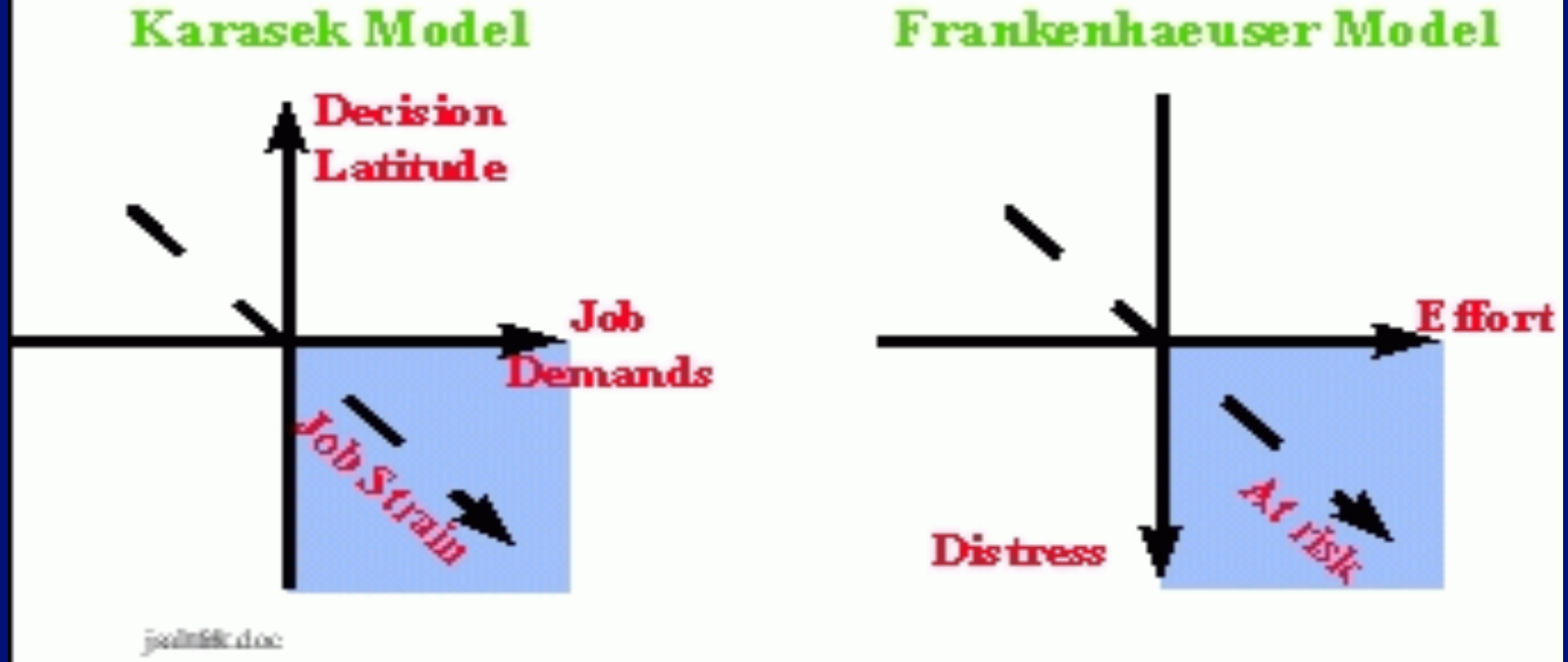
↑ epinephrine & ↑ cortisol excretion

--Task requiring effort and low control

↑ epinephrine & ↑ cortisol excretion & ↑ BP (diastolic)

Laboratory studies—Note similarity to Job Strain Model

Comparison of Karasek and Frankenhaeuser Models



Job strain and Sustained ↑ BP

- For a work stressor to contribute to a tonic ↑ BP, the blood pressure of the exposed individual would have to be ↑ not only in the presence of a stressor but also during rest.
- Job Strain=Low- or moderate-grade stress, usually present over longer periods of time
- Exposure to job strain is associated with ↑ BP not only during work, but also at home and, in some studies, during sleep

Summary of Statistically Significant (p<.05) Findings from the Work Site BP Study on Job Strain* and Ambulatory BP**

Design	Wave	AmBP	Location	Effect Size (mm Hg)
Cross-	1	SBP	work	+6.8
Sectional	(n=264)	DBP	work	+2.8
		SBP	home	+6.5
		SBP	sleep	+6.2
	2	SBP	work	+6.4
	(n=195)	DBP	work	+5.0
		SBP	home	+6.9
		DBP	home	+4.9
		SBP	sleep	+5.0
Longitudinal	1 & 2	SBP	work	+11.1
Repeated exposure		DBP	work	+9.1
(job strain at both		SBP	home	+11.1
Time 1 and 2)		DBP	home	+7.3
		SBP	sleep	+10.8

Change in exposure ***

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)

Social Status and Coronary Artery Atherosclerosis in Female Monkeys

Initial social Area Status	Manipulated Social Status	Total Cholesterol/ HDL	Coronary Artery Plaque
Dominant	Dominant	7.0	0.03
	Subordinate	9.1	0.19
Subordinate	Dominant	8.0	0.09
	Subordinate	7.9	0.04

Shively CA, Clarkson TB. Arterioscler Thromb 1994.

Atherogenesis & Stress Mechanisms*(2)*

Later Stages (thrombogenesis) :

↑ *Fibrinogen* (converted to fibrin=major constituent of thrombi, ↑ platelet aggregation, ↑ blood viscosity)

Increased fibrinogen linked to:

--Low socioeconomic status

--Low control over work

--Effort reward imbalance

Platelets and Acute Cardiac Syndromes

Activated platelets appear to play a key role in acute cardiac syndromes

(*adhere to damaged endothelium,their cytokines stimulate cell proliferation, recruit further platelets into thrombi*)

--Platelet activation in CHD patients associated with hostility & generally increased with emotional stress

--No direct data in relation to work stressors, as yet (but + relationship with emotional stress -> see e.g., Reid etal. 2009)

ERI and inflammatory responses

- **The Effects of Effort-Reward Imbalance on Inflammatory and Cardiovascular Responses to Mental Stress**

- **Objective:** We examined the influence of effort-reward imbalance, a stressful feature of the work environment, on cardiovascular and inflammatory responses to acute mental stress.

- **Methods:** Ninety-two healthy men (mean age, 33.1 yeasr) in full-time employment were recruited. Effort-reward imbalance was measured using a self-administered questionnaire. Blood, for the analysis of C-reactive protein (CRP) and von Willebrand factor (vWF) antigen, was sampled at baseline and 10 minutes after two mental stress tasks, whereas cardiovascular activity was measured throughout.

- **Results:** Plasma CRP and vWF were significantly elevated following the stress period, and cardiovascular activity was increased during and after both tasks ($p < .001$). Multiple linear regression analysis adjusted for age, body mass index, and baseline levels revealed that men with higher effort-reward imbalance demonstrated greater CRP and vWF responses to the stress tasks but blunted cardiovascular responses. Inflammatory and cardiovascular responses to stress appeared to be unrelated.
- **Conclusions:** These findings suggest that the association between chronic work stress and cardiovascular disease risk may be mediated in part by heightened acute inflammatory responsivity. These responses appear not to result from differences in sympathoadrenal activation.

- **Mark Hamer, PhD, Emily Williams, MSc, MS, Raisa Vuonovirta, MSc, Pierluigi Giacobazzi, PhD, E. Leigh Gibson, PhD and Andrew Steptoe, Dphil**

Assessment of Atherosclerosis in Epidemiologic Studies:Carotid Ultrasound

- Carotid intima-medial wall thickness and plaque can be measured *non-invasively* with high resolution carotid ultrasound
- Appropriate method for population screening
- ↑ progression carotid atherosclerosis over 4 year in Finnish men with high demands and low economic rewards (Lynch 1997)

Heart Rate Variability (HRV)

- Definition: Beat-to-beat oscillations in the heart rate.
- The major determinant of the fluctuations between consecutive heart beats is the respiratory cycle.
  (Respiratory sinus arrhythmia)
- Appears to reflect Parasympathetic outflow

HRV Analysis and Example

Time Domain: Sd of the normal sinus (N-N) intervals in all 5-minute segments, and other methods (SDNN)

Frequency Domain (Power spectral analysis):

1) High frequency component (0.15 - 0.4 Hz) = Respiratory sinus arrhythmia (RSA)

2) Low frequency component (0.04 - 0.15 Hz)

- P. 433 Friedman 1977

Prognostic Significance of Depressed HRV

Significant independent predictor of:

- Incident coronary heart disease
- Arrhythmia-related death after myocardial infarction

Depressed HRV and Environmental Stressors:

- Heavy mental workload

  (A key physiologic indicator in cognitive ergonomics research)

- Can occur with long work hours, shift work

- Recent evidence of association with exposure to job strain or high noise levels (Van Amelsvoort 2000)

Job strain and HRV

- Research involved working people in which job strain, HRV, and diary data were collected
- Job strain and low decision latitude were associated with a reduction in cardiac vagal control (HFP) throughout 48 hour measurement period while job strain was associated with elevation in sympathetic control during working hours

- Collins and Karasek: Job strain and autonomic indices of cardiovascular disease risk. AJIM 2005

Myocardial Ischemia

↑ Myocardial O2 Demand:

- ↑ HR
- ↑ BP
- ↑ Myocardial contractility
- ↑ Left ventricular mass

↓ O2 Supply to Myocardium

- ↓ Coronary blood flow
  --Coronary artery disease
  --Coronary artery spasm
  -- ↑ blood viscosity
  -- ↑ Left ventricular mass
  (compressed intramyocardial vessels)
- ↓ O2 content of blood
  (CO exposure)

Myocardial Ischemia & Mental Stress

- 18 participants with single-vessel coronary artery disease
- Recall of an incident which elicited anger
- Evoked a greater ↓ in ejection fraction (EF) than exercise
- (↓ EF = ↓ pumping action of the heart ventricle, a consequence of myocardial ischemia)
- ----------
- Ironson G et al. Am J Cardiol 1992.

Stress-Mediated Mechanisms of Cardiac Electrical Destabilization

- Sympathetic Overdrive

↑ automaticity, ↑ triggered activity, reentry, catecholamine damage

- Other Autonomic Imbalances

PSP versus SP, R versus L sympathetic ganglia

- Increased Left Ventricular Mass

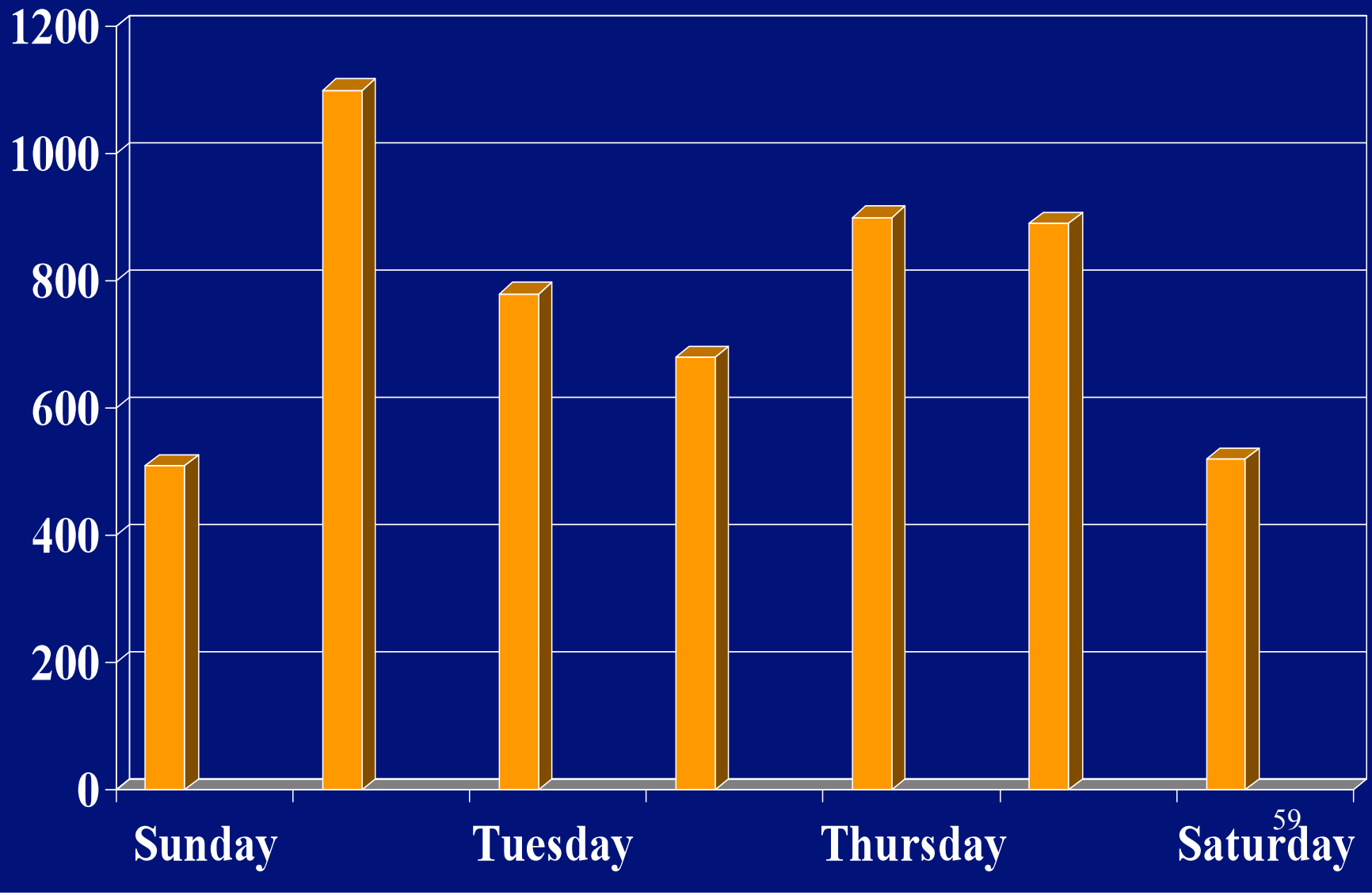
↑ automaticity, ↑early & late triggering, reentry

- Acute Myocardial Ischemia

Acidosis → ↑ automaticity, slowed conduction → reentry,

Reflex sympathetic overdrive

Septadian Distribution of Life-threatening Arrhythmias (AICD activation) Peters et al. (1996)



Work Stressors and CVD - Summary

- Job Strain
- Effort-Reward Imbalance
- Long Work Hours
- Shift Work
- Threat Avoidant Vigilance
- Physical Noxins

Work stressors & Untoward CV Changes Empirical Evidence*(1)*

- Job strain:

↑ AmBP, ↑ LV mass, adverse HRV profile, ↑ fibrinogen (low control), ↓fibrinolysis (high demands)

- Effort-Reward Imbalance:

↑ AmBP, ↑ BP + adverse lipid profile, ↑ fibrinogen, adverse HRV profile, progression of atherosclerosis

Work stressors & Untoward CV Changes Empirical Evidence*(2)*

- Long work hours:
- ↑AmBP, ↑ prevalence self-reported hypertension, adverse HRV profile

- Shift work:

  Adverse AmBP & HRV profile, ↑ BP

Work stressors & Untoward CV Changes Empirical Evidence*(3)*

- Threat Avoidant Vigilance

  Adverse HRV profile, cardiac electrical instability (experimental animal data), ↑ BP (indirect data from human laboratory studies)

Work stressors & Untoward CV Changes Empirical Evidence*(4)*

Physical Noxins:

--*Noise*: ↑ AmBP, myocardial ischemia

--*Heavy lifting*: ↑ BP, cardiac arrhythmias

--*Glare*: ↑ BP, cardiac arrhythmias (drivers)

--*Cold*: ↑ BP, myocardial ischemia (vasospasm)

--*Heat*: ↑ HR, myocardial ischemia

--*Vibration*: vasoconstriction

Work stressors & Untoward CV Changes Empirical Evidence*(5)*

- Chemical Noxins:

--*Carbon monoxide*: myocardial ischemia, ↓ cardiac electrical stability

--*Lead*: ↑ BP, adverse HRV profile

--*Halogenated organic solvents*: ↓ cardiac electrical stability

--*Nitrate esters*: sudden cardiac death (acute re-exposure)

Stress Summary

- The impact of allostatic load has been most clearly demonstrated in the cardiovascular system where chronic stress has been shown to be linked to increases in cholesterol, elevations in plasma fibrinogen, increases in heart muscle mass, disturbances in cardiac rhythm, and increases in heart rate (19). More recently researchers have examined the impact of stress-related muscle tension on the muscle skeletal system (20) and have linked the stress related modulation of the immune system to inflammatory, infectious and autoimmune disease (1).

Summary Stress Effects

- In the presence of acute or chronic stressors the body struggles to adapt. Over time this process causes the wear and tear that researchers now refer to as allostatic load (5, 6). As stress increases in frequency, intensity and duration, the efficiency in coordinating the body's adaptive responses begins to break down. Allostatic responses are no longer terminated appropriately, thereby maintaining a level of neurohormonal activation within the body long after the stress in the environment has ceased. This may explain why after exposure to years of job stress blood pressure may become permanently elevated above earlier baseline levels (18).

Work versus non-work BP

It is estimated that systolic BP is approximately 4-5 mm higher on work days compared to non-work days.

Yet, blood pressure is most commonly measured outside work, in the clinic situation (”Casual Clinic BP”)

Clinical Implications

Clinical Implications of finding work stressors present → leads to increased risk for hbp and cvd

Clinical Problems informed by presence of workplace stressors

- Increased likelihood of developing hypertension and CVD
- Increased risk of stroke or heart attack
- Hidden Hypertension
- Increased risk 2nd heart attack on RTW
- Lack of chronicity of hypertension (unnecessary treatment)

Clinical Implications of Misclassification

Type I errors: False positives

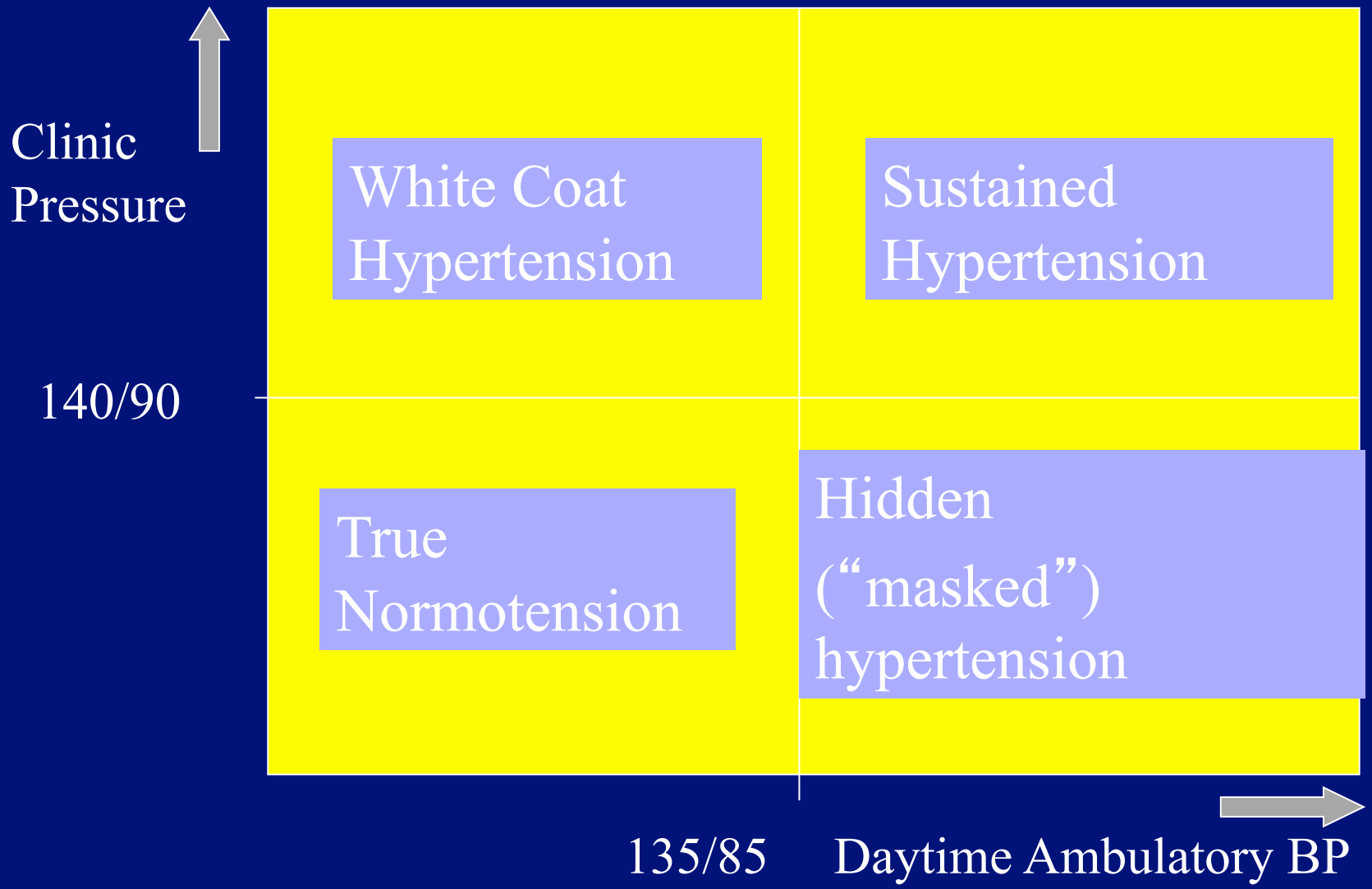
– (*white coat hypertension*)

Unnecessary treatment

Type II errors: False negatives

-(*Occult workplace hypertension*)

Failure to treat individuals at high risk with elevated worksite blood pressure


Clinic Pressure
White Coat Hypertension
Sustained Hypertension
140/90
True Normotension
Hidden ("masked") hypertension
135/85
Daytime Ambulatory BP

Occult Workplace Hypertension

Classification of Hypertension using Casual BP versus Ambulatory BP in a Sample of Working Men in New York City*

	Work Site Diastolic BP Ambulatory		Total
Casual Diastolic BP taken at the Work Site Clinic	>85mmHg (N)	< = 85mmHg (N)	(N)
>85mmHg	59	27	86
< = 85mmHg	**36**	145	181
Total	95	172	267

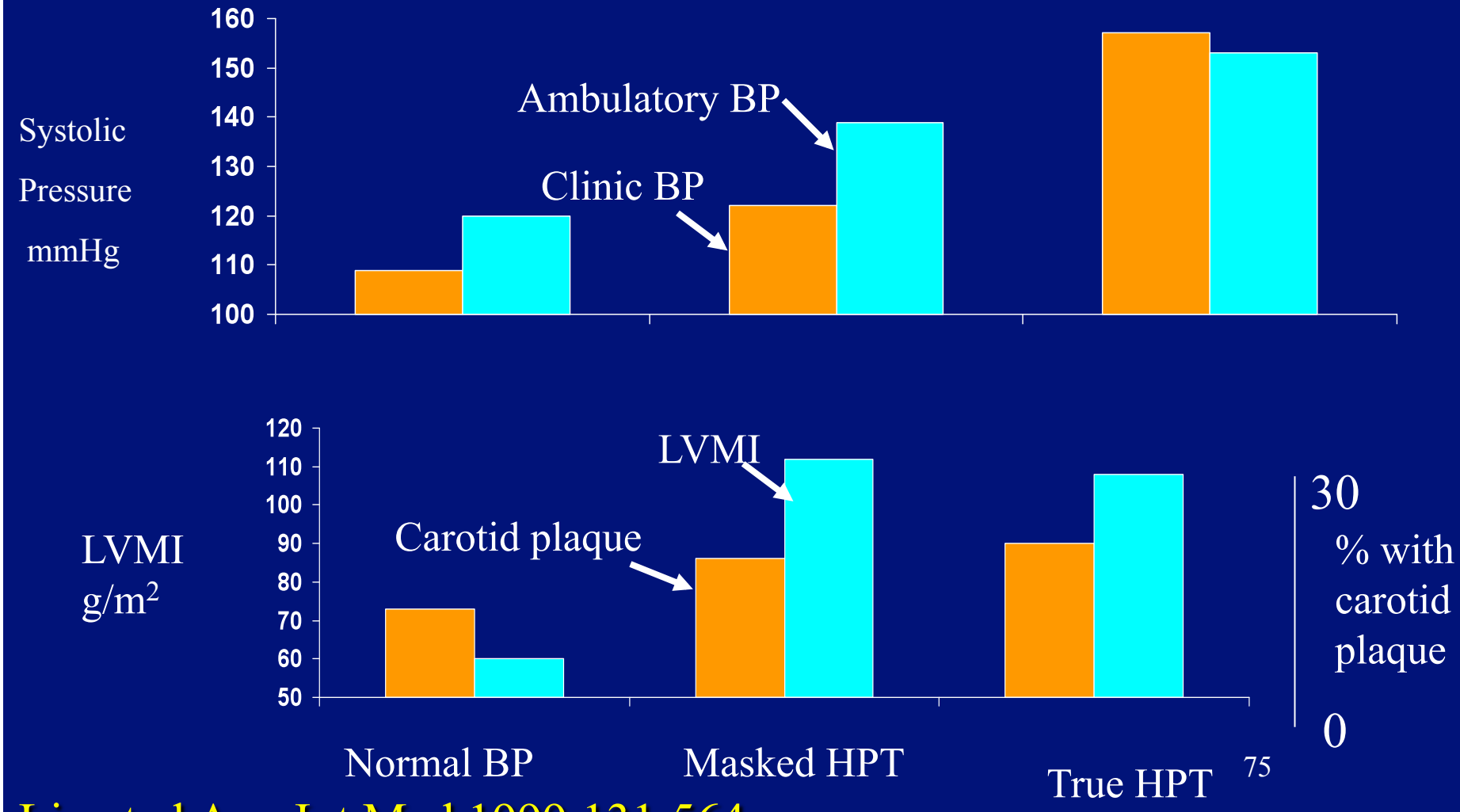
Occult/Hidden Workplace Hypertension in NYC Work Site BP Study: A public health epidemic?

	Work diastolic ambulatory pressure (mm Hg)		
	>85	≤85	Total
Clinic DBP (worksite)>85	55	24	79
Clinic DBP (worksite)≤85	36	139	175

false positives = 24/79 = 0.30 (White Coat Hypertension)
false negatives = 36/175 = 0.21 (Occult Workplace Hypertension)

Schnall PL, Belkic KL, Landsbergis PA, Schwartz JE, Gerber LM, Baker D, Pickering TG. Hypertension at the workplace - often an occult disease: The relevance and potential in Japan for work site surveillance? The Japanese Journal of Stress Sciences; 15(3), 2000.

Masked Hypertension is associated with higher LV Mass & more carotid plaque



Liu et al Ann Int Med 1999;131:564

Masked/Hidden hypertension

- NYC Work Site BP Study
  - Using criteria of <140/90 for clinic BP and >135/85 for daytime ABP
  - JOB STRAIN:
    - Adjusted OR=1.54 (0.61-3.91) at Time 1
    - Adjusted OR=5.74 (1.86-17.72) at Time 2
- ABP monitoring expensive ($6 billion/yr, U.S. if routine)
- Target high-risk groups (with normal clinic BP)
  - Diabetes, carotid plaque
  - Smoke, alcohol use
  - Job stress exposures

Landsbergis P, et al. Working conditions and occult hypertension. Scandinavian Journal of Work, Environment and Health (submitted).

Ambulatory BP monitoring

- Advantages

  Naturalistic setting—sampling of ”real world” situations

  Accuracy: No observer bias, no white coat effect

  Large number of readings

  Very reliable averages

  Enhanced predictive validity

- Disadvantages

  Naturalistic setting, uncontrolled circumstances

  Lower precision of each individual reading

  Logistics--inconvenience

  Expense

Ambulatory Monitoring of the Work Environment

- Method of choice
- Allows assessment of

  --the effect of chronic and acute occupational stressors upon BP

  --the additive burden of multiple exposures
- Note that results can be *acutely* affected by physical activity and position, mood, psychological state, non-work related occurrences

AmBP in Male City Bus Drivers

	Drivers (N=15) Split Shift	Significance	Referents (Day shift)(N=20)
Systolic BP			
3:00-7:00	119.9 ± 12.2	**	109.3 ± 5.3
12:00-15:00	134.3 ± 5.2	***	126.7 ± 4.8
Diastolic BP			
3:00 – 7:00	66.4 ± 5.3	**	61.0 ± 5.5
12:00-15:00	89.4 ± 5.2	***	83.9 ± 5.4
Systolic BP	Afternoon Shift		
13:00 – 15:00	133.2 ± 4.8	***	127.1 ± 4.3
20:00 – 24:00	116.6 ± 8.3	**	108.9 ± 8.1
Diastolic BP			
13:00 – 15:00	89.1 ± 5.7	**	83.8 ± 5.1
20:00 – 24:00	73.8 ± 6.0	**	66.7 ± 6.2

Worksite Point Estimates of BP

- Potential alternative to AmBP
- Suitable for workplace surveillance

(more feasible for monitoring large numbers of working people)

- An observer measures the subject's BP with minimum interruption of work.
- A protocol has been developed and is being tested

Assessment of CV function at work

- AmBP and Amb ECG (Holter) monitoring

Integrated assessment of multiple parameters

Potential for detecting trigger mechanisms.

Example:

Acute stressor →

↓ HRV + ↑BP + ↑HR →

Silent myocardial ischemia (↓ST segment) →

Complex ventricular arrhythmias

Laboratory Monitoring

- Controlled environment
- Possibilities for sophisticated physiologic study

  (multiple channels-EEG, ECG, BP, digital plethysmography, Oximetry, etc.)

The paradigm should be
”ecologically relevant”
for the occupational group

The Occupational Psychosocial Interview

- ”Personally relevant mental stress”
- In 10 young male blue collar workers, discussion of stressful workplace events→
  + 12.4 / +15.1 ↑ in BP

- In a patient who had suffered an acute myocardial infarction → ventricular tachycardia

The Glare Pressor Test

Intermittent Exposure to headlight glare impulses

Elicits Among male Professional Drivers (N=15)
--Desynchronization of the Electroencephalogram (Cortical arousal)
--Significant ↑ in diastolic blood pressure,
--Significant ↓ in Digital Pulse amplitude (peripheral vasoconstriction)
--Ventricular arrhythmias in some cases

No significant physiologic changes found in referents who had no driving experience whatsoever

"These results indicate that drivers show cardiovascular hyperreactivity to the GPT, with strong central arousal as expected during night driving when an on-coming headlight can represent impending danger and the need for accurate and timely responses to avoid a collision"

Belkic et al. European Heart Journal 1992.