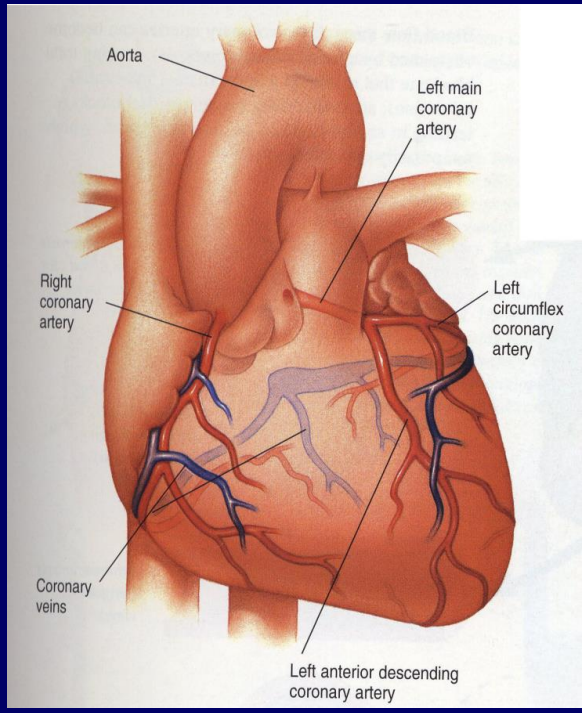
Cardiovascular Disease:

Exploring Disease Progression and Preventative Strategies



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Approach

Heart Disease

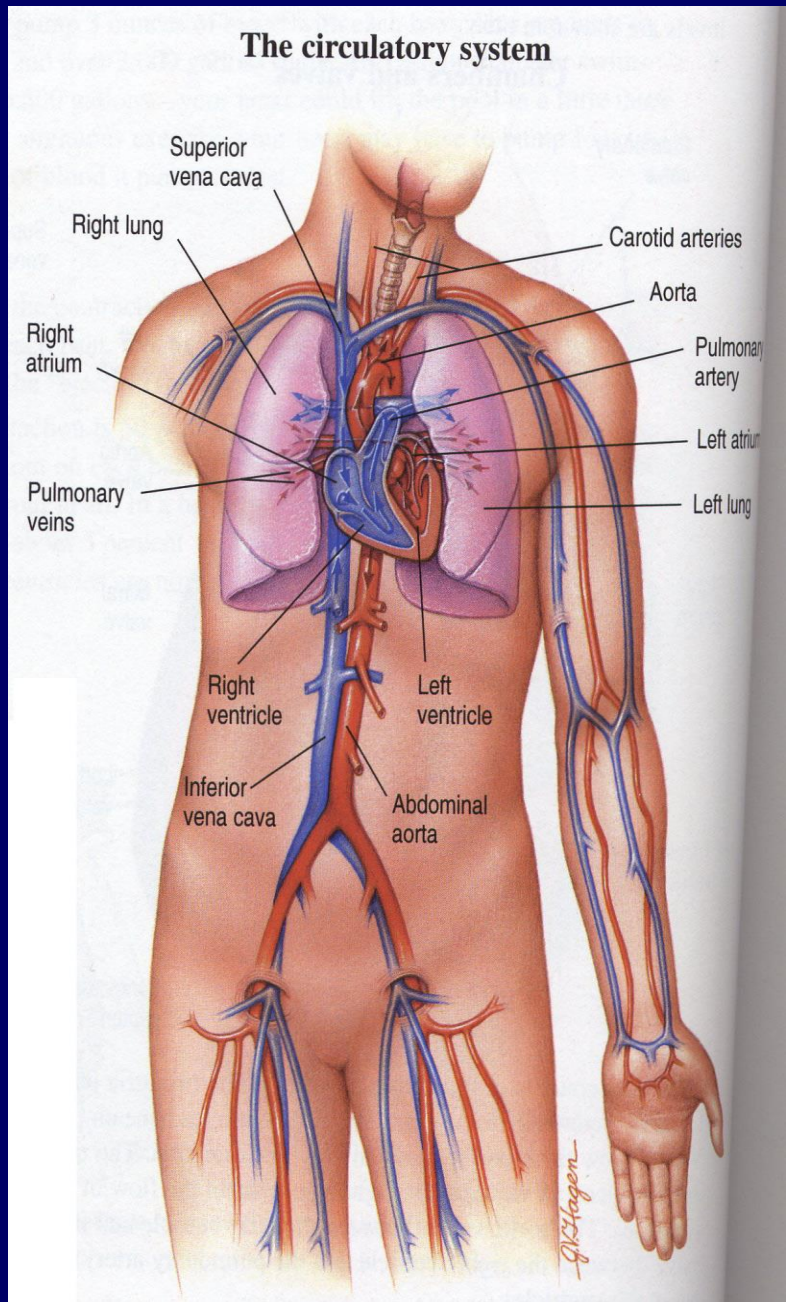
- **What is it?** (definition)
- **Who has it?** (prevalence/impact)
- **What can you do about it?** (prevention/trt)
- **How does it relate to my research program?**

What is CVD? (definition)

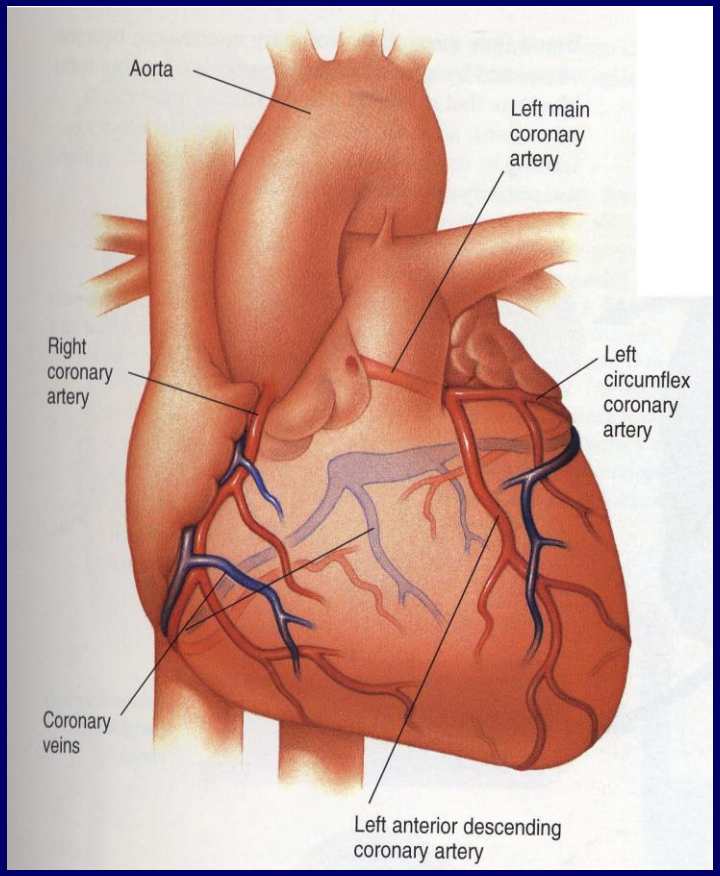
- Heart disease?
- Heart failure?
- Clogged arteries?
- Arrhythmias?
- Heart attack?
- Myocardial infarction?
- High blood pressure?
- High cholesterol?

What is CVD? (definition)

- Cardiovascular disease is any disease of pathology that affects the cardiovascular system---
  - HEART
  - BLOOD VESSELS
  - BLOOD



CVD

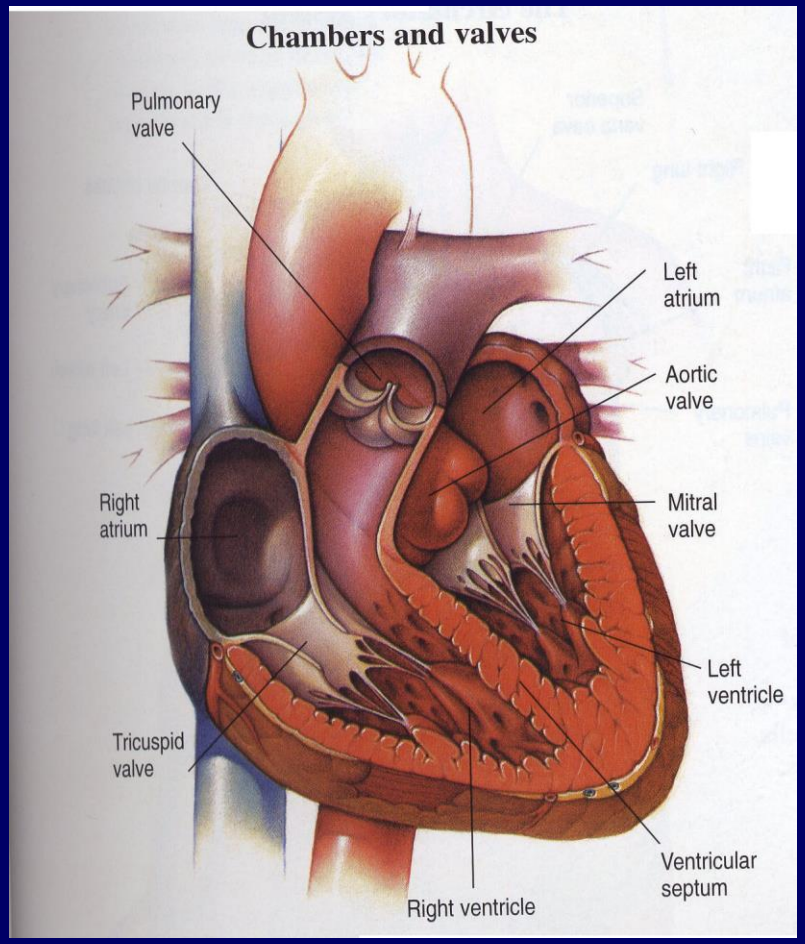


- Atherosclerotic heart disease affects all three systems

The Heart

Overview

Coronary Circulation



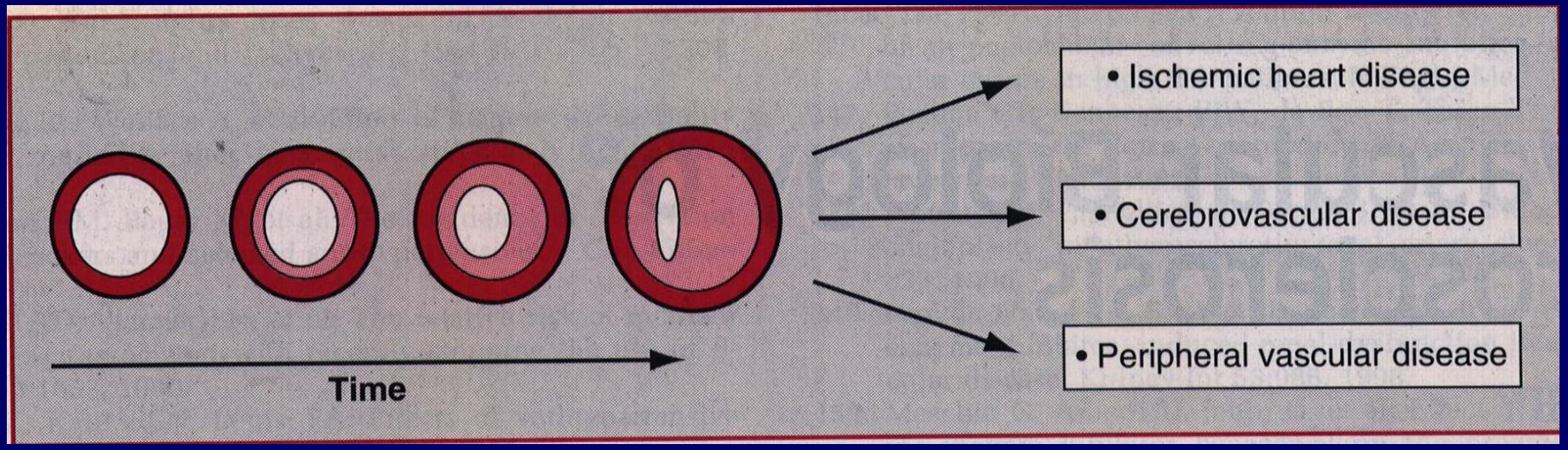
Cardiovascular Disease

- We will focus on atherosclerotic heart disease, also called
  - ischemic heart disease
  - coronary artery disease
- Atherosclerotic heart disease leads to:
  - sudden cardiac syndromes (heart attacks, MI)
  - chronic heart failure

Progression of Atherosclerotic CVD

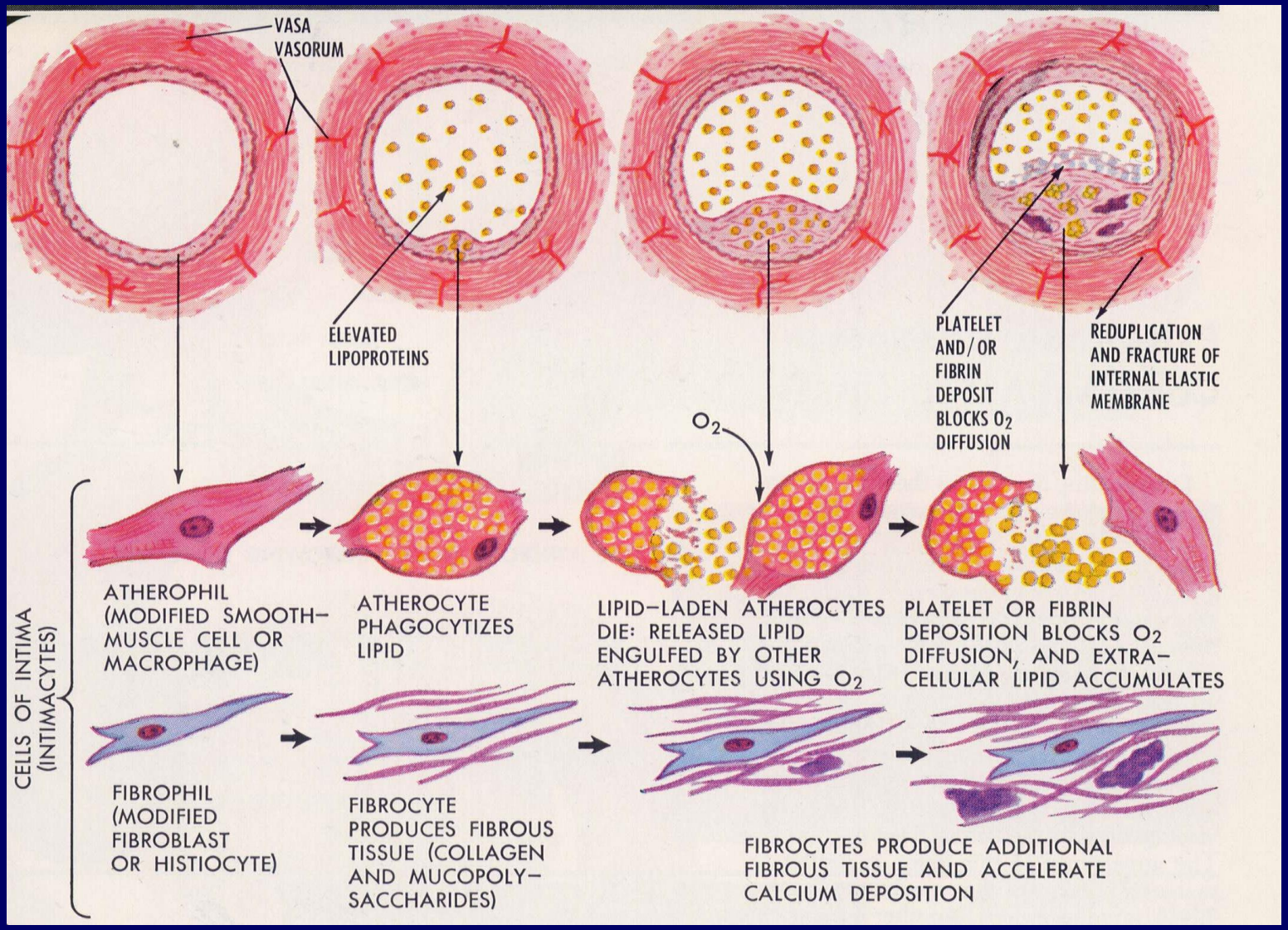
- Long-term disease
- Silent, undetected in early stages
- General progression
  - Narrowing of arteries caused by plaque buildup (atherosclerosis)
  - If artery is completely blocked by plaque or a clot, then blood supply to organ stops (ischemia)
    - Plaque rupture may trigger blood clot formation
    - If an artery in the heart is blocked ⇨ Heart Attack
    - If an artery in the brain is blocked ⇨ Stroke
  - If artery is partially blocked over a period of many years, then blood supply is diminished ⇨ Heart Failure

A Schematic History of an Atherosclerotic Lesion (plaque)



Libby, P. In: Braunwald, Zipes, & Libby. *Heart Disease: A Textbook of Cardiovascular Medicine*. 6th Ed. Volume 1 Page 996. Figure 30-1

Progression of CVD



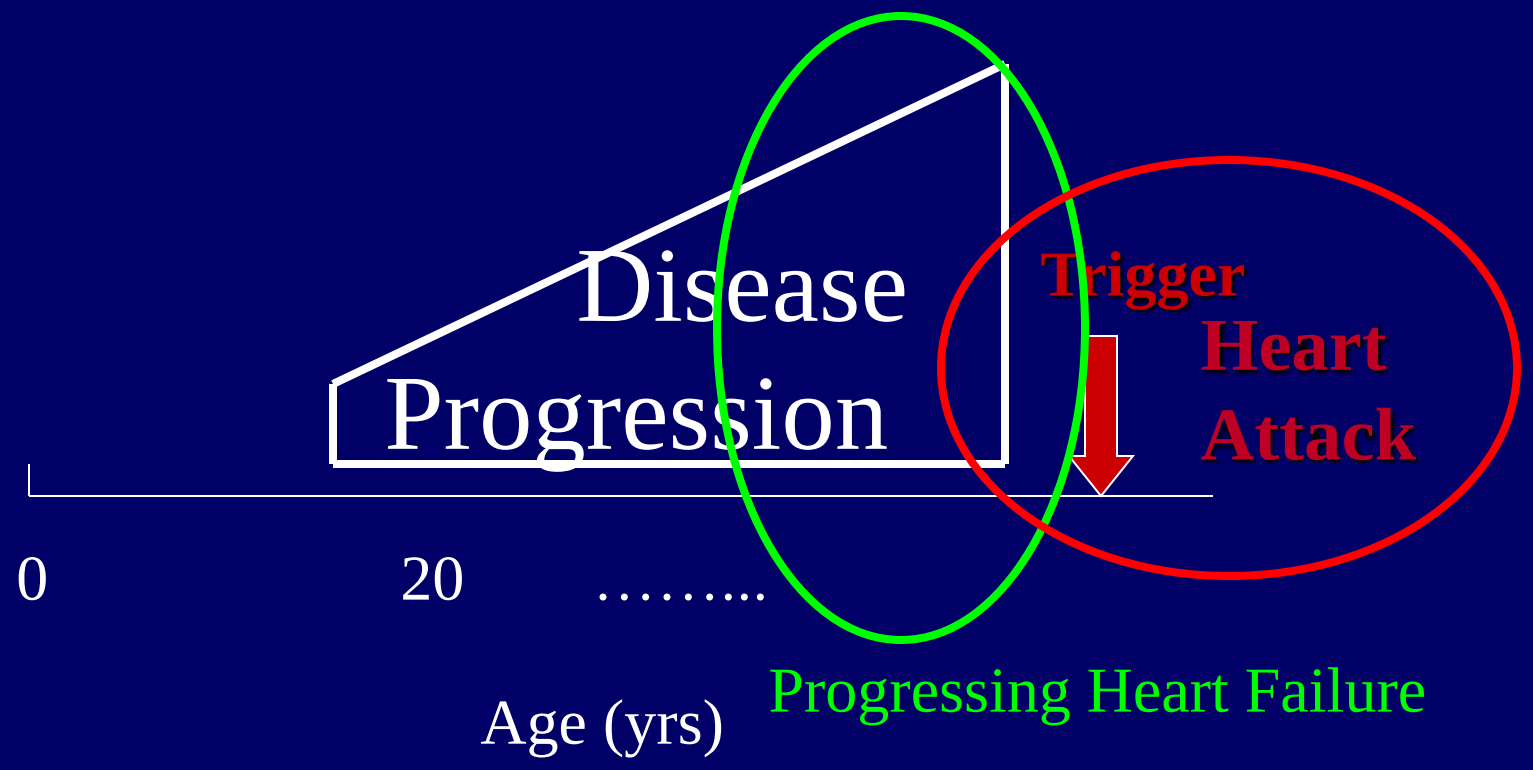
Netter, F.

The CIBA Collection of Medical Illustrations. Volume 5 The Heart. 1978

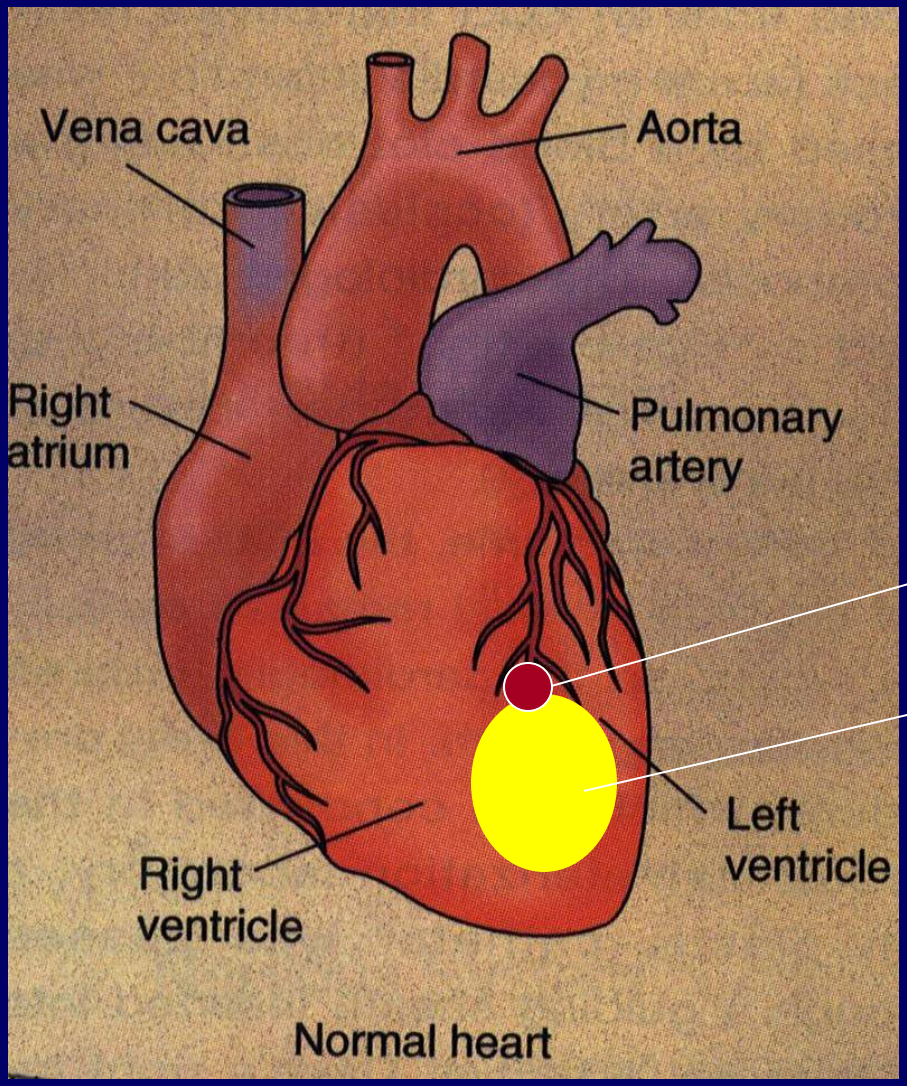
A Model to Describe Atherosclerotic CVD

Sudden – acute coronary events

Chronic – progressive

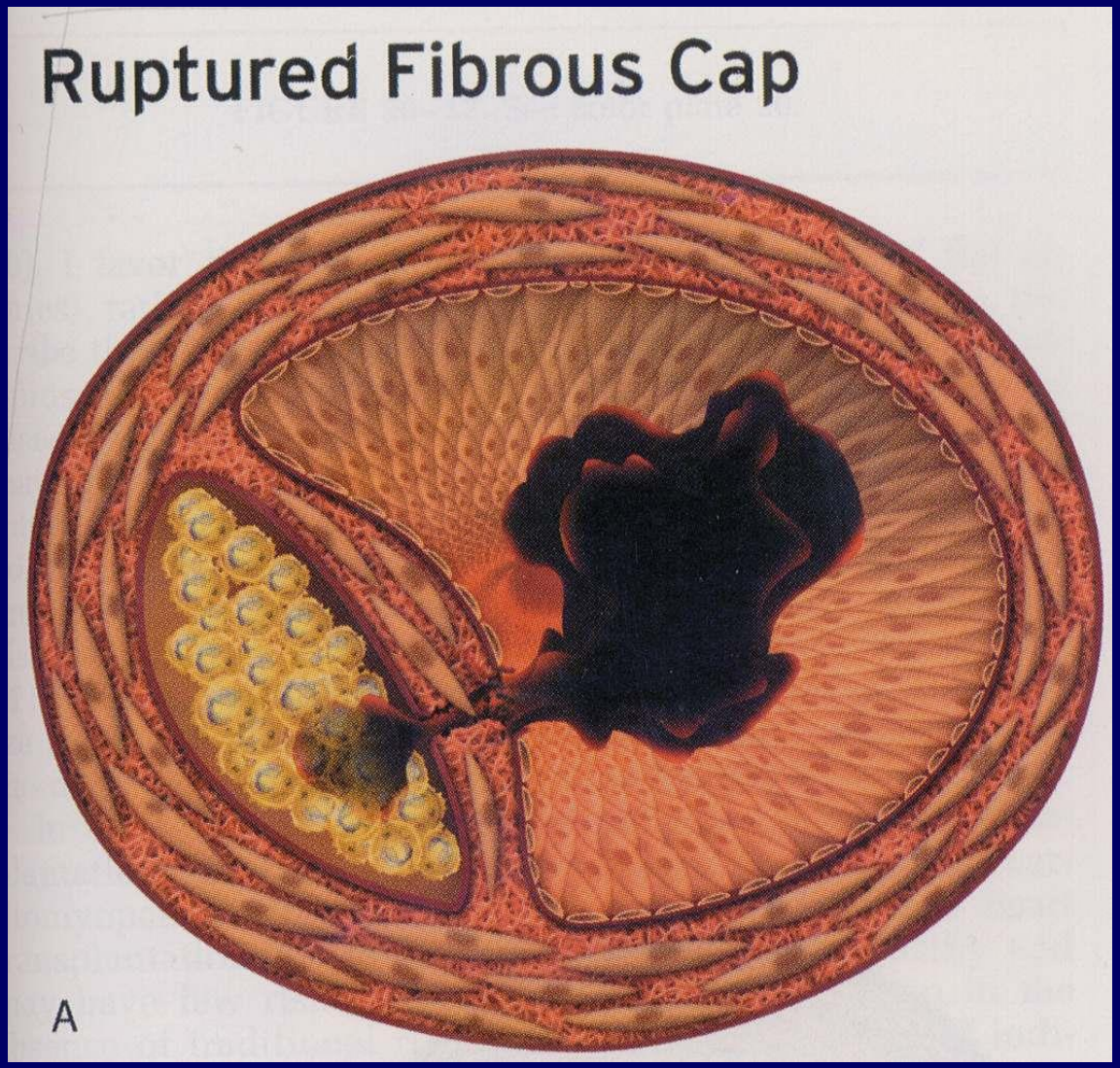


Blocked Coronary Artery



Blockage (Occlusion)

Area of tissue death (infarct)



Libby, P. In:Braunwald, Zipes, & Libby. *Heart Disease: A Textbook of Cardiovascular Medicine*. 6th Ed. Volume 1 Page 1004.

Who Has It?
Prevalence/Cost of CVD

CVD is leading cause of death in the U.S.

~ 1,000,000 deaths per year (911,000 in ’03)

Economic cost (direct and indirect) of CVD in the U.S.

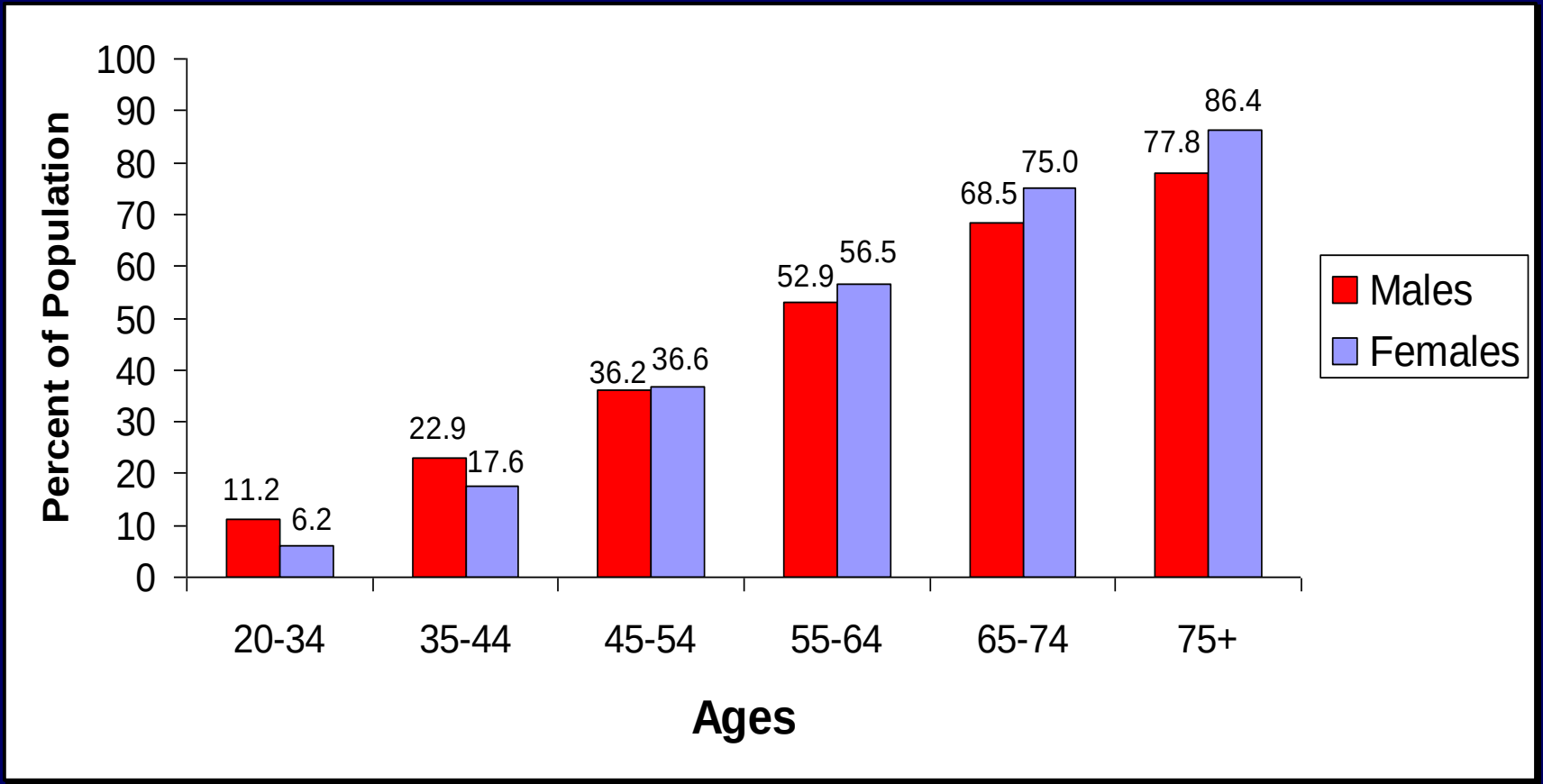
~ $403 billion in 2006 (AHA)

CVD is a major cause of death worldwide

- proportion of deaths expected to increase from 28.9% in 1990 to 36.3% in 2020 (Hanson, 1993)

Prevalence of Cardiovascular Diseases in Americans Age 20 and Older by Age and Sex

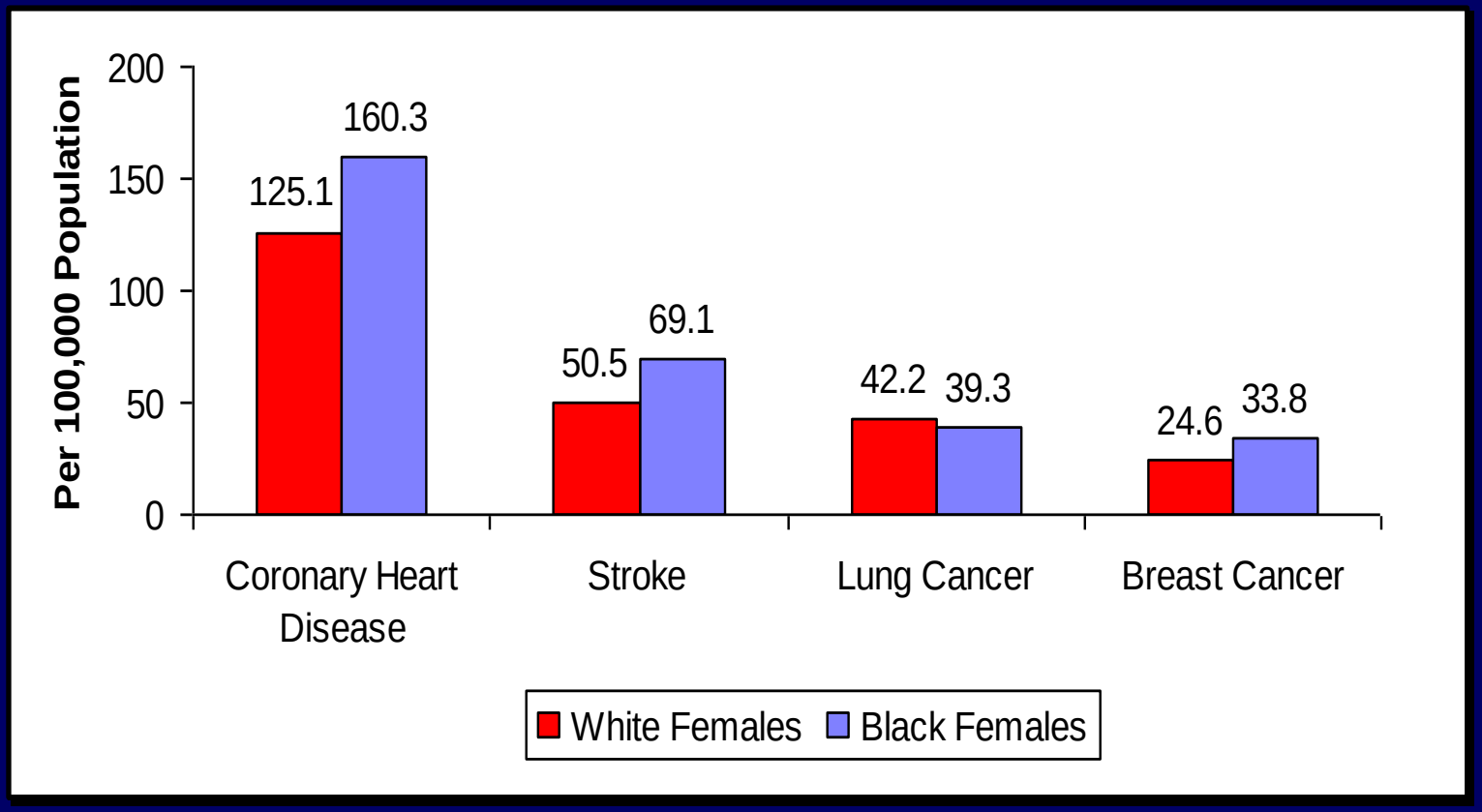
NHANES: 1999-2002



Source: CDC/NCHS and NHLBI. These data include coronary heart disease, heart failure, stroke and hypertension.

Age-Adjusted Death Rates for Coronary Heart Disease, Stroke, and Lung and Breast Cancer for White and Black Females

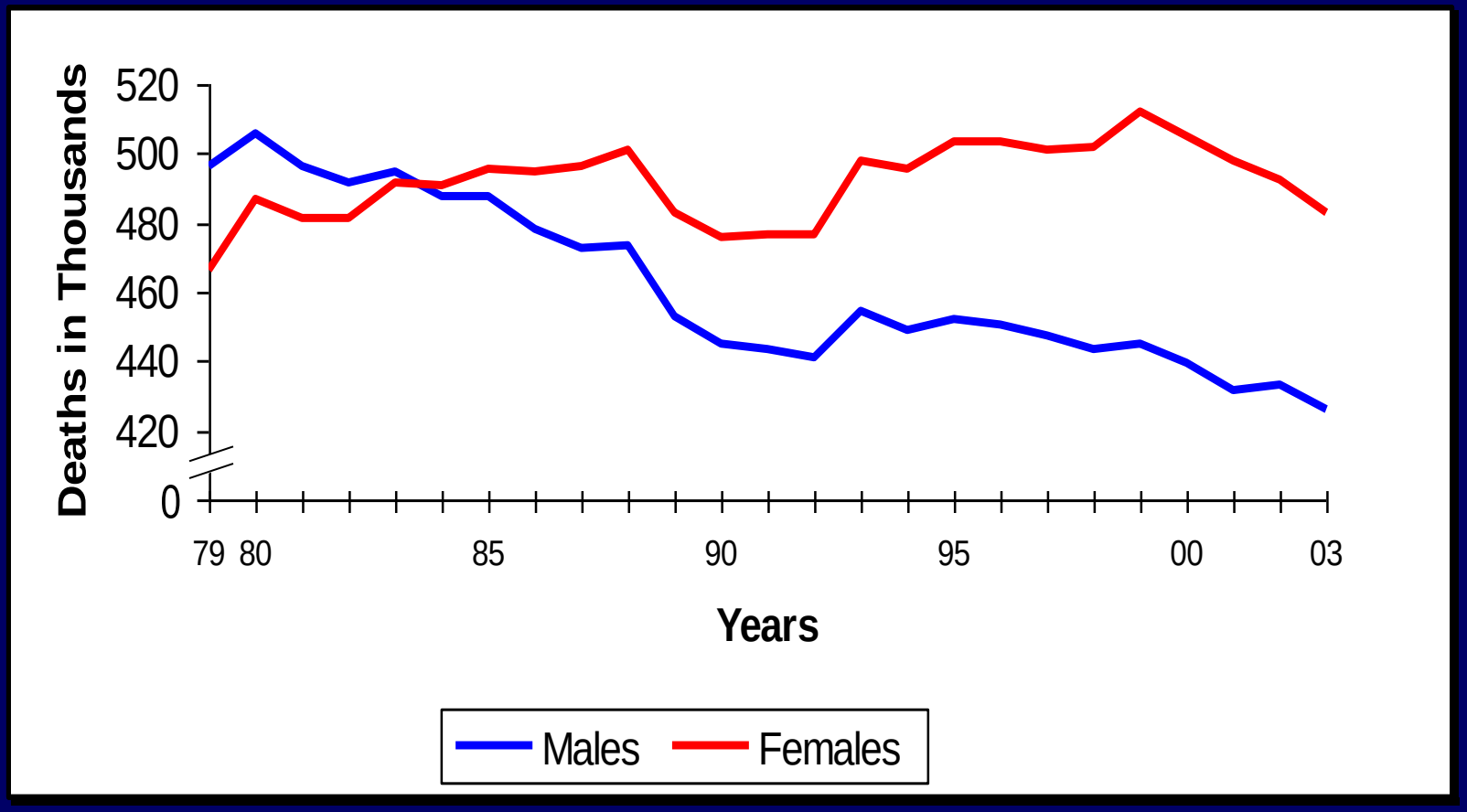
United States: 2003*



Source: CDC/NCHS and NHLBI. ** Preliminary*

Cardiovascular Disease Mortality Trends for Males and Females

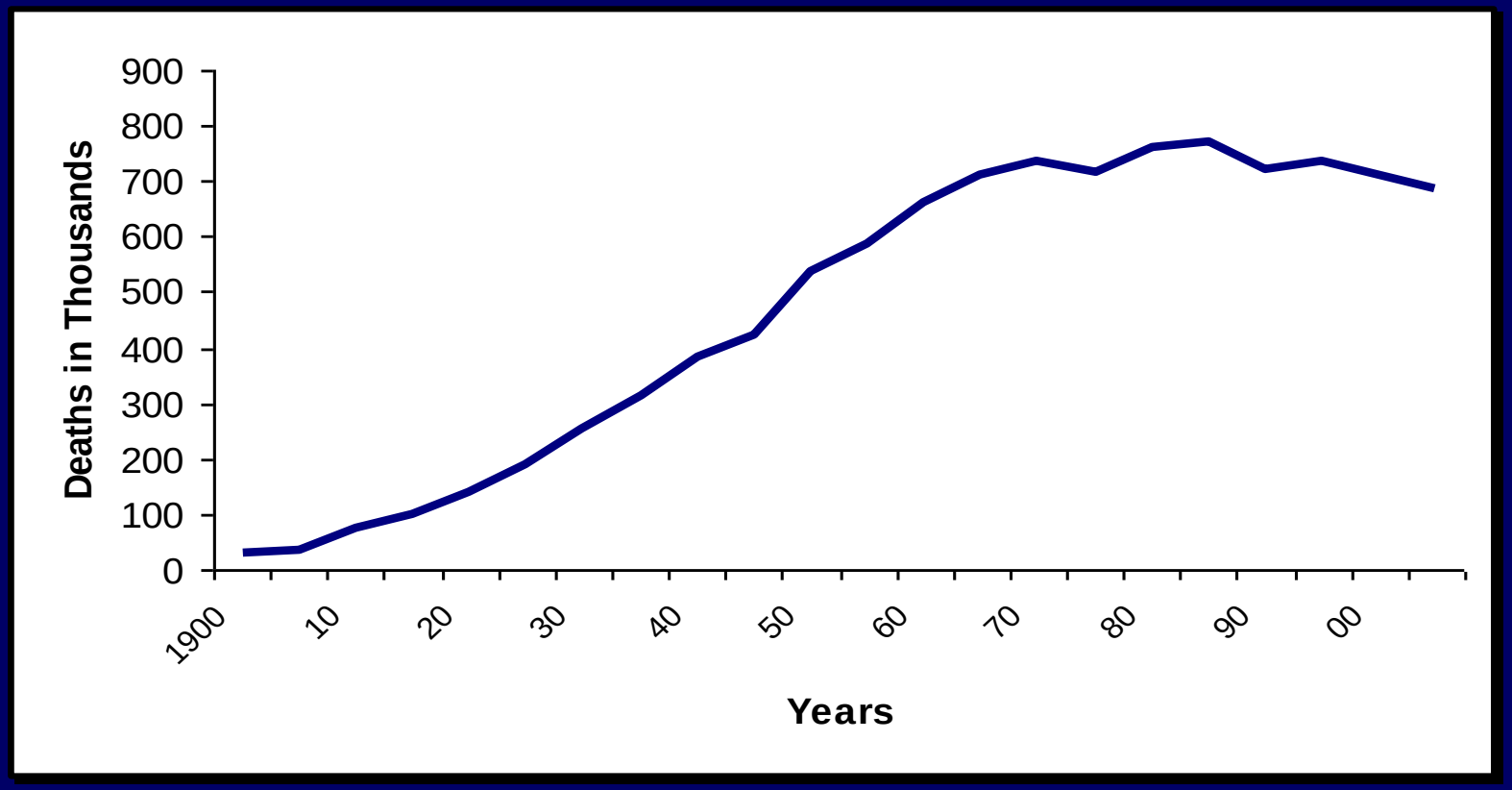
United States: 1979-2003*



*Source: CDC/NCHS. * Preliminary*

Deaths From Diseases of the Heart*

United States: 1900–2003*

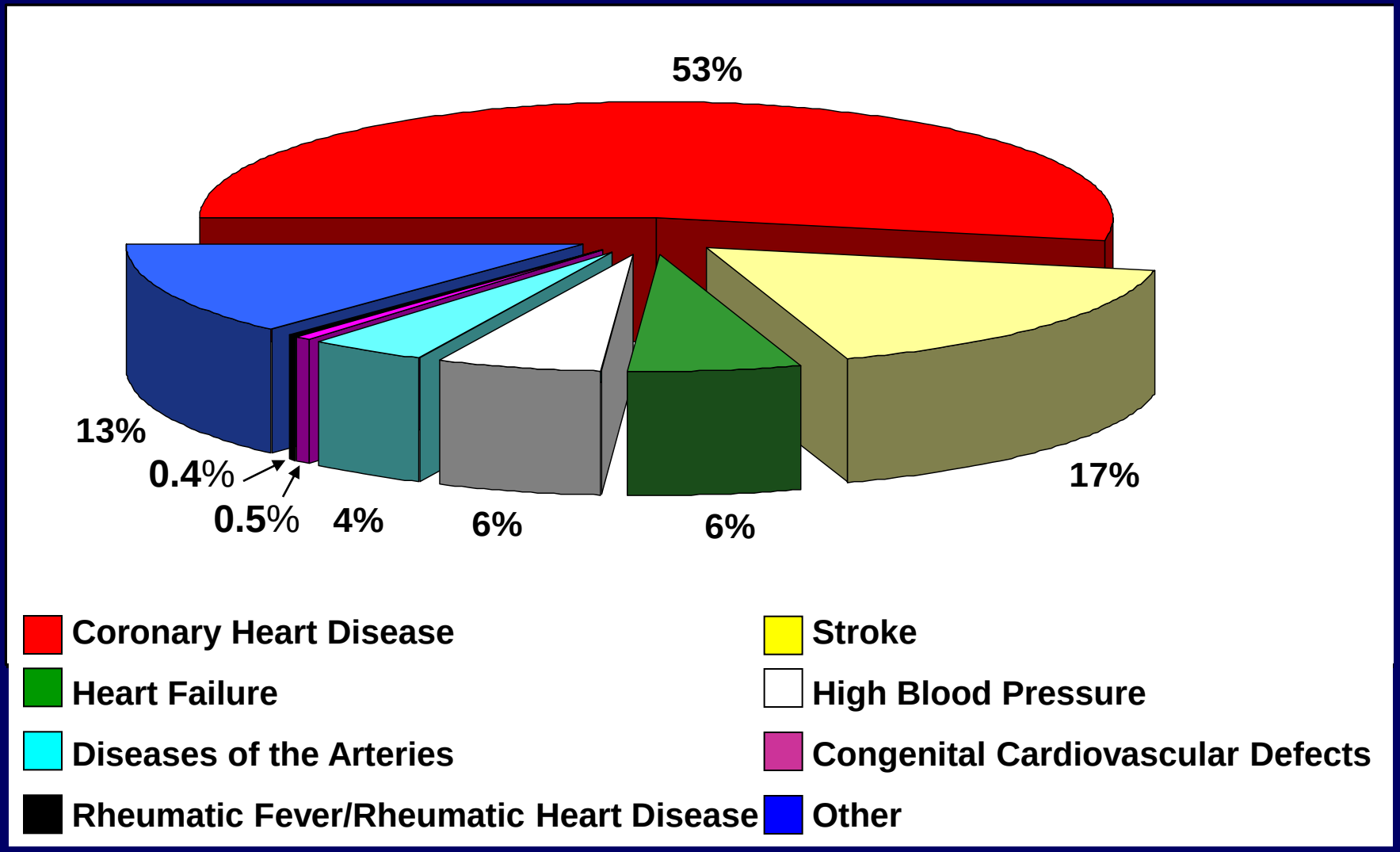


Note: Total CVD data are not available for much of the period covered by this chart.

*Source: CDC/NCHS. *Preliminary.*

Percentage Breakdown of Deaths From Cardiovascular Diseases

United States:2003*



*Source: CDC/NCHS and NHLBI. *Preliminary*

What Can We Do About It?

Decreasing Risk Factors

Atherosclerosis often progresses without any symptoms, so how do we predict who is at risk of a heart attack?

Risk factor – a characteristic that is present early in life and is associated with an increased risk of developing future disease.

Risk Factors for Developing CVD

Non-Modifiable

- Age
- Sex
- Race
- Family History

Modifiable Risk Factors

- Smoking
- Obesity
- High Blood Pressure
- High Cholesterol
- Type II Diabetes (impaired glucose tolerance)
- Inactivity

Risk Factors for Developing CVD

Non-Modifiable

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- Sex
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Modifiable Risk Factors

- Smoking
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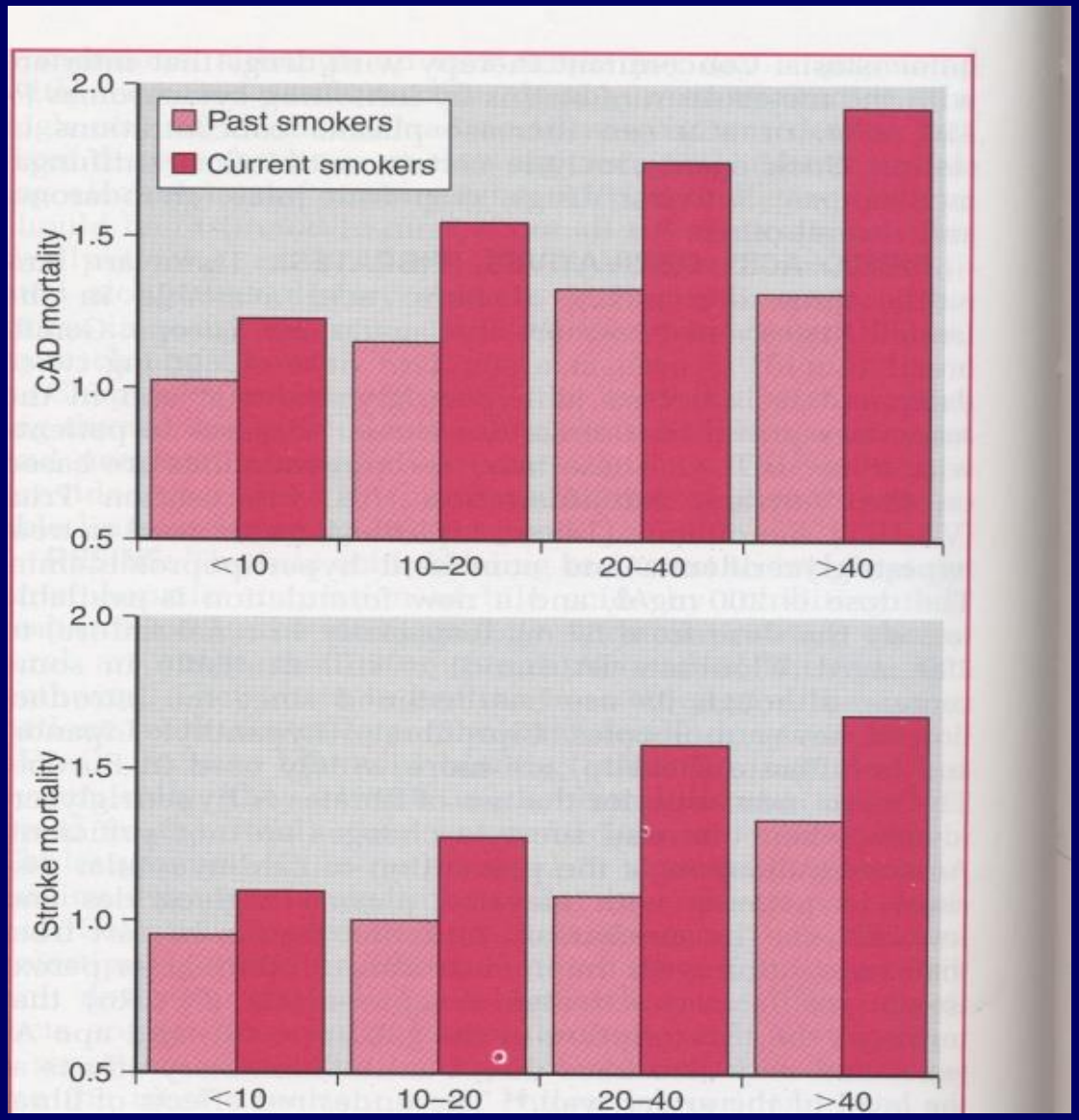
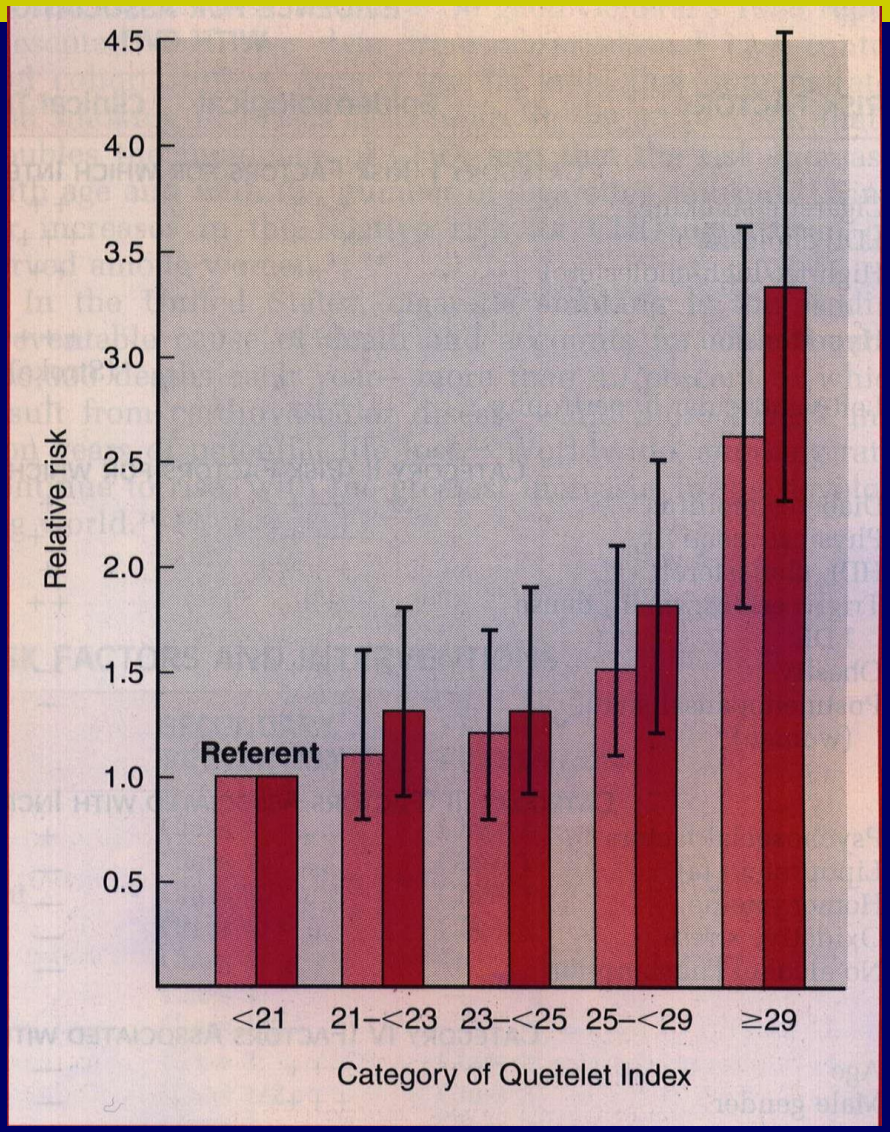
Metabolic Syndrome

Smoking Cessation (cont)



Association Between BMI and CVD



$BMI = Wt/Ht^2$

Example

Wt = 220 lbs or 100 kg

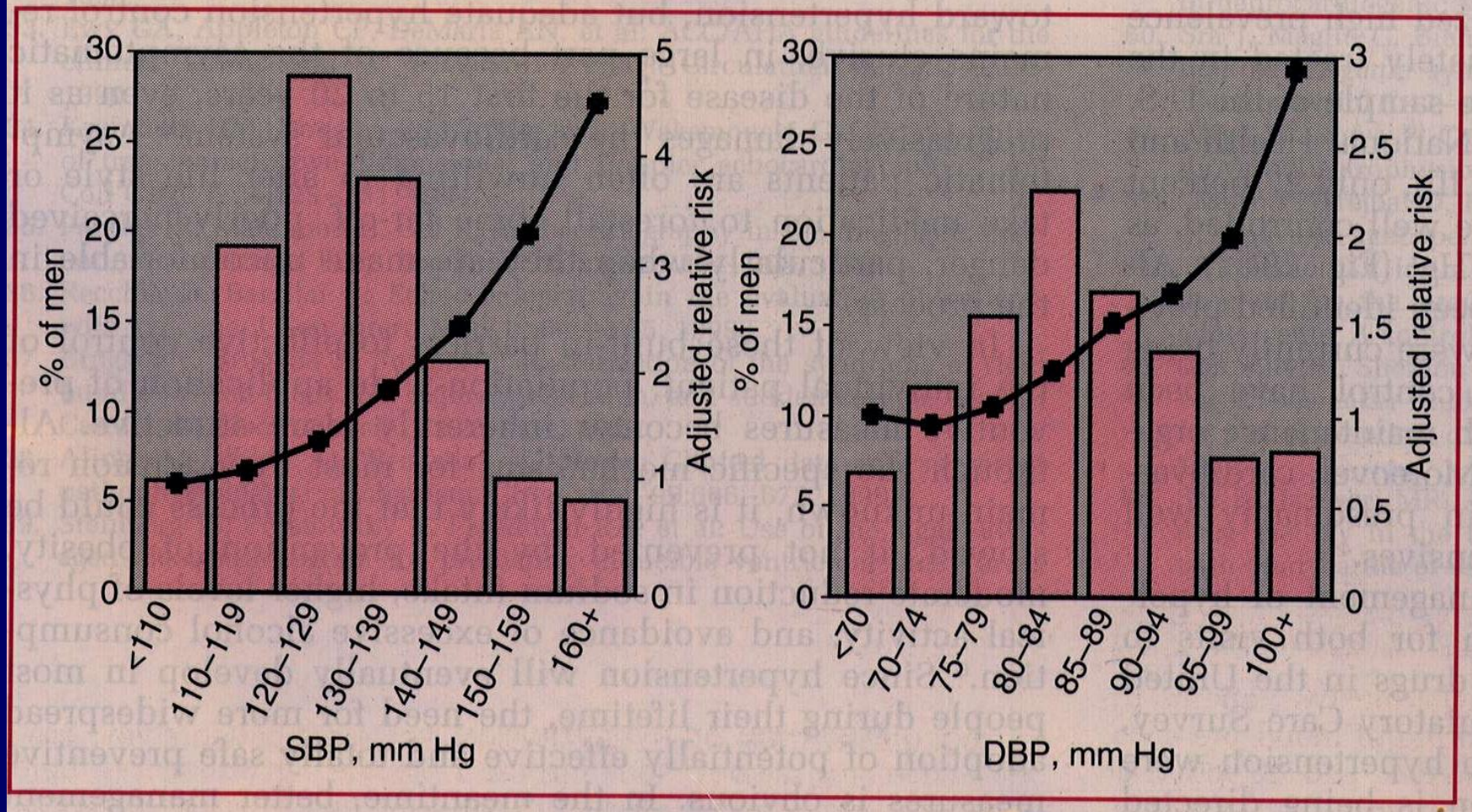
Ht – 5’10” or 177 cm or 1.77 m

$BMI = 100/(1.77^2)$

$= 31.9$

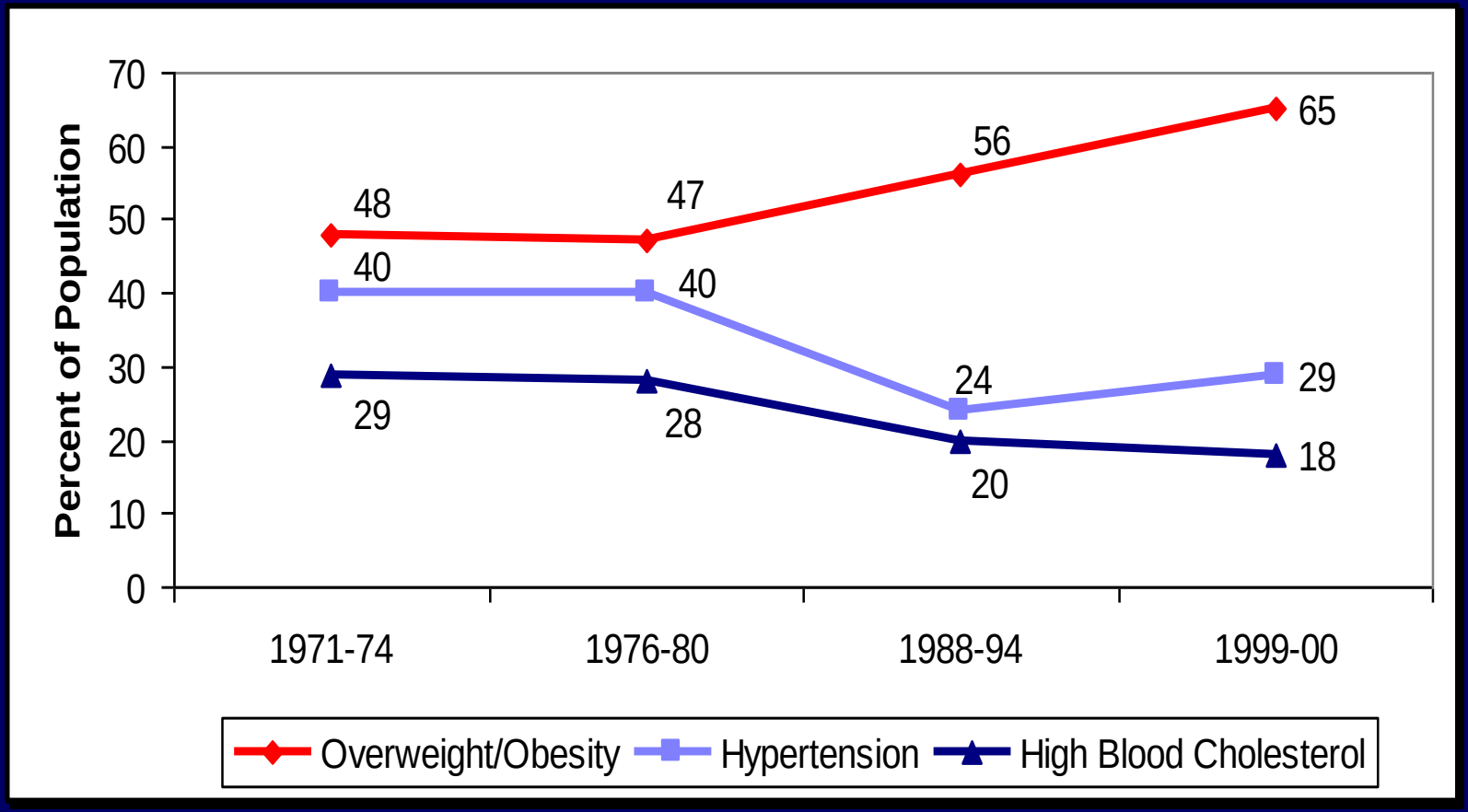
Gaziano, Manson &Ridker. In: Braunwald, Zipes, & Libby. *Heart Disease: A Textbook of Cardiovascular Medicine*. 6th Ed. Volume 1 Page 1045 Figure 32-4
Manson et al. *N Engl J Med*, 1990.

Relative Risk of CVD versus BP and Percent Population at Given BP



Trends in Age-Adjusted Prevalence of Health Conditions, U.S. Adults Ages 20-74

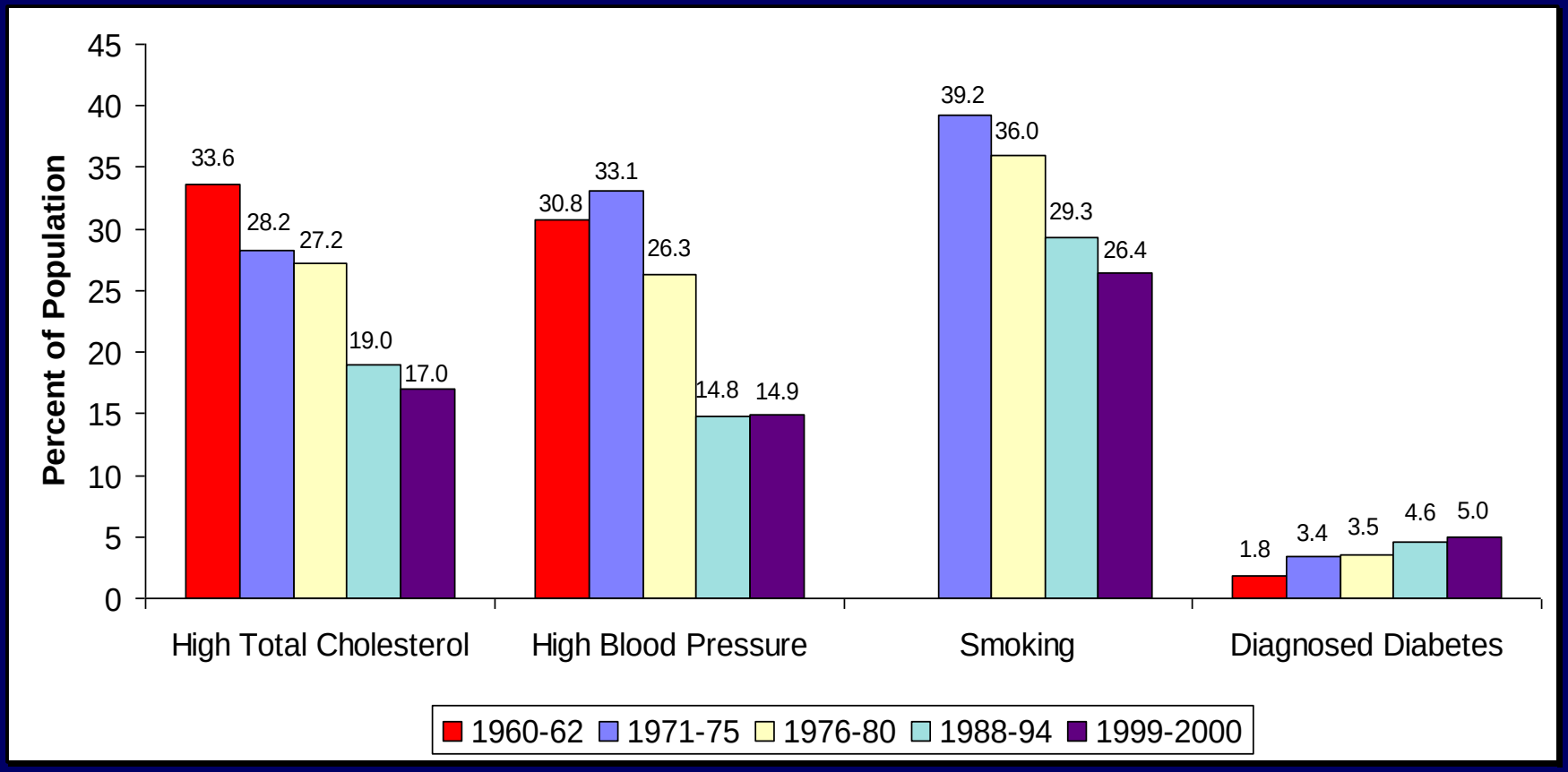
NHANES:1971-74 to 1999-2000



Source: Ann. Rev. of Nut. July 2004. Vol.24: 401-431

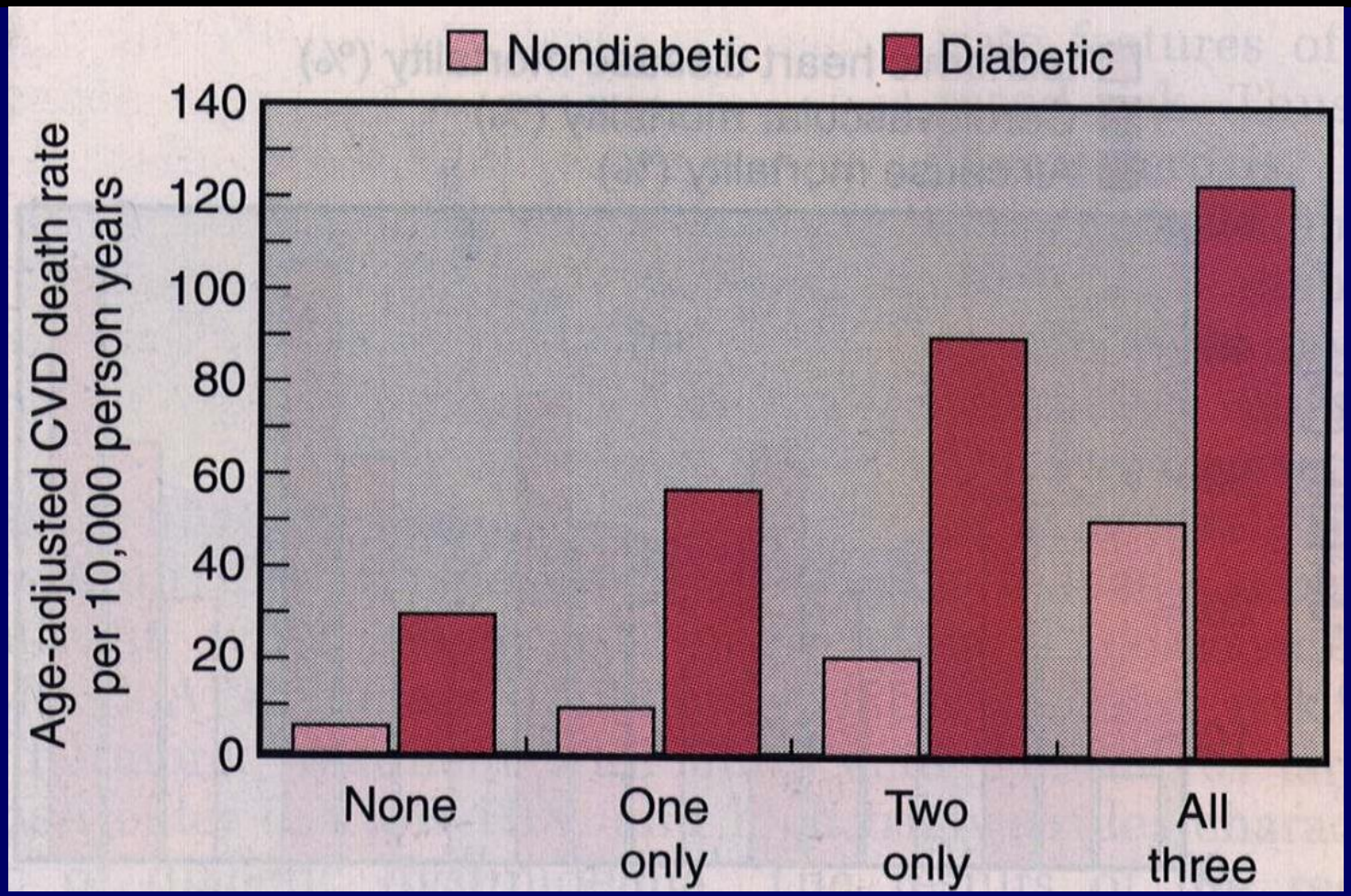
Trends in Cardiovascular Risk Factors in the U.S. Population Aged 20-74

NHES: 1960-62, NHANES:1971-75 to 1999-2000



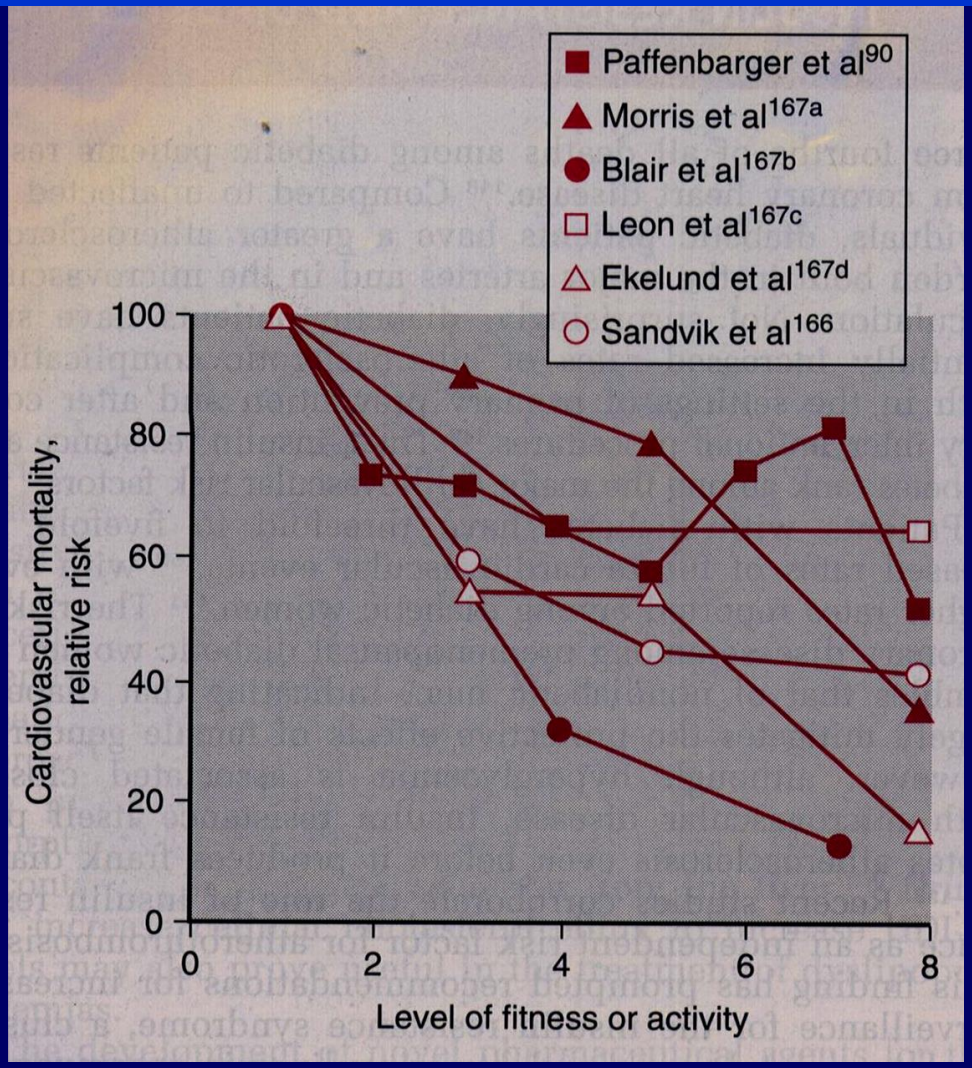
Source: JAMA 2005. 293: 1868-74.

Risk of CHD - Diabetes

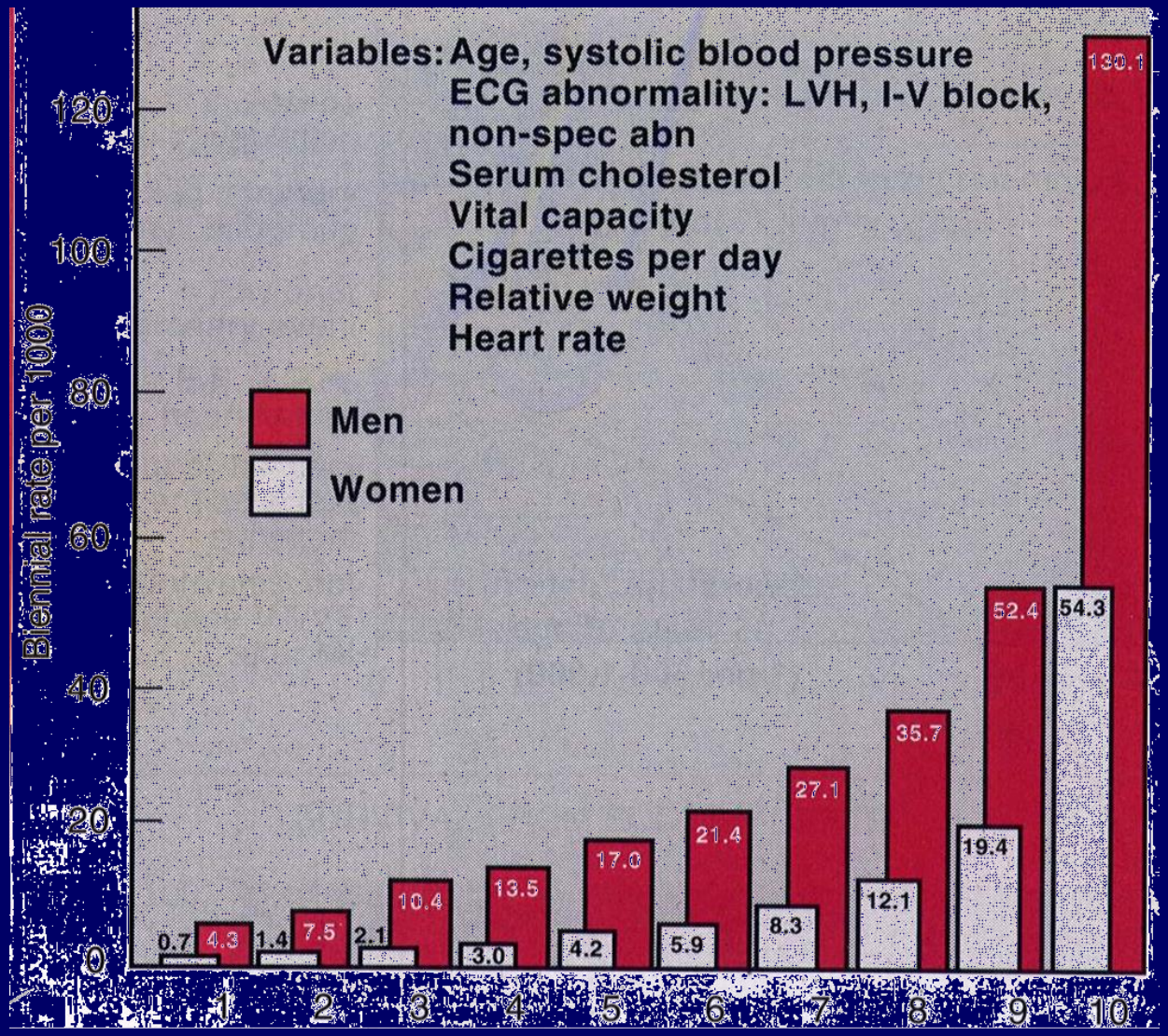


Nesto & Libby. In: Braunwald, Zipes, & Libby. *Heart Disease: A Textbook of Cardiovascular Medicine*. 6th Ed. Volume 2 Page 2137 Figure 63-3
Haffner et al. *N Engl J Med*. 1998.

Physical Activity & CV Risk



Multiple Risk Factors versus Risk of Sudden Death



Myerburg & Castellanos. In: Braunwald, Zipes, & Libby. *Heart Disease: A Textbook of Cardiovascular Medicine*. 6th Ed. Volume 1 Page 894

Kannel & Shatzkin. *J Am Coll Cardiol*. 1985

What Can We Do About Risk Factors…and Disease Progression?

Strategies for Modifying Risk Factors

A. Increased Physical Activity/Exercise

B. Improved Diet/Nutrition

Strategies for Reducing CV Risk

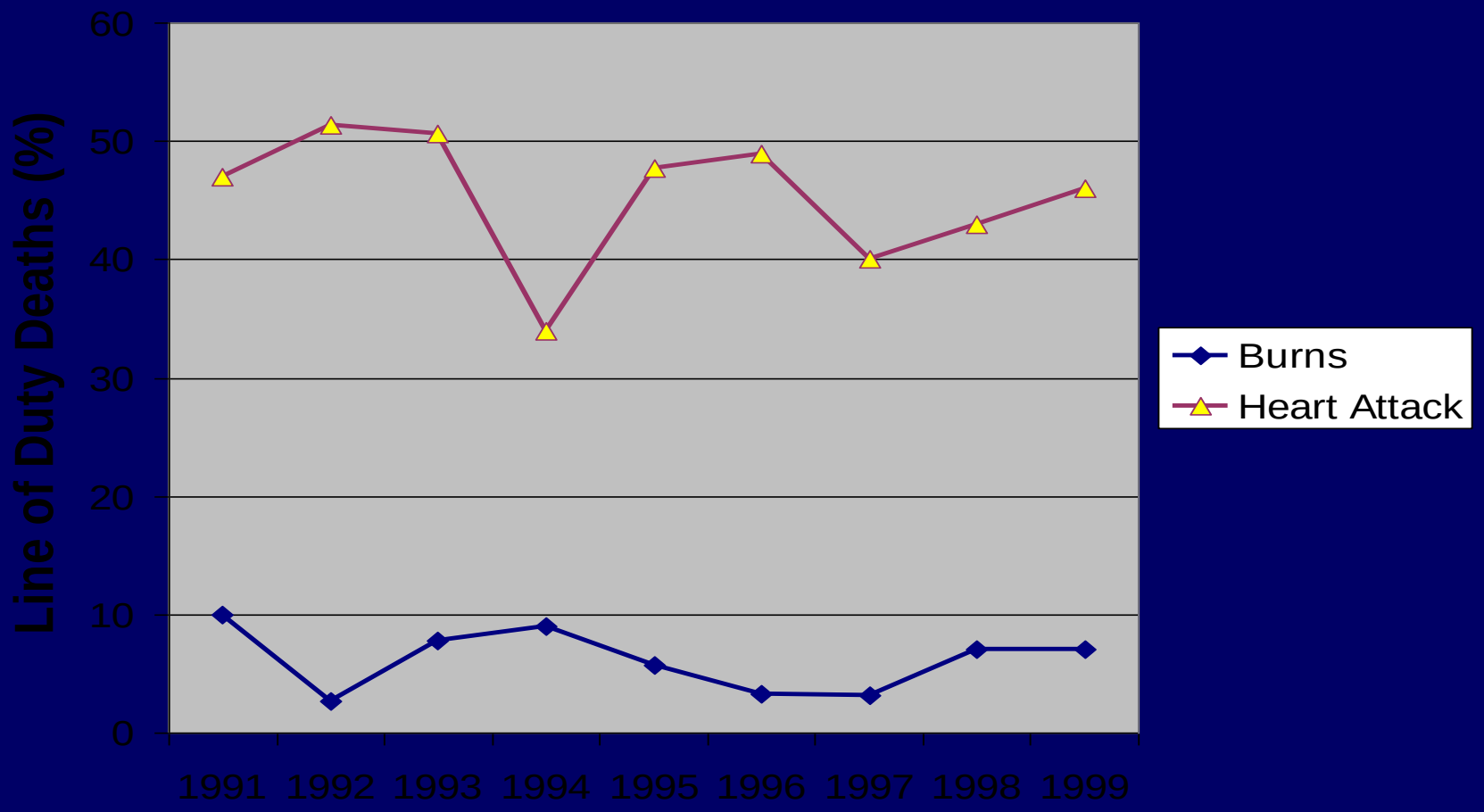
Recommendations	Risk Factor Influenced
Exercise Moderately	Decreased Blood Pressure Improved Lipid (Chol) Profile Decreased Body Weight Improved Glucose Tolerance
Eat a Balanced Diet	Improved Lipid (Chol) Profile Decreased Body Weight Improved Glucose Tolerance May Decrease Blood Pressure
Don’t Smoke	Smoking

Heat Stress and Cardiovascular Strain

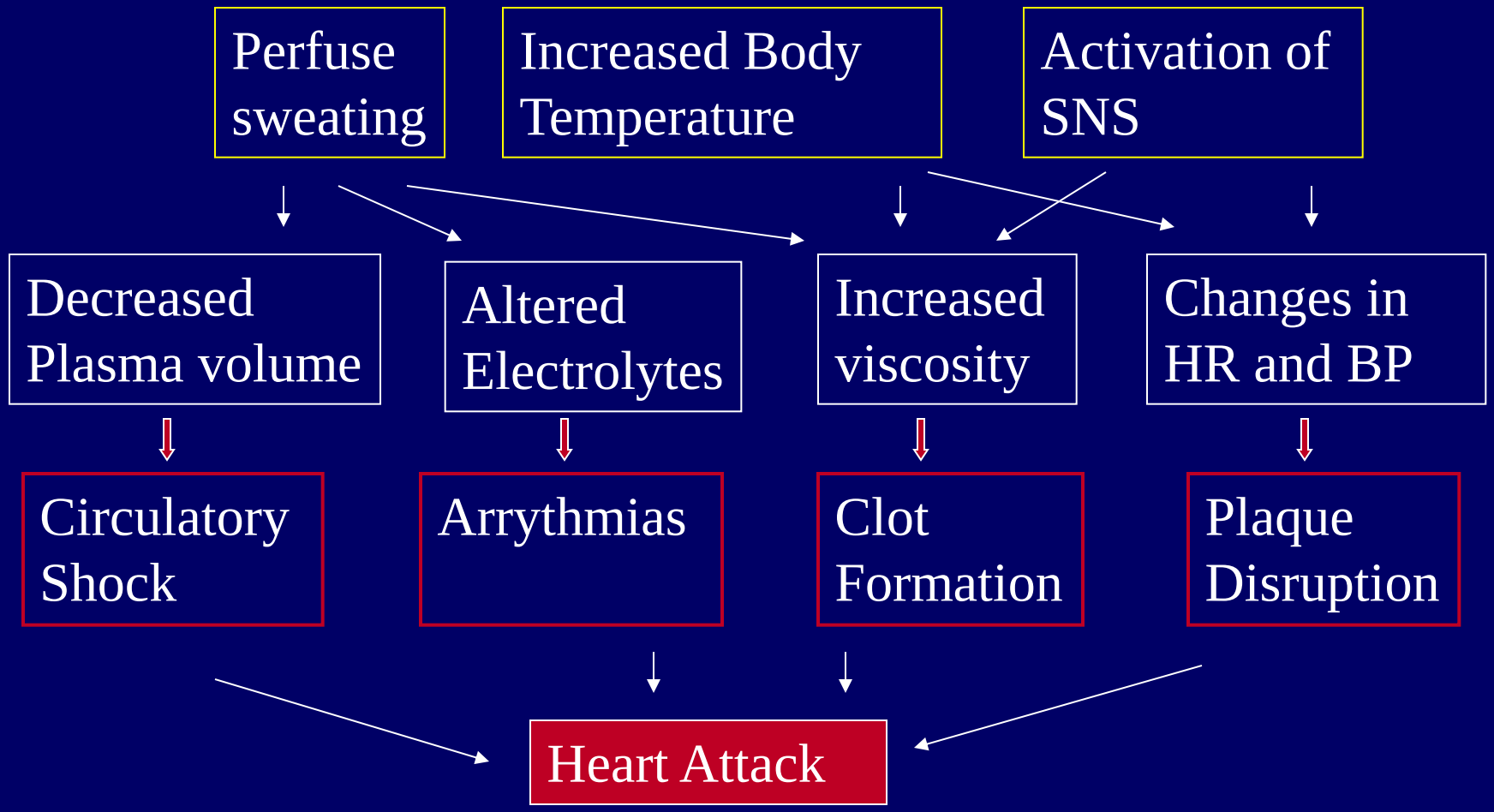
Firefighting Fatalities

- The leading nature of line of duty deaths (LODD) is heart attack (43.9%)
- The leading cause of LODD is overexertion/strain (46.6%)
- 800-1,000 non-fatal heart attacks while on duty
- Number of fatal and non-fatal heart attacks among off duty FF is not known

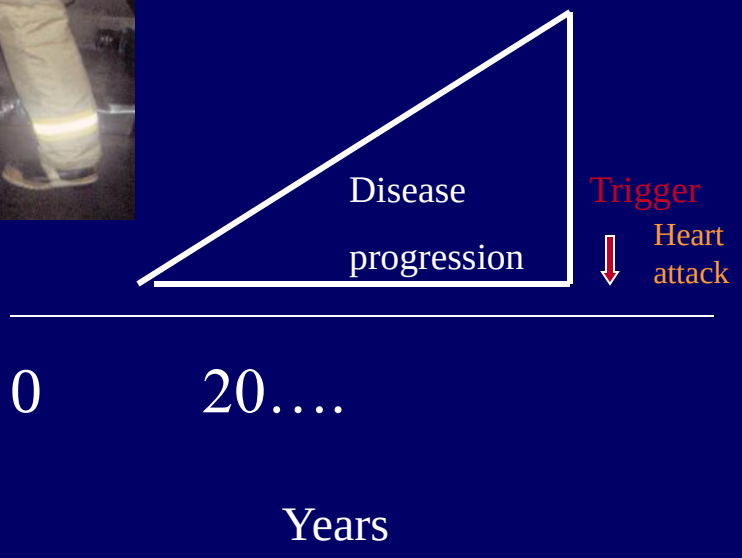
LODD by Cause

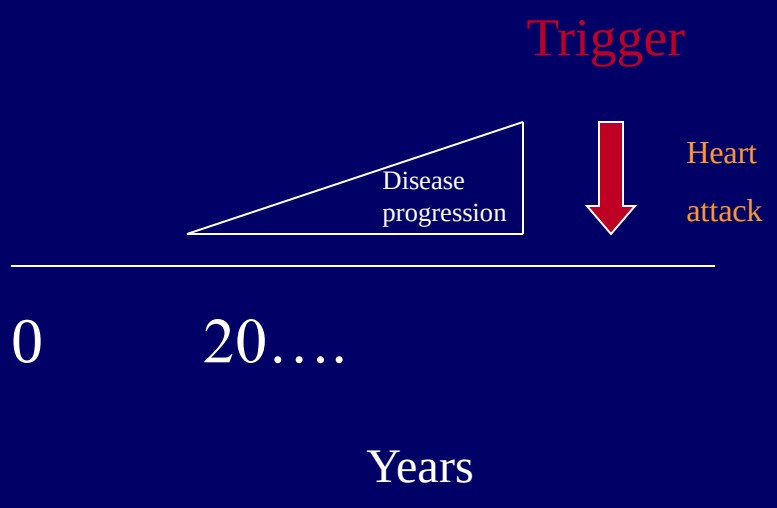


Simplified Schematic of Possible Causes of Heart Attack in FF



Models of Lessening CV Fatalities in the Fire Service





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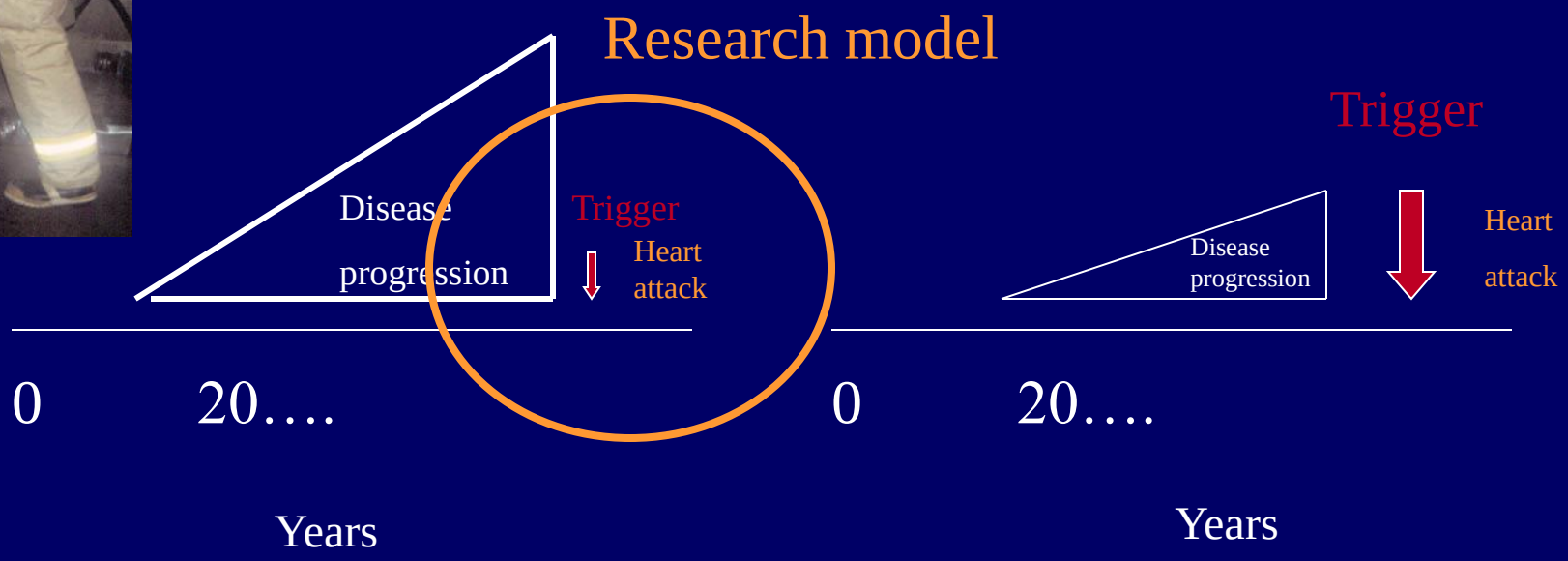
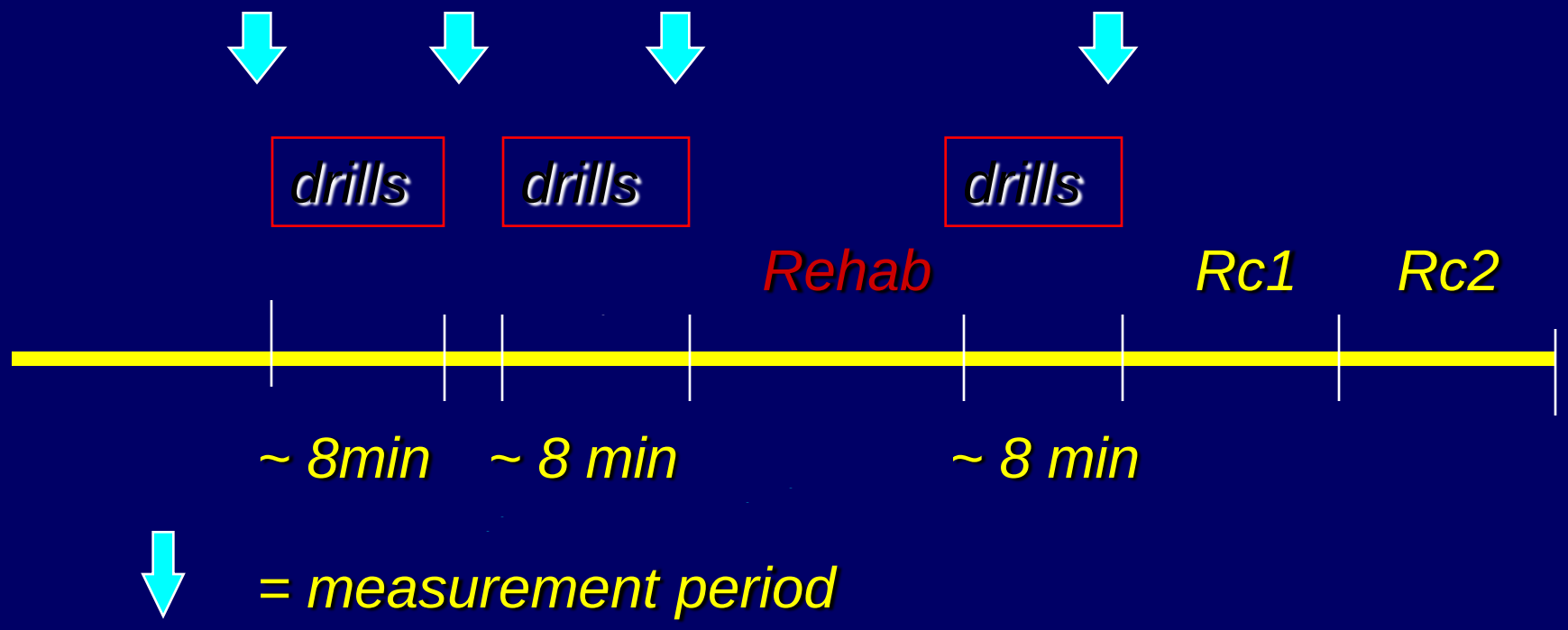


Theoretical Background
(need for research)

"Probably the greatest stress ever imposed on the human cardiovascular system is the combination of exercise and hyperthermia. Together these stresses can present life-threatening challenges, especially in highly motivated athletes who drive themselves to extremes in hot environments."

L.Rowell, 1993. In *Human Cardiovascular Physiology*, Oxford Press.

Changes During FF

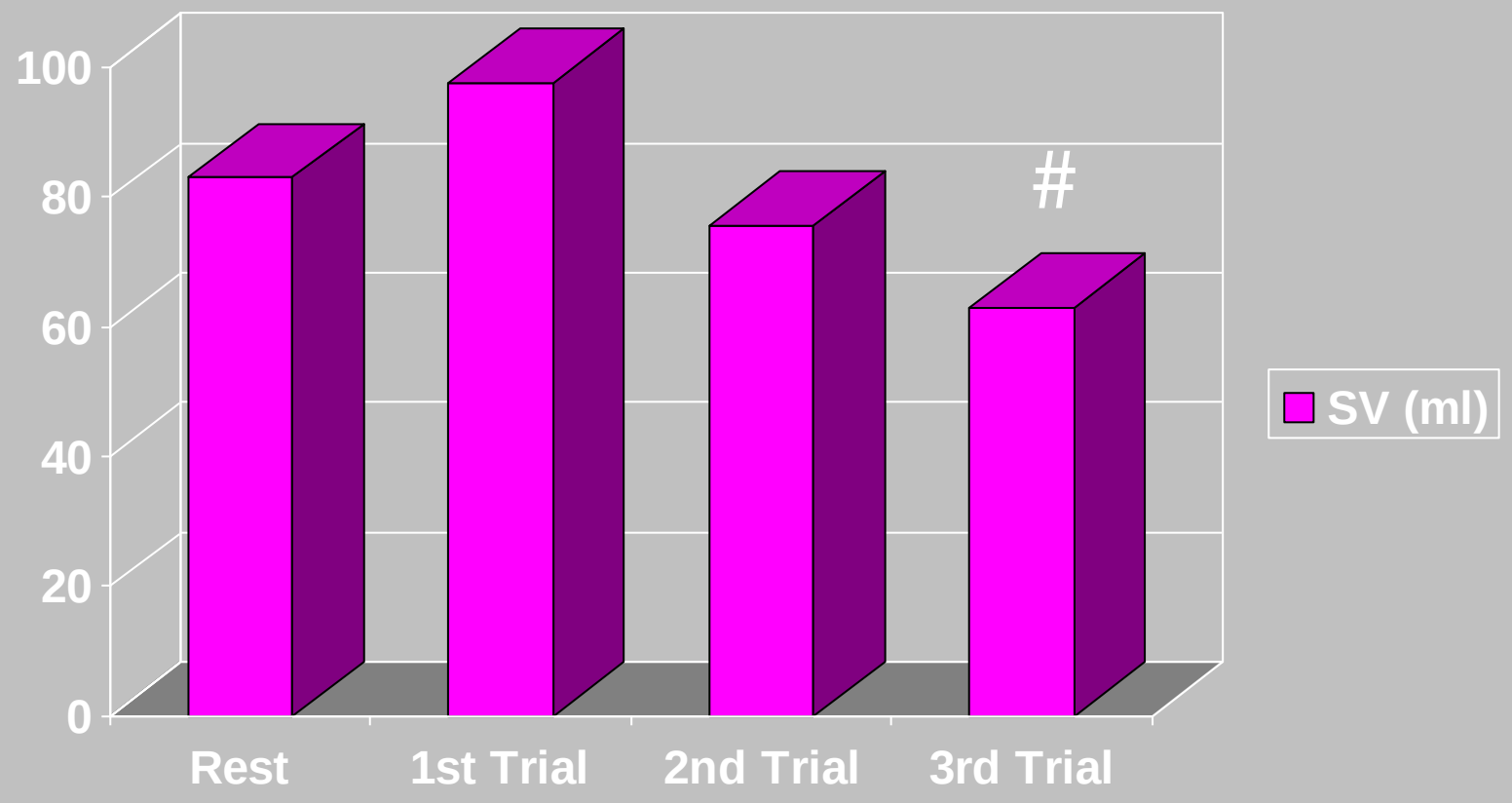


Physiological/Psychological Stress

<u>Firefighting Tasks</u>

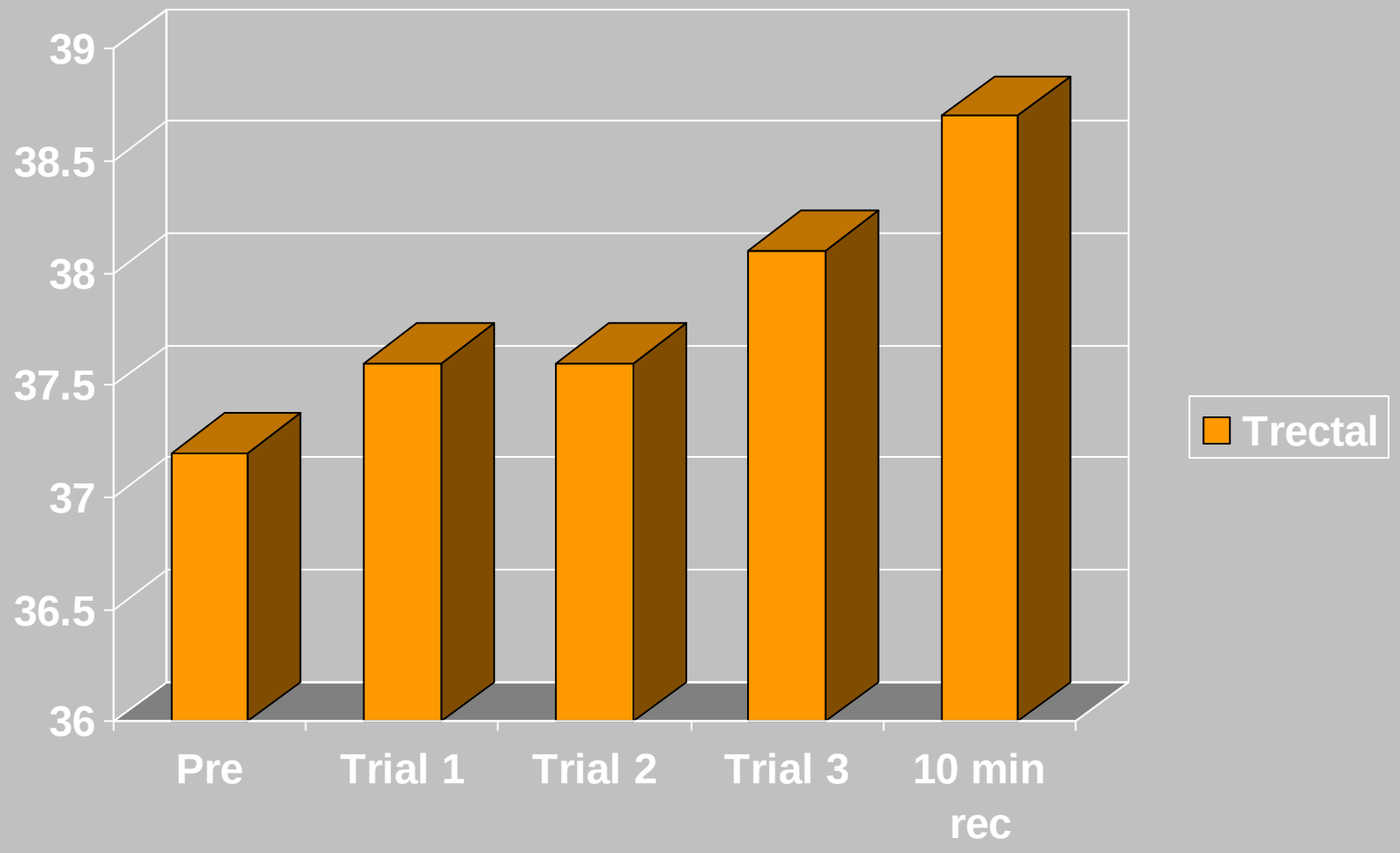
- Dummy drag
- Carry and discharge extinguisher
- Hose pull
- Wood chopping

Stroke Volume Response

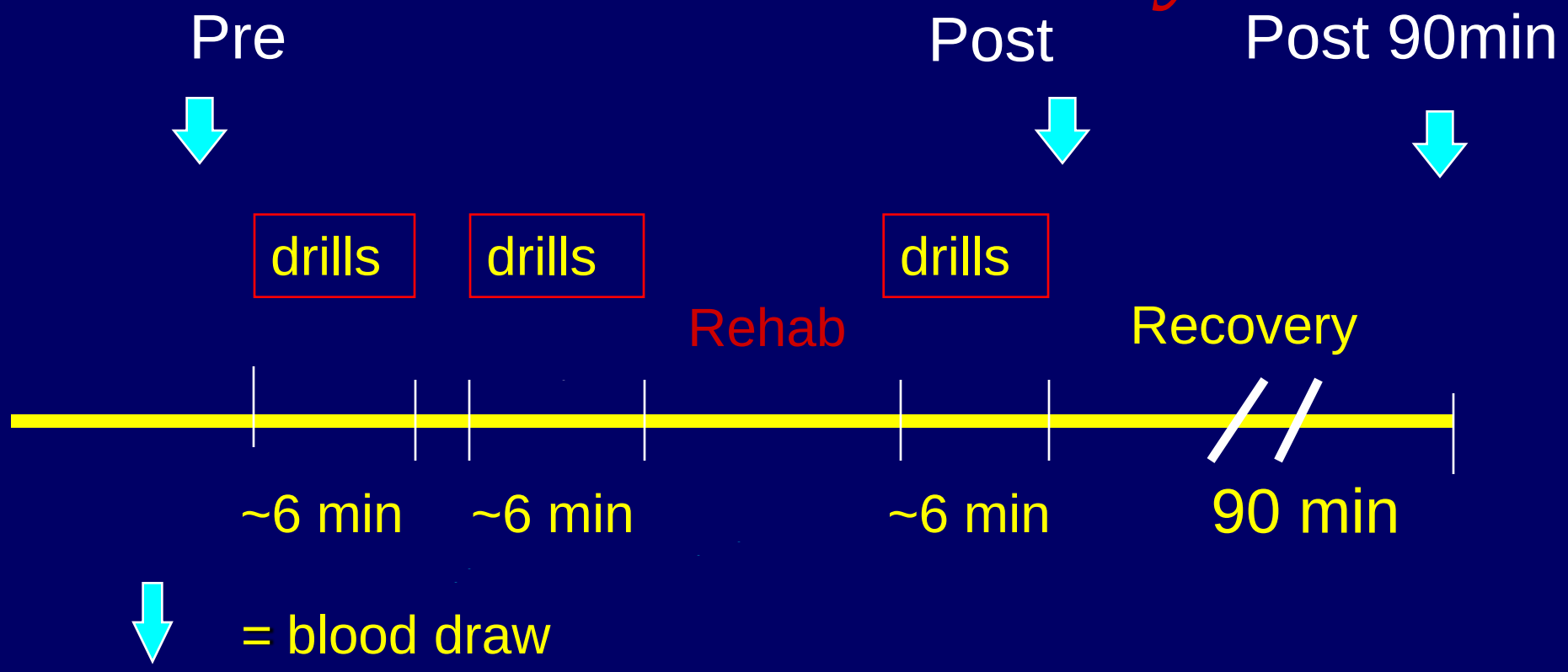


# p <.05 vs T1

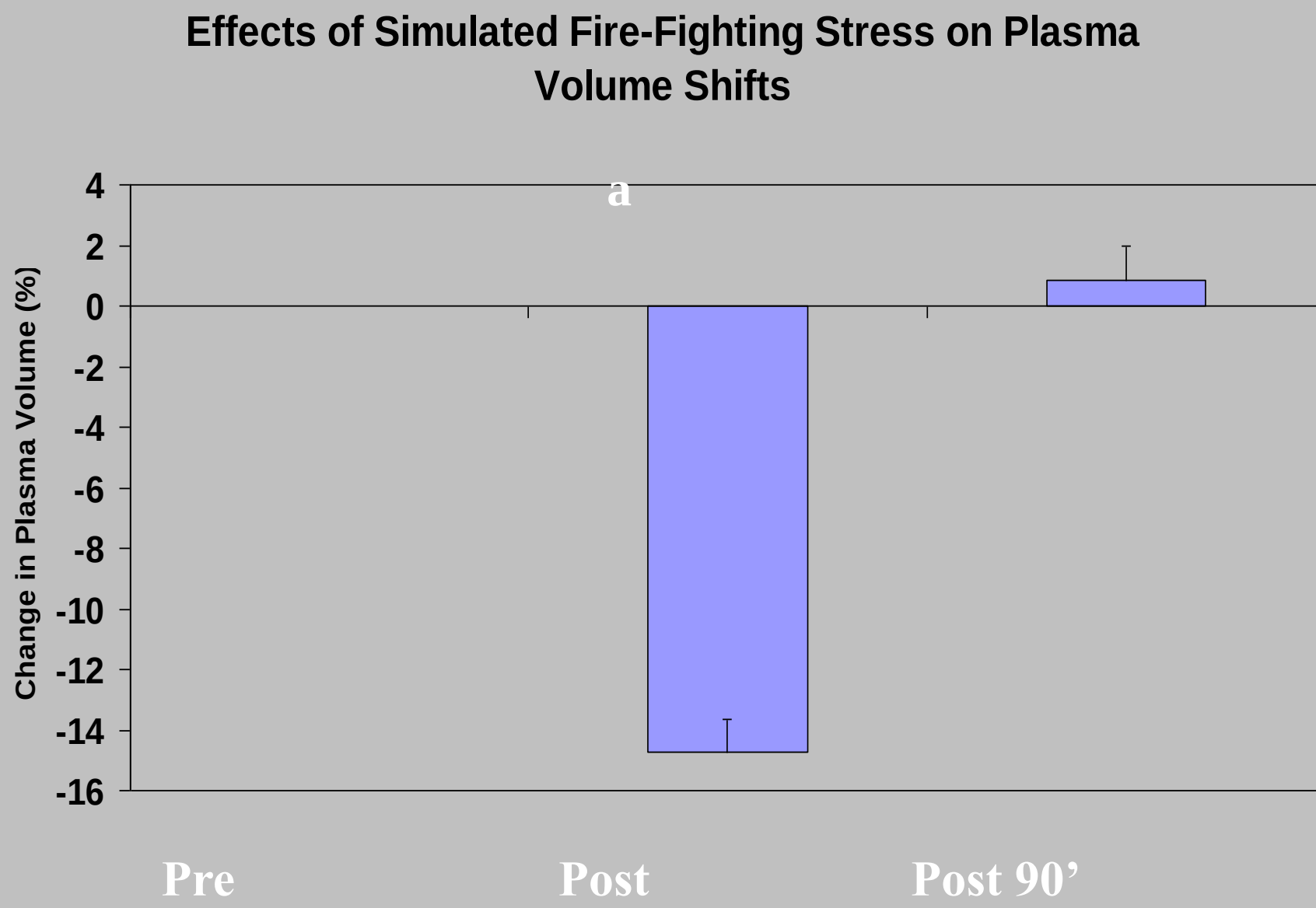
Changes in Core Temperature



Changes after 90 min Recovery

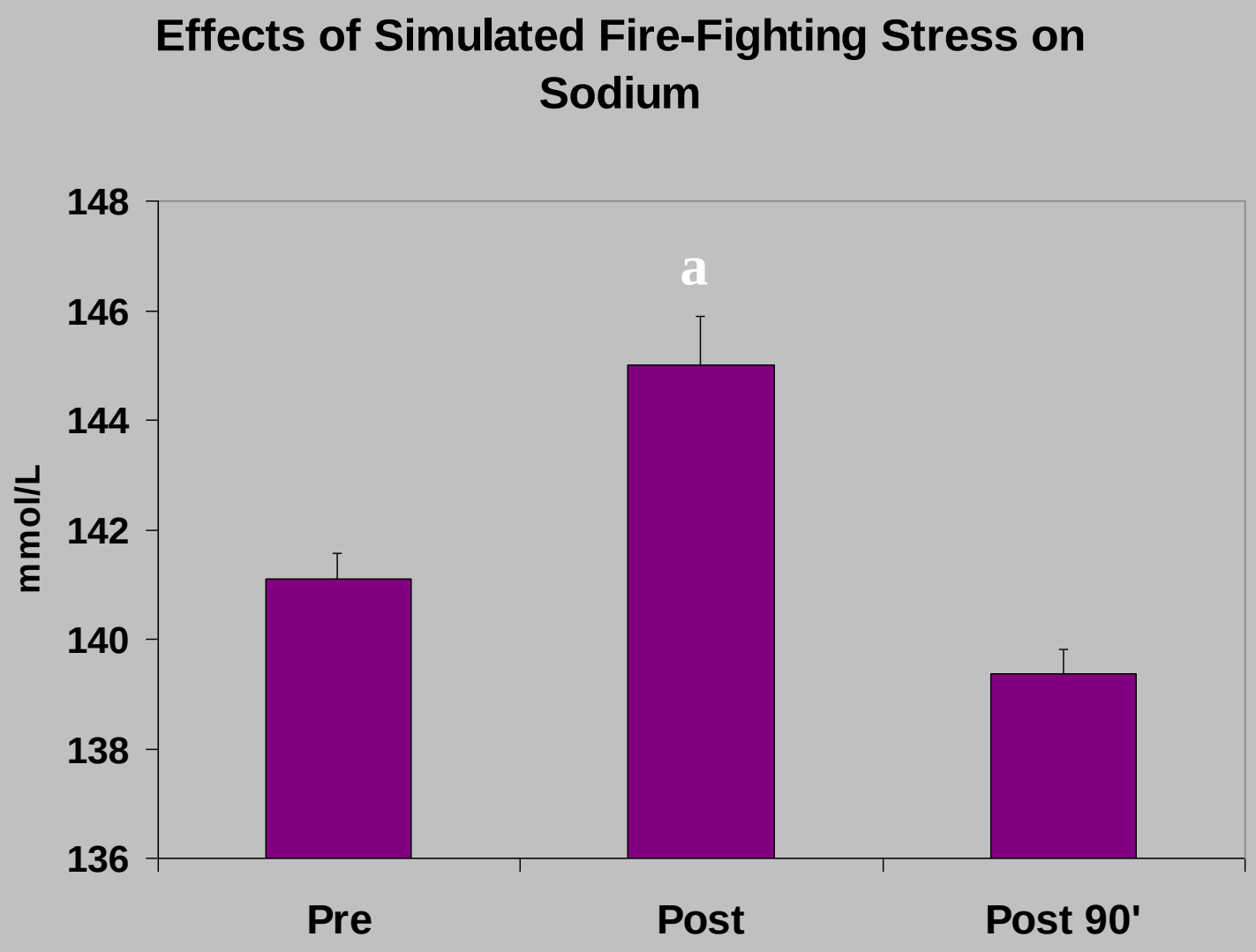


Physiological/Psychological Stress



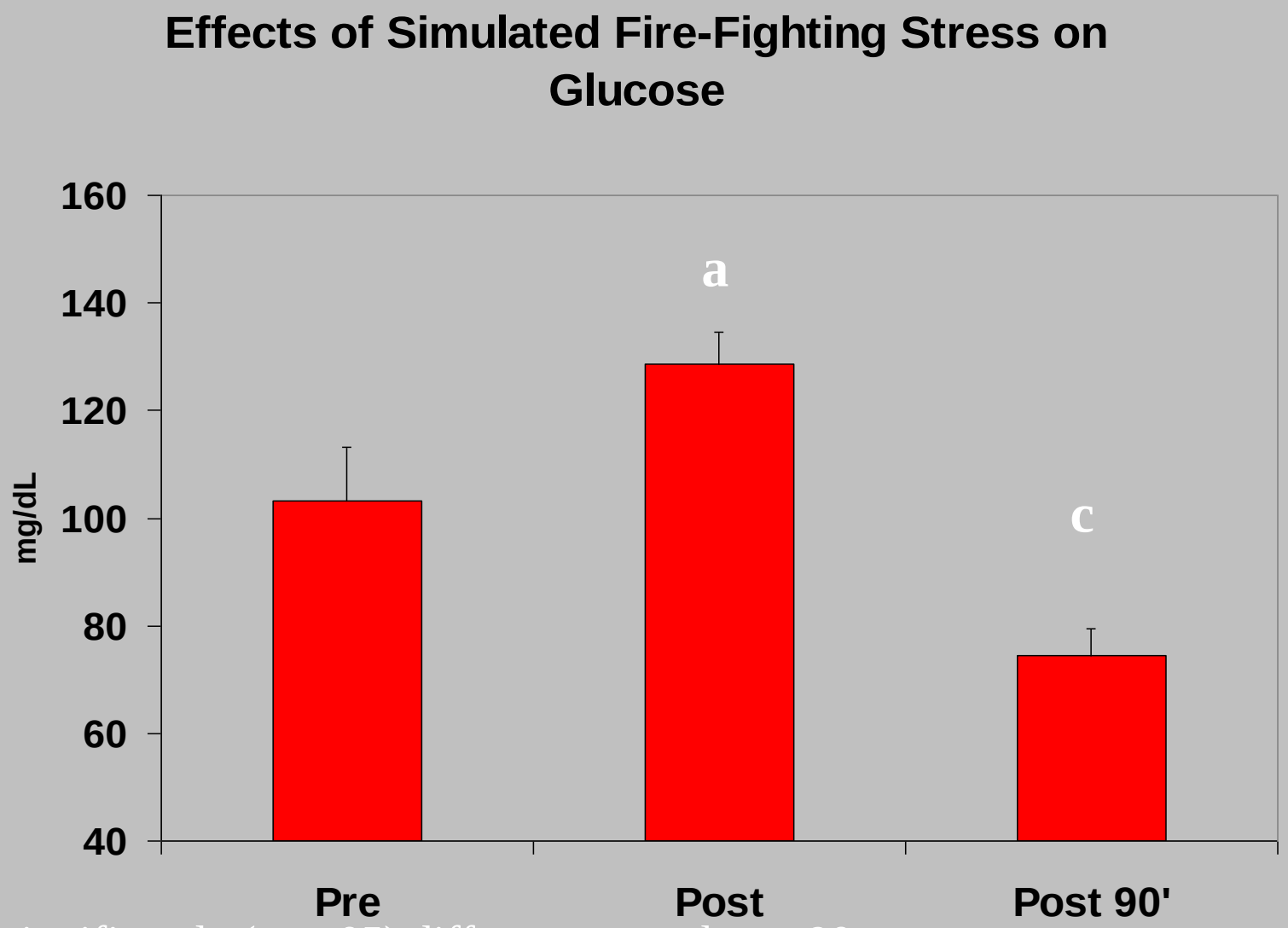
[a] significantly ($p < .05$) different pre and post 90'

Physiological/Psychological Stress



[a] significantly ($p < .05$) different pre and post90

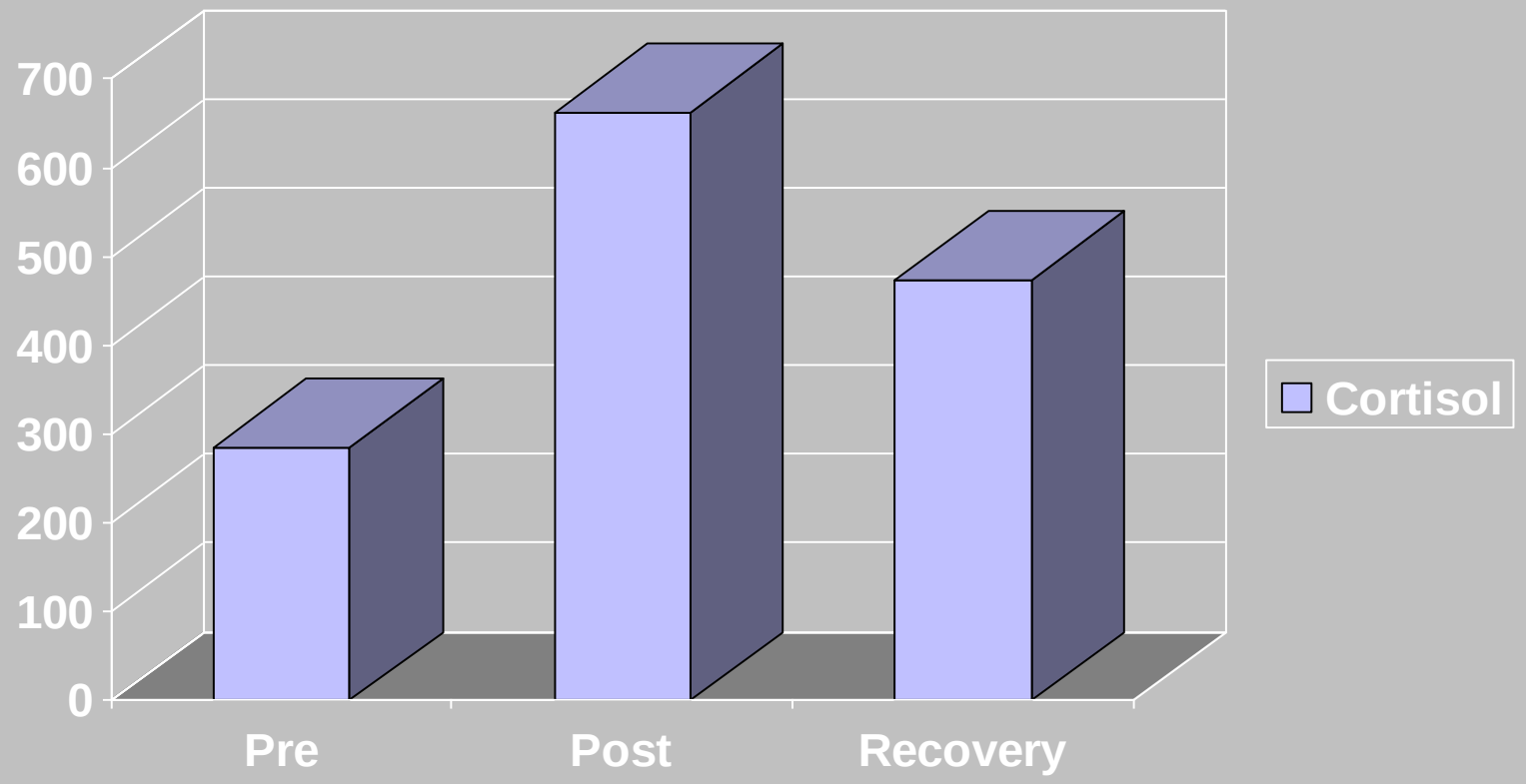
Physiological/Psychological Stress



[a] significantly ($p < .05$) different pre and post 90

[c] significantly ($p < .05$) different pre and post 90'

Changes in Cortisol



Effects of Simulated Fire-Fighting Stress on Leukocyte Numbers

Variable ($x10^9/L$)	Pre	Post	Post 90'
Total Leukocytes	4.94 ± 0.3	9.15 ± 0.7[a]	8.12 ± 0.6[a]
Neutrophils	2.74 ± 0.2	4.22 ± 0.3[a]	6.27 ± 0.5[b]
Lymphocytes	1.67 ± 0.2	4.03 ± 0.4[a]	1.25 ± 0.1[b]
Monocytes	0.29 ± .04	0.68 ± 0.2[a]	0.44 ± 0.1[b]
Eosinophils	0.15 ± .02	0.16 ± .02	0.06 ± .01[b]
Basophils	0.09 ± 0.1	0.07 ± .01[c]	0.04 ± 0.01

[a] significantly ($p < .05$) different from pre,
[b] significantly ($p < .05$) different from pre and post
[c] significantly ($p < .05$) different from pre and post 90'

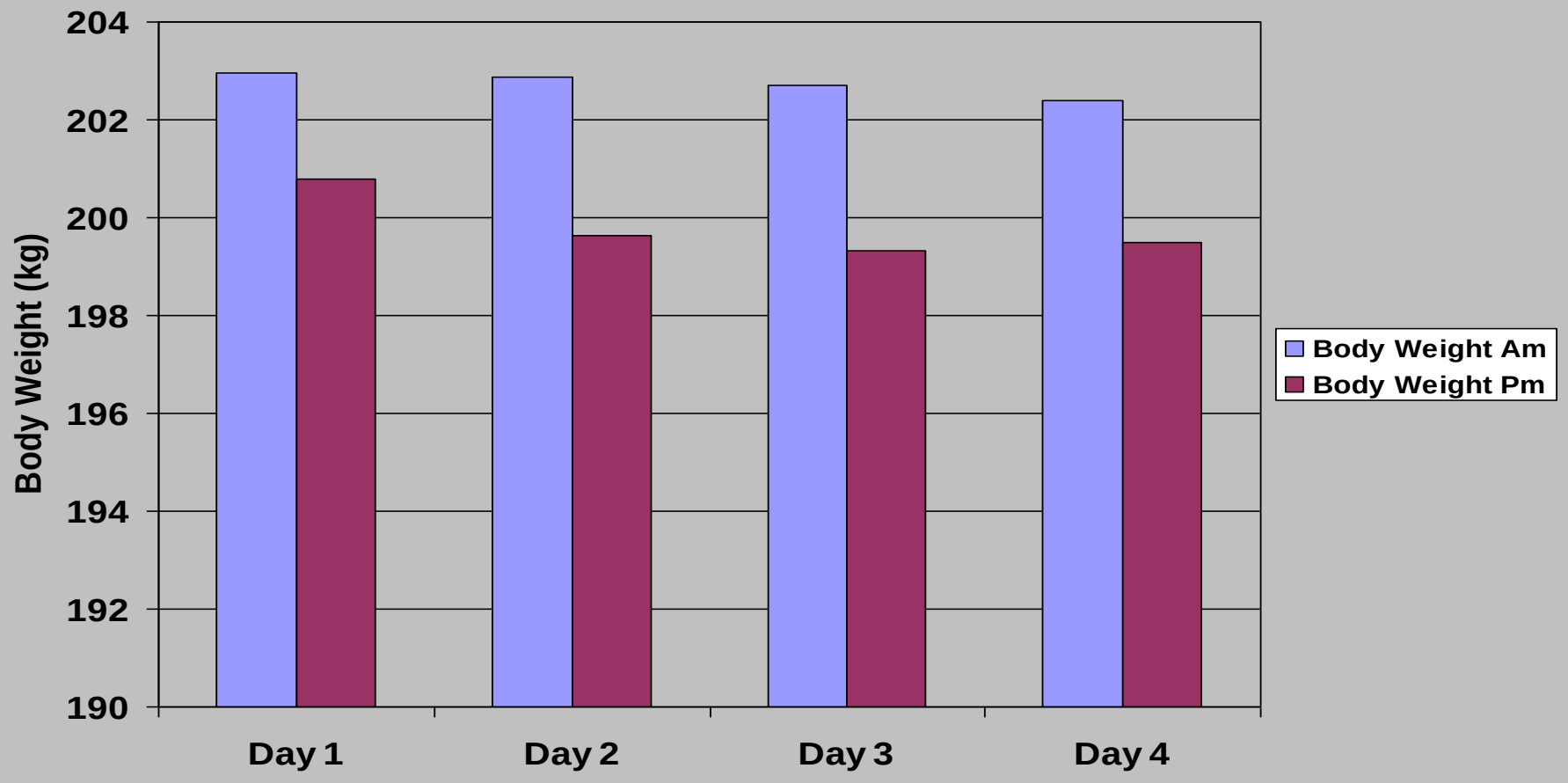
Effect of Firefighting on Coagulation Factors (N=10; Mean ± SD)

Variable	Pre	Post
Platelets ($x10^3$/uL)	236.6 (48.2)	290.37 (83.4) *
Prothrombin Time (s)	10.18 (0.6)	10.13 (0.6)
Activated Partial Thrombopastin Time (s)	25.2 (2.3)	25.5 (2.7)
Fibrinogen (mg/dL)	254.5 (17.2)	243.9 (20.8) †
Antithromin III (%)	109.7 (4.9)	116.8 (6.9) *

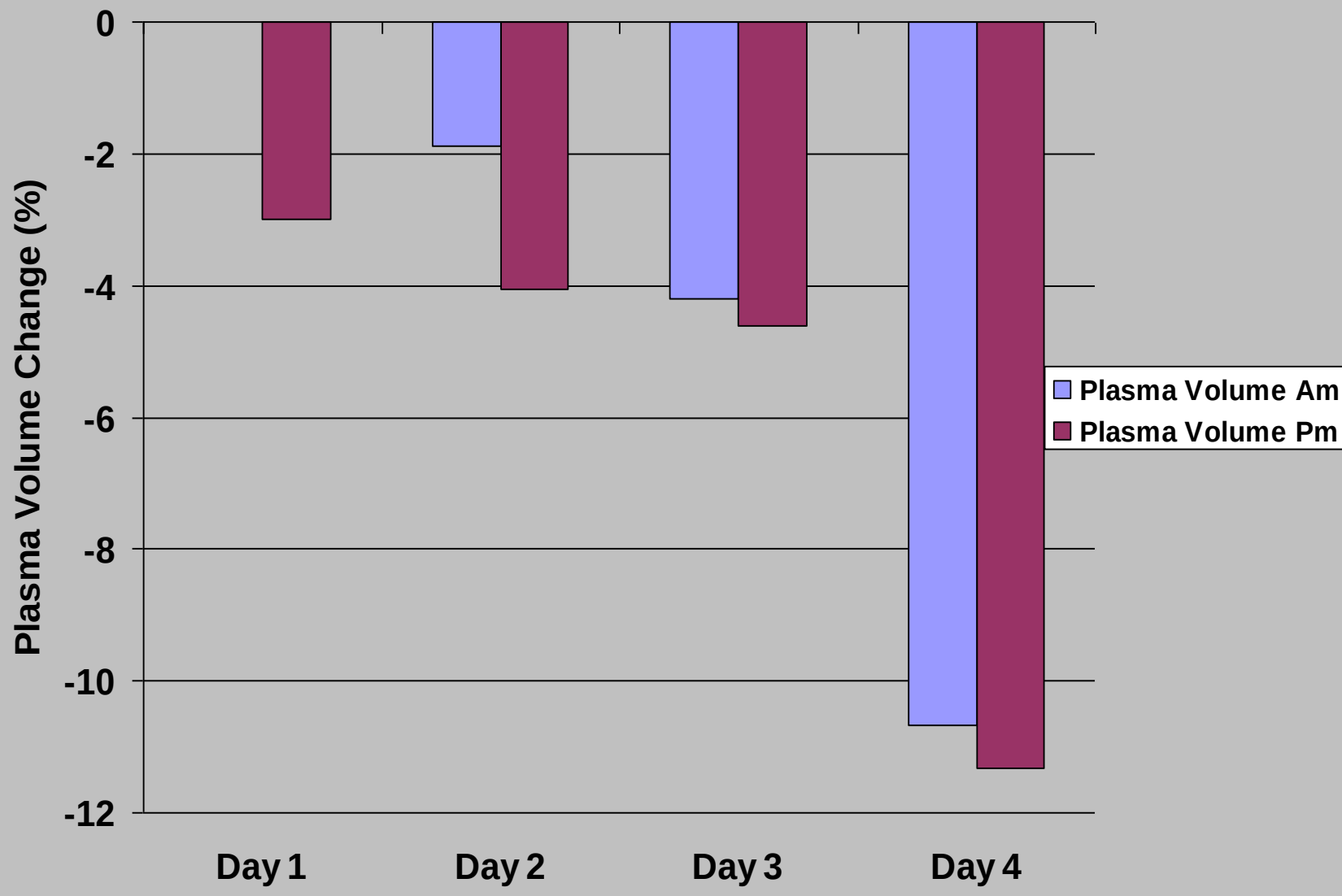
* $p<0.001$

† $p < 0.05$

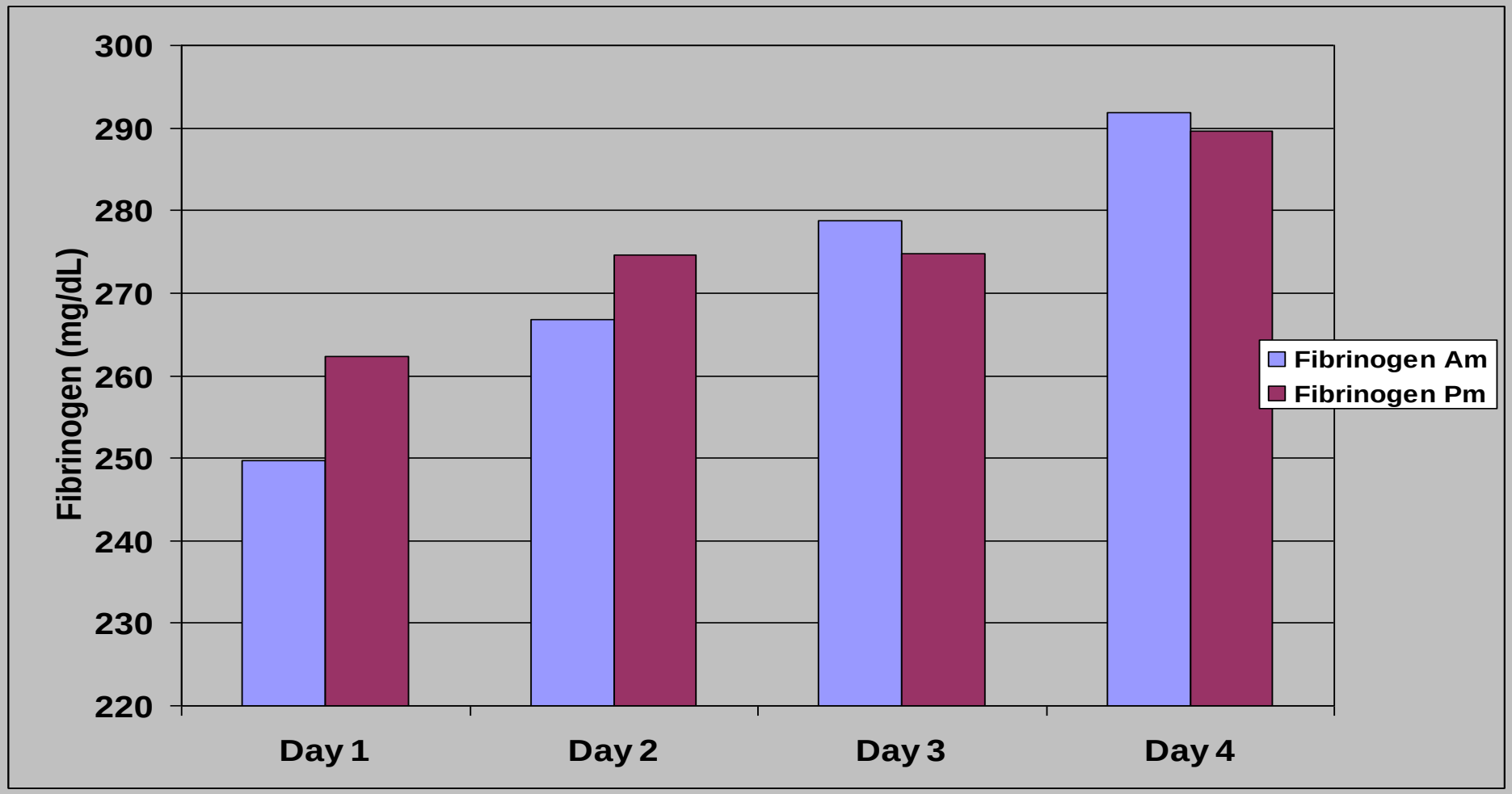
Changes during Serial Days of Firefighting



Physiological/Psychological Stress



Physiological/Psychological Stress



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- University of Illinois Fire Service Institute, especially Dick Jaehne, Dave Clark, Brian Brauer and Brad Bone
- University of Illinois Fire Service Institute Scholarship Foundation, especially Mac McCastland,
- University of Illinois Department of Kinesiology
- Champaign Fire Department
- Carle Medical Center, especially Dr. Manchanda, Dr. Scaggs, Dr. Reed and Kelly Dyer
- United States Fire Administration

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