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Physiology of Aging

Brent C. Williams, MD, MPH
Associate Professor of Medicine
University of Michigan

Intended Learning Outcomes

- Distinguish usual from successful aging.
- Describe the major age-associated changes in human physiology.
- Understand the “anti-aging” effects of exercise.
- Be able to assess nutritional status of older adults, including risks from medications.
- Appreciate the importance of functional assessment of older individuals.

What is Aging?

Aging

- **is not a disease**
- **occurs at different rates**
  - among individuals
  - within individuals
- **does not generally cause symptoms**

Characteristics of Mammalian Aging

- **cellular and physiologic deterioration**
- **increased mortality with age following maturation**
- **increased vulnerability to disease**
- **decreased ability to adapt to stress**
  - impaired homeostasis

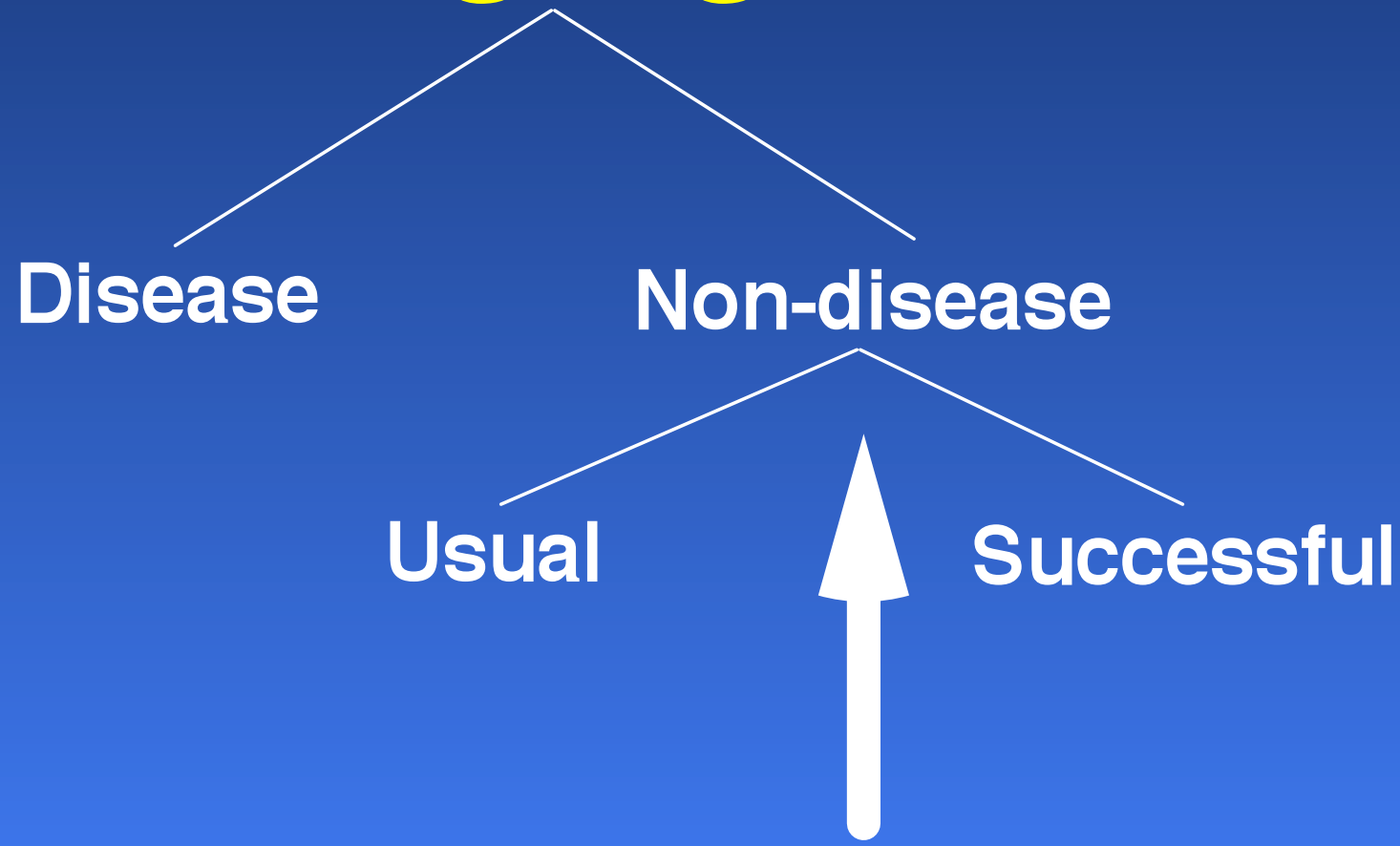
“Normal” Aging as:

- **Optimal – Best example or idealized**
- **Usual - most common**
- **Universal – seen in all humans**
- **All are influenced by:**
  - Genetics - Lifestyle
  - Physiology - Socioeconomics

Problems with Normal Aging

- heterogeniety
- normal does not imply without risk
- normal does not imply natural

Aging



Rowe & Kahn, Science 237:143, 1987

From Usual to Successful Aging – Clinical Approach

- **Normalizing - Helps patients understand what to expect**
  - Adjust to likely changes (e.g., sleep/wake, bowels, balance, benign forgetfulness)
  - Identify potential symptoms of disease (sleep apnea, depression; hypothyroidism; gait disorder; cognitive impairment)

Usual to Successful Aging for Clinicians (cont'd)

- **Maintain or improve modifiable causes of age-related change**
  - Exposures (UV radiation, noise)
  - Psychological well-being (social isolation)
  - Cognition (mental inactivity)
  - Nutrition (cholesterol, sodium, calcium)
  - Exercise (fitness, strength, balance)

Most people live nowhere near their limits. They settle for an accelerated aging, and early and precipitous fall.

They give aging a bad name.

George Sheehan, M.D.

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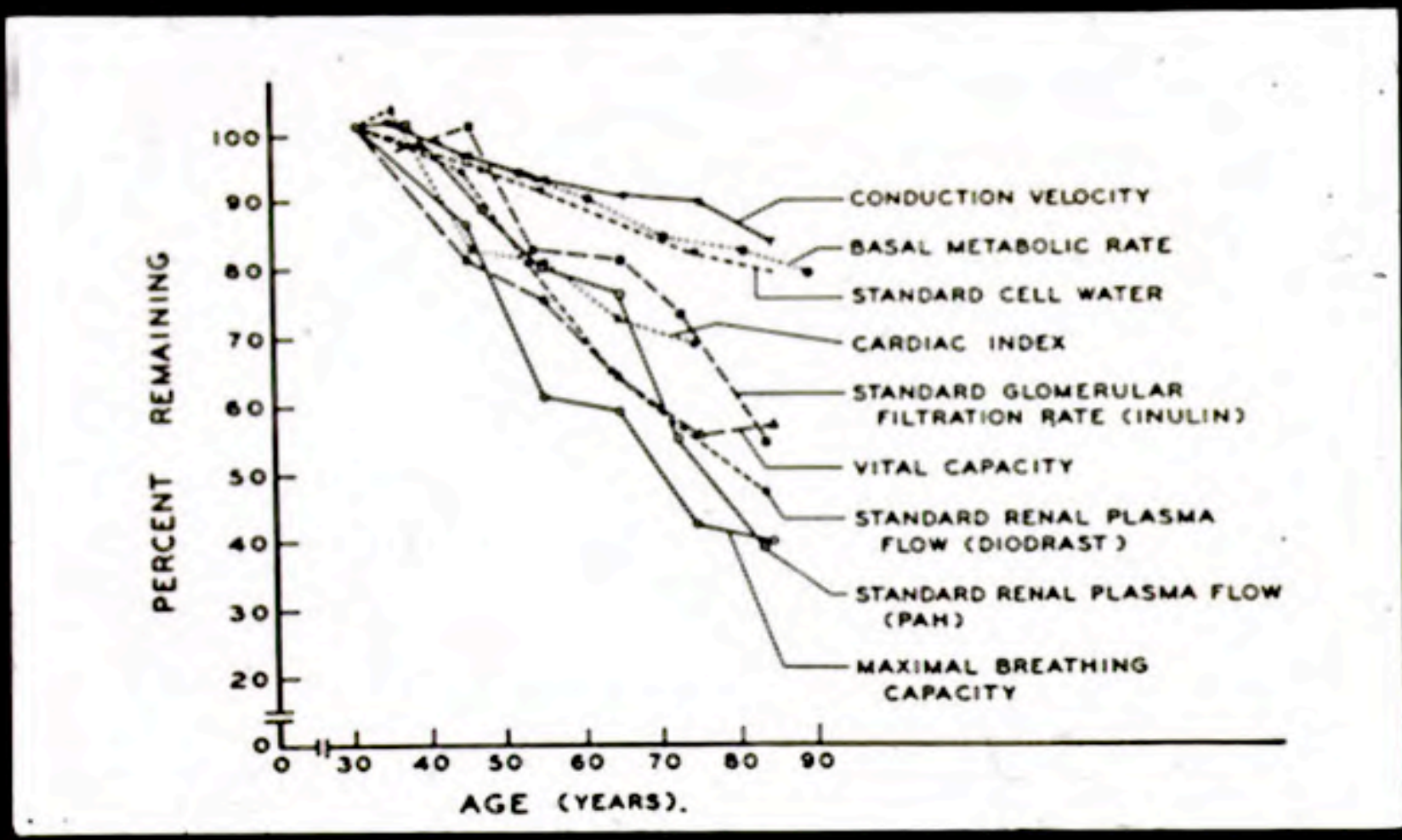
What is normal (clinically expected) aging physiology?

Aging Physiology



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Overview of Aging Physiology

- Skin
- Body Composition
- Vision
- Special Senses
- Nervous System
- Musculoskeletal System
- Renal
- GI
- Cardiovascular

Aging Skin

TABLE 40-7
Physiologic Changes in the Dermis with Aging

Skin more easily damaged
Delayed wound healing
Decreased inflammatory response
Decreased protection from ultraviolet light
Decreased urticarial reaction
Wrinkling, sagging skin
Skin easily stretched under low loads
Loss of resiliency
Diminished absorption
Altered thermal regulation
Decreased sensitivity to pain and pressure

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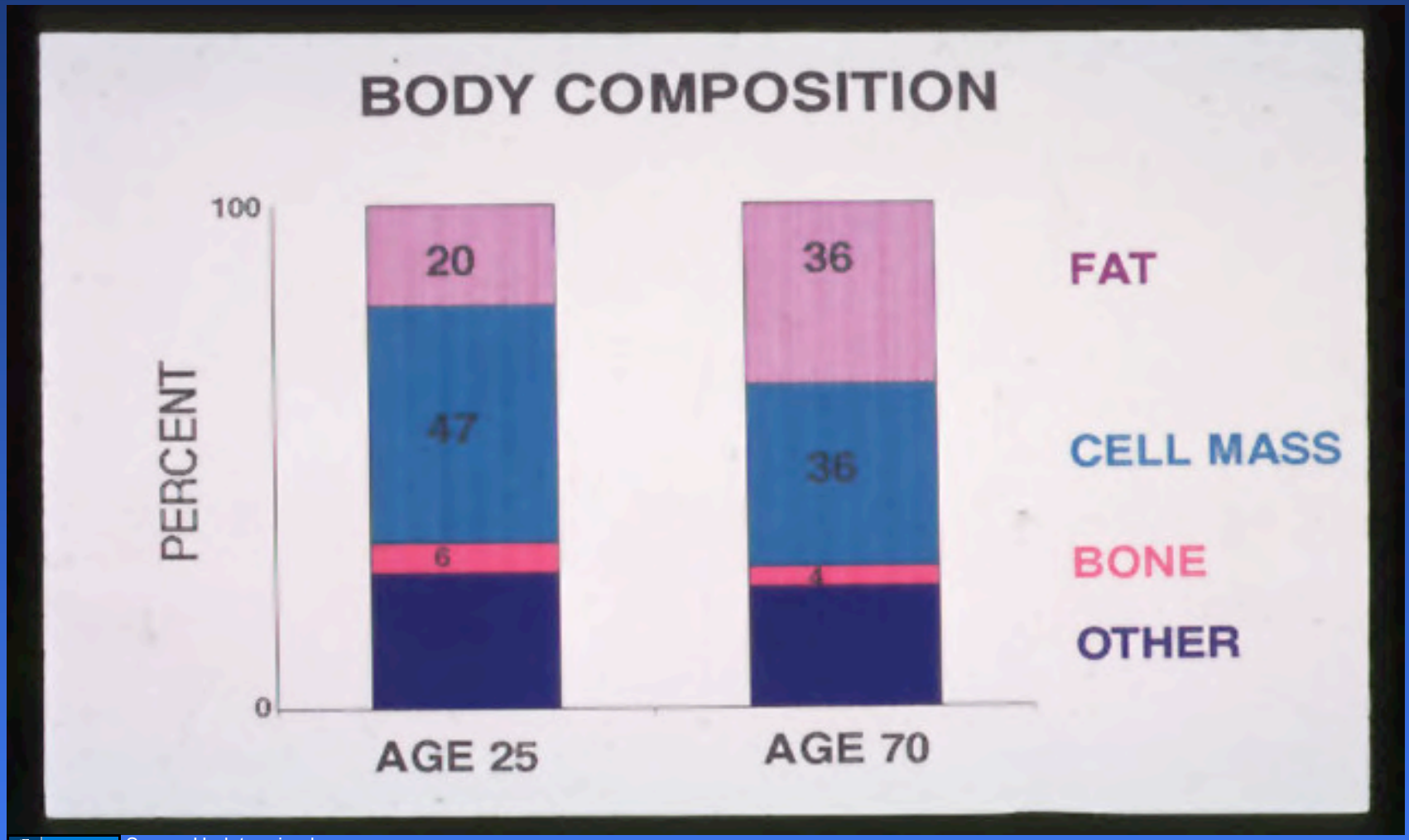

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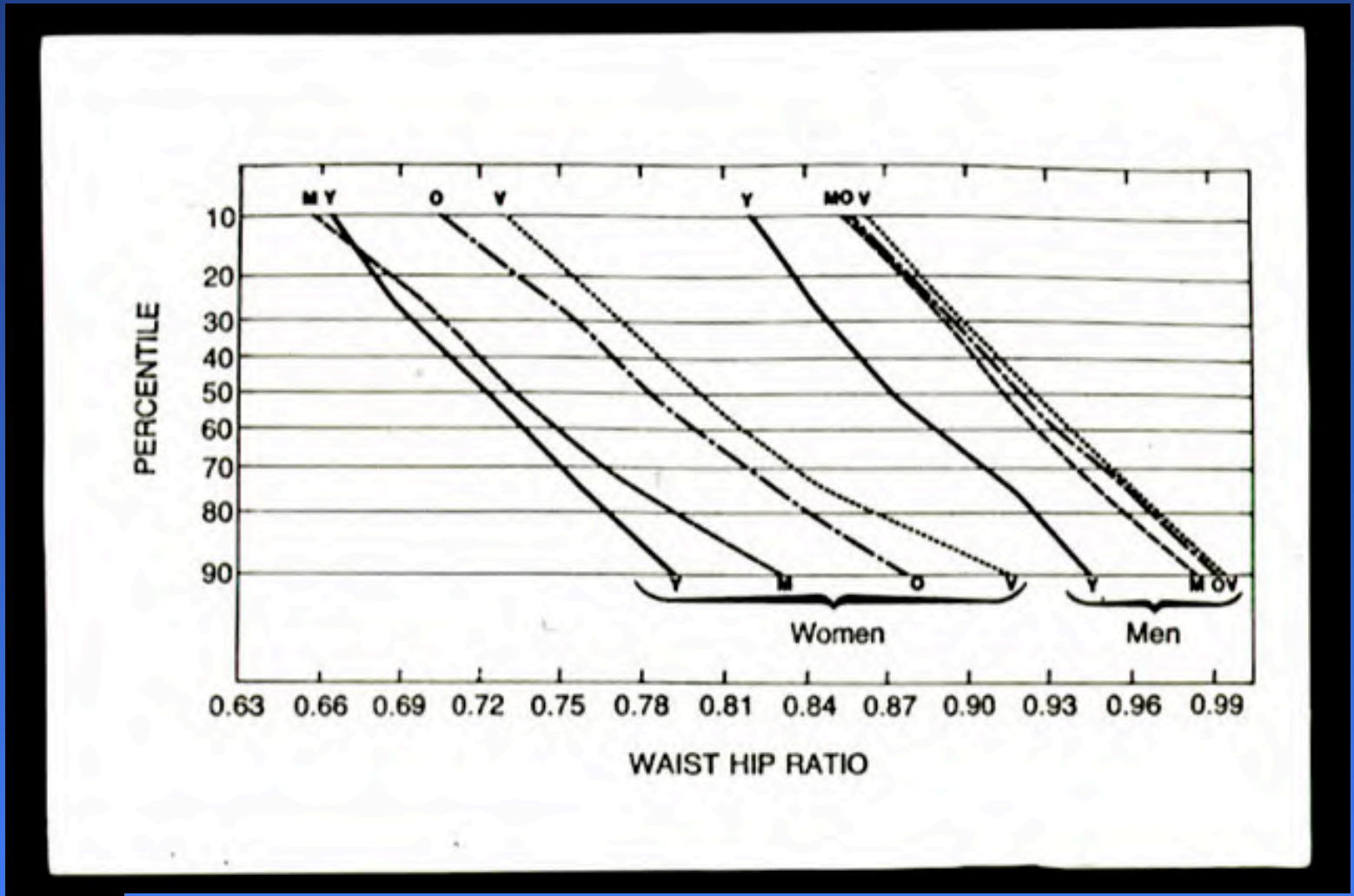
Aging and Central Adiposity



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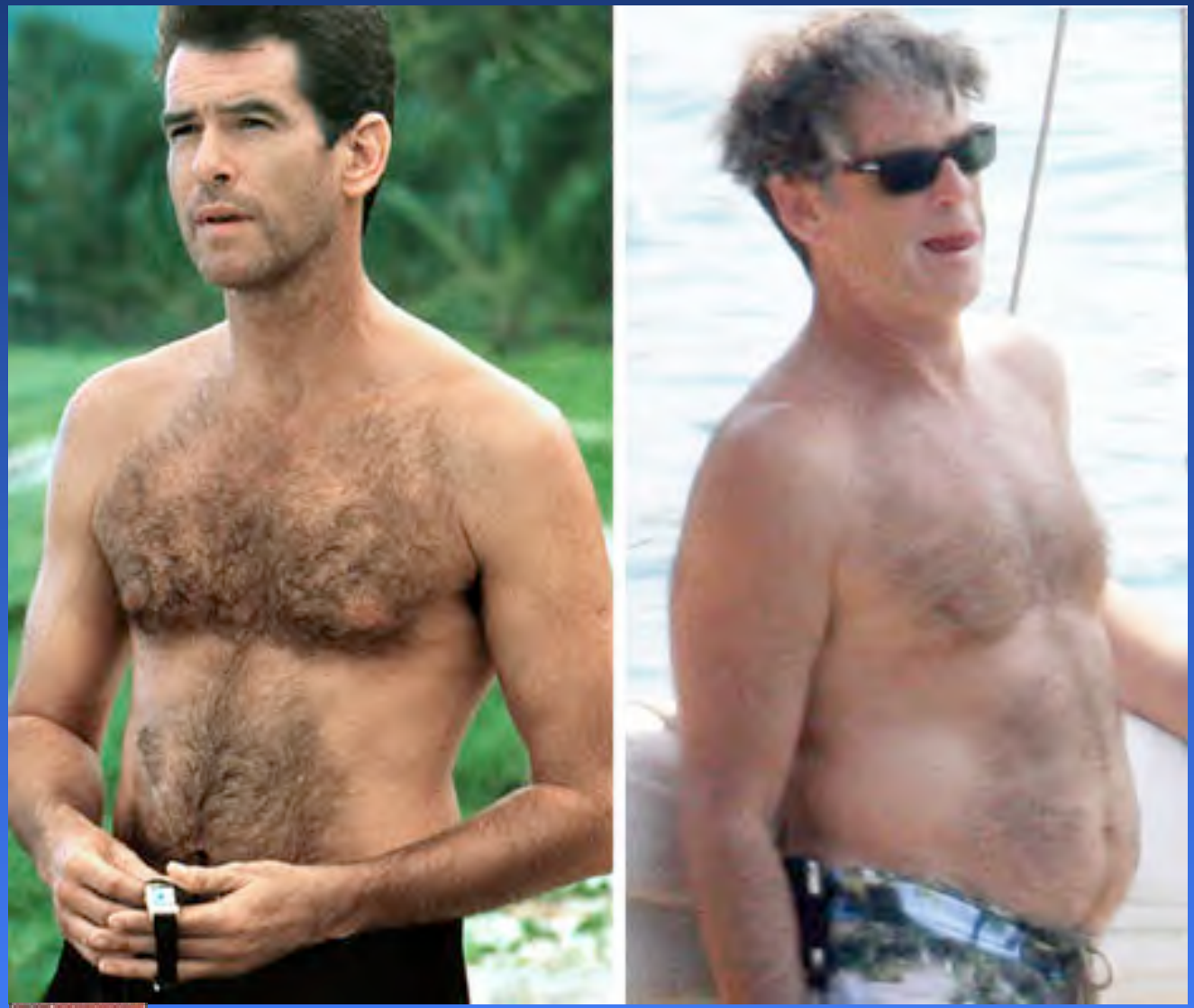

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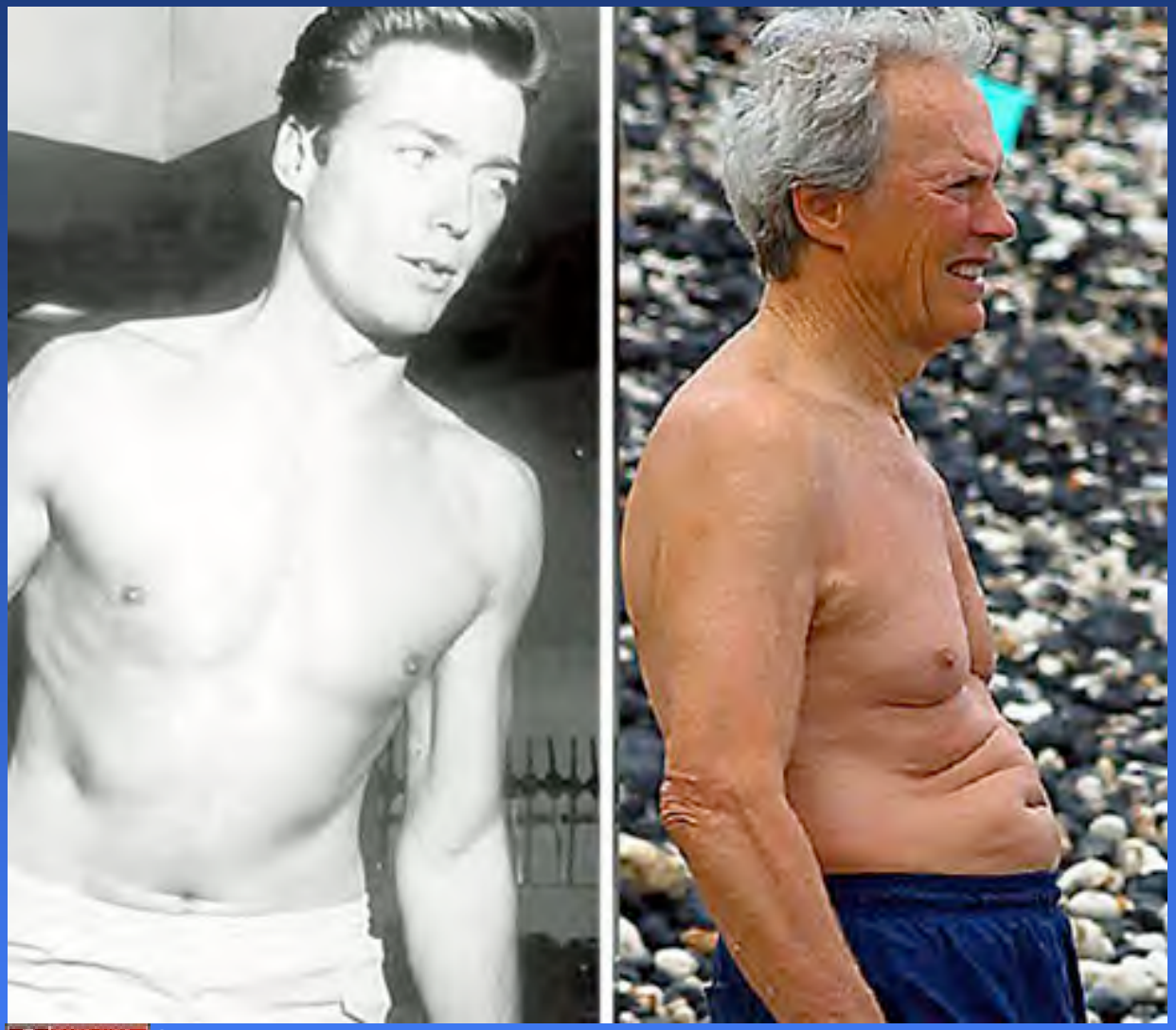

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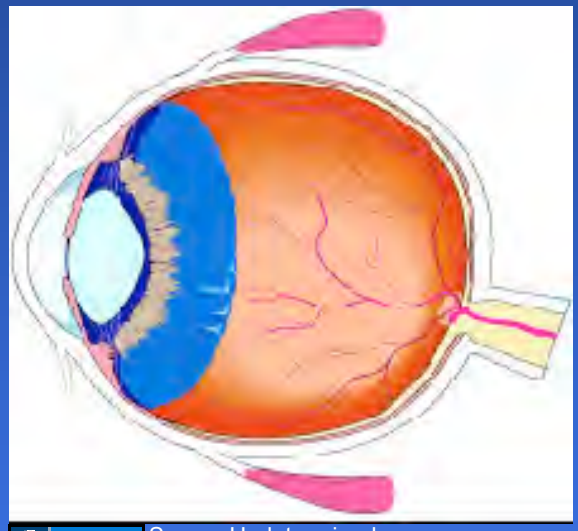
Age-Associated Factors - Vision

- visual acuity (cataracts, macular degeneration)
- dark adaptation
- peripheral vision (glaucoma)
- contrast sensitivity
- accommodation



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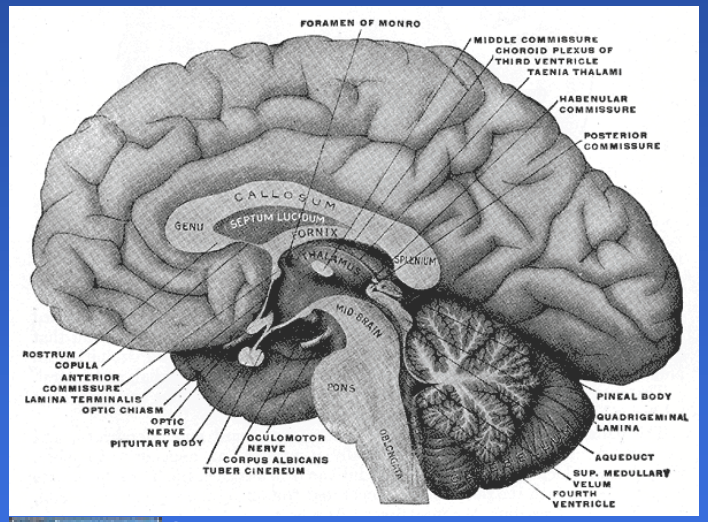
Age-Associated Factors- Special Senses

- **Auditory and Vestibular**
  - Presbycusis: high frequency hearing loss
  - Vestibular dysfunction
- **Smell**
- **Oral/Dental**
  - Teeth: 40% of elderly are edentulous
  - Taste
  - Salivary function

PD-SELF Pearson Scott Foresman, wikimedia commons

Age-Associated Factors- Nervous System

- CNS: decrease in nerve cell number
- basal ganglia atrophy
- ↓ dopamine and ↑muscular rigidity
- ↓ step height
- ↑ reaction time
- PNS: decreased vibratory sensation



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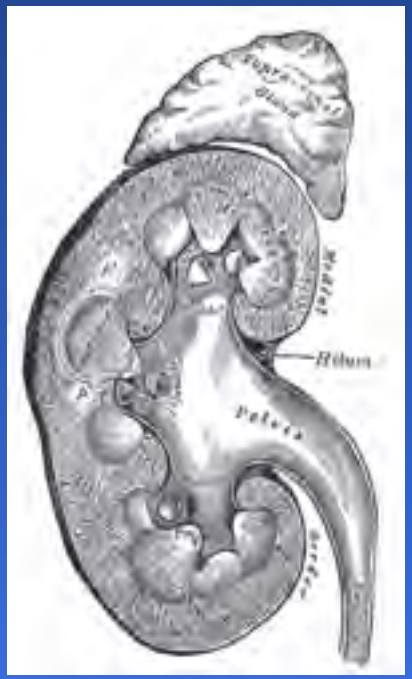
Age-associated Factors: Musculoskeletal system

- **30% loss in muscle mass 3rd to 8th decade - sarcopenia.**
- **Osteoarthritis**
  - weight bearing (spine/knees/1st metatarsophalangeals)
  - repeated strain (distal interphalanges/1st carpometacarpals)
- **Osteopenia/-porosis (80% women >65 y/o osteopenia)**
  - decreased activity, dietary calcium, estrogen withdrawal

Aging Renal Physiology

- GFR ↓ 30-46%
- ↓ Tubular function
- Renal plasma flow ↓ ~50%
- CrCl = [(140 - age) x (BW)]/[72 x SrCr]
  - Multiply x 0.85 for females
  - BW in kg (LBW or IBW with edema or obesity)



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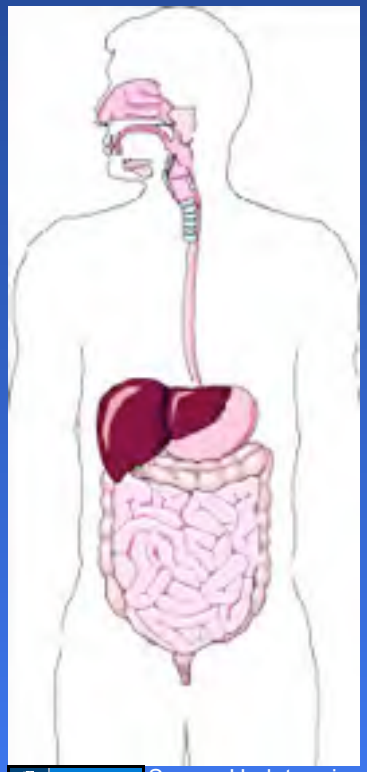
Absorption: GI Physiology

- GI absorptive cells ↓
- GI motility ↓ or normal
- Sphincter activity ↓
- GI blood flow ↓
- Gastric acid secretion ↓
- Active transport ↓



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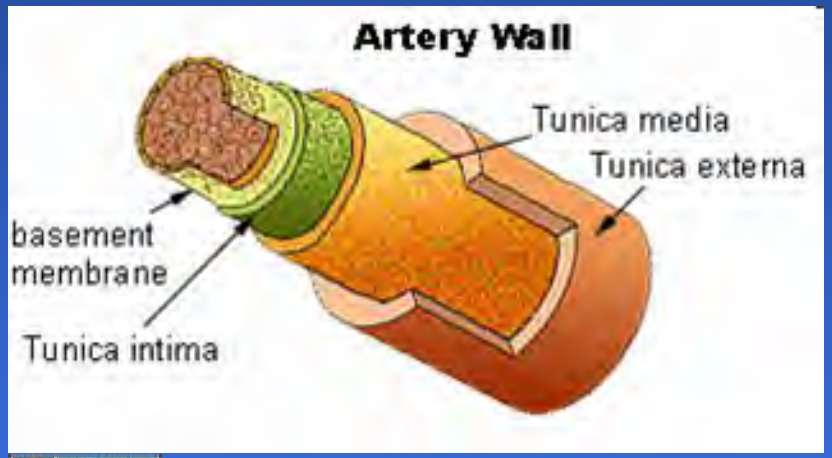

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Afterload: Vascular Changes

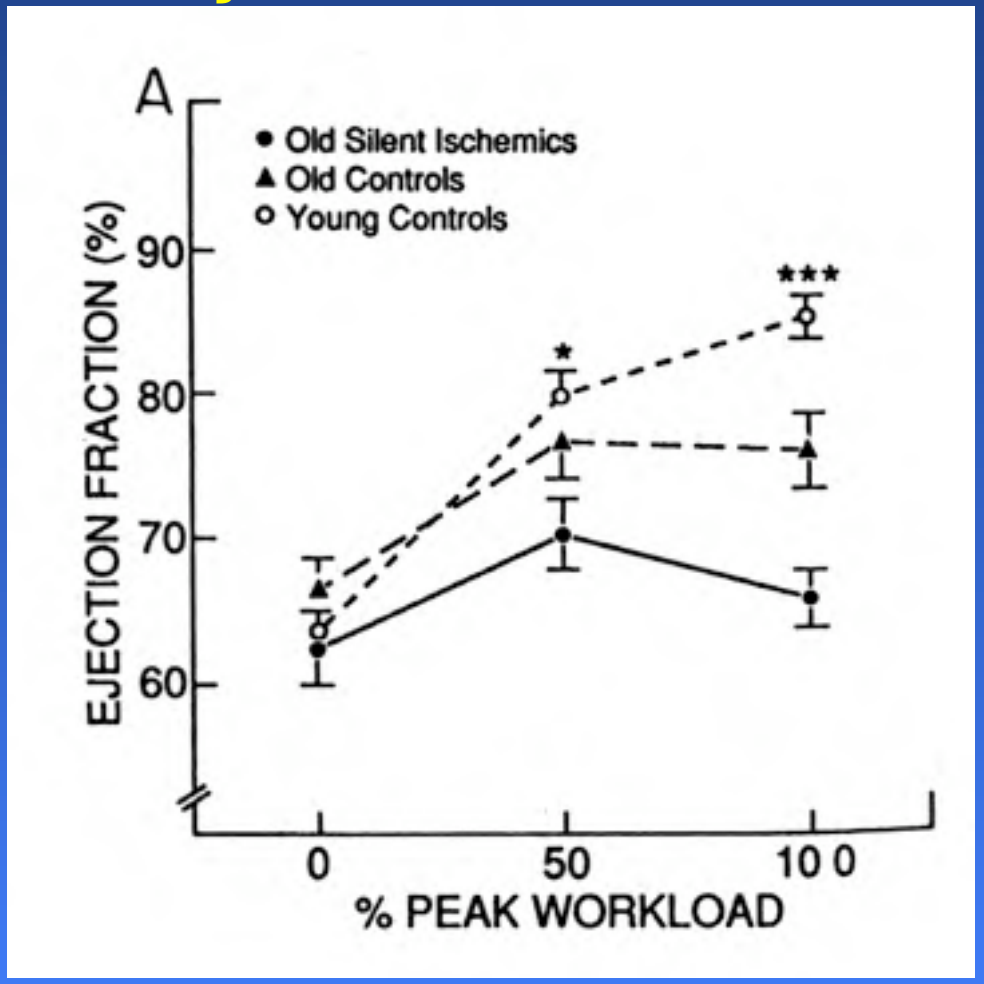
- Vascular Smooth Muscle
  - Increased thickness of intima and media
  - Matrix
    - » Collagen deposition, increased fibronectin, crosslinking (AGEs)
    - » Fragmentation of elastin, calcium deposition

Net result is increased vascular stiffness.

Summary: Age-associated changes in cardiovascular physiology

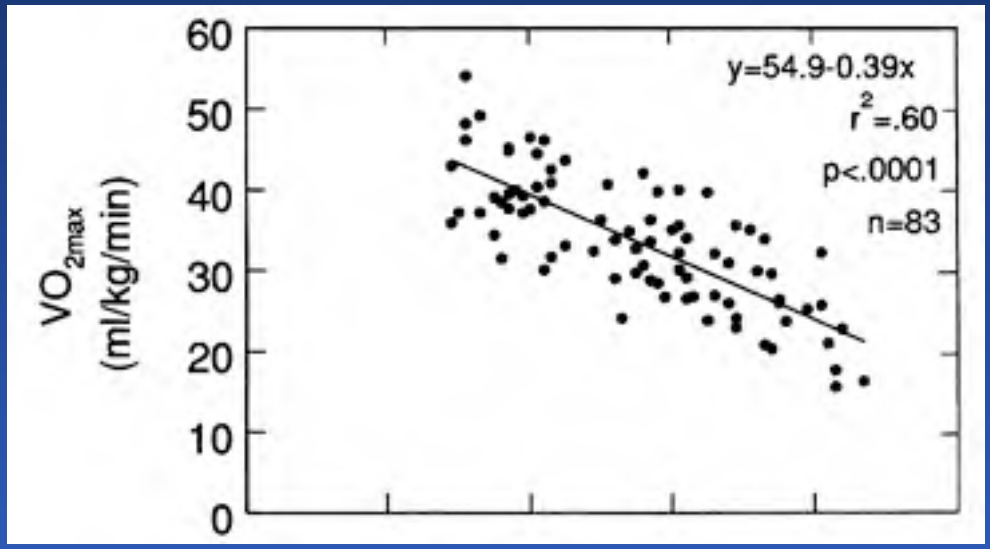
- **Maintenance of resting left ventricular function.**
- **Decreased ability to compensate for stress or impaired LV function.**
  - Blunted heart rate response to exercise requires a compensatory increase in stroke volume to increase cardiac output.

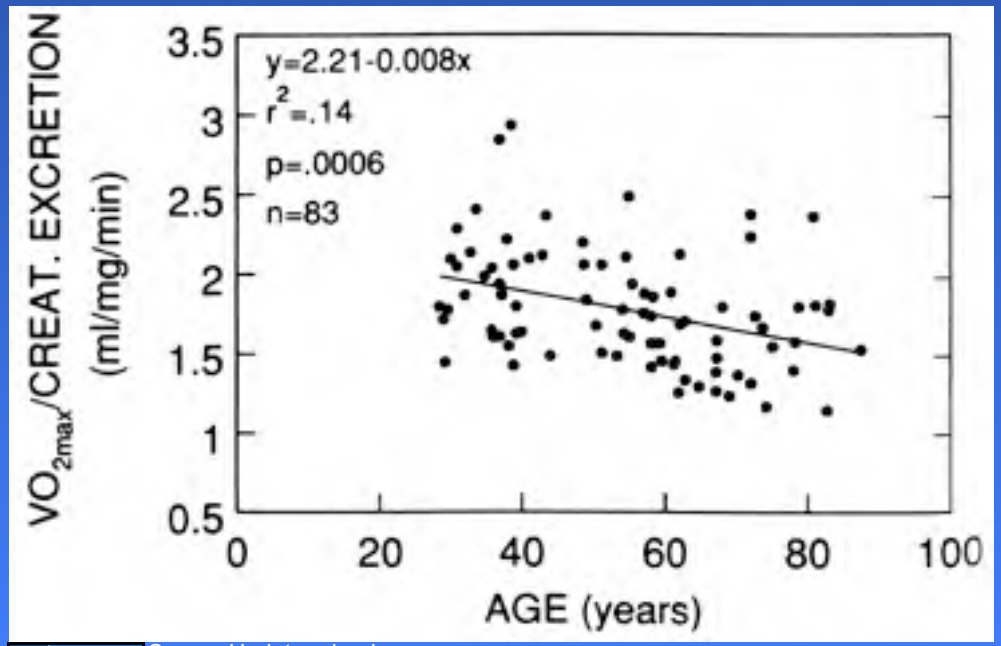
Effect of Aging & CAD on Exercise LV Ejection Fraction



Fleg et al., J App Physiol, 1993

Aging and Aerobic Capacity





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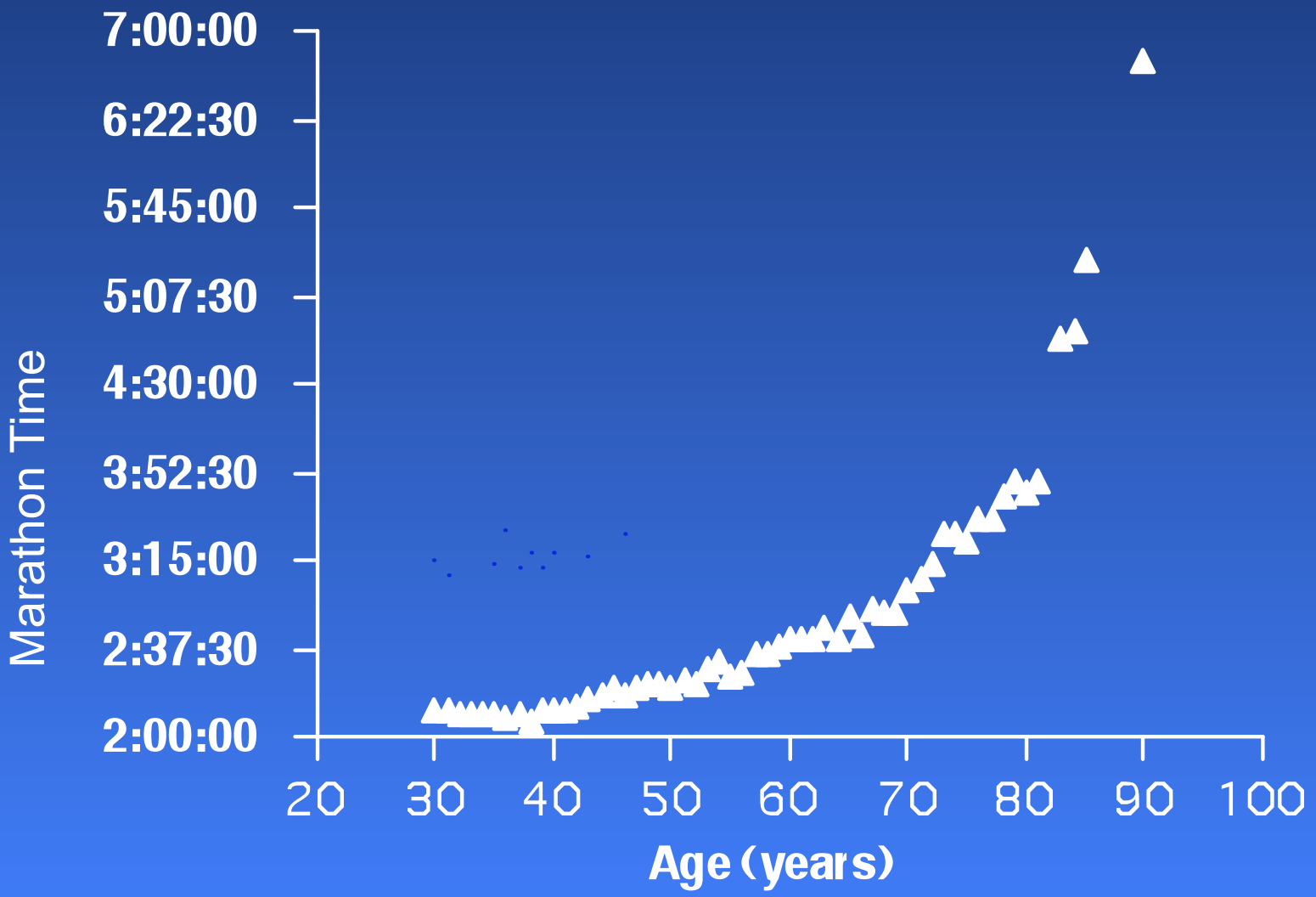

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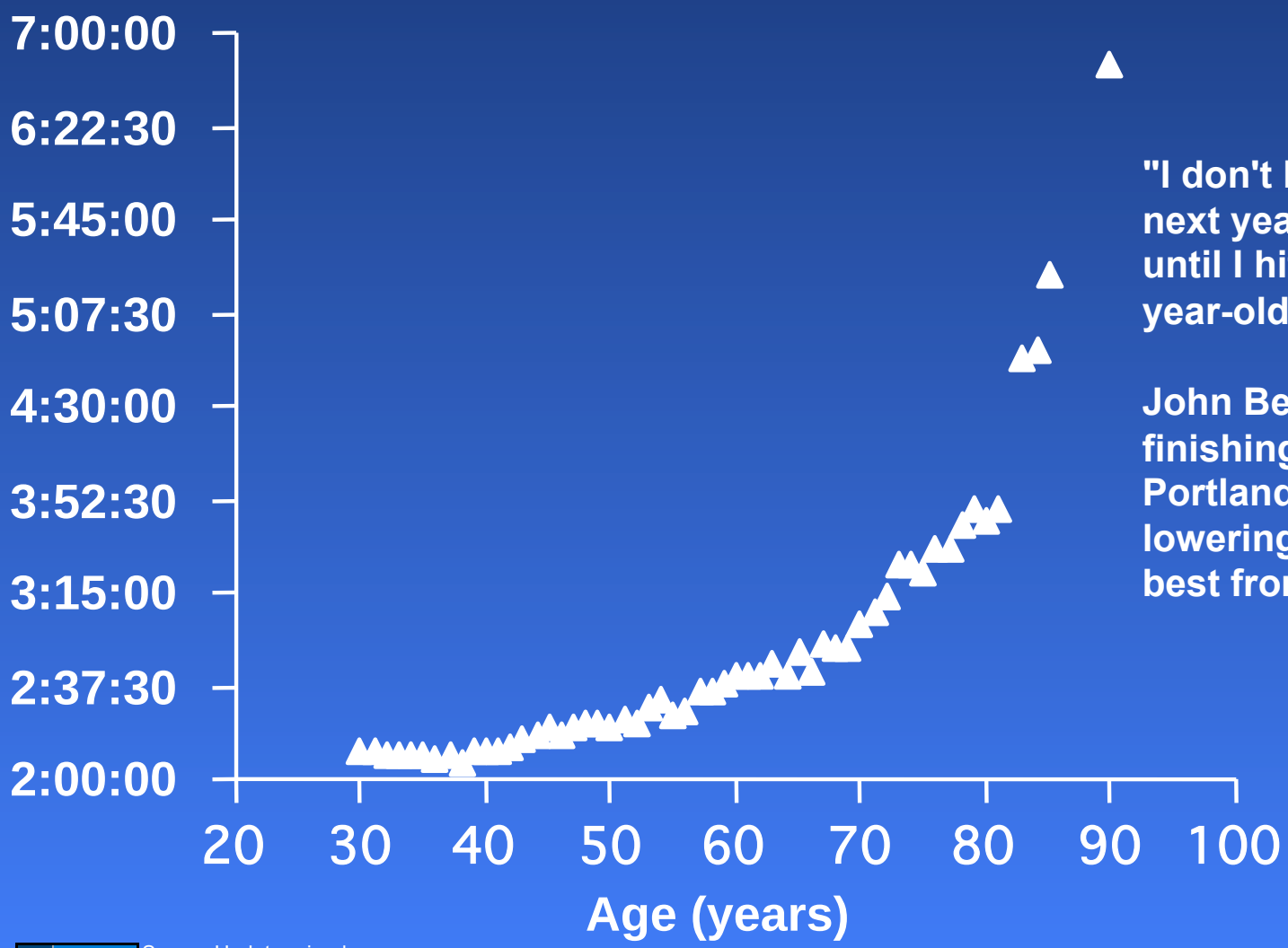

"I don't know if I'll do it next year. ... But wait until I hit that magic 95-year-old age group."

John Besson, Jr., after finishing the 2002 Portland Marathon, and lowering the 90+ U.S. best from 7:25 to 6:48

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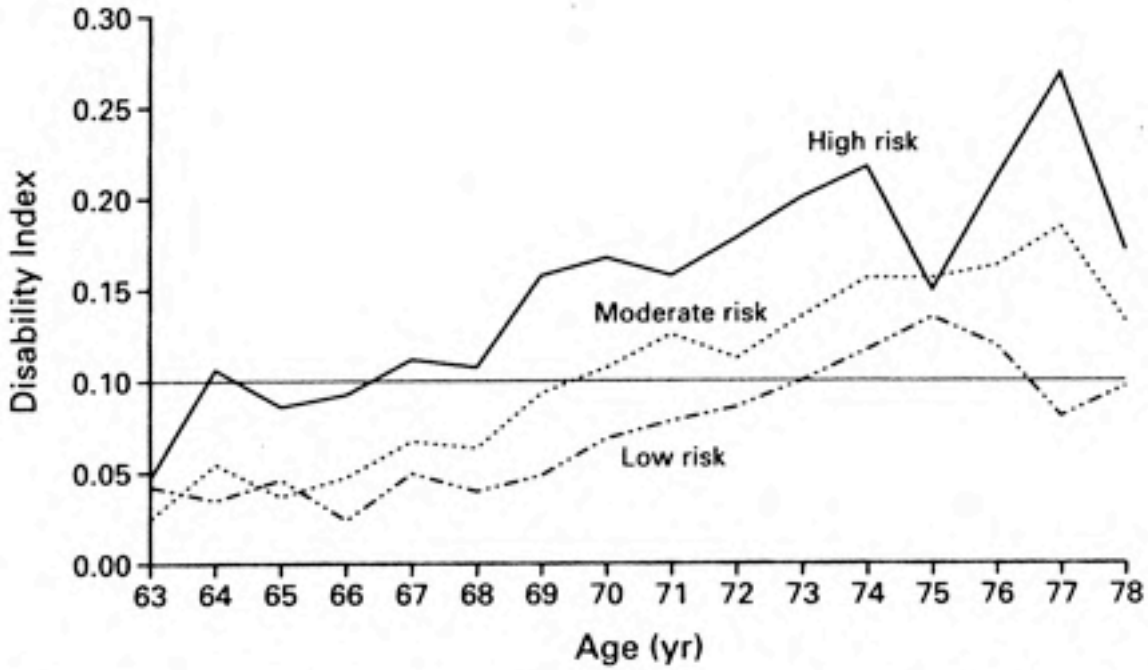
Aging, Health Risks and Cumulative Disability

- Longitudinal study of 1741 U Penn alumni
- Health Risk in 1962 (age mean 43 yrs.) determined from BMI, smoking, and exercise; low, moderate, high
- Disability index determined in 1986: 100% greater in high than low risk group (1.02 vs, 0.49; $P<0.001$)
- Progression in disability postponed by 7 years.

Source: Vita et al., NEJM 338:1035, 1998



Disability Index According to Age at the Time of the Last Survey and Health Risk in 1986.

Vita et al., NEJM 338:1035, 1998

True or False?

Older people should stop exercising and rest.

Rather than seeking permission to exercise, you should have to get permission to be sedentary.

Maria Fiatarone, M.D.

Aging: A state of chronic exercise deficiency?

Only 29% of elderly report any regular exercise.

Physiologic Characteristic	Aging	Exercise
Fat mass	↑	↓
Bone mineral density	↓	↑
VO_2 max	↓	↑
Muscle strength	↓	↑
Glucose tolerance	↓	↑
Insulin sensitivity	↓	↑
Cholesterol	↑	↓

Benefits of Exercise

- **Weight loss**
  - Decrease central adiposity
  - Increase lean body mass
- **Blood pressure decline**
- **Aerobic capacity increase**
- **Insulin sensitivity increase**
- **Increase bone mass**
- **Increase muscle strength**
- **Increase perceived well being**

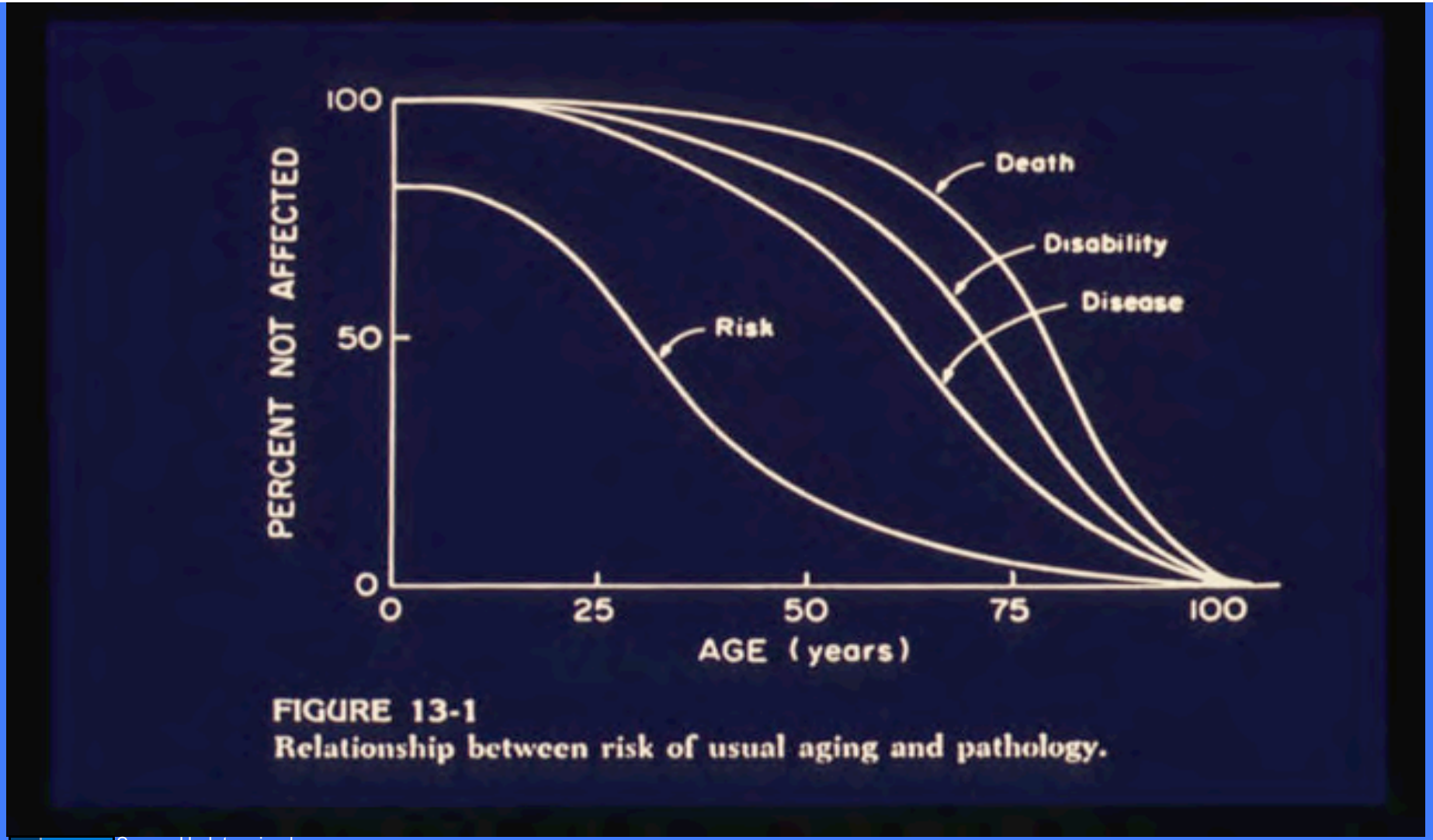


FIGURE 13-1
Relationship between risk of usual aging and pathology.

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Protein-Calorie Malnutrition Among Older Persons

- 5-12% in community
- 30-61% hospitalized
- 40-85% in long-term care facilities.

Inadequate Nutrition Among Older Individuals

- Increases severity of disease
- Increases possibility of physical limitations due to decreased musculature
- Decreases functional status
- Can increase drug effects due to changed metabolism and/or weight loss

Importance of Nutrition for Older Adults

- **Older Adults are at increased risk of inadequate diet from:**
  - Diseases - acute/chronic
    - » half of hospitalized older patients are malnourished.
  - Physical limitations
  - Inability to chew and poor oral health
  - Social isolation/depression/low income
  - Impaired functional status
  - Alcohol use and abuse
  - Drug - nutrient Interactions

Causes of Malnutrition

Medications
Emotional probs
Anorexia
Late-life paranoia
Swallowing disorders

Oral factors
Neoplasia

Wandering (dementia)
Hyperthyroidism etc
Enteric problems
Eating problems
Low-salt /chol
Social problems

Source: Morley Ann Int Med 1995;123:850-859

Assessing Nutritional Status

- **Screening tools (e.g. DETERMINE; Mini-Nutritional Assessment) to identify patients at risk.**
- **Anthropometric data**
  - BMI, percent weight change
  - Changes in body composition
- **Albumin, cholesterol**
- **Vitamin levels - 25-OH-D3, B_{12}**
- **Involuntary weight loss > 10% (high specificity)**

Food Check List

- Activities of Daily Living
  - What are they able to do?
- Food intake
  - Food preparation capability or food provided
  - What is being consumed?
    - » Total amount of food
    - » Types of food (fruits, vegs, protein foods, grains)
    - » Fluids: Water especially

Medication Check List

- Number of medications
- Possible nutrient-drug interactions
- Vitamin B12 status (B12 is less absorbed with increasing age due to less intrinsic factor being produced in the stomach)
- Vitamin D status (low milk intake, no sunshine)

How Drugs Affect Nutritional Status

- **Approximately 34 million Americans are 65 years or older yet they consume 30% of all medications.**
  - Average patient taking 3 to 7 medications at one time.
- **Medications alter food intake, absorption, metabolism and excretion of nutrients.**
- **Decreases in appetite, taste and smell.**
- **May cause GI disturbances such as nausea, constipation, and/or diarrhea.**

Dietary Recommendations for Older Individuals

- Adequate protein (1.0 gm/kg rather than 0.8).
- Ample fruits and vegetables for nutrients and to avoid constipation.
- Optimal Calcium intake for men and women > age 65: 1500 mg daily
- Whole grain products (nutrient density and fiber).
- Ample fluids, especially water.

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True or False?

The majority of older people are self sufficient.

Katz Activities of Daily Living (ADL) Scale

- Definition: Things you needed to be able to do to go to kindergarten.
- Components
  - Bathing
  - Dressing
  - Toileting
  - Transfer
  - Grooming
  - Feeding
- Rated by level of assistance required

  Independent, needs some assistance, unable to perform task

Instrumental Activities of Daily Living

- **Definition**: Things you needed to do for yourself when you went off to college.
  - Grocery Shopping
  - Meal preparation
  - Driving or using public transportation
  - Taking medications
  - Laundry
  - Using telephone
  - Managing finances
  - Housework

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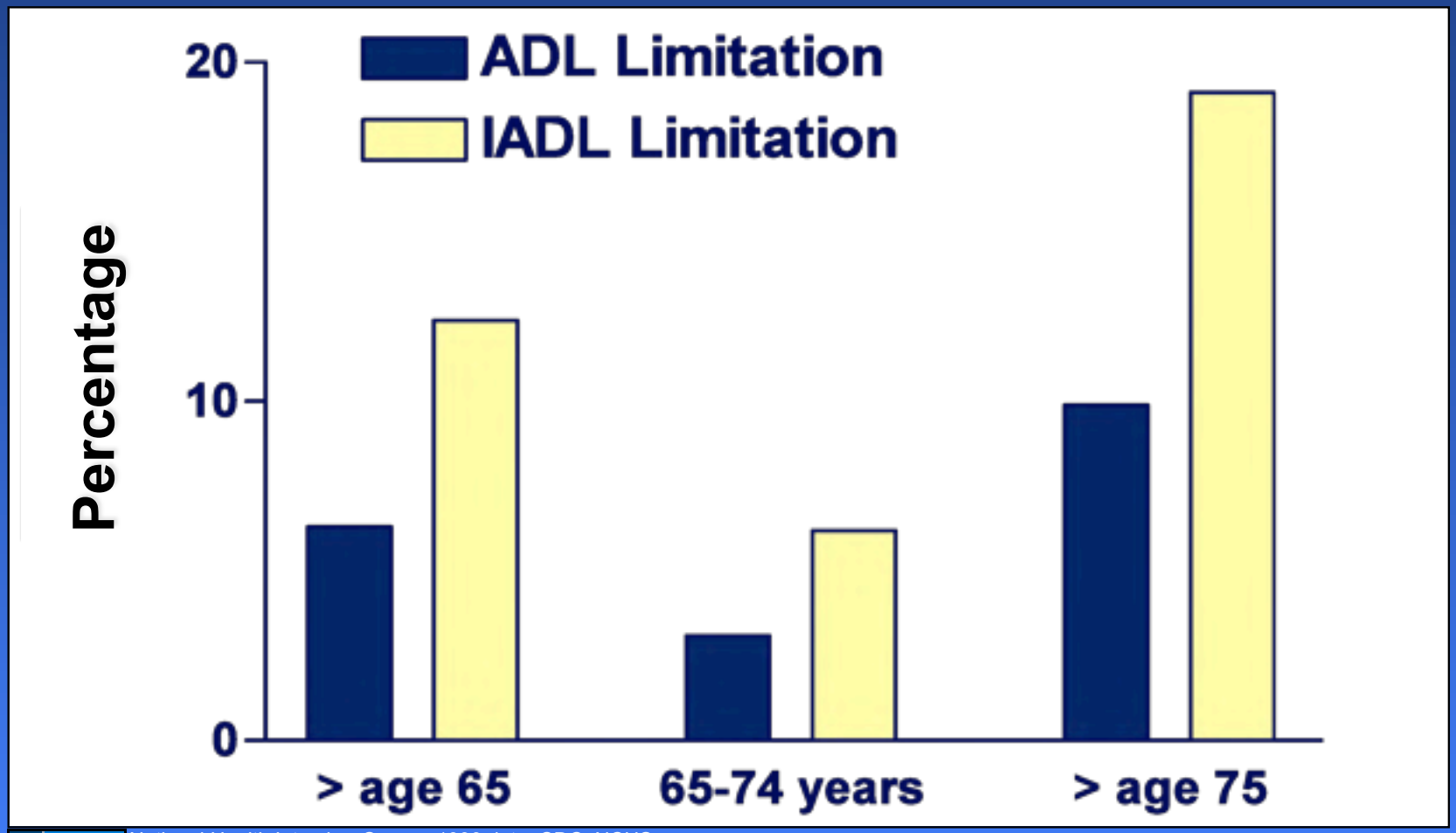
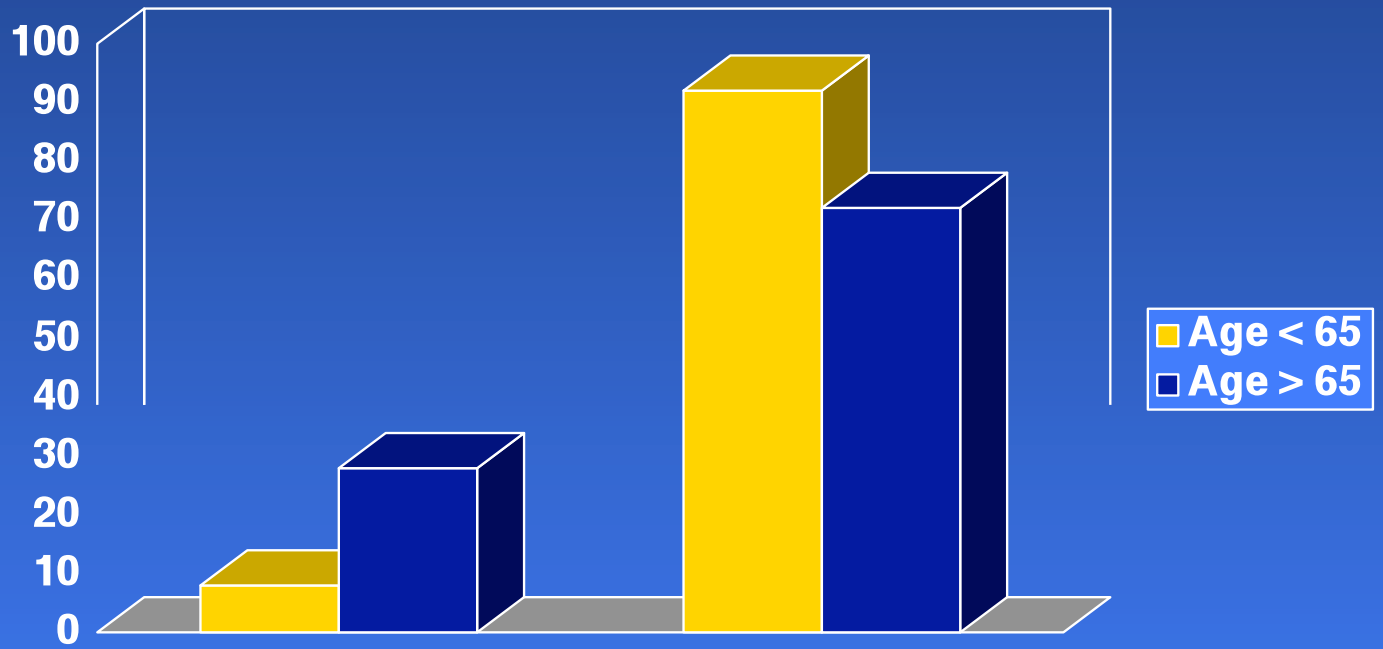
ADL/ IADL Limitations



National Health Interview Survey, 1999 data. CDC. NCHS.

Self-rated Health



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