PT Cardiopulmonary Educators

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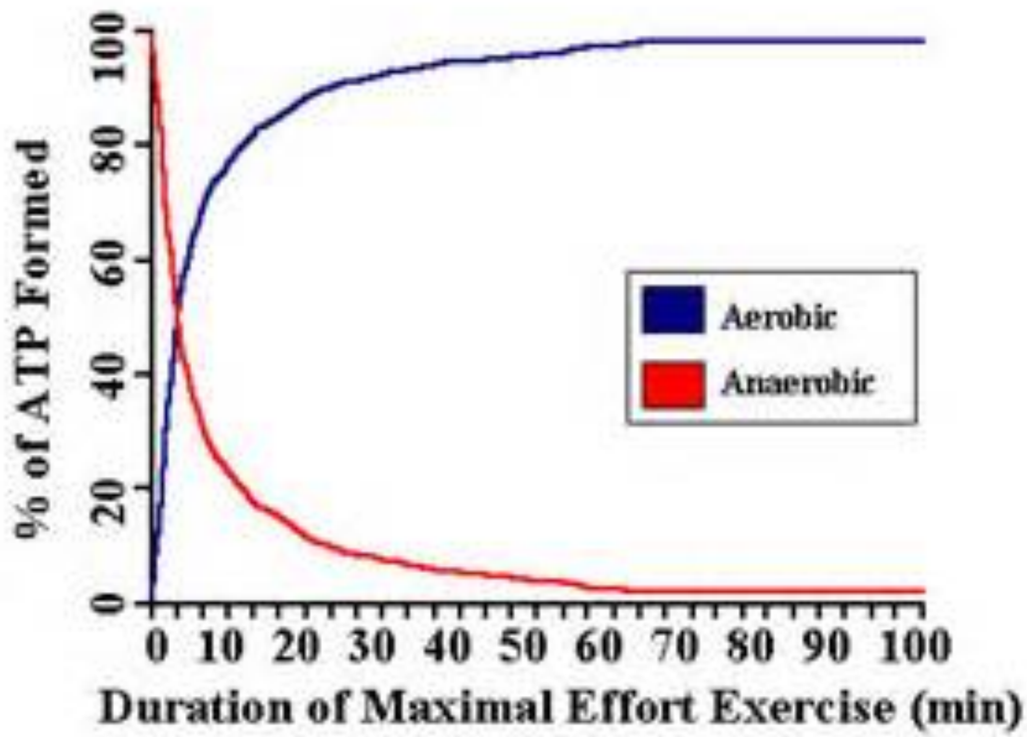
Basic Exercise Physiology, Pathophysiology, Hemodynamics, and Exercise Prescription

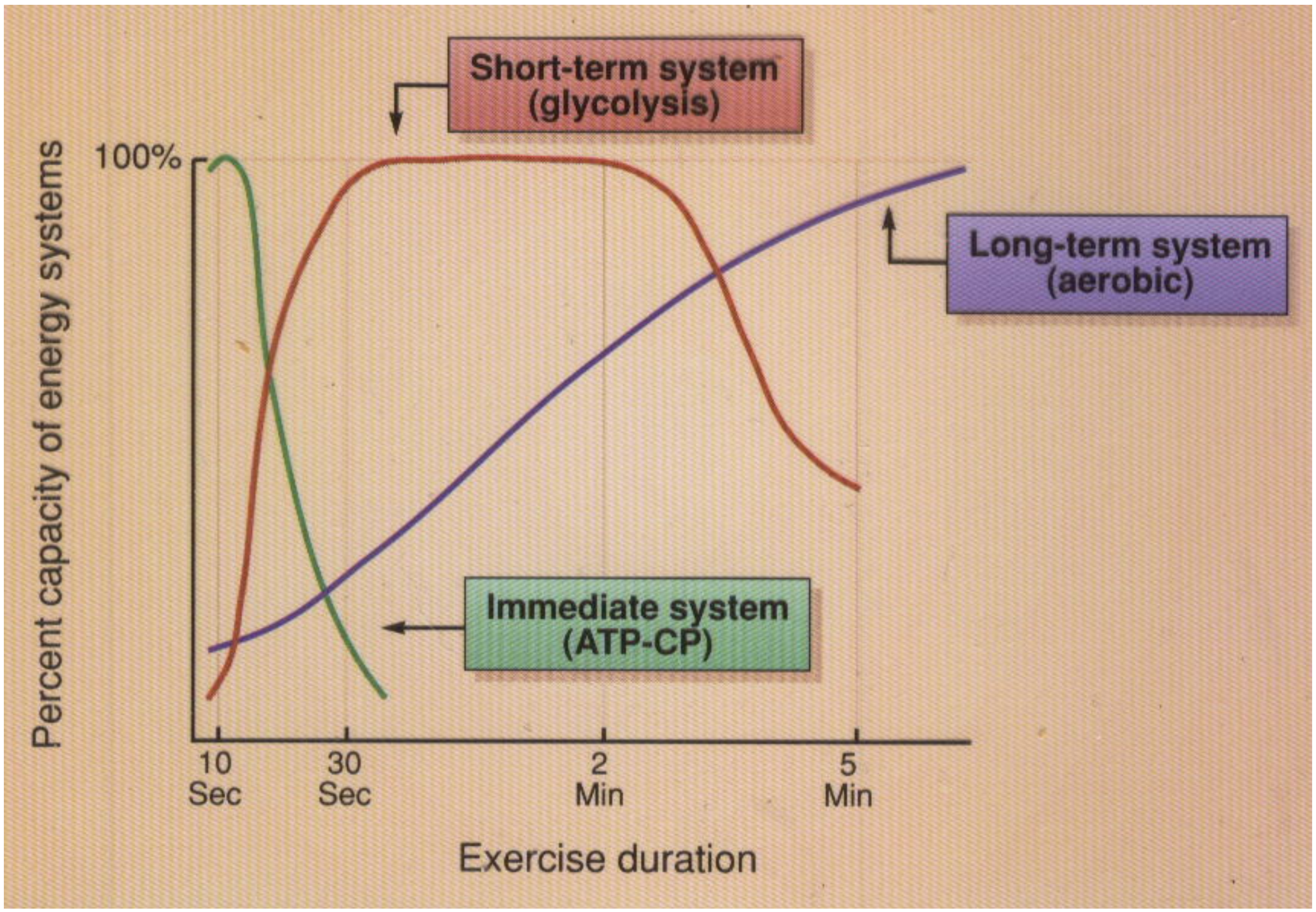
Objectives

- Discuss principles of exercise physiology as they apply to the abnormal population of patients with cardiovascular and pulmonary dysfunction
- Discuss skeletal muscle physiology and endocrine physiology in health and disease
- Apply principles of exercise physiology to case examples of patients with primary cardiovascular and pulmonary impairments

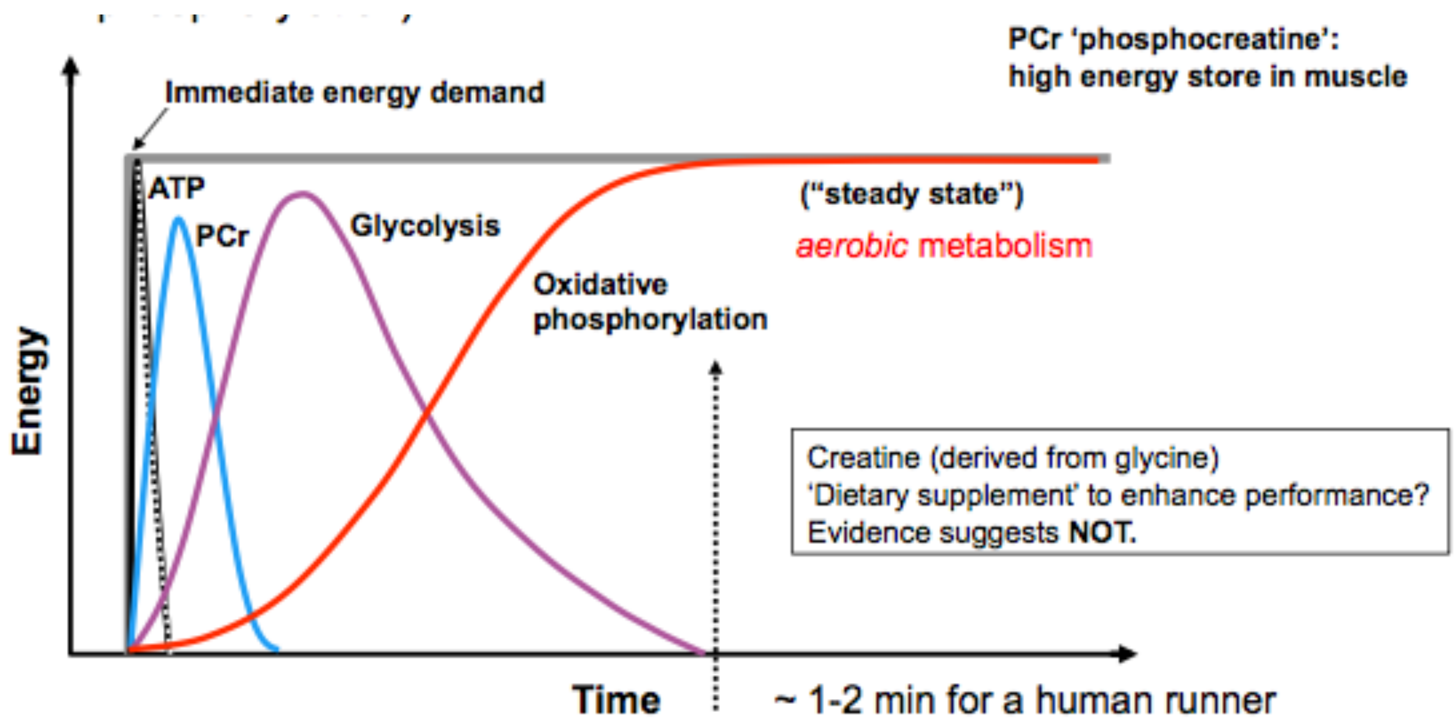
Overview of Energy Transfer



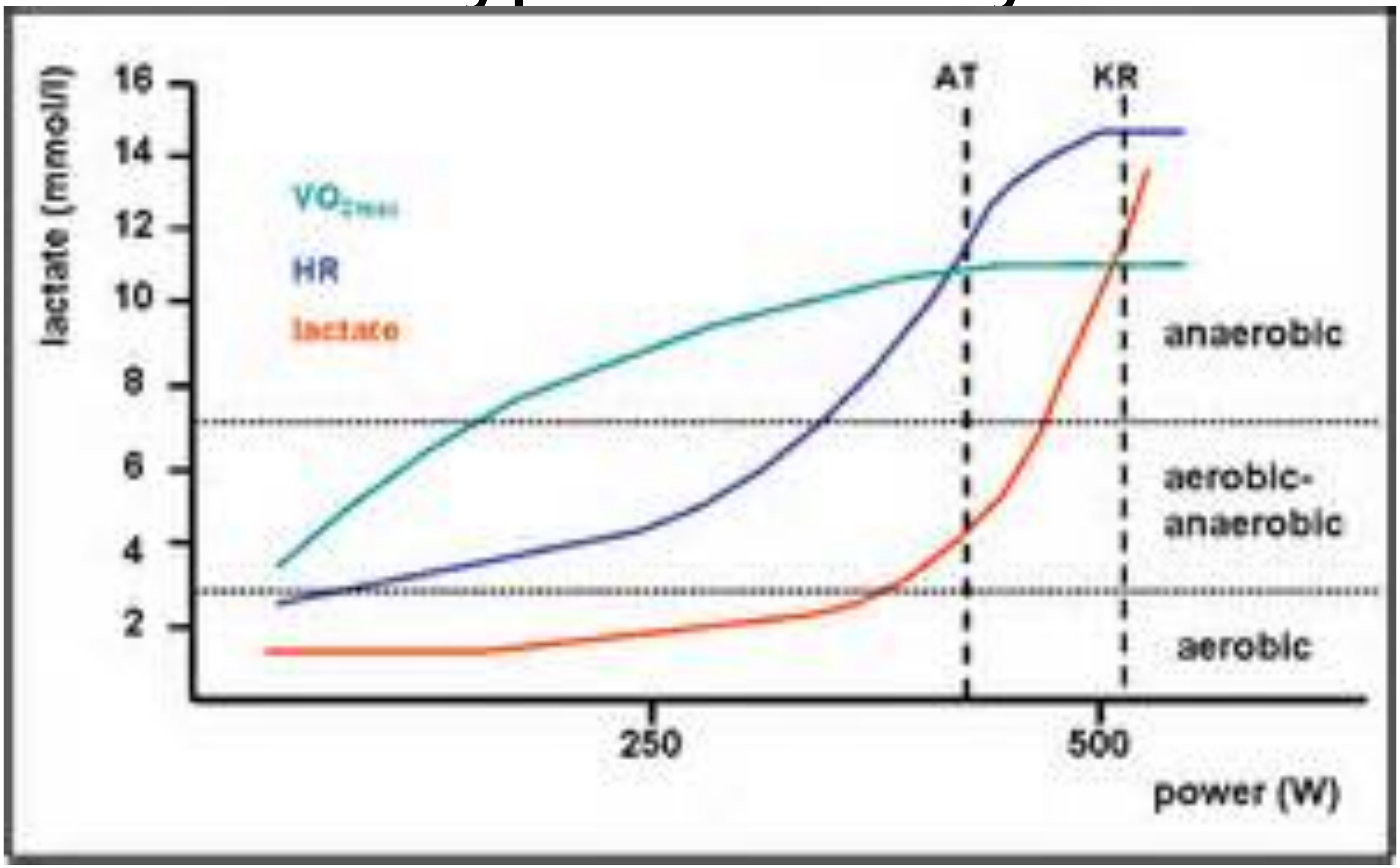
Aerobic Metabolism and Anaerobic Metabolism



Relationships of metabolism



Relationship of lactate buildup with type of activity



Exercise Prescription for Training the different systems

- Anaerobic work
  - Goal: Improve short duration activities such as sit to stand or walking from bed to chair to improve function and to assess tolerance to high intensity
  - Goal: tolerate high intensity activities
    - Anaerobic work requires short bursts with rests in between
    - Anaerobic work increases HR fast and RPE would be above 13 on 6-20 or above 6 on 0-10 modified VAS
    - LONG TERM: studies on STABLE HF patients showed improved Ejection Fraction with High intensity interval training…so anaerobic activity may be something to initiate in ALL patients

Exercise Prescription for Training the different systems

- Anaerobic work
  - Need to establish safety when performing these aggressive workouts
  - Task specific activities work best with the compromised population
    - Sit to stand
    - Lifting thing to put on shelves
    - Bending over and lifting activities
  - Utilize outcome measures that are appropriate for these activities
    - Gait speed
    - Chair rise
    - UE grocery shelving

Exercise Prescription for Training the different systems

- Aerobic
  - Goal: improve walking tolerance to be able to walk outside or to be a community ambulator
  - Goal: improve exercise tolerance to be able to perform ADLs or kitchen activities
    Aerobic work:
    - Longer duration – a minimal of 2 minutes of activity
    - Can still perform multiple bouts until duration increases, but aerobic initiates early and continues unless performing above somewhat hard (anaerobic threshold)

Keep in mind: Nutrition!!!!

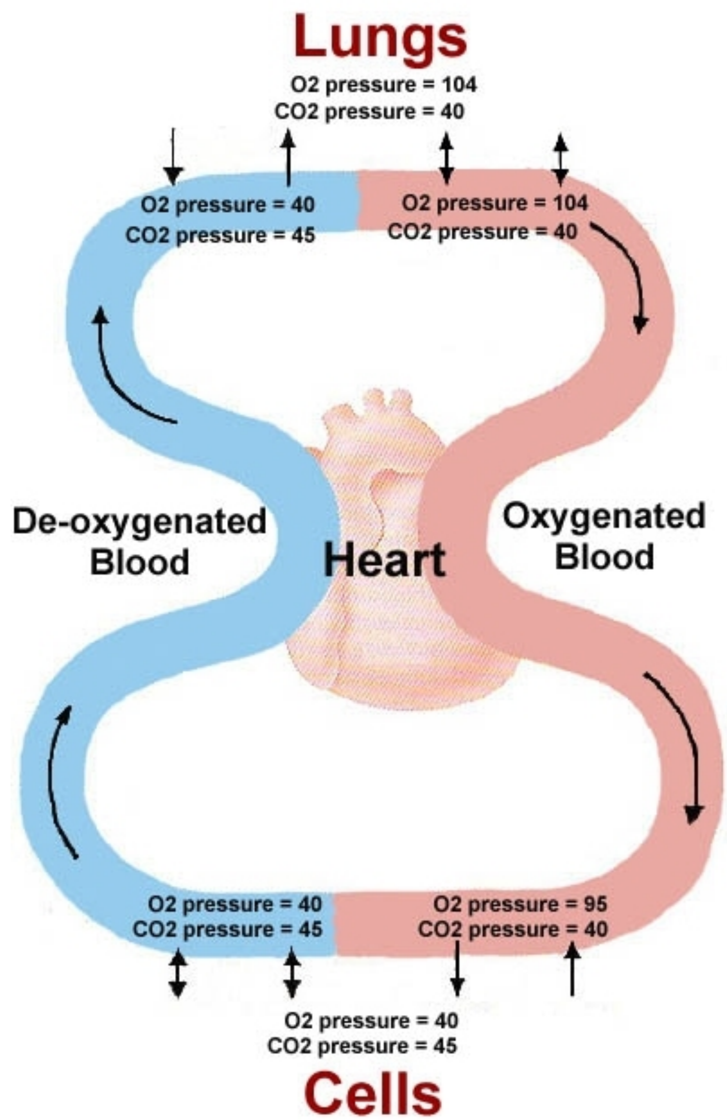
- Anaerobic: uses ATP and CP stored in muscle and glycogen only
  - NEED CARBOHYDRATES
- Aerobic: uses carbohydrates and fats
  - Untrained individuals: 50% carbs and 50% fats
  - Trained individuals <50% carbs, > 50% fats

When I learned, 'You are what you eat', I realized I was **nuts**.
THERAPY
Reynolds

Question

- You are working in the ICU. Your patient is able to sit edge of bed but has poor endurance due to 3 days bedrest while stabilizing for HF admission. On IV positive inotropes. Goal is to return home hopefully NOT on IV medicine. What type of exercise do you want to work on with this patient today (as long as hemodynamically stable and BP acts appropriately)?
  - A. Edge of bed sitting and stand only
  - B. OOB to chair next to bed
  - C. OOB to chair across room by walking short distances and sitting in chair, then back to bed: multiple reps
  - D. OOB to hallway, around entire ICU and back to bed before resting.

The oxygen transport system



O_2 Transport

- Individual’s ability to perform endurance activity depends entirely on the oxygen transport system.
  - Any impairment in oxygen transport will impair performance
  - Any conditioning in oxygen transport will demonstrate improvement in performance

Cardiovascular physiology

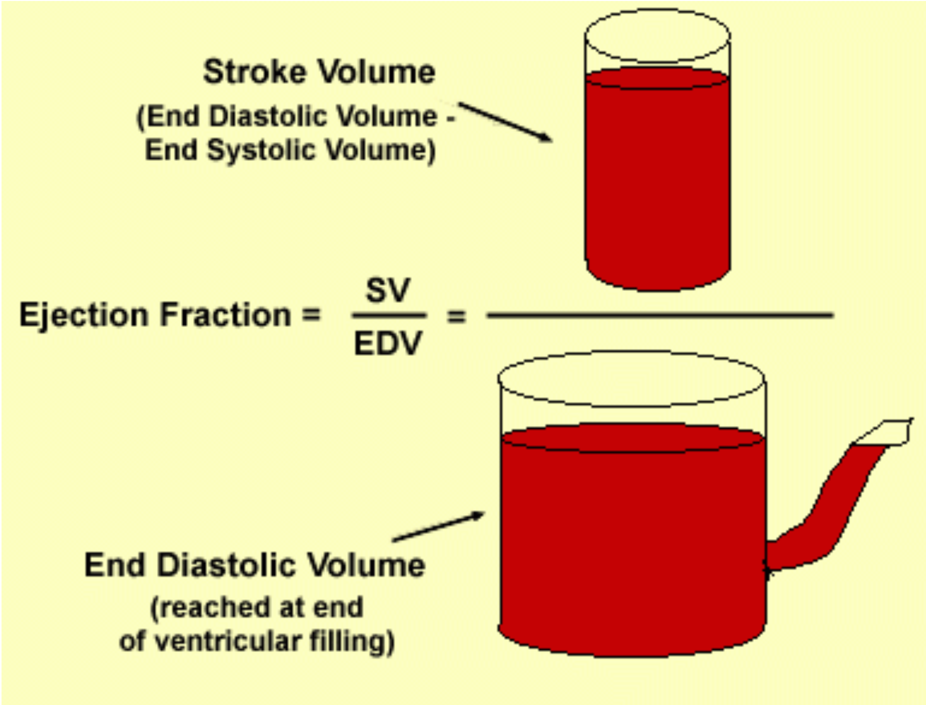
Cardiac output = Stroke Volume X HR

- Normal rest CO = 5 liters
- Max exercise: normal CO can increase 5-6X (25-30 liters)

Stroke volume: made up of

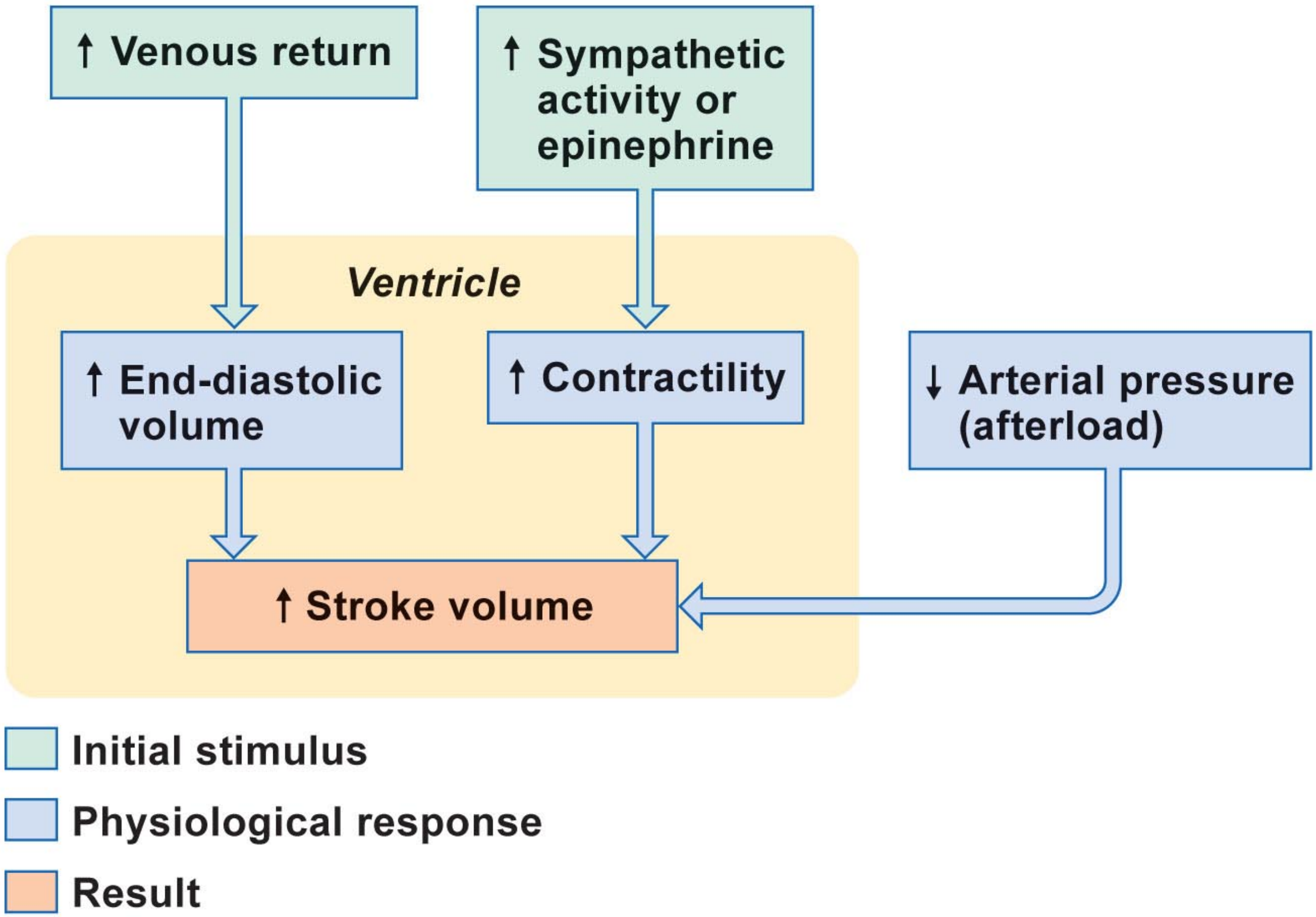
- pre load
- contractility
- afterload

Cardiovascular Physiology



Calculation of Ejection Fraction

Stroke Volume

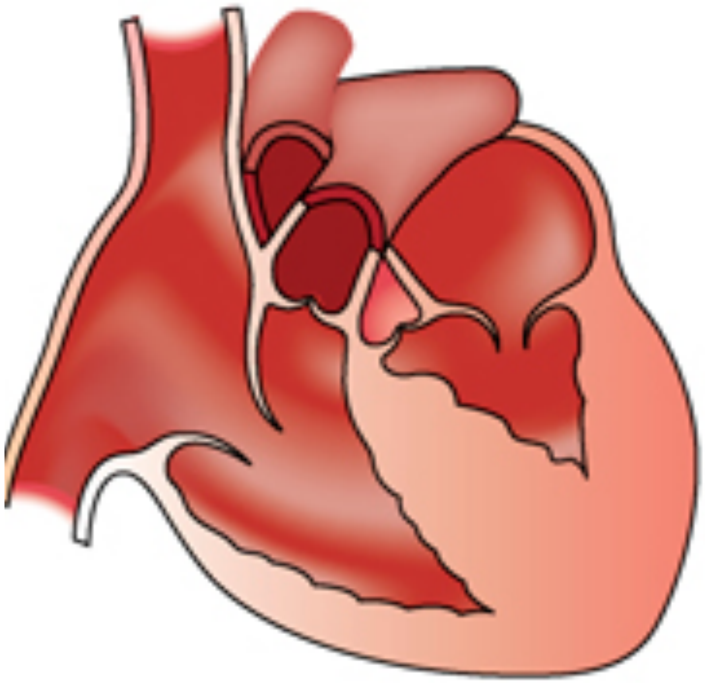


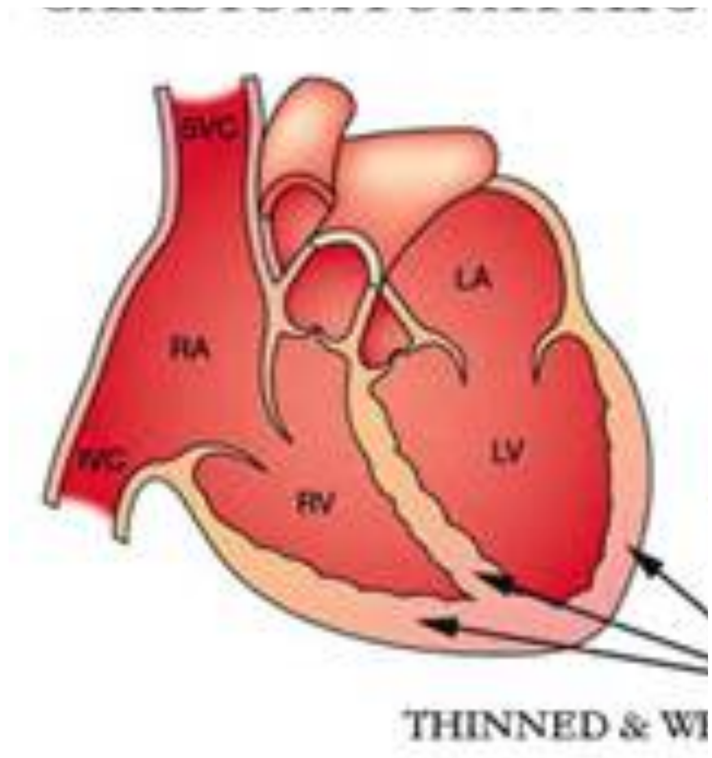
Cardiovascular Physiology and Pathophysiology

Factors Affecting Stroke volume

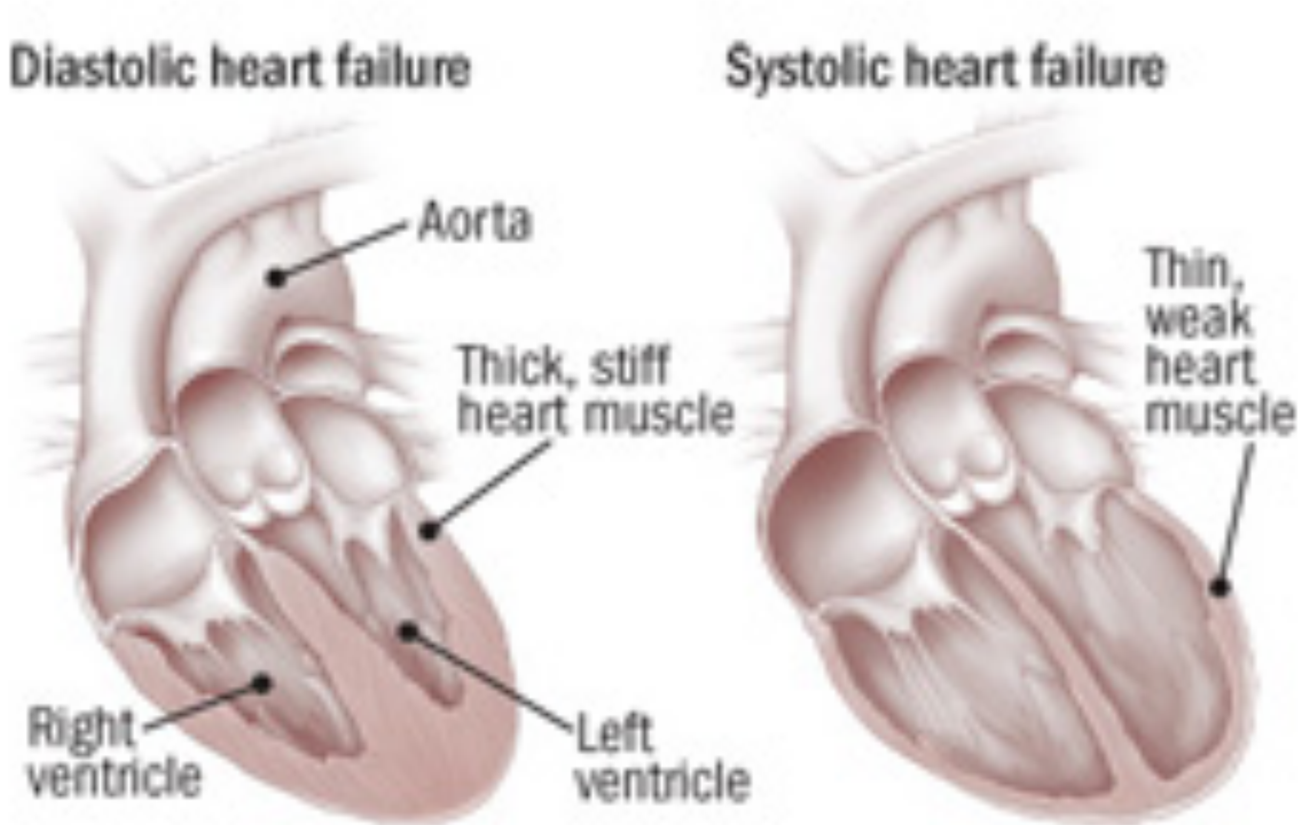
- Preload
  - Increased venous return
    - Exercise with muscle pump will increase venous return
    - Increased blood volume or plasma
  - Decreased venous return
    - Dehydration
    - Too much volume taken out of system with dialysis or CRRT
  - Increased Distensibility of cardiac muscle
    - Dilated cardiac muscle
  - Decreased Distensibility of cardiac muscle
    - Hypertrophied muscle walls
    - Ischemic cardiac muscle
    - Decreased cardiac muscle due to loss of protein from all muscles
      As seen in anorexia

Distensability





Systolic vs Diastolic Pathology



Pathology

- Systolic failure (HFREF):
  - Heart failure REDUCED Ejection Fraction
  - Left ventricular hypertrophy: often decreased ability to pump blood OUT often due to overstretched myocardium (dilated) or scarred myocardium or reduced chamber size from a hypertrophic wall
- Diastolic failure (HFPEF)
  - Heart Failure PRESERVED Ejection Fraction
  - LV dysfunction due to risk factors (Diabetes, long standing hypertension, increased age) or due to increased ventricular wall thickness and decreased SV. Preserved EF at rest, dysfunction during activity
  - Often converts to HFREF over time

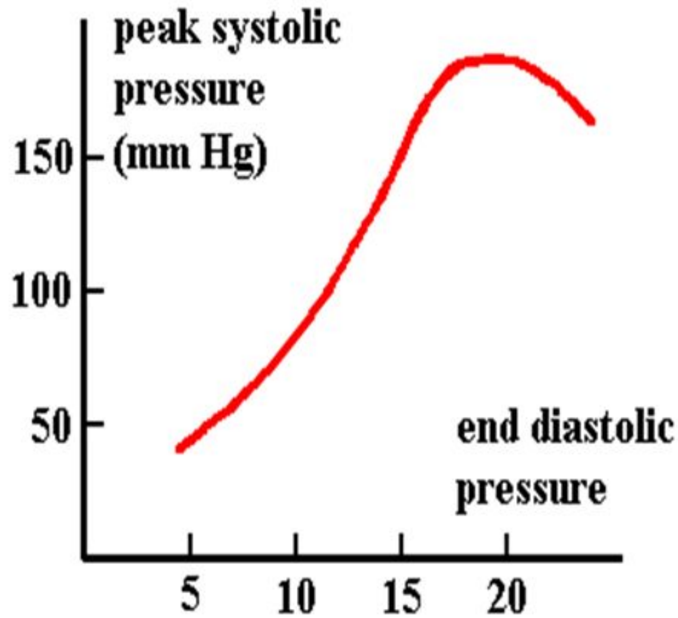
Cardiovascular Physiology and Pathophysiology

Factors Affecting Stroke volume

- Contractility
  - Increased force of contraction
    - Increased sympathetic tone
    - Inotropic support
  - Decreased force of contraction
    - Pathology – dilation of ventricle as seen in cardiomyopathy
    - Negative inotropic effects of medications
      - » BETA BLOCKERS
  - Increased speed
    - Increased HR decreases the filling time of the ventricles
    - >120 contractility actually decreases
  - Decreased speed
    - Decreased HR increases filling time of the ventricles
    - Beta Blockers help to improve contractility by decreasing HR

Stroke Volume: Frank Starling Law

STROKE VOLUME



- **Frank Starling's Law**
  - The greater the volume of blood in the heart during diastole, the more forceful the cardiac contraction, the more blood the ventricle will pump (to a point)

Marian Williams RN

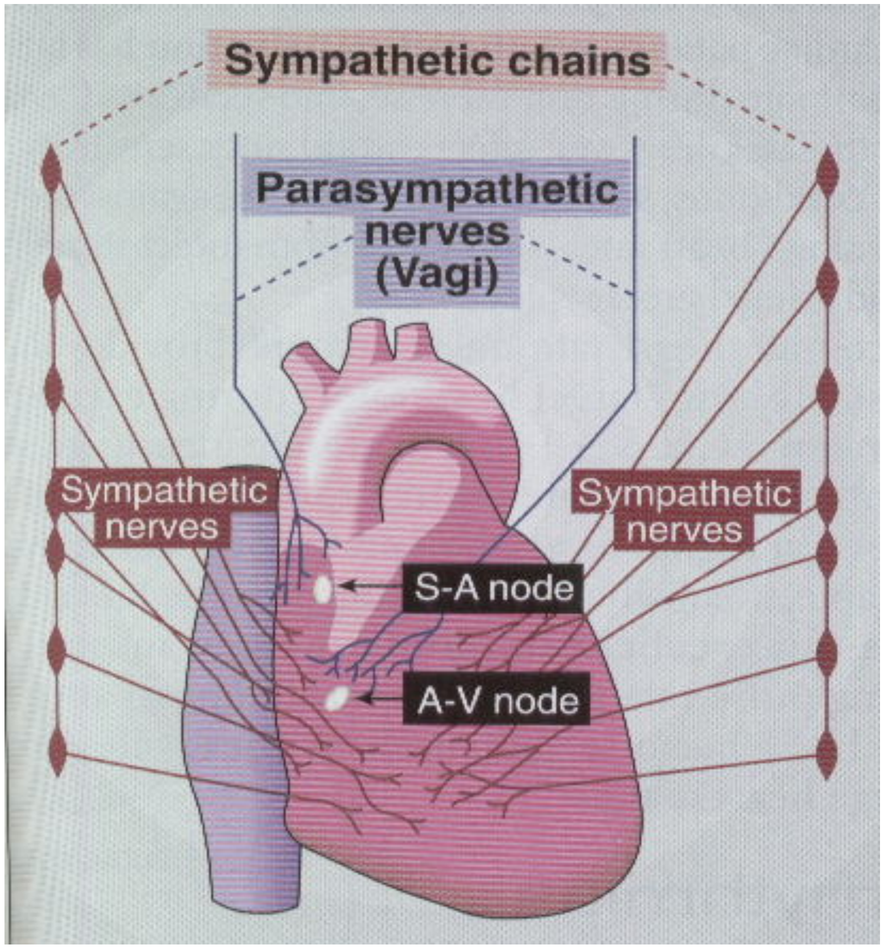
Cardiovascular Physiology and Pathophysiology

Factors Affecting Stroke Volume

- Afterload
  - Increased resistance
    - Hypertension
    - Aortic stenosis
    - Atherosclerotic plaque on aorta
  - Decreased resistance
    - vasodilation

Autonomic Nervous System

Nerve Fibers to Heart: Beta 1



Autonomic Nervous System

- B1 receptors
  - Heart
    - SA node
    - AV node
    - Cardiac muscle
- B2 receptors
  - Lungs
    - Smooth muscle of bronchioles
  - Skeletal muscle
    - Smooth muscle of vasculature to muscle
- Alpha receptors
  - Receptors on smooth muscle of vascular wall

Stroke volume affects HR

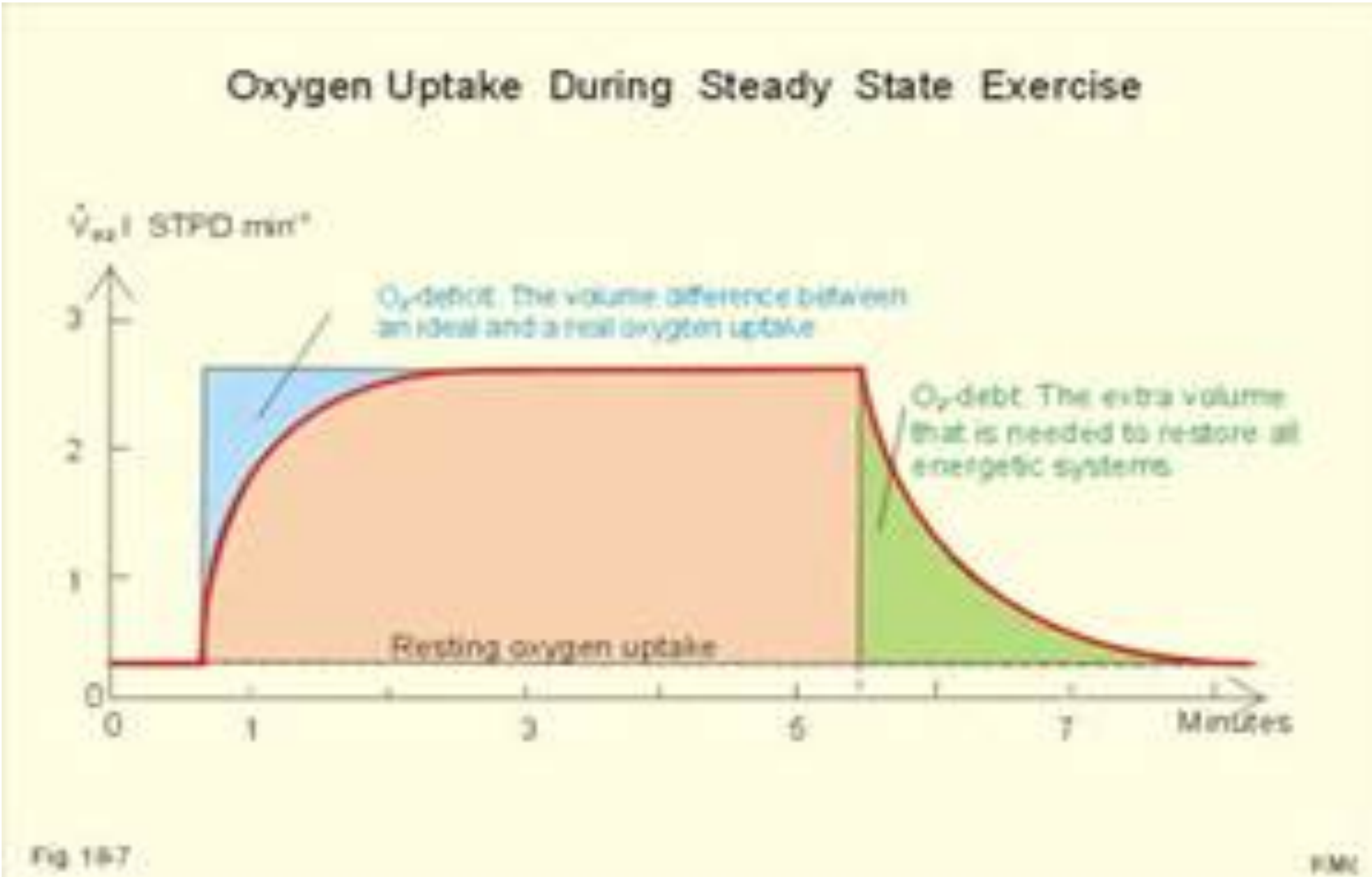
- Increased SV at rest, and with activity:
  results in lower REST HR, submax HRs

    This if found in trained athletes or regular aerobic exercisers
- Decreased SV at rest and with activity
  - Found in individuals who do not have heart muscle adaptations to regular exercise, have coronary artery disease, other cardiac dysfunction, older and not a regular exerciser, deconditioned, etc
  - May see increased REST HR, Increased submax HRs
    - Depends on whether or not on beta blockers!
- Individuals on beta blockers
  - Independent of underlying condition, beta blockers decrease sympathetic input to myocardium which decreases contractility. Blocks sympathetic to SA and AV nodes, lower resting HRs not due to an increased stroke volume in athletes and regular exercises

What is NORMAL HR response?

- Normal: gradual increase in HR with increase in workload (aerobic)
  - 8-12 beats/minute per MET of activity
- Normal: HR stays the same during steady state activity (or when maintaining same workload)
- Normal with B Blocker: Low resting HR, very gradual rate of rise with HR with activity…HR not related to intensity of activity in many patients

Oxygen uptake during steady state exercise



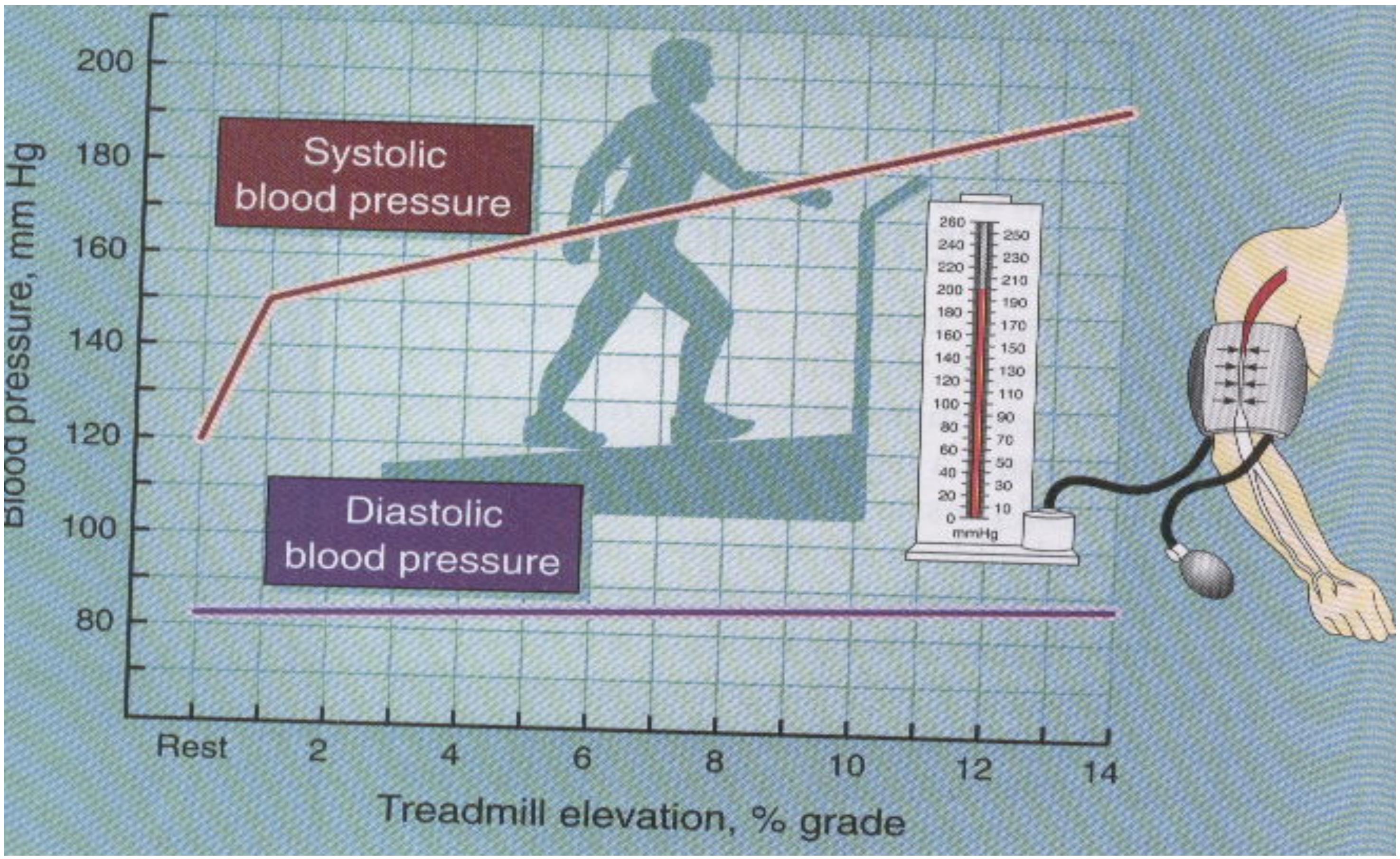
Blood Pressure Categories

American Heart Association | American Stroke Association

BLOOD PRESSURE CATEGORY	SYSTOLIC mm Hg (upper number)		DIASTOLIC mm Hg (lower number)
NORMAL	LESS THAN 120	and	LESS THAN 80
ELEVATED	120 – 129	and	LESS THAN 80
HIGH BLOOD PRESSURE (HYPERTENSION) STAGE 1	130 – 139	or	80 – 89
HIGH BLOOD PRESSURE (HYPERTENSION) STAGE 2	140 OR HIGHER	or	90 OR HIGHER
HYPERTENSIVE CRISIS (consult your doctor immediately)	HIGHER THAN 180	and/or	HIGHER THAN 120

Blood Pressure: 2017 guidelines

BP Responses to Activity



Myocardial Oxygen Consumption

- Mvo2 is dependent upon 2 major factors:
  - Systolic Blood pressure
  - Heart rate
- Mvo2 increases when:
  - Heart rate increases
  - Systolic BP increases
  - Both HR and Systolic BP increase
- If patient cannot tolerate activity:
  - Patient will be symptomatic or have abnormal HR and/or Systolic BP response with the activity!
    - Example: angina
    - Example: blood pressure drop
    - Example HR rise rapidly and patient symptomatic

Cardiovascular Physiology

- WORK = Rate Pressure Product (RPP)
  - Work on heart = HR x Systolic Pressure
- Examples:
  - Rest: HR 72, BP 120/80 RPP = 8640
  - Walking – patient develops chest tightness/angina
    - HR 102 BP 160/90 RPP = 16,320
  - Performing ADLs – no symptoms
    - HR 90BP 150/90 RPP = 13,500
  - Patient using restroom – symptomatic
    - HR 90 BP 180/90 RPP = 16,200
  - Patient forgets to take medicine
    - HR 90 at rest, BP 140/80 RPP =12,600
    - HR 110 with ADLS BP 150/90 RPP 16,500 symptomatic

Problem Solving with Cardiovascular Physiology

- Patient transitions sit to stand:
  - Rest: HR 78 BP 120/80
  - Stand: HR increases by 20-30, systolic BP decreases to 90/70 patient symptomatic
- How do you affect physiology?

  Preload problem
  - Standing: blood pooling in LEs without muscle pump
  - Overcome orthostasis with muscle pump
    - Use UE for muscle pumping or marching in place with LEs

Problem Solving with Cardiovascular Physiology

- Patient transitions sit to stand and patient taking Beta Blocking mediation:
  - Rest: HR 64 BP 120/80
  - Stand: HR stays at 64, systolic BP decreases to 90/70 patient symptomatic
- How do you affect physiology?

  Preload problem
  - Standing: blood pooling in LEs without muscle pump
  - Overcome orthostasis with muscle pump
    - Use UE for muscle pumping or marching in place with LEs
  - If muscle pumping does not work then need to discuss with MD about discontinuing B Blocker until patient can tolerate upright activity

Problem Solving with Cardiovascular Physiology

- Patient with cardiomyopathy
- Poor contractility problem
  - Other factors: preload…with exercise preload is going to increase due to increased venous return
  - Afterload will increase with exercise
  - Increased speed will decrease contractility due to decreased filling time
  - Optimize for poor contractility by monitoring BP closely with activity and stopping activity when HR and BP rising significantly or BP plateauing with HR rising

Problem Solving with Cardiovascular Physiology

- Patient with hypertension or aortic valve stenosis
- Problem: increased afterload
  - Monitor BP with activity keeping rise in BP to a minimal to moderate rise and then stopping activity when BP increases > 20-30 mm Hg to optimize cardiac muscle performance

Problem Solving with Cardiovascular Physiology

- Patient with history of hypertension, diabetes or just older and has been relatively inactive.
  - Review of cardiac diagnostic tests tell you patient has diastolic dysfunction or HFPEF (heart failure with preserved ejection fraction)
- Problem: poor distensibility…unable to relax and let large volumes into heart, especially with fluid overload or exercise
  - Monitor BP with activity keeping rise in BP to a minimal to moderate rise and then stopping activity when BP increases > 20-30 mm Hg to optimize cardiac muscle performance

Just doing a spot check to see what you are doing

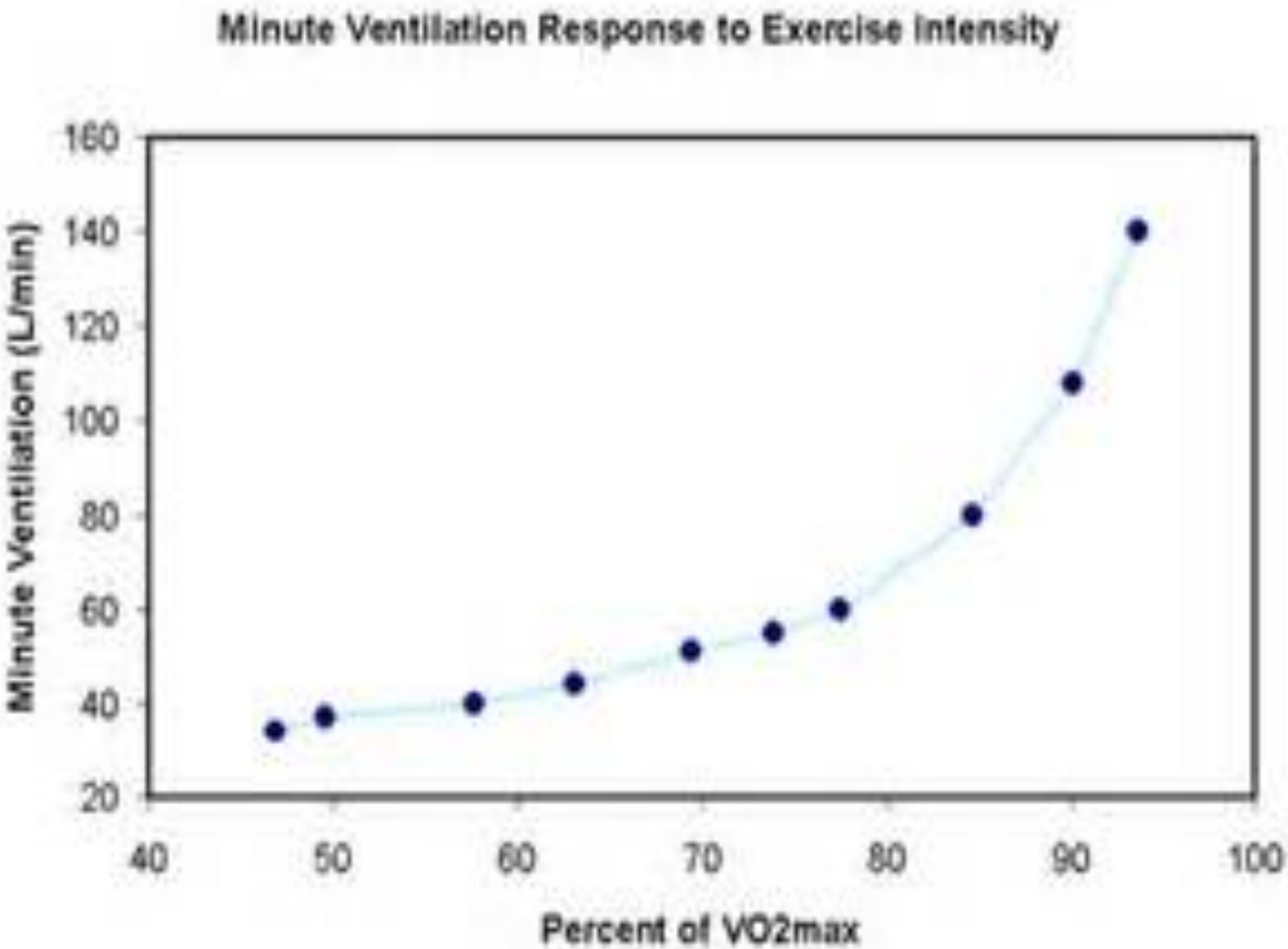
Yip.....sitting at your computer again!!

Question

- Describe work on the heart
  - A. work on heart is a result of the afterload, preload and contractility
  - B. work on the heart is systolic blood pressure times the heart rate
  - C. work on the heart is based on the medication patient is taking and the resulting vital signs
  - D. work on the heart is related to EF, HR, medications and afterload

Pulmonary Physiology

- Minute Ventilation = Tidal Volume X RR
  - In normal…tidal volume increases until submaximal level and then RR will rapidly increase
  - RR also increases more rapidly above anaerobic threshold
  - Athletes may have larger tidal volumes due to training effect on lungs but will not be "hyperinflated"

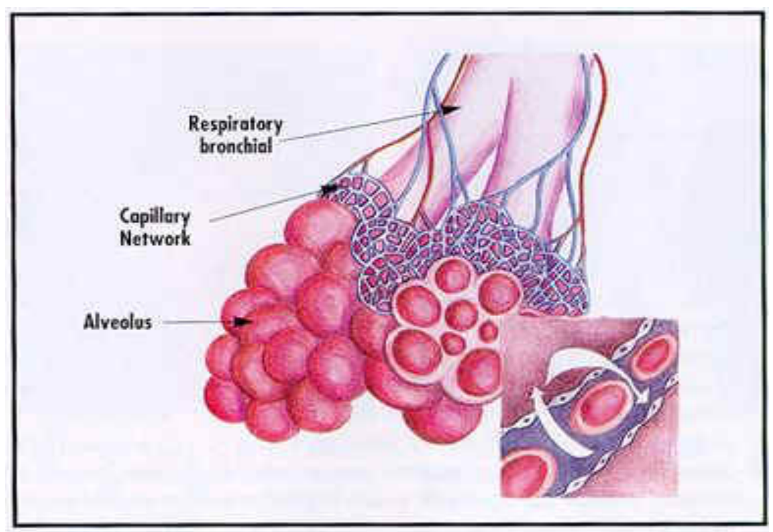

Minute Ventilation Response to Exercise Intensity
Minute Ventilation (L/min)
160
140
120
100
80
60
40
20
40
50
60
70
80
90
100
Percent of VO2max

Pulmonary Physiology

- Minute Ventilation = Tidal Volume X RR
  - Factors affecting volume
    - Restrictive disease will decrease maximal volume patient can achieve
    - RR rate will increase with activity more rapidly to compensate for low volumes
    - If RR and volume cannot bring enough air/O2 into lungs for gas exchange, supplemental O2 will be required
    - Obstructive disease – increased volumes, but does not mean volume is effective in gas exchange

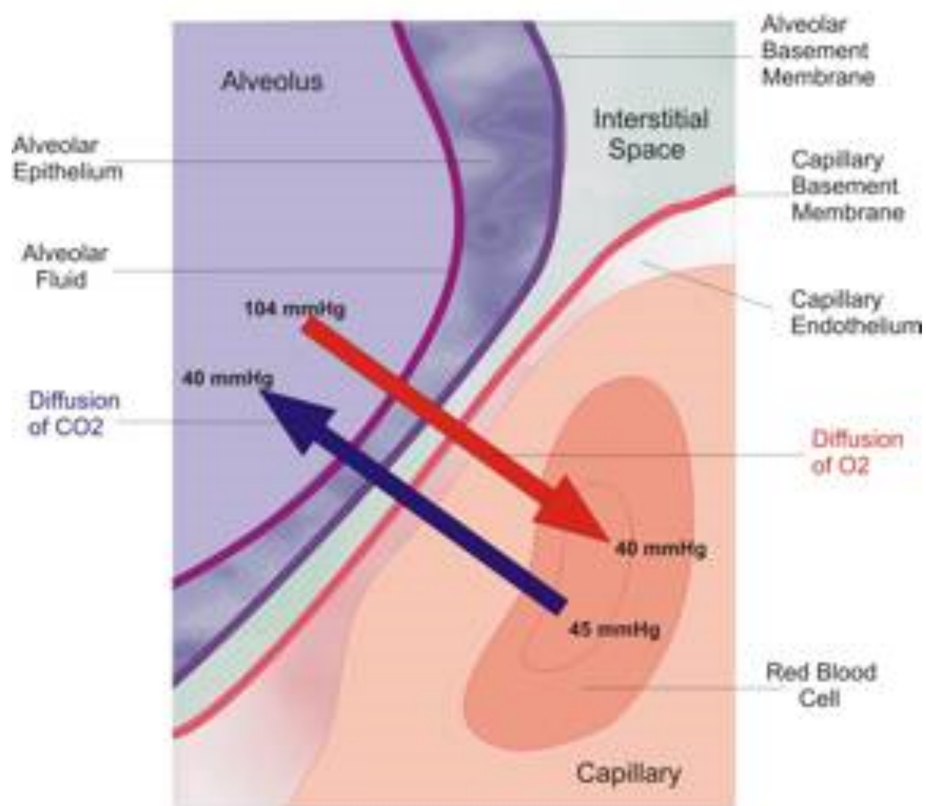
Pulmonary Physiology

- The key factor beyond minute ventilation is gas exchange
  - Is there any interference in the alveolar capillary membrane that will affect gas exchange

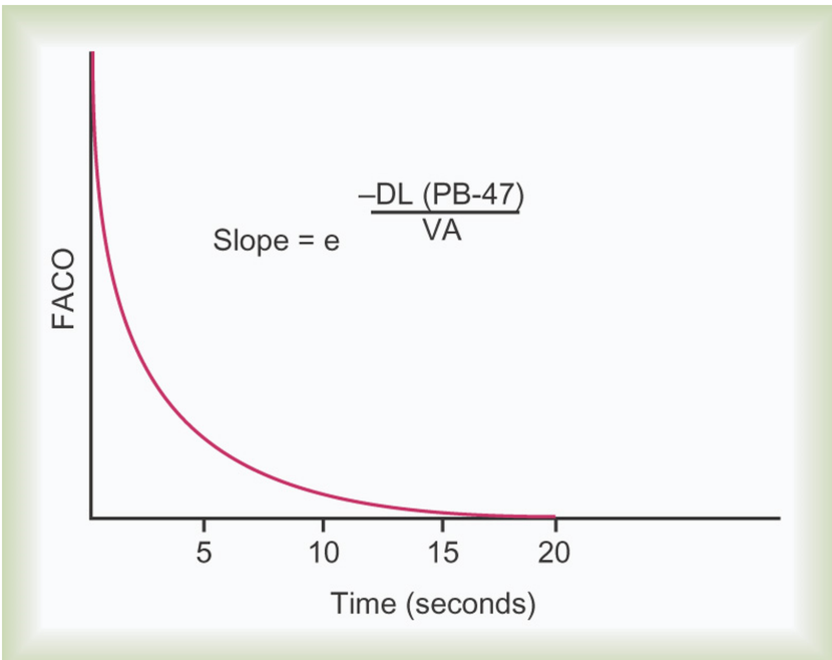


Diffusion Capacity (D_L)

- Represents the gas exchange capabilities of the lungs
- Measures the ability of gas to diffuse across the alveolar-capillary membrane using carbon monoxide: D_LCO



D_LCO



- Diseases that reduce surface area – ↓D_L
  - emphysema
- Interstitial altering of the membrane integrity - ↓D_L
  - Pulmonary fibrosis, Asbestosis, Sarcoidosis

Pathology

- Restrictive lung disease
  - Low volumes, so one sees higher RR with all activities
- Obstructive lung disease
  - LARGE volumes, but does not mean the volume provides for larger surface area of gas exchange.
  - In disease: due to decreased gas exchange, one sees increased RR with activity despite large lung volumes (as seen in COPD)

Classification of Lung Defects

OBSTRUCTIVE

- Expiratory flow is below normal
- Anatomic site can be identified
- Diseases:
  - Cystic fibrosis
  - Bronchitis
  - Asthma
  - Bronchiectasis
  - Emphysema

RESTRICTIVE

- Lung volumes are reduced
- Diseases:
  - Neuromuscular
  - Cardiovascular
  - Pulmonary
  - Trauma/chest wall dysfunction
  - Obesity

FEV_1

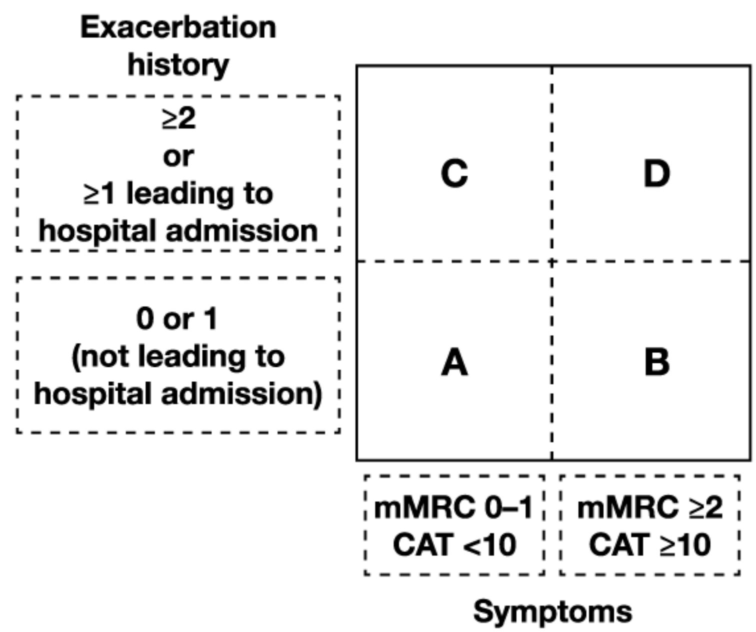
- Maximal volume exhaled during the first second of expiration
- Best indicator of obstructive lung disease
- Flow characteristics of the larger airways
- Best expressed as a percentage of the FVC (FEV_1/FVC)
  - Should be able to exhale 70% of the vital capacity in the first second
  - Decreased in obstructive disorders

COPD GOLD Guidelines

Spirometrically confirmed diagnosis → **Assessment of airflow limitation** → **Assessment of symptoms/risk of exacerbations**

Post-bronchodilator $FEV_1/FVC < 0.7$

	FEV_1 (% of predicted)
GOLD 1	≥80
GOLD 2	50–79
GOLD 3	30–49
GOLD 4	<30



FEV_1=forced expiratory volume in the first second; FVC=forced vital capacity; mMRC=modified Medical Research Council; CAT=COPD assessment test.

GOLD Guidelines

- Grade (1-4) is based on FEV1
  - Used mainly for diagnosis, prognosis
  - FEV1 limited used for making tx decisions
- Group (A-D) is based on symptoms and exac history
  - Correlates better with QOL, functional limitation and risk of exacerbation
  - Used to make treatment decision

MMRC

TABLE 3: MODIFIED MEDICAL RESEARCH COUNCIL (MMRC) QUESTIONNAIRE FOR CATEGORIZING COPD SEVERITY

MMRC Questionaire		
Severity	**Score**	**Level of Breathlessness**
None	0	Only breathlessness with strenuous exercise
Mild	1	Shortness of breath hurrying or walking up a slight hill
Moderate	2	Walks slower than age group or has to stop for breath when walking on level ground at own pace
Severe	3	Stops for breath after walking 100 meters or a few minutes on level ground
Very severe	4	Breathless when dressing/undressing or too breathless to leave the house

Adapted from reference 3.

Problem Solving in Pulmonary Physiology

- Patient with Restrictive Lung Disease
  - Examples, pneumonia or IPF or pleural effusion
  - Less lung volume, most notably with activity
  - Increase in RR with activity, maybe not at rest unless volume is severely compromised
    - Patient demonstrates ↑ RR and ↓ SpO2 with activity but not at rest
    - Thought question: What would you do to improve exercise tolerance to activity? What do you need to know?

Problem Solving in Pulmonary Physiology

- Patient with Restrictive Lung Disease
  - Exercise Prescription
    - Increase Supplemental O2 with activity
    - ***Anaerobic work***: when works anaerobically, remember that they build up lactic acid
      - $C_6H_{12}O_6$ ➔ lactic acid and 2 ATP and heat
      - With ↑ lactic acid, RR will ↑ more rapidly to help to rid body of excess acid
      - Therefore, bouts of activity monitoring SpO2, especially in post exercise period (when they may have > decreases in SpO2 than they had DURING exercise)

Problem Solving in Pulmonary Physiology

- Patient with Restrictive Lung Disease
  - Exercise Prescription
    - Increase Supplemental O_2 with activity
    - ***Aerobic work:*** when works aerobically remember that they increase CO_2 production
      - $C_6H_{12}O_6 \rightarrow 6\ CO_2 + 6\ H_2O$ and 36 ATP
      - Breathing deeper may help with gas exchange in some patients and may not have SpO_2 ↓ as much
      - Monitor SpO_2, Dyspnea (provide them a level of dyspnea for intensity), and create ex prescription based on SpO_2 and RR changes
        - » Frequent bouts

Problem Solving in Pulmonary Physiology

- Patient with Obstructive Lung Disease
  - Exercise Prescription
    - Often activity increases ventilation/perfusion mismatches resulting in worsening of gas exchange
      - ↑ supplemental oxygen often required to compensate for gas exchange worsening
      - Pursed lip breathing important
      - Frequent bouts with rests in between to keep patient in aerobic exercise phase and not anaerobic
    - Keep in mind when short of breath with activity, will decrease activity indicating many patients are deconditioned and not just presenting with lung disease
    - Optimize oxygen to maximize exercise, but work patient in intervals as much as possible and return O2 to resting liters/minute at end of exercise session when SpO2 returns to normal

Problem Solving in Pulmonary Physiology

- Patient with Obstructive Lung Disease
  - Exercise Prescription
    - Increase Supplemental O2 with activity
    - ***Aerobic work:*** when works aerobically remember that they increase CO2 production
      - $C_6H_{12}O_6 \rightarrow 6\ CO_2 + 6\ H_2O$ and 36 ATP
      - Pursed lip breathing exercises may help with gas exchange in patients and may not have SpO2 ↓ as much
      - Titrate O2 to activity but decrease the oxygen at rest
      - Monitor SpO2, Dyspnea (provide them a level of dyspnea for intensity), and create ex prescription based on SpO2 and RR changes
        - » Frequent bouts

Problem Solving in Pulmonary Physiology

- Patient with Obstructive Lung Disease
  - Exercise Prescription
    - Increase Supplemental O2 with activity
    - ***Anaerobic work***: when works anaerobically, remember that they build up lactic acid
      - $C_6H_{12}O_6$ ➔ lactic acid and 2 ATP and heat
      - With ↑ lactic acid, RR will ↑ more rapidly to help to rid body of excess acid
      - Therefore, bouts of activity monitoring SpO_2, especially in post exercise period (when they may have > decreases in SpO_2 than they had DURING exercise)

Skeletal Muscle Physiology

Blood Supply to Skeletal Muscle

- Arteries and veins lie parallel to individual muscle fibers
  - These divide into numerous arterioles, capillaries, and venules to form a network in and around the endomysium
  - This extensive branching ensures adequate oxygen and rapid removal of carbon dioxide
    - What diseases/diagnoses might have decreased branching and therefore decreased O_2 to muscle and CO_2 removal?

Blood Supply to Skeletal Muscle

- During intense exercise the vascular bed delivers large quantities of blood through active tissues to accommodate the increased oxygen need
- Physical activities that require straining elevate intramuscular pressure to occlude local blood flow during muscular contractions

  - What physical activities might cause increased intramuscular pressure?
    - What sorts of diseases/diagnoses might require monitoring or caution with these exercises

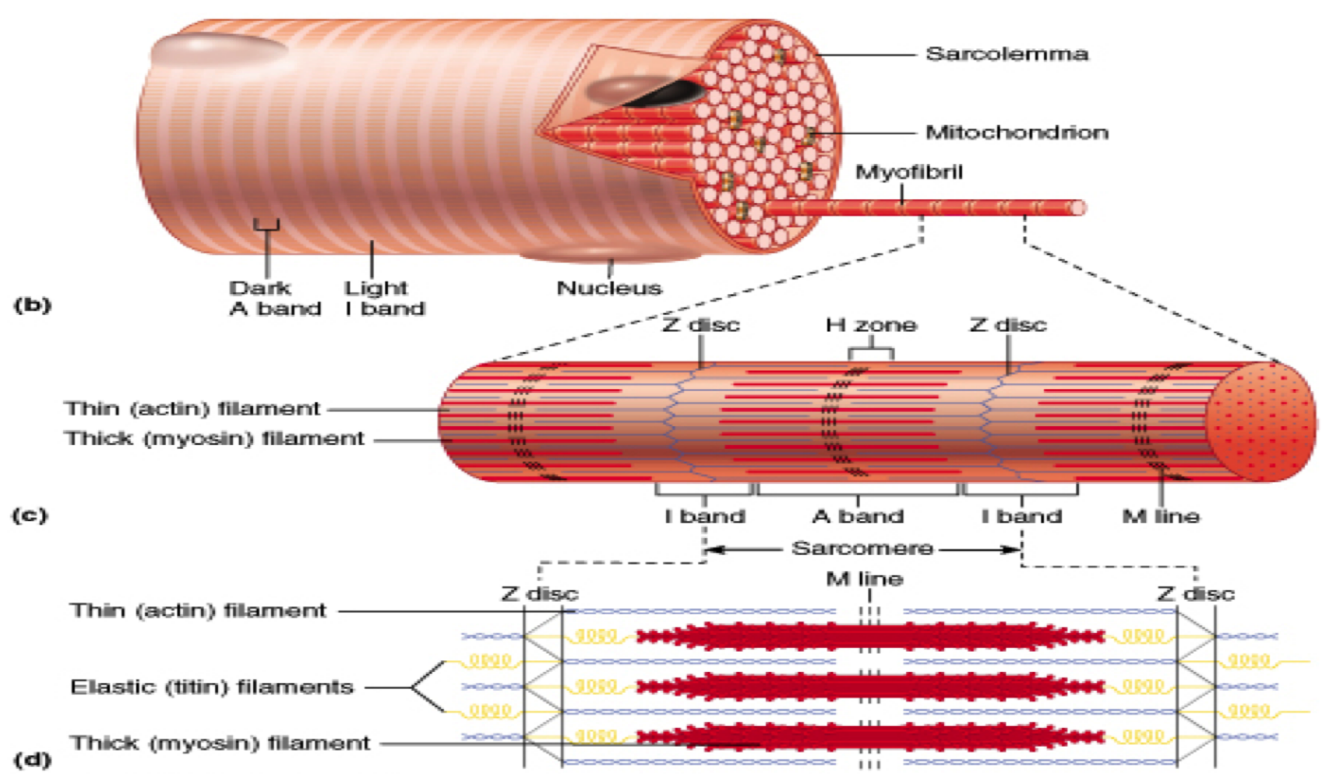
Capillarization

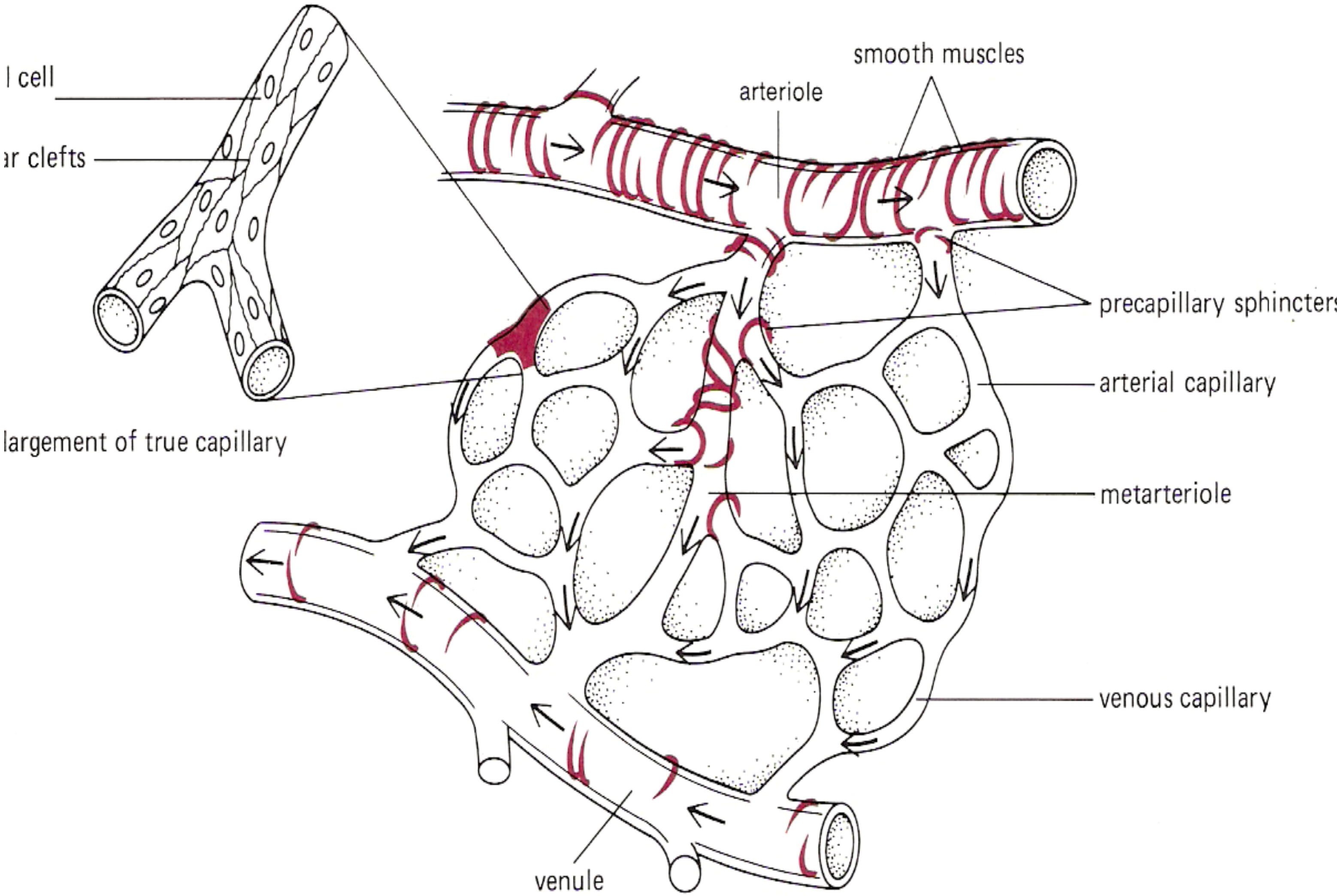
- A trained muscle has an increased capillary-to-muscle fiber ratio
  - This enhanced capillary microcirculation expedites the removal of heat and metabolic byproducts from active tissues in addition to facilitating delivery of oxygen, nutrients, and hormones
    - WHAT IS A TRAINED MUSCLE?
- Total number of capillaries per muscle averages 40% higher in endurance-trained athletes than untrained counterparts
- Vascular stretch and shear stress on the vessel walls from increased blood flow during exercise stimulates capillary development with intense aerobic training

Question

- What diseases would have difficulty with peripheral blood supply, vasodilation and supply of oxygen to muscle?
    - A. heart failure and atherosclerosis of coronary arteries
    - B. peripheral arterial disease and diabetes
    - C. adult respiratory distress syndrome
    - D. restrictive lung disease

Skeletal muscle





U-47 Diagram of microcirculation. Note the absence of smooth muscle in the true capillaries. *(Adapted from B. B*

Muscle Fiber Type

- Skeletal muscle contains two main types of fibers that differ in:
  - The primary mechanisms they use to produce ATP
  - The type of motor neuron innervation
  - The type of myosin heavy chain expressed
- The proportions of each type of muscle fiber vary from muscle to muscle and from person to person

Fast-Twitch Fibers (FT or Type II)

- Exhibit the following four characteristics:
  - High capability for electrochemical transmission of action potentials
  - High myosin ATPase activity
  - Rapid Ca^{2+} release and uptake by an efficient sarcoplasmic reticulum
  - High rate of crossbridge turnover
- These factors contribute to this fiber's rapid energy generation for quick, powerful muscle actions
- What type of activities utilize FT?

Fast-Twitch Fibers (Type II) cont'd

- The fast-twitch fiber's intrinsic speed of shortening and tension development ranges three to five times faster than slow-twitch fibers
- Fast-twitch fibers rely on a well-developed, short-term glycolytic system for energy transfer
- Fast-twitch fiber activation predominates in anaerobic-type sprint activities and other forceful muscle actions that rely almost entirely on anaerobic energy metabolism
- Activation of fast-twitch fibers plays an important role in the stop-and-go or change-of-pace sports such as basketball, soccer, lacrosse, or field hockey

Fast-Twitch Fibers (Type II) cont'd

- Type II fibers distribute in three primary subtypes:
  - Type IIa: Represent the fast–oxidative–glycolytic fibers
  - Type IIx: Possess the greatest anaerobic potential and most rapid shortening velocity; represents the "true" fast–glycolytic fiber
  - Type IIb

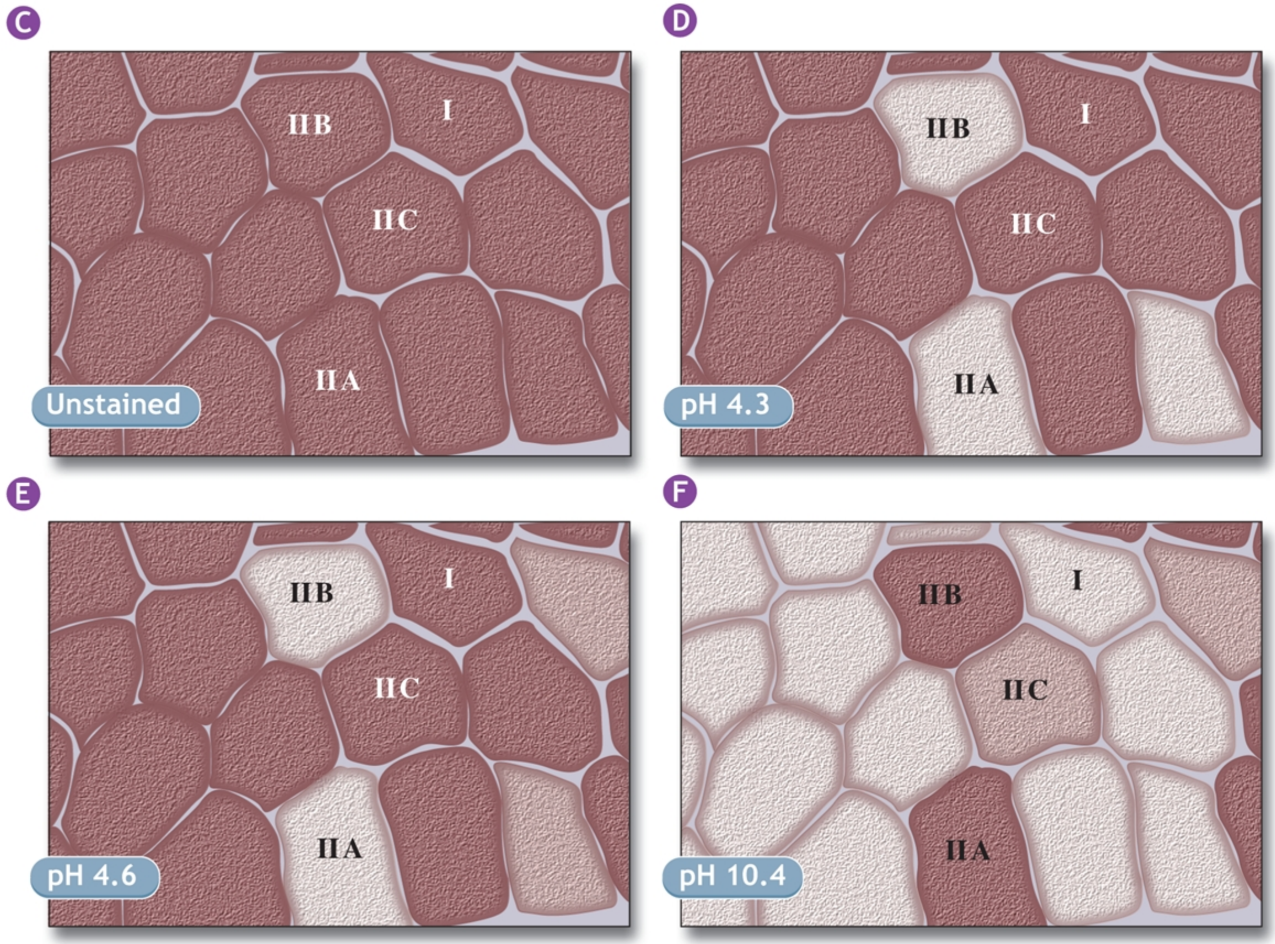
Slow-Twitch Fibers (SO or Type I)

- Generate energy for ATP resynthesis predominantly through the aerobic system of energy transfer
- Their four distinguishing characteristics include:
  - Low myosin ATPase activity
  - Slow calcium handling ability and shortening speed
  - Less well-developed glycolytic capacity than fast-twitch fibers
  - Large and numerous mitochondria

Slow-Twitch Fibers (Type I) cont'd

- Are highly fatigue resistant and ideally suited for prolonged aerobic exercise
- Are slow-oxidative fibers with slow shortening speed and rely on oxidative metabolism
- Both slow and fast muscle fiber types contribute during near-maximum aerobic and anaerobic exercise

Muscle types



Fiber Type Differences

- Men, women, and children on average possess 45-55% slow-twitch fibers in their arm and leg muscles
- The fast-twitch fibers probably distribute equally between type IIa and type IIb subdivisions
- While no gender differences exist in fiber distribution, large inter-individual variation occurs
- Generally, the trend in one’s muscle fiber type distribution remains consistent among the body’s major muscle groups

Fiber Type Differences Among Athletic Groups

- Certain patterns of muscle fiber distribution appear in comparisons among highly proficient athletes
  - Ex: endurance athletes possess predominantly slow-twitch fibers; fast-twitch fibers predominate for elite sprint athletes
- Performance success is dependent not only on muscle fiber composition, but on a blending of many physiologic, biochemical, neurologic, and biomechanical “support systems”
- Larger muscle fibers in male athletes and a larger total muscle mass are the principal gender differences in muscle morphology

Sleeping on the job???

Question

- Fast-twitch muscle fibers exhibit all of the following characteristics except:
  a. High capability for electrochemical transmission of action potentials
  b. Low myosin ATPase activity
  c. Rapid Ca^{2+} release and uptake by an efficient sarcoplasmic reticulum
  d. High rate of crossbridge turnover

Answer

- Fast-twitch muscle fibers exhibit all of the following characteristics except:
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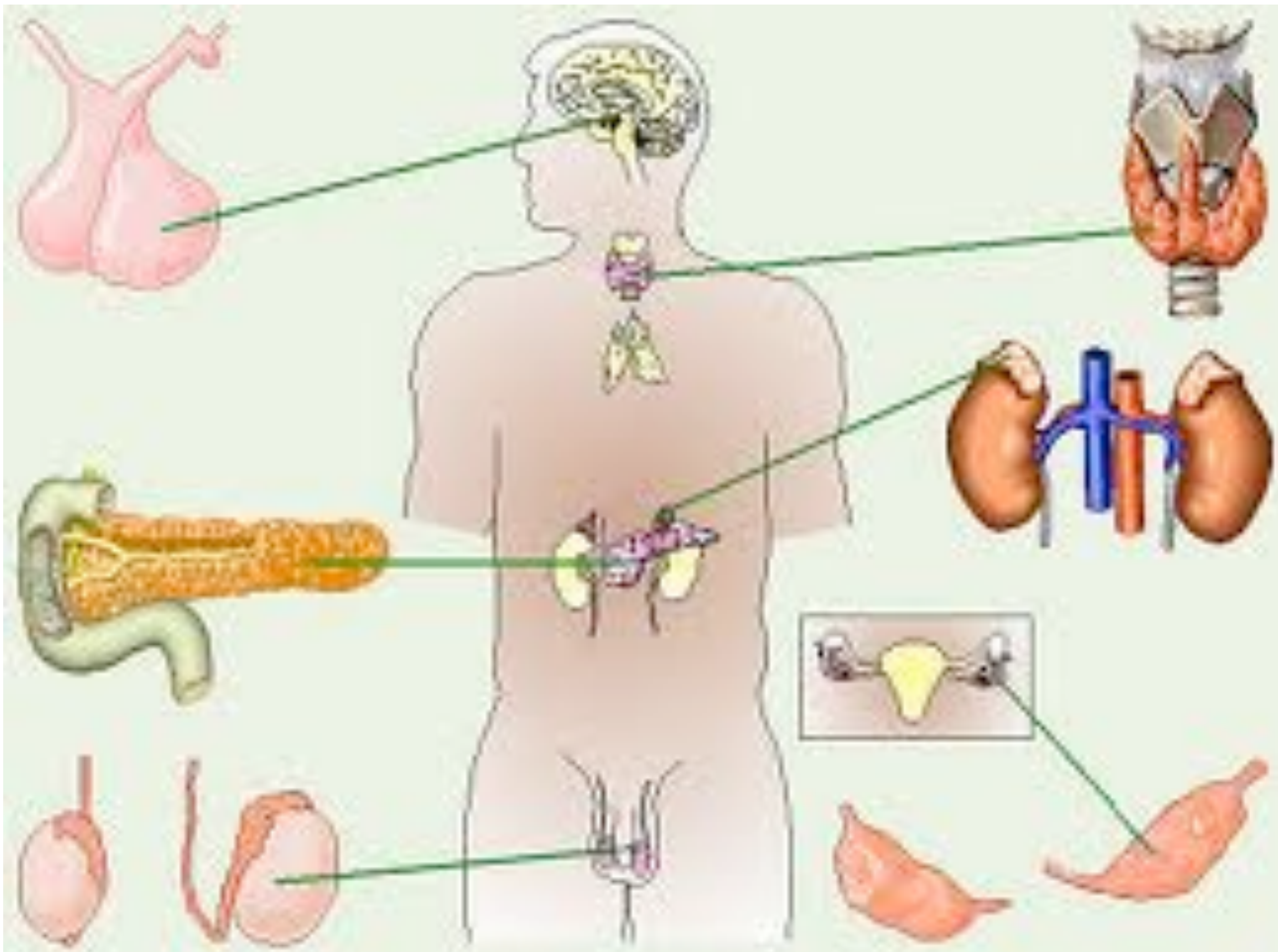
Neural Control of Human Movement

- Neuromotor System Organization
  – Central Nervous System
    - Brain
    - Spinal Cord
  – Peripheral Nervous System
    - Sympathetic and Parasympathetic nervous system
    - Reflex Arc

Endocrine System in Health and Disease

Endocrine System



Neuroendocrine Response to Stress

- Endocrine, immune and nervous system all respond to stress
- Sympathetic system activated during stress causing medulla of adrenal gland to release catecholamines
  - Epinephrine
  - Norepinephrine
  - Dopamine
- Pituitary gland releases hormones:
  - ADH, prolactin, GH and ACTH

Sympathetic activation during stress

- Catecholamines
  - Released at sympathetic nerve endings
  - Result in Inc in HR, cardiac muscle contraction, peripheral vessel constriction
    - Inc HR, BP, glucose, breakdown of fats
    - Glycogenesis in liver
- Cortisol
  - Released from adrenal cortex
  - Regulates metabolism of carbs, proteins, lipids,
  - Provides glucose for energy during stress
  - Reduces inflammatory response to invasion…
  - Inhibits fibroblast proliferation: causes increase susceptibility to infection, decreases wound healing

Sympathetic activation during stress

- Other Hormones:
  - Growth
    - Stimulates rate of skeletal and visceral growth by affecting metabolism
  - Endorphins raise pain threshold and induce sedation
  - Testosterone decreases after stress, restrains growth and production

Aging and Endocrine System

- Associated with higher incidence of disorders or diseases
  - DM (type II)
  - Hypothyroidism
  - Atypical endocrine diseases
- Anatomic changes
  - Pituitary gland – decreases in size, greater risk of adenomas
  - Thyroid decreases and becomes fibrotic
  - Increased risk of hyperparathyroidism in >50
  - Adrenal glands become more fibrotic
  - Reproductive glands change

Hormone Changes with Aging

- Female reproductive changes – menopause leads to bone loss, lipid changes
- Male hormone changes increase risk of BPH
- Decreased GH cause loss of body hair, change in skin collagen and decrease in Lean body mass, decrease in bone and decrease in protein synthesis

Is this you?

In Summary…….

Summary

- Consider patient's nutritional status
  - Pre morbid nutritional status affects long term stores of energy
  - Current nutritional status will affect current stores and available energy
- Consider their oxygen transport system, and their maximal oxygen consumption or maximal aerobic capacity
  - What was their premorbid activity level
    - Trained? Diseased? Deconditioned? Impaired?
  - What is condition of entire oxygen transport system
    - Any impairments?
- Assess their responses to exercise and determine if you have normal or abnormal responses to exercise
  - Are they on beta blockers?
  - If abnormal responses is there a contraindication to exercsie?

Exercise Prescription

- Components of GOOD exercise prescription
  - MODE
  - Intensity
  - Frequency
  - Duration

- Exercise Prescription is related to goal for therapy: improve strength? Improve endurance? Improve both? What is their functional aerobic capacity? (their reserve)

Exercise Prescription

- Intensity is hardest to determine
  - Can use RPE, rating of dyspnea, VAS scale
  - Can use Target HR
  - Can give a prescribed workload such as on TM or bike
- Duration
  - Build up to 30 minutes of continuous
- Frequency
  - If performing 5 minute bouts…do multiple times per day
- Mode:
  - Choose something patient enjoys

Case Studies

- Patient who is older, very thin, low albumin, poor dietary intake, diagnosed with Systolic Heart Failure
  - Energy issues?
  - O2 transport issues
  - CV physiology issues
  - Ex Prescription suggestions

Case Study

- Patient diagnosed with Heart Failure
  - Read history and physical from hospital… patient has normal EF (> 50-55%)

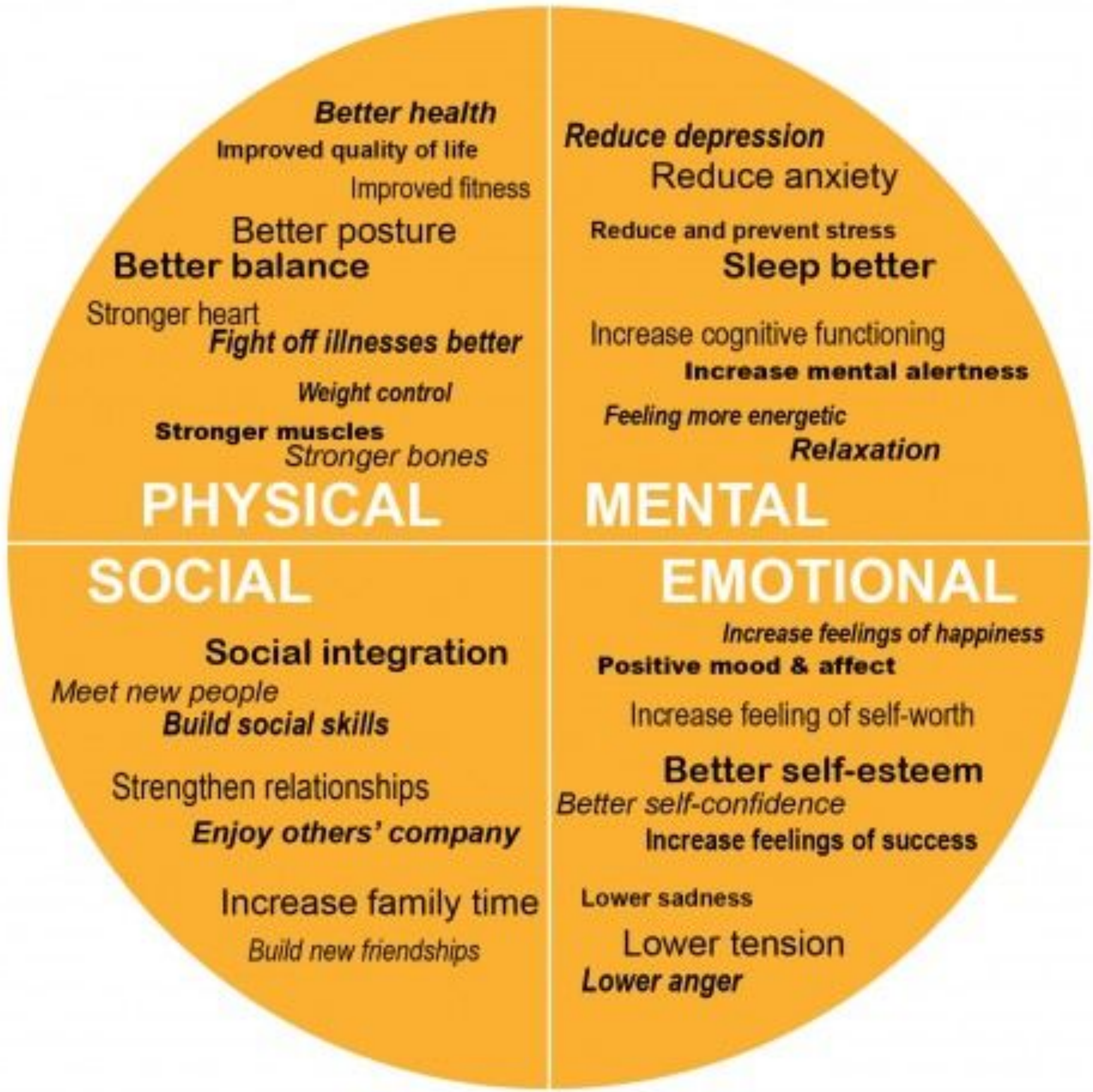
Case Study

- Patient with COPD

Case Studies

- Patient with Restrictive lung disease, steroid use, low muscle mass
  - Energy issues?
  - O2 transport issues?
  - Pulmonary physiology issues?
  - Ex prescription?

Benefits of Exercise Training



Whooooo has questions????