Cardiac Rehabilitation

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Cardiac Rehabilitation: Introduction

CR is comprehensive long-term services involving:

- Medical evaluation
- Prescribed **exercise**
- Cardiac **risk-factor** modification
- Health **education**
- **Counseling**
- Behavioral interventions

Wenger NK, et al. [NHLBI Clin Pract Guidel No. 17]. *Clin Pract Guidel Quick Ref Guide Clin*. 1995 Oct;(17):1-23.

Outline

- Indications for cardiac rehabilitation
- Scope of cardiac rehabilitation programs
- Exercise testing and prescription

Team Members

Indications for cardiac rehab

Per CMS (Medicare Part B) guidelines

Ischemic Heart Disease
- Acute MI within 12 mo.
- CABG surgery
- PCI/stent
- Stable angina pectoris

Valvular Heart Disease
- Heart valve repair
- Heart valve replacement (incl. TAVR)

Heart Failure
- Heart transplantation
- Chronic heart failure*

Symptomatic Peripheral Artery Disease

*Added 2014. LVEF ≤ 35%, NYHA Class II-IV symptoms despite GDMT tolerated x 6 wk without major CV hospitalizations or procedures.

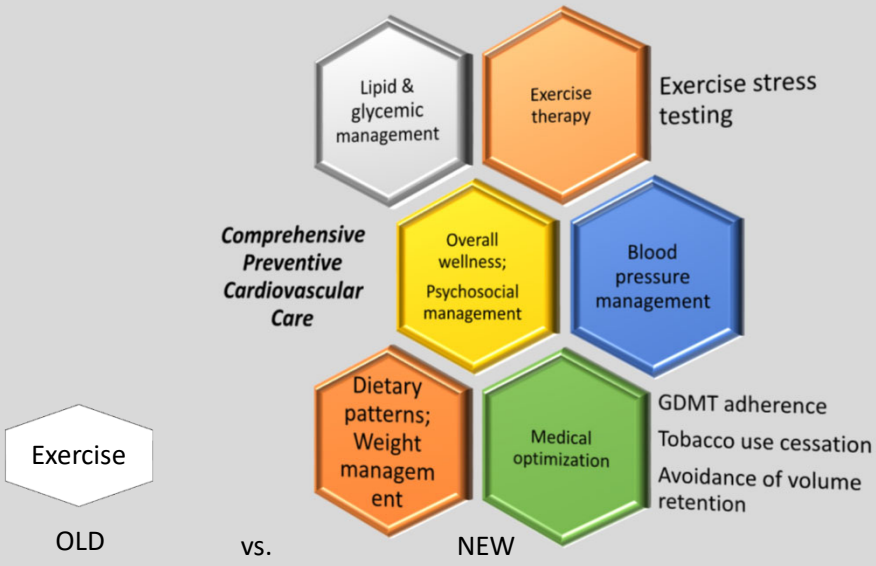
Phases of Cardiac Rehab

Phase I
- In-hospital
- Goals of education, early ambulation, and encouragement of referral to phase II

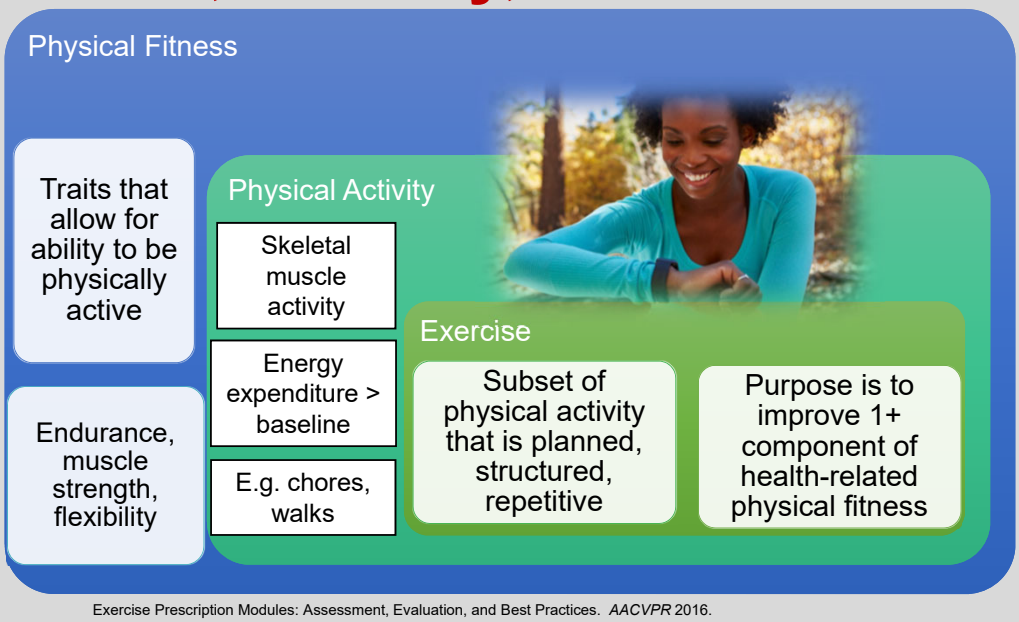
Phase II
- 12-week intensive outpatient program
- Goals
  - ***Return to work, hobbies, lifestyle***
  - ***Improved QOL / perception***
  - ***Anxiety and depression management***
  - ***Risk factor modification***
  - ***Tobacco use cessation***

Phase III
- Long-term maintenance (no ins. coverage)

Shifting paradigms in CR



Fitness, Activity, Exercise



Exercise Prescription Modules: Assessment, Evaluation, and Best Practices. *AACVPR* 2016.
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Exercise Testing & Prescription

METs

- Ratio of oxygen uptake by the body at a given activity level to resting oxygen uptake by the body
  - 1 MET = 3.5 ml[O_2]/kg/min
  - Equivalent to 58.2 W/m^2 BSA, or about 100 W for a standard 1.73 m^2 individual
  - Sleep: 0.9 METs sleeping
  - Extreme exercise: 23 METs running a 4:17 mile

Stock photo was purchased from istock.com by the Ohio State Heart & Vascular Center.

Exercise: Is it Safe?

Contraindications to exercise (selected)

Absolute
- Unstable angina / ACS
- Acute myocarditis
- Uncontrolled arrhythmias
- Severe/decompensated valve disease / HF
- Severe resting hypertension (e.g. >200/110 mmHg)
- Acute pulmonary embolism
- Acute non-cardiac illness
- Physical disability rendering exercise unsafe

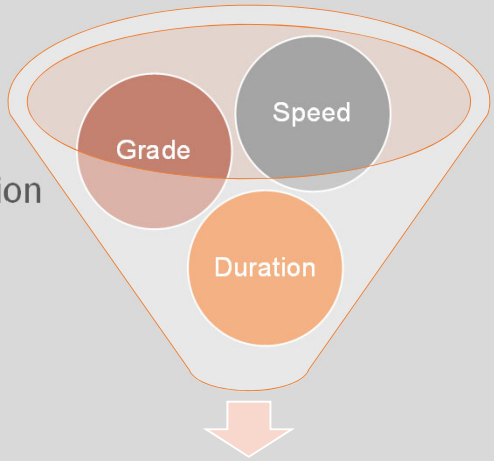
Relative
- Electrolyte abnormalities
- Arrhythmias / high gr. AVB
- Hypertrophic cardiomyopathy with LVOTO > 25 mmHg
- Known significant left main coronary artery stenosis
- Asymptomatic severe AS
- Cognitive impairment or psychiatric disease

Adapted from: Henzlova MJ, et al. *J Nucl Cardiol* 2016 Jun;23(3):606-39.

Exercise Prescription

Parameters assessed

- Routine
  - Heart rate, rhythm
  - Blood pressure
  - Symptoms; rating of perceived exertion (RPE)
- Optional
  - Oxygen saturation
  - Oxygen consumption
  - Ventilatory/lactate threshold
  - V_E/VO_2 slope
  - CO_2 production



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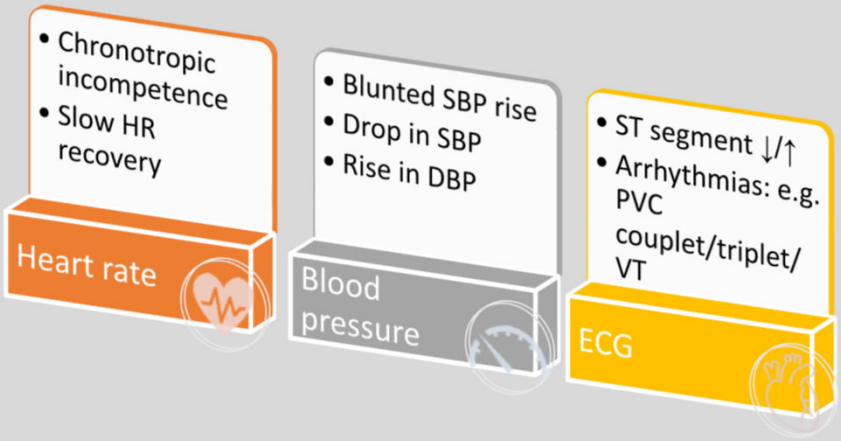
Exercise Testing

NHYA Class	Workload (Bruce, approx.)
IV	
III	3 METs
II	
I & Normal	5 METs
↓	7 METs
Workload by time and stage	10 METs

	BRUCE			BALKE		
Time (min)	Stage	Speed (mph)	Grade (%)	Stage	Speed (mph)	Grade (%)
0	0	1.7	0			
1	1	1.7	10	1	3.3	0
2	1	1.7	10	2	3.3	2
3	1	1.7	10	3	3.3	3
4	2	2.5	12	4	3.3	4
5	2	2.5	12	5	3.3	5
6	2	2.5	12	6	3.3	6
7	3	3.4	14	7	3.3	7
8	3	3.4	14	8	3.3	8
9	3	3.4	14	9	3.3	9
10	4	4.2	16	10	3.3	10
11	4	4.2	16	11	3.3	11
12	4	4.2	16	12	3.3	12

Exercise Prescription Modules: Assessment, Evaluation, and Best Practices. *AACVPR* 2016.

Exercise Responses



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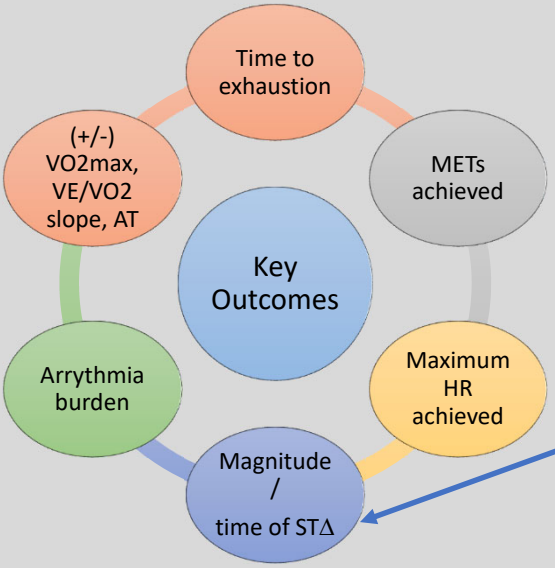
Exercise Responses



Resting EKG abnormalities which reduce test accuracy
- LVH
- LBBB
- Ventricular pacing
- Resting ST-depression ≥ 0.5 mm
- Digitalis effect

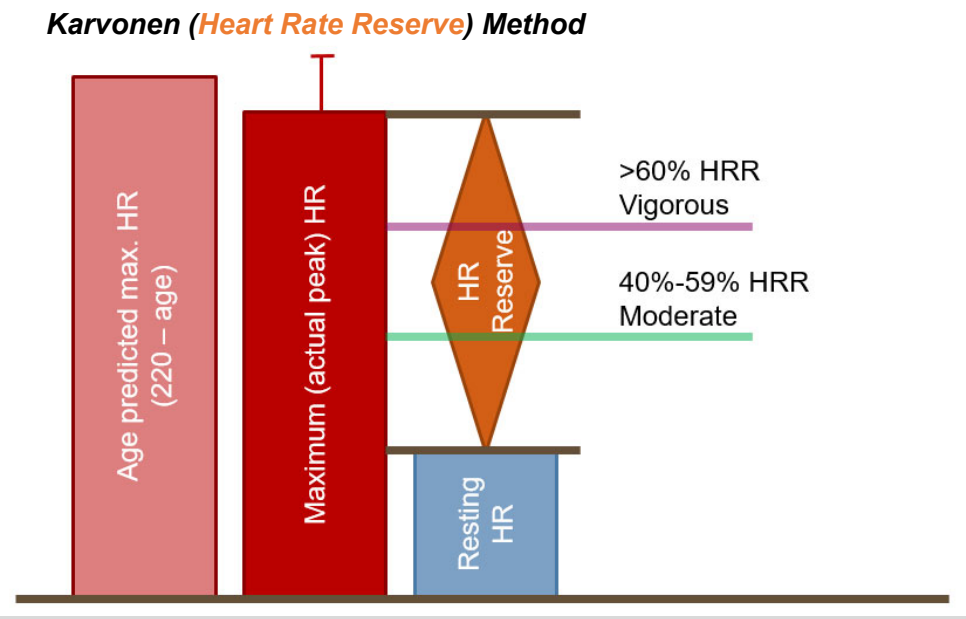
Adapted from: Henzlova MJ, et al. *J Nucl Cardiol* 2016 Jun;23(3):606-39.

Intensity of Exercise

- Absolute predicted maximal heart rate method
  - **HR_{max} = 220 – [age]**
  - Entry to CR: may be approximately **50% x HR_{max}**, depending on level of conditioning
  - Exercise goal and prescription: target HR of **60-85% x HR_{max}**
- Karvonen (proportion of **HR reserve**) method
  - Target HR = 0.5 to 0.8 * **(HR_{max} – HR_{rest})** + HR_{rest}
- Oxygen consumption method
  - Exercise at 60-80% of maximal oxygen consumption

Braverman DL et al. *Am J Phys Med Rehabil* 2011;90:599-611.

Exercise Prescription



Exercise Prescription Modules: Assessment, Evaluation, and Best Practices. *AACVPR* 2016.

Exercise Testing & Rx.

Intensity	Examples	Workload (*METs*)	Range of HR or $VO2_{max}$ reserve	Rating of Perceived Exertion
Sedentary	Seated/lying activities	*1.0 - 1.5*		
Light	Easy walking	*1.6 - 2.9*	< 40%	< 12
Moderate	Brisk walking (4+ mph) Household chores	*3.0 - 5.9*	40 – 59%	12 – 13
Vigorous	Jogging Moving furniture	*6.0 – 8.8*	60 – 90%	14 – 17
(Near) Maximal	Fastest running, cycling, rowing	*Above*	>90%	18 – 20

Exercise Prescription Modules: Assessment, Evaluation, and Best Practices. *AACVPR* 2016.

Exercise Prescription

Creating an Exercise Prescription: FITT(VP) principle

F	**Frequency**	**Number of sessions/wk. Most days of the week recommended for all**
I	Intensity	Level of exertion: most potent stimulus for improved fitness. May be relative or objective (e.g. METs, %maxHR, $\%VO2_{max}$)
T	Time	Time spent per exercise session 5-10 min warm up, cool-down
T	Type	Type of exercise, e.g. walking, jogging, cycling, weightlifting
(V)	Volume	E.g. moderate ≥ 150 mins/wk; vigorous ≥ 75 mins/wk
(P)	Progression	E.g. increase duration by 5 min/session every 1-2 weeks until reaching goal (e.g. 30m)

Exercise Prescription Modules: Assessment, Evaluation, and Best Practices. *AACVPR* 2016.

Exercise Prescription

Special Considerations

Osteoarthritis	Diabetes mellitus	Heart Failure
• Emphasis on **flexibility** • **Light-moderate** intensity • >150 min/wk recommended but may need to occur in shorter bouts	• **Moderate to vigorous** intensity • Suggest not going 2+ **consecutive** days without physical activity due to glycemic control benefits • Consider glucose monitoring	• Emphasis on **aerobic** activity • **Avoid excessive strength training** (sustained maximal isometric activity)

Exercise Prescription Modules: Assessment, Evaluation, and Best Practices. *AACVPR* 2016.

Return to Sexual Activity

AHA Scientific Statement on Sexual Activity and Cardiovascular Dis.

- Risk of coital MI is elevated in sedentary individuals (RR 3.0) vs. physically active individuals (RR 1.2).
- Sexual activity is the precipitant of <1% of all acute MIs

Prior to resumption of sexual activity	Resumption of sexual activity is reasonable	Defer sexual activity
Evaluate with H&P (IIa, C)	Low risk of cardiovascular complications based on clinical eval. (IIa, B)	Unstable, **decompensated**, severe symptomatic CVD (III, C)
Perform exercise **stress testing for those at elevated risk** or have unknown ex. cap (IIa, C)	Ability to exercise **≥ 3 to 5 METs** without angina, excessive dyspnea, ST∆ or BP drop (IIa, C)	Cardiovascular **symptoms precipitated** by sexual activity (III, C)

Levin GN et al. *Circulation* 2012;125:1058-1072.

Benefits of Cardiac Rehab

Exercise capacity
- Expect 33% increase in tolerated METs
- Increased $VO2_{max}$ by 16%

Improved symptom burden
- Decreased dyspnea or angina
- Decreased BP/HR for given workload

Improved prognosis
- Improved cardiovascular mortality (OR 0.74)
- Improve all-cause mortality (OR 0.80)

Potential risks:
- Arrhythmias (AF, VT)
- Inappropriate defibrillation (consider waiting 6 wk post ICD implant to avoid lead dislodgement)
- Death: 1/60,000-80,000 hrs supervised exercise

Braverman DL et al. *Am J Phys Med Rehabil* 2011;90:599-611.

Conclusions

- Cardiac rehab is a **comprehensive secondary prevention** program
- Safe return to **physical activity** is key in promoting recovery & wellness
- **Risk factor** modification can reduce risk of recurrent events

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Pulmonary Rehabilitation

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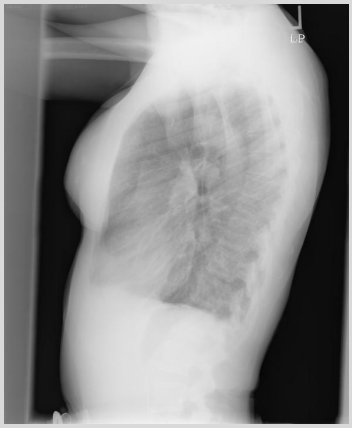
Outline

- Definition/Background
- Physiologic rationale
- Program components
- Outcomes
- Rehab in non-COPD settings

- 59 y.o. female with COPD
- Long standing dyspnea with minimal exertion
- No acute exacerbations in the last year
- On daily umcledinium/vilanterol (Anoro); prn albuterol
- FEV1 – 0.52 liters, 26% of predicted
- Residual volume 199% pred

Which of the following intervention is likely to provide the greatest improvement in her shortness of breath?

1. Replace Anoro with twice daily budesonide/formoterol (Symbicort)
2. Add Roflumilast (Daliresp)
3. Replace Anoro with daily Umeclidinium/Vilanterol/Fluticasone (Trelegy)
4. Pulmonary rehabilitation.

Combination inhalers for COPD

- **LAMA/LABA**
  - Umeclidinium/Vilanterol
    - ***Anoro***
  - Tiotropium/Olodaterol
    - ***Stiolto***
  - Glycopyrrolate/Formoterol
    - ***Bevespi***
  - Glycopyrrolate/indacaterol
    - ***Utibron***
- **ICS/LABA**
  - Fluticasone/Salmeterol
    - ***Advair***
  - Budesonide/Formoterol
    - ***Symbicort***
  - Mometasone/Formoterol
    - ***Dulera***
  - Fluticasone/Vilanterol
    - ***Breo***

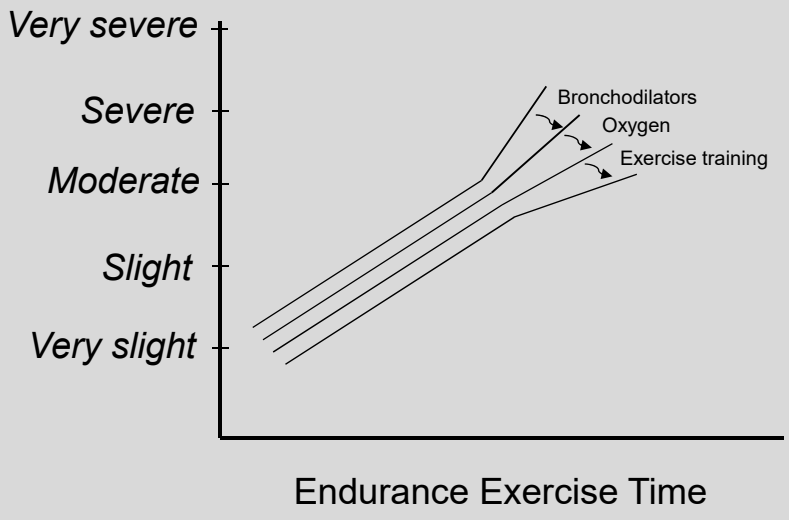
LAMA/LABA/ICS

- Umeclidinium/Vilanterol/Fluticasone
- ***Trelegy***

Glycopyrrolate/Formoterol/Budesonide

- ***Breztri***

Dyspnea Scale



Adapted from Am J Respir Crit Care Med 1999

Pulmonary Rehabilitation

"A comprehensive intervention based on a thorough patient assessment followed by patient tailored therapies that include but are not limited to exercise training, education and behavioral change designed to improve the physical and psychological condition of people with chronic respiratory diseases and to promote the long-term adherence to health-enhancing behaviors."

American Thoracic Society/European Respiratory Society, 2013

PR – Historical Perspective

- Originally described 1960's by Barach
- Advanced by Petty in 1970's
- Remained controversial as a treatment until mid-1990's

Which of the following pulmonary physiologic parameters is consistently improved following pulmonary rehabilitation?

A. FEV1
B. FVC
C. PO2
D. Oxygen saturation during exercise
E. None of the above

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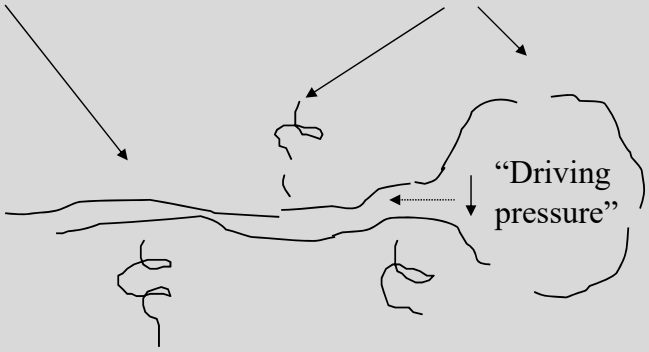
Airflow obstruction in COPD

Small airways disease – obstructive bronchiolitis

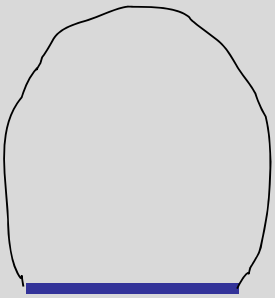
Small airway inflammation and narrowing

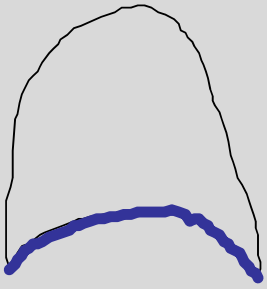
Emphysema – tissue destruction

Loss of elastic recoil



Hyperinflation and respiratory muscle weakness





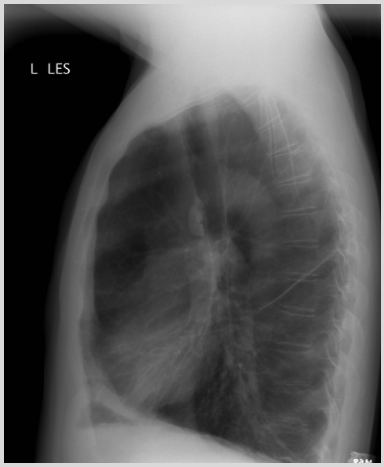
Shorter muscle length - less actin, myosin overlap

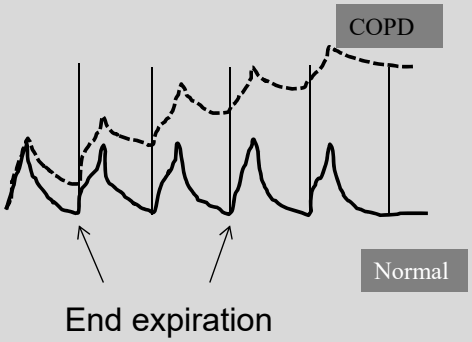
Decreased zone of apposition

Emphysema

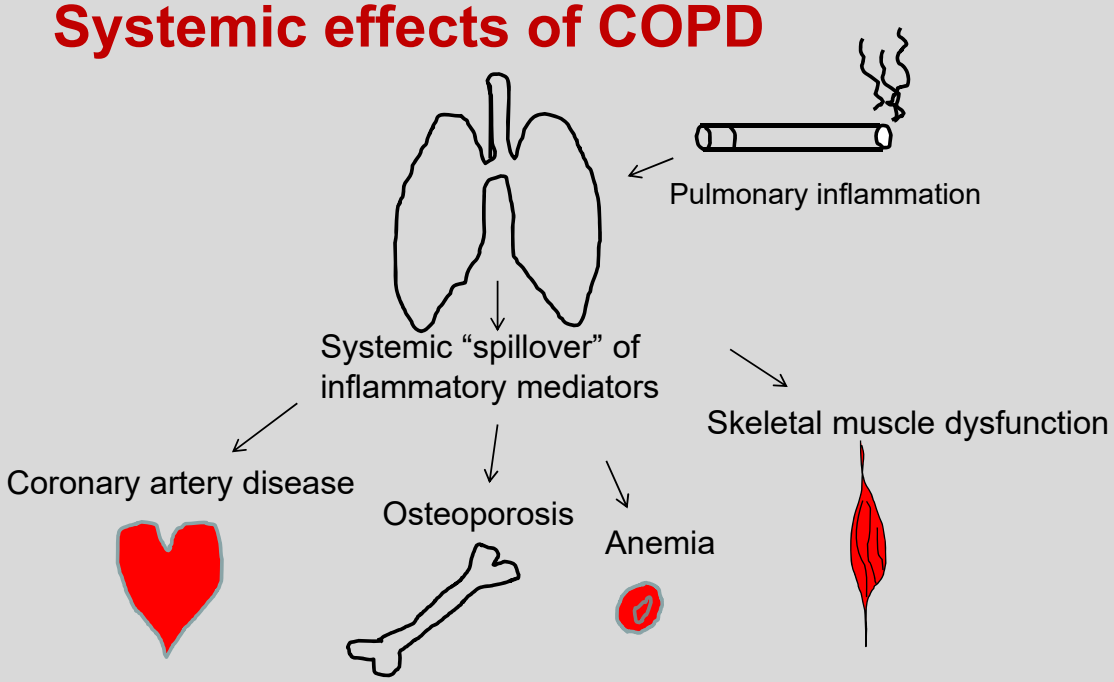
Normal

Dynamic hyperinflation in COPD





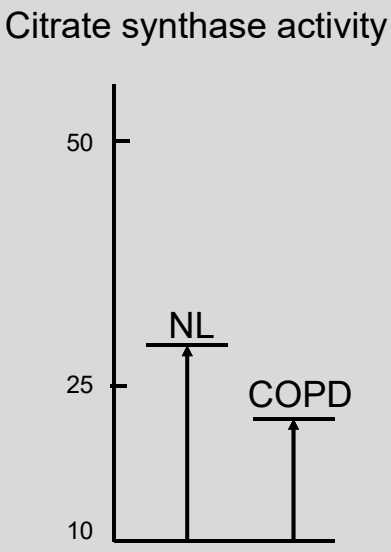
Systemic effects of COPD



Impaired oxygen utilization in skeletal muscles of patients with COPD

A. Decreased capillary density
B. Decreased type I muscle fibers
C. Decreased oxidative enzyme activity in mitochondria
   - Reduction in citrate synthase – critical enzyme in Krebs cycle and metabolism of oxygen

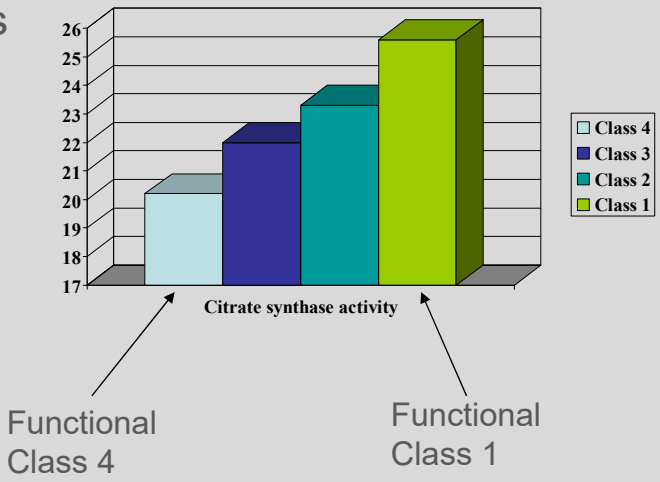
- Citrate synthase activity is significantly decreased in the vastus lateralis muscle of COPD patients. *Maltais et al 2000; Thorax*



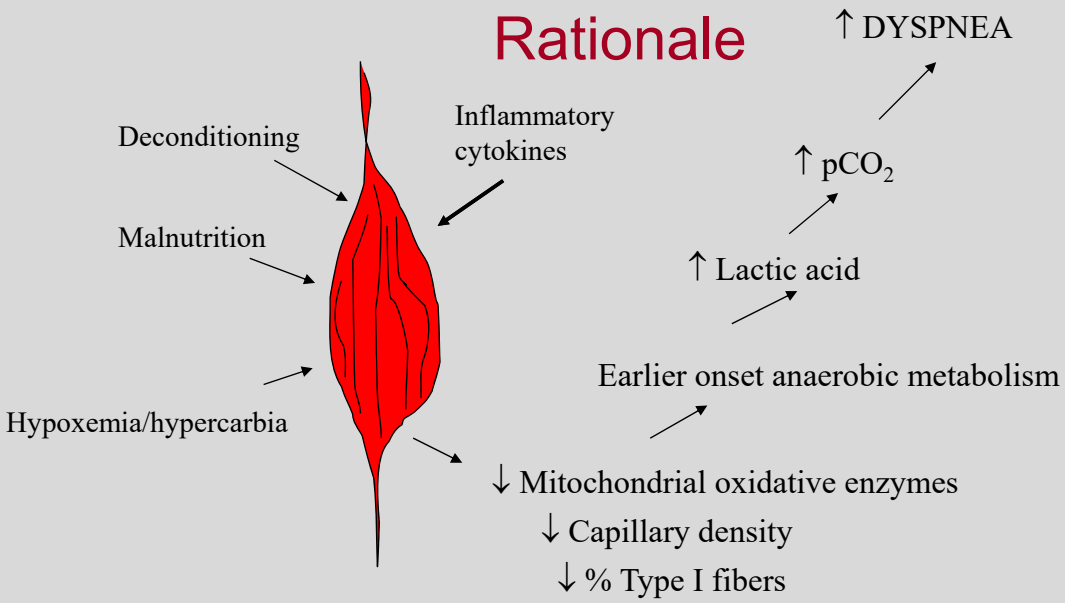
Correlation of citrate synthase activity and functional status in COPD

Maltais et. al. Thorax 2000

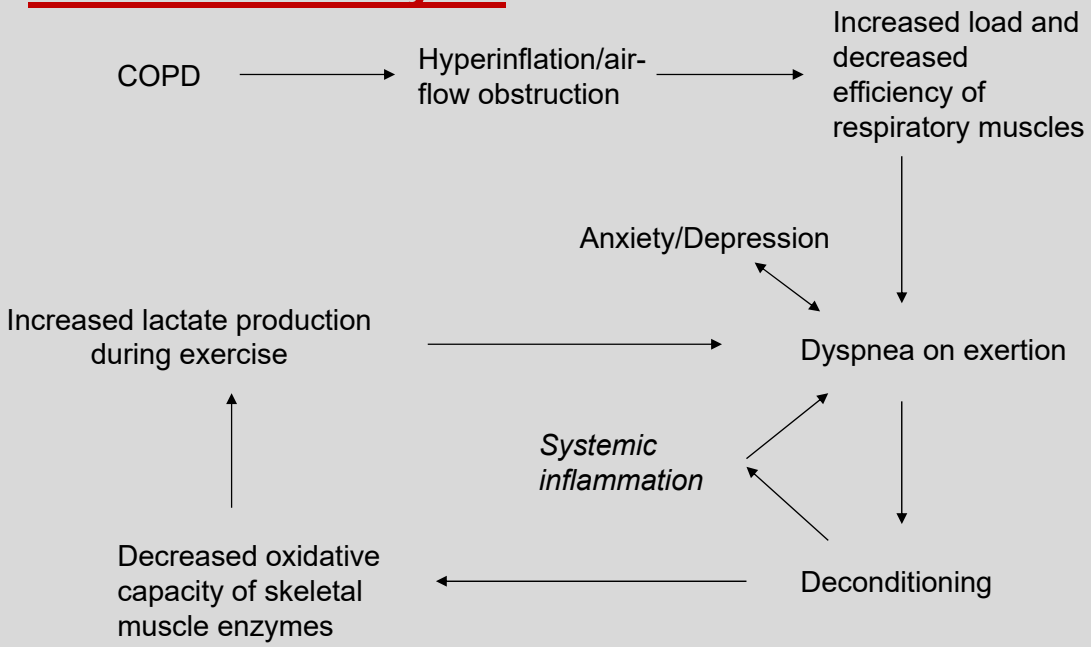
- Least functional patients have lowest citrate synthase activities



Rationale



COPD vicious cycle

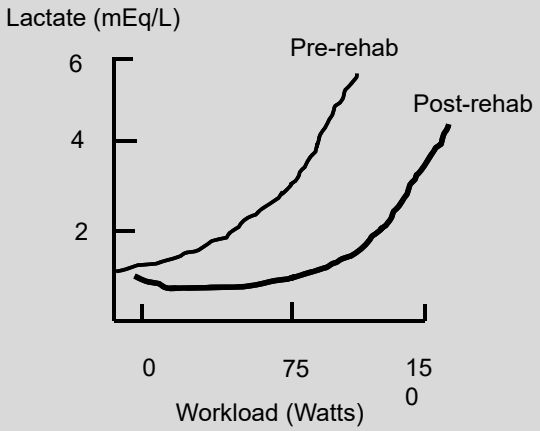


Improvement in citrate synthase with rehab (Maltais et al 2000)

	Pre-rehab	Post-rehab	P value
Citrate Synthase	22.3+/- 3.5	25.8 +/- 3.8	< 0.05

Reductions in exercise lactic acidosis and ventilation as a result of exercise training in patients with obstructive lung disease.

Casaburi et al Am Rev Respir Dis 1991



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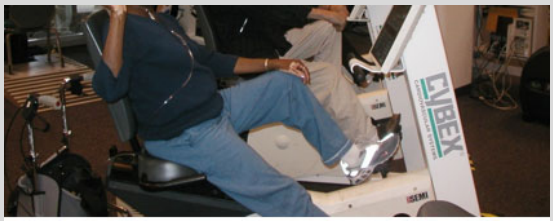
Lower extremity endurance training

Exercise Prescription

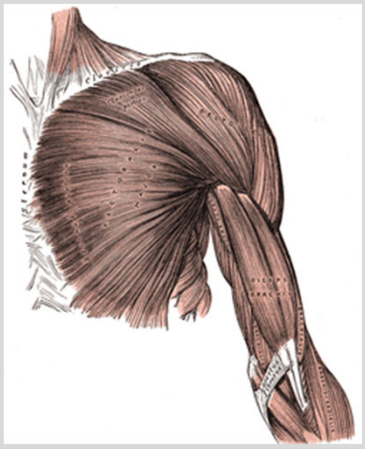
- Treadmill (Walking)
  - Start
    - 60-80% of the speed walked on the initial six-minute walk
    - 10 or more minutes (intervals are appropriate)
  - Once patient is able to walk continuously for 20 minutes, the speed is increased by 10%
  - Use Borg dyspnea scale (0-10) with target of 4-6 to titrate exercise
  - Once patient is able to walk 2.0 mph, then an incline is added

- Bicycle ergometry
  - Start
    - Based on 60-80%% of workload extrapolated from 6 minute walk speed
  - Once patient is able to do 15 minutes then the resistance is increased in 5-10 Watt increments



Upper extremity training in COPD

- Upper extremity tasks divert shoulder girdle muscles that COPD patient uses to assist in breathing
- Upper extremity exercises
  - Unsupported weight lifting 2-3 pounds
  - Therabands
  - Arm ergometry



Upper extremity exercise prescription

- Upper Body Ergometer
  - Start - 6 minutes at constant
  - Increase
    - Resistance based on Borg dyspnea scale
    - Time – aiming for 15 minutes of continuous training

Inspiratory muscle training in COPD

- Rationale – Inspiratory muscle dysfunction
  - Geometric changes in the thorax and diaphragm
  - Systemic factors
  - Possible structural changes in the respiratory muscles

'Dumb-bells for your diaphragm'

- Used in patients with inspiratory muscle weakness (maximum inspiratory pressure < 50% of predicted)
- Spring-loaded device with adjustable pressure
- Two 5 minute sets, adjust resistance weekly

Breathing retraining

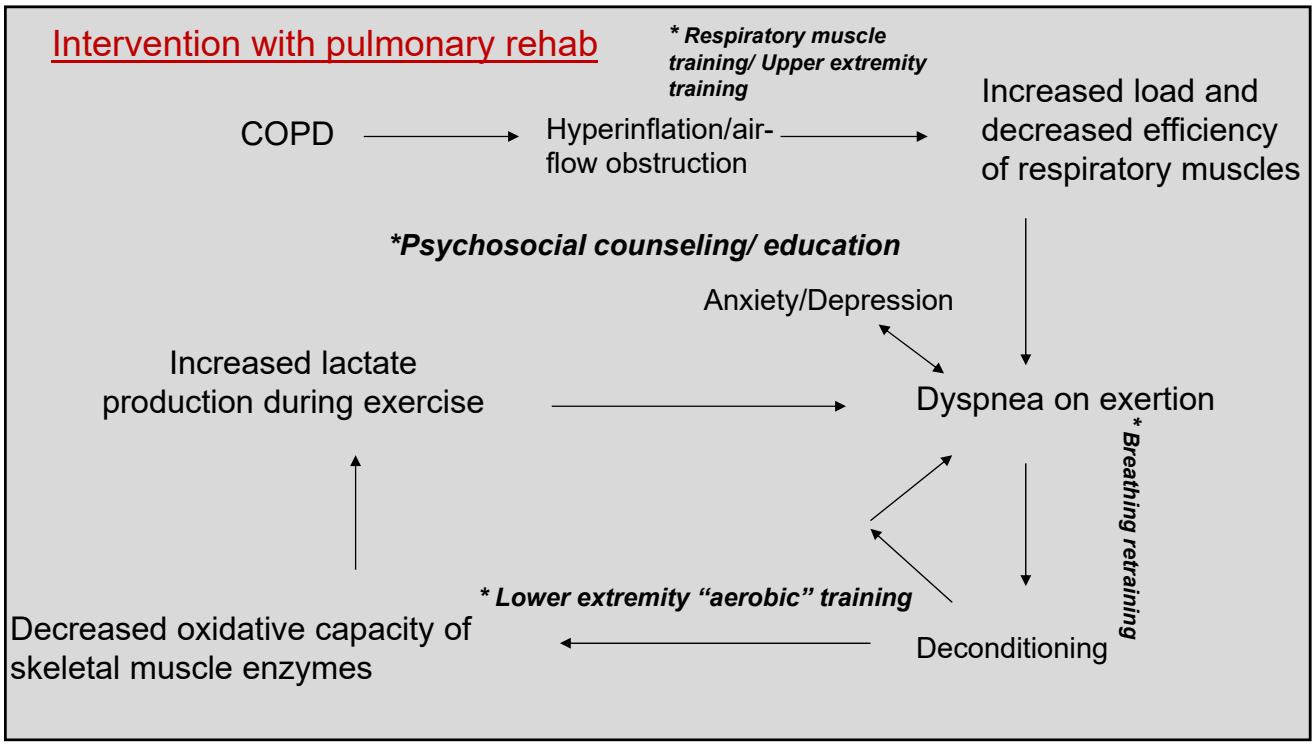
- Pursed lip breathing
  - Increase pressure in the mouth transmitted to small airways
  - Prolonged expiratory phase
  - Minimize dynamic hyperinflation

Psychosocial/Behavioral Component

- Prevalence of anxiety and depression very high in chronic lung disease
- Group sessions
  - Introduction/Stress
  - Physical symptoms
  - Cognitive issues
  - Emotional issues
  - Coping

Education topics

- Orientation
- Anatomy and physiology of lungs
- Benefits of exercise
- Respiratory muscles
- Oxygen and oxygen therapy
- Infection control
- Medication management
- Energy conservation
- Diet/Nutrition
- Importance of continuing maintenance exercise



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2015 Cochrane Review: Pulmonary Rehabilitation for COPD. (McCarthy et al.)

- Review of 65 randomized controlled studies
- Conclusions – *Pulmonary Rehabilitation is an important component of disease management*:
  - Improves exercise tolerance, relieves dyspnea and fatigue and enhances sense of control
  - Effects are moderately large and clinically significant
  - Additional randomized trials comparing pulmonary rehab to usual care for COPD are not warranted

COPD and Pulmonary Rehab

- Consider in:
  - Any patient with dyspnea on exertion despite medical management
  - Medicare covers patients with GOLD II disease (FEV1/FVC < 0.70 and FEV1 < 80% of predicted)
  - Sessions at OSU are 3/week for ~ 8 weeks. Each sessions lasts ~2 hours

Association Between Initiation of Pulmonary Rehabilitation After Hospitalization for COPD and 1-Year Survival Among Medicare Beneficiaries Lindinauer et al., JAMA 2020

- Retrospective cohort study – 4446 hospitals
- Medicare beneficiaries hospitalized for COPD in 2014
- Evaluated 1 year mortality in those receiving pulmonary rehabilitation within 3 months of discharge compared to those who did not

Association Between Initiation of Pulmonary Rehabilitation After Hospitalization for COPD and 1-Year Survival Among Medicare Beneficiaries Lindinauer et al., JAMA 2020

- 2721 (1.5%) patients had pulmonary rehab within 3 months of discharge
- Mortality of those having rehab within 3 months – 7.3% vs 19.6% ($p < 0.001$)
- Every 3 additional rehab sessions was significantly associated with a lower risk of death

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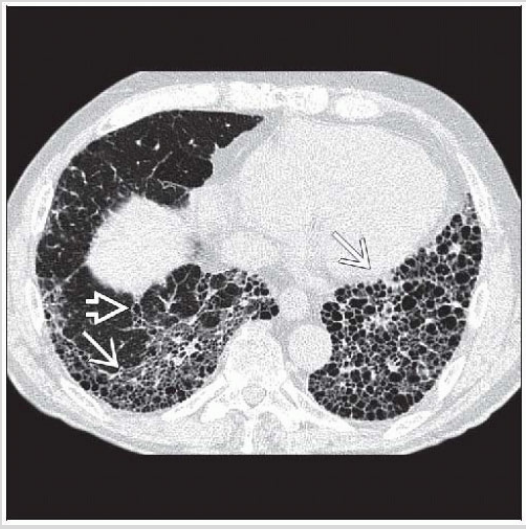
Pulmonary rehab in interstitial lung disease



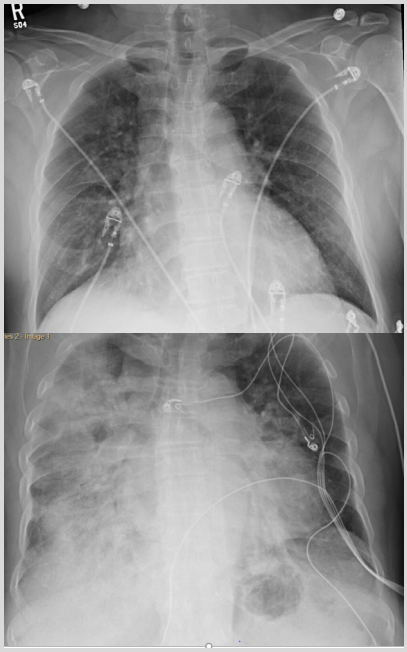
- Exercise Training in ILD
  - Improved 6 minute walk distance
  - Improved respiratory symptoms
  - Improved peripheral muscle oxygen extraction

Pulmonary Rehabilitation for Non-COPD Patient Groups

- IPF
- Asthma
- Pulmonary Hypertension
- Sarcoidosis
- Kyphoscoliosis
- Bronchiectasis
- Pre-post lung transplant
- Pre-post lung volume reduction surgery
- Pre-post lung cancer resection

64 y.o 2 days of N/V
Mild cough and dyspnea
COVID+

2 days later – severe hypoxemic respiratory failure requiring mechanical ventilation



After 14 days, patient discharged on supplemental O2

Post-discharge imaging shows evidence of post-inflammatory fibrosis. PFT's show severe restriction