Pulmonary Rehabilitation
Focusing on Rehabilitative Exercise
Prof. Richard Casaburi

Historical perspective on rehabilitative exercise training for COPD

- The foundations
- The dark ages
- The long road
- Optimization

Dr. Alvan Barach
1895-1977
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• Perfected the oxygen tent (1922)
• Used heliox in asthma and emphysema (1934)
• Investigated oral penicillin for pneumonia (1945)
• Developed portable oxygen supplies (1950s)
• 128 Pub Med citations, 6 in the year of his death;
  Several books

In two patients with pulmonary emphysema…an exercise program was instituted with subsequent marked improvement of capacity to exercise…The progressive improvement in ability to walk without dyspnea suggested that a physiological response similar to a training program in athletes may have been produced

When I see a patient, then, whose pulse on walking back and forth two or three times in the hallway in my office increases to 140, it is evident he hasn’t walked enough to maintain cardiovascular efficiency. It may seem unusual perhaps to suggest exercise to those breathless people, but in fact it is one of the ways by which they can restore physical fitness. I am unhappy about patients who always use an elevator to go up stairs. I will say that from now on you can practice walking up the stairs breathing oxygen. The muscles in the legs of these people are very often atrophied.
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Pulmonary rehabilitation for COPD

- Established at the University of Colorado - 1966 standardized outpatient program:
  - Individual instruction about their disease
  - Teaching about bronchial hygiene
  - Breathing retraining
  - Physical reconditioning
  - Individualized pharmacologic therapy
  - Oxygen, mostly for right heart failure

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Pulmonary rehabilitation for COPD

- Established at the University of Colorado -1966
- Outcomes:
  - At 3 months, 91 of 124 patients judged as “better”
  - Evidence for:
    - Improved exercise tolerance
    - Reduced hospitalization
    - Return to gainful employment

Professional organizations recognize pulmonary rehabilitation

- ACCP - 1974
  - Provides definition
- ATS - 1980
  - Issues official statement

Pulmonary rehabilitation components and benefits specified…
Exercise conditioning “essential”

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Futility of exercise training in pulmonary rehabilitation (1)

- Exercise tolerance is limited by pulmonary factors
- Exercise training doesn’t improve pulmonary function
- Critical training intensity can’t be exceeded by most patients

Futility of exercise training in pulmonary rehabilitation (2)

Exercise training fails to increase skeletal muscle enzymes in patients with COPD

A study very much ahead of its time!

Belman and Kendregan, 1981 (1)

- 15 COPD patients underwent a 6-week training program: half trained their arms, half trained their legs
- Muscle biopsies were taken of the trained limb before and after the program
- No changes in aerobic enzymes were observed, indicating that a physiological training effect had not occurred
Belman and Kendregan, 1981 (2)

“We conclude that patients with COPD are incapable of exercising at an intensity high enough to induce the classical training response and associated changes in muscle enzymes”

Belman, 1986

• Mechanisms of improvement in exercise tolerance associated with a training program include:
  – Increased motivation
  – Desensitization to dyspnea
  – Improved mechanical skill

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What makes pulmonary rehabilitation so effective?

- Candidate assessment
- Education
- Psychological support
- Optimization of medications
- Exercise training
- Chest physical therapy
- Controlled breathing techniques
- Nutritional therapy
- Continuing care programs

Characteristics of an effective training program (1)

- Session duration
- Frequency of sessions per week
- Length of program
- Intensity of training

Characteristics of an effective training program (2)

- Session duration: 30-60 minutes
- Frequency of sessions per week: 3-5 sessions
- Length of program: 5-10 weeks
- Intensity of training: above the critical training intensity... there is an intensity of training below which no physiologic training effect will be obtained
Endurance exercise training at maximal targets in patients with COPD

Ries AL, Archibald CJ.
J Cardiopulmonary Rehabil. 1987

"Many patients with chronic disease, particularly when severe, can be trained at high percentages of maximum exercise tolerance"

“We are all heroes of our own story”
-Mary McCarthy

Mediation of reduced ventilatory response to exercise after endurance training

J. Appl Physiol, 1987
Evidence for a physiologic training effect in COPD

• Decreased lactic acidosis for a given level of exercise
• Increased levels of aerobic enzymes in muscles undergoing training
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Reduction in exercise lactic acidosis and ventilation as a result of exercise training in obstructive lung disease
Casaburi, R, Patessio A, Ioli F, Zanaboni S, Donner CF and Wasserman K

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Evidence for a physiologic training effect in COPD

- Decreased lactic acidosis for a given level of exercise
- Increased levels of aerobic enzymes in muscles undergoing training
Skeletal muscle adaptation to endurance training in patients with chronic obstructive pulmonary disease


Skeletal muscle dysfunction in COPD: mechanisms

- Low muscle mass
- Poor capillarity
- Low aerobic enzyme concentration
- Low fraction of type I fibers
- Muscle inflammation
- Corticosteroid myopathy
- Low levels of anabolic hormones
- Vasoregulatory abnormalities
A physiologic approach to exercise training in COPD

- Objective measure of muscle fatigue employed
- Half of patients were limited in their exercise tolerance primarily by leg fatigue rather than by dyspnea
- In these patients, improving lung function (with a bronchodilator) did not improve exercise tolerance
- Therefore, in many patients improving leg muscle function is a primary goal

Contractile Leg Fatigue after Cycle Exercise
A Factor Limiting Exercise in Patients with Chronic Obstructive Pulmonary Disease

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- Half of patients were limited in their exercise tolerance primarily by leg fatigue rather than by dyspnea
- In these patients, improving lung function (with a bronchodilator) did not improve exercise tolerance
- Therefore, in many patients improving leg muscle function is a primary goal
Rehabilitative exercise training decreases hyperinflation and increases exercise tolerance

Porszasz, J., M. Embrner, S. Goto, A. Somfay, B.J. Whipp and R. Casaburi. High intensity training decreases exercise-induced hyperinflation in patients with COPD.
Chest 128: 2025-2034, 2005

Methods

• 24 patients with COPD (age = 66 ± 8 years; FEV1=35 ± 9% pred.)
• Training program: high intensity cycle ergometer exercise, 45 min/session, 3 sessions/week, 7 weeks
• Constant work rate exercise to tolerance at 75% of peak work rate in an incremental test
• Dynamic hyperinflation assessed by inspiratory capacity maneuvers

Effect of exercise training on oxygen uptake and ventilation during constant-work rate exercise

Porszasz et al. Chest, 2005
Effect of exercise training on hyperinflation during constant work rate exercise

- Pre-training
- Post-training

Effect of exercise training on breathing pattern and hyperinflation in COPD

Endurance exercise training reduces ventilatory drive and slows breathing, allowing more time for exhalation, thereby decreasing dynamic hyperinflation during exercise ...and improving exercise tolerance
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Optimization of rehabilitative exercise training

- Good bronchodilator medication
- Supplemental oxygen
- Anabolic drugs
- Pressure support ventilation
- Heliox breathing

Where are we today?
Evidence based rehabilitation guidelines for COPD (1)

- Pulmonary rehabilitation:
  - Both low- and high-intensity exercise training produce clinical benefits - 1A
  - Improves the symptom of dyspnea - 1A
  - Improves health-related quality of life - 1A

These benefits are generally of greater magnitude than for any other COPD therapy

Evidence based rehabilitation guidelines for COPD (2)

- Pulmonary rehabilitation:
  - Reduces the number of hospital days and other measures of health care utilization - 2B
  - Induces psychosocial benefits - 2B
  - Education should be an integral component - 1B
A paradigm shift for pulmonary rehabilitation

Focus on strategies to improve activity levels in COPD patients

Activity promotion as goal for COPD patients

- COPD patients are inactive
- Active COPD patients have improved survival

Are other benefits possible?
COPD patients are inactive (1)

Respir Med, 2010
Physical inactivity in patients with COPD, a controlled multi-center pilot-study
Troosters T, F Sciurba, S Battaglia, D Langer, S Rao Valluri, L Martino, R Benzo, D Andre, I Weisman, M Decramer

70 COPD and 30 normal subjects wore a sensewear armband activity monitor continuously for 6-8 days

COPD patients are inactive (2)

Physical inactivity in patients with COPD, a controlled multi-center pilot-study

Activity promotion as goal for COPD patients

• COPD patients are inactive
• Active COPD patients have improved survival
170 COPD patients underwent activity monitoring and then were followed for a median of 4 years. The probability of survival was as follows:

- Active group: very good
- Sedentary group: less good
- Very inactive group: much worse

Do current therapies for COPD increase activity level?

- Bronchodilators and anti-inflammatory drugs
- Supplemental oxygen
- Pulmonary rehabilitation

Each of these interventions improves exercise tolerance.

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<th>Author Year</th>
<th># subjects</th>
<th>Monitoring Device</th>
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<td>Coronado</td>
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Activity promotion in COPD: a paradigm shift

- Rethink pulmonary rehabilitation to optimally promote and maintain activity
  - Consider alternate training strategies
  - Incorporate behavior modification strategies