Exercise Prescription in Pulmonary Rehabilitation and Considerations for Exercise Training©

Kim Eppen, PT, PhD
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kim-eppen@uiowa.edu

Disclosure

I have nothing to disclose.

All of the opinions expressed are my own.

Supplemental Handout

- Table 1: ACSM MET Conversion Table for Treadmill Walking
- Table 2: 6MWT Distance Conversion Table

Key Resources

1. AACVPR Statement: Pulmonary Rehabilitation Exercise Prescription in Chronic Obstructive Pulmonary Disease: Review of Selected Guidelines—An Official Statement from the AACVPR. *J Cardiopulm Rehabil Prev*. 2016;36(2):75-83.
2. AACVPR Guidelines for Pulmonary Rehabilitation Programs, 4th ed. Champaign, IL: Human Kinetics. 2011. *(5th Edition in progress)*
3. ATS/ERS Statement: Key Concepts and Advances in Pulmonary Rehabilitation. *Am J Respir Crit Care Med.* 2013;88(8): e13-e64.
4. Holland A, Spruit MA, Troosters T, et al. An Official European Respiratory Society/American Thoracic Society technical standard: field walking tests in chronic respiratory disease. *Eur Respir J* 2014;44:1428-1446.
5. ACSM Guidelines for Exercise Testing and Prescription Manual, 9th ed. Philadelphia, PA: Wolters Kluwer-Lippincott Williams & Wilkins. 2014. (GETPM) and *10th edition, 2018*
6. ACSM Resource Manual for Guidelines for Exercise Testing and Prescription, 7th ed. Philadelphia, PA: Wolters Kluwer-Lippincott Williams & Wilkins. 2014.

Disclaimer Statement

We won't be able to go over everything there is to know about exercise prescription and training in Pulmonary Rehab in 75 minutes.

Exercise prescription "guidelines," not absolutes.
Applying guidelines requires knowledge,
clinical judgment, experience and individual patient circumstances.
Combination of "art and science"

Learning is an ongoing process.

Objectives

1. Identify core components of exercise prescription
2. Review current evidence based exercise prescription guidelines/recommendations
3. Discuss how pulmonary impairment affects exercise tolerance and other potential contributing causes for exercise limitations in people with pulmonary disease
4. Discuss how to apply exercise prescription principles when designing individualized exercise training programs
5. Apply concepts using case examples, as time allows

Learner Objectives

By the end of today's session, you should be able to:

1. Identify core components of exercise prescription
2. List at least 3 potential causes for exercise limitations in people with pulmonary disease
3. Apply exercise prescription and training principles when designing individualized exercise training programs

My Primary Objectives

- Provide relevant information and strategies that can be directly applied to your clinical practice
- I want you to leave here feeling like it was worth it and you have something concrete and tangible that you can take home and use

Essential
Background Information for
Exercise Training and Prescription

Terminology/Definitions

- MET: "Metabolic equivalent of a task." Unit for expressing rate of expenditure (EE). Standard unit for expressing workload.
  - 1 MET=rate of EE of rest: 3.5ml$O_2 \cdot kg^{-1} \cdot min^{-1}$ (basal metabolism)
    - Max exercise capacity of healthy untrained person: ≅ 10-12 METs
    - Peak exercise capacity of pulmonary patient: ≅ 3-5 METs
  - 1 MET=1kcal · kg^{-1}· hr^{-1}
    - Example: 100kg person=100kcal·hr^{-1} ·24hr=2400kcal·day^{-1}
- $\dot{V}O_2$: Oxygen uptake. Measure of energy cost. Rate of O_2 consumption
  - Units: $mLO_2 \cdot min^{-1}$, $mLO_2 \cdot kg^{-1} \cdot min^{-1}$, METs

Definitions

- $\dot{V}O_{2max}$: Maximal oxygen uptake
  - Maximal amount of oxygen the body can use under maximal exercise conditions
  - Criterion measure for cardiorespiratory fitness
  - $\dot{V}O_{2max} = \max (HR \cdot SV) \cdot (a\text{-}\bar{v})O_2$ diff (Fick equation) — Heart | Lungs | Muscle
  - Reflects the functional capacity of the major systems of the body.
  - May be measured directly or estimated using standardized metabolic prediction equations[1]
    - Important to recognize the limitations of accuracy in persons with pulmonary disease

[1]ACSM Guidelines for Exercise Testing and Prescription, 9th Ed. p. 173 or Table 6.3, p 152, 10th Ed
Estimating energy cost for activities: Metabolic calculations for the estimation of energy expenditure for various common physical activities.

Terminology/Definitions

- Exercise capacity
  - Max vs peak
    - $\dot{V}O_2$
    - Work rate
    - METs

Recommended PR Exercise Training Components[1,2,3]

1. Cardiorespiratory exercise Strong evidence
2. Muscle strengthening Strong evidence
3. Joint range of motion/flexibility Limited evidence

[1]AACVPR Official Statement: Pulmonary Rehabilitation Exercise Prescription in Chronic Obstructive Pulmonary Disease: Review of Selected Guidelines. JCRP 2016;36(2):75-83.
[2]ATS/ERS Statement: Key Concepts and Advances in Pulmonary Rehabilitation. Am J Respir Crit Care Med 2013;188(8):e13-e64.
[3]Ries AL. Bauldoff GS, Carlin BW, et al. Pulmonary Rehabilitation: Joint ACCP/AACVPR Evidence-Based Clinical Practice Guidelines. Chest 2007;131(5 Suppl):4S-42S.

3 Basic Principles of Exercise Training

1. Overload
2. Specificity of training
3. Progression or maintenance

Core Components for Exercise Prescription
FITT-Pro

- **F**requency
- **I**ntensity
- **T**ime

(Overload)

- **T**ype (Specificity)
- **P**rogression (Progression or Maintenance)

ACSM Core Components

Summary of Evidence Based Exercise Prescription Guidelines/Recommendations for Endurance Exercise Training in PR (COPD)[1,2,3]

FITT-Pro principles should be adjusted to patient's capabilities, disease-specific limitations, therapeutic objectives, and goals.

[1]AACVPR Statement: *J Cardiopulm Rehabil Prev*, 2016
[2]ACSM's Guidelines for Exercise Testing and Prescription, 10th ed, 2018
[3]ATS/ERS Statement: *Am J Respir Crit Care Med*, 2013

- **Frequency**: 3-5 d·week^{-1}
  - e.g., 3 d·week^{-1} in PR + 2-3 d·week^{-1} independently

AACVPR, ACSM, ATS/ERS

- **Intensity**: Individualized, based on **exercise assessment**
  - Target training intensity: 60 to 80% of peak work rate (or peak METs) if tolerated
    - Initial training intensity: ≥ 60% peak work rate
    - Goal: work toward ≥ 80% of peak work rate
  - ACSM:
    - Light intensity: 30-40% peak work rate: improves symptoms, health-related QOL, and ADL performance
    - Vigorous intensity: 60-80% peak work rate: optimizes physiologic improvements

AACVPR, ACSM, ATS/ERS

Exercise Assessment Example:
Clinical Symptom-Limited Treadmill Graded Exercise Test for Patient with Moderate COPD

Time (min)	Speed (mph)	Grade (%)	O2 (LPM)	SpO2 (%)	HR	BP	RPE (6-20)	RPD (0-10)	Pain (0-10)	METs
0	----	----	0	98	100	140/84	---	1	0	(estimated)
0-1	1.2	0	0	96	104					
1-2	1.2	0	0	96	114					
2-3	1.2	0	0	94	115	160/82	6	4	0	1.9
3-4	1.4	3	0	92	118					
4-5	1.4	3	0	92	120					
5-6	1.4	3	0	91	122	170/84	13	5	0	2.6
6-7	1.6	6	0	90	130					
7-8	1.6	6	0	90	138					
8-9	1.6	6	0	89	142	180/88	17	8-9	0	**3.5**

Peak HR: "upper limit HR" for guiding exercise training sessions. Peak MET level (12.25 $mLO_2 \cdot kg^{-1} \cdot min^{-1}$)

Reason for stopping: "Dyspnea and fatigue."

- Peak MET level=3.5
- Target training intensity range (60-80%):
  - 0.6 x 3.5 METs=__2.1__METs
  - 0.80 x 3.5 METs=__2.8__METs
- Determine a corresponding treadmill walking training workload range:
  _____mph to _____mph

Table 1: MET levels for treadmill walking
based on ACSM formula for estimating MET levels[1]

% Grade \ Speed (mph)	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0
0.0	1.92	2.00	2.07	2.15	2.23	2.30	2.38	2.45	2.53	2.61	2.68	2.76	2.84	2.91	2.99	3.07	3.14	3.22	3.30
0.5	2.00	2.08	2.17	2.26	2.32	2.42	2.50	2.59	2.67	2.75	2.84	2.92	3.00	3.09	3.17	3.25	3.34	3.42	3.50
1.0	2.08	2.17	2.26	2.35	2.44	2.54	2.63	2.72	2.81	2.90	2.99	3.08	3.17	3.26	3.35	3.44	3.53	3.62	3.71
1.5	2.17	2.26	2.36	2.46	2.55	2.65	2.75	2.85	2.94	3.04	3.14	3.24	3.33	3.43	3.53	3.63	3.72	3.82	3.92
2.0	2.25	2.35	2.45	2.56	2.66	2.77	2.87	2.98	3.08	3.19	3.29	3.40	3.50	3.60	3.71	3.81	3.92	4.02	4.12
2.5	2.33	2.42	2.55	2.65	2.77	2.89	3.00	3.11	3.22	3.33	3.44	3.55	3.66	3.78	3.89	4.00	4.11	4.22	4.33
3.0	2.42	2.50	2.65	2.77	2.88	3.00	3.12	3.24	3.36	3.48	3.59	3.71	3.83	3.95	4.07	4.18	4.30	4.42	4.54
3.5	2.50	2.65	2.76	2.87	3.00	3.12	3.25	3.37	3.50	3.62	3.75	3.87	4.00	4.12	4.25	4.37	4.49	4.62	4.74
4.0	2.58	2.76	2.87	2.98	3.10	3.24	3.37	3.50	3.63	3.77	3.90	4.03	4.16	4.29	4.42	4.56	4.69	4.82	4.95
4.5	2.66	2.80	2.94	3.08	3.22	3.36	3.49	3.63	3.77	3.91	4.05	4.19	4.33	4.46	4.60	4.74	4.88	5.02	5.16
5.0	2.78	2.89	3.10	3.18	3.33	3.47	3.62	3.76	3.91	4.06	4.20	4.35	4.49	4.64	4.78	4.93	5.07	5.22	5.36
5.5	2.93	3.10	3.13	3.28	3.44	3.59	3.74	3.90	4.05	4.20	4.35	4.50	4.66	4.81	4.96	5.11	5.27	5.42	5.57
6.0	3.10	3.17	3.23	3.39	3.55	3.71	3.87	4.03	4.19	4.34	4.50	4.66	4.82	4.98	5.14	5.30	5.46	5.62	5.78

[1]Walking (METs): [(3.5mLO2·kg^{-1}·min^{-1}) + (0.1 x speed[a]) + (1.8 x speed[a] x grade[b])] ÷ 3.5mLO2·kg^{-1}·min^{-1}
[a]speed in m·min^{-1} (Note: mph → m·min^{-1}conversion: mph x 26.8)
[b]grade is % grade expressed in decimal format (e.g., 10%=0.10).
(Most accurate for speeds of 1.9-3.7mph)

Note: Formulas are available for estimating VO_2 (METs) for other types of exercise as well.
[1]ACSM Guidelines for Exercise Testing and Prescription, 9th ed. p. 173 (p.152, 10th ed)

- Peak MET level=3.5
- Target training intensity range (60-80%):
  - 0.6 x 3.5 METs=__2.1__METs
  - 0.80 x 3.5 METs=__2.8__METs
- Determine a corresponding treadmill walking training workload range:
  _____mph to _____mph

Other Exercise Assessment Options: Field Walking Tests:[1,2]

- ERS/ATS Update, 2014:
  - Evidence, protocol, interpretation, safety
  - Targets chronic lung disease in adults

[1]Holland AE, Spruit MA, Troosters T, et al. An Official European Respiratory Society/American Thoracic Society technical standard: field walking tests in chronic respiratory disease. *Eur Respir J* 2014;44:1428-1446.
[2]Holland AE, Spruit MA, Singh SJ. How to carry out a field walking test in chronic respiratory disease. *Breathe* 2015;11(2):128-139.
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4487379/pdf/EDU-0213-2014.pdf

Prescribing intensity based on 6MWT:

- *General* guidelines for determining target training intensity:
  - ≥85% of estimated MET level corresponding to average walking speed achieved
  - 80% of average walking speed[1]

[1]Zainuldin R, Mackey, Alison J. Prescription of walking exercise intensity from the 6-minute walk test in people with chronic obstructive pulmonary disease. *J Cardiopulm Rehabil Prev* 2015; 35(1):65-69.

6 MWT Example

- 6 Minute Walk Distance (6MWD): 800 feet
  - Average walking speed (mph)?_____
  - Estimated MET level? _____
  - 85% of this MET level?_____
  - Determine a corresponding treadmill walking training speed:_____mph

- Refer to Table 2 in your handout: 6MWT Distance Conversion Table

(Includes distances: 500-3000 feet)

Formula for estimating VO_2 (METs) for horizontal walking(ACSM):
$[(3.5mLO2{\cdot}kg^{-1}{\cdot}min^{-1}) + (0.1 \times speed^{a})] \div 3.5mLO2{\cdot}kg^{-1}{\cdot}min^{-1}$
[a]speed expressed in $m{\cdot}min^{-1}$

AACVPR PR Outcomes Resource Guide (Outcomes Toolkit):
6MWT conversion table for walking distances 980-3000. AACVPR.org

6MWT Conversion Table

Distance (ft)	Distance (m)	MPH	Meters·min^{-1}	VO2(mL·kg^{-1}·min^{-1})	METs
500	152	.94	25	6.04	1.73
510	155	.96	26	6.09	1.74
520	159	.98	26	6.14	1.75
530	162	1.00	27	6.19	1.77
540	165	1.02	27	6.24	1.78
550	168	1.04	28	6.29	1.80
560	171	1.06	28	6.35	1.81
570	174	1.08	29	6.39	1.83
580	177	1.10	29	6.45	1.84
590	180	1.11	30	6.50	1.86
600	183	1.13	30	6.55	1.87
610	186	1.15	31	6.59	1.89
620	189	1.17	32	6.65	1.90
630	192	1.19	32	6.70	1.91
640	195	1.21	33	6.75	1.93
650	198	1.23	33	6.80	1.94
660	201	1.25	34	6.85	1.96
670	204	1.27	34	6.90	1.97
680	207	1.28	35	6.95	1.99
690	210	1.30	35	7.00	2.00
700	213	1.32	36	7.06	2.02
710	216	1.34	36	7.11	2.03
720	219	1.36	37	7.16	2.05
730	223	1.38	37	7.21	2.06
740	226	1.40	38	7.26	2.07
750	229	1.42	38	7.31	2.09
760	232	1.44	39	7.36	2.10
770	235	1.45	39	7.41	2.12
780	238	1.47	40	7.46	2.13
790	241	1.49	40	7.51	2.15
800	244	1.51	41	7.56	2.16

6 MWT Example

- 6 Minute Walk Distance (6MWD): 800 feet
  - Average walking speed (mph)?_____
  - Estimated MET level? _____
  - 85% of this MET level?_____
  - Determine a corresponding treadmill walking training speed:(Table 1) _____ mph

FYI: ADL's = 2.5-3.0 METs
≅ 2.0-2.5mph

Table 1: MET levels for treadmill walking
based on ACSM formula for estimating MET levels[1]

% Grade	Speed (mph) 1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0
0.0	1.92	2.00	2.07	2.15	2.23	2.30	2.38	2.45	2.53	2.61	2.68	2.76	2.84	2.91	2.99	3.07	3.14	3.22	3.30
0.5	2.00	2.08	2.17	2.26	2.32	2.42	2.50	2.59	2.67	2.75	2.84	2.92	3.00	3.09	3.17	3.25	3.34	3.42	3.50
1.0	2.08	2.17	2.26	2.35	2.44	2.54	2.63	2.72	2.81	2.90	2.99	3.08	3.17	3.26	3.35	3.44	3.53	3.62	3.71
1.5	2.17	2.26	2.36	2.46	2.55	2.65	2.75	2.85	2.94	3.04	3.14	3.24	3.33	3.43	3.53	3.63	3.72	3.82	3.92
2.0	2.25	2.35	2.45	2.56	2.66	2.77	2.87	2.98	3.08	3.19	3.29	3.40	3.50	3.60	3.71	3.81	3.92	4.02	4.12
2.5	2.33	2.42	2.55	2.65	2.77	2.89	3.00	3.11	3.22	3.33	3.44	3.55	3.66	3.78	3.89	4.00	4.11	4.22	4.33
3.0	2.42	2.50	2.65	2.77	2.88	3.00	3.12	3.24	3.36	3.48	3.59	3.71	3.83	3.95	4.07	4.18	4.30	4.42	4.54
3.5	2.50	2.65	2.76	2.87	3.00	3.12	3.25	3.37	3.50	3.62	3.75	3.87	4.00	4.12	4.25	4.37	4.49	4.62	4.74
4.0	2.58	2.76	2.87	2.98	3.10	3.24	3.37	3.50	3.63	3.77	3.90	4.03	4.16	4.29	4.42	4.56	4.69	4.82	4.95
4.5	2.66	2.80	2.94	3.08	3.22	3.36	3.49	3.63	3.77	3.91	4.05	4.19	4.33	4.46	4.60	4.74	4.88	5.02	5.16
5.0	2.78	2.89	3.10	3.18	3.33	3.47	3.62	3.76	3.91	4.06	4.20	4.35	4.49	4.64	4.78	4.93	5.07	5.22	5.36
5.5	2.93	3.10	3.13	3.28	3.44	3.59	3.74	3.90	4.05	4.20	4.35	4.50	4.66	4.81	4.96	5.11	5.27	5.42	5.57
6.0	3.10	3.17	3.23	3.39	3.55	3.71	3.87	4.03	4.19	4.34	4.50	4.66	4.82	4.98	5.14	5.30	5.46	5.62	5.78

[1]Walking (METs): $[(3.5mLO2{\cdot}kg^{-1}{\cdot}min^{-1}) + (0.1 \times speed^{a}) + (1.8 \times speed^{a} \times grade^{b})] \div 3.5mLO2{\cdot}kg^{-1}{\cdot}min^{-1}$
[a]speed in $m{\cdot}min^{-1}$ (Note: mph → $m{\cdot}min^{-1}$conversion: mph x 26.8)
[b]grade is % grade expressed in decimal format (e.g., 10%=0.10).
(Most accurate for speeds of 1.9-3.7mph)
Note: Formulas are available for estimating VO_2 (METs) for other types of exercise as well.
[1]ACSM Guidelines for Exercise Testing and Prescription, 9th ed. p. 173 (p 152, 10th ed)

6 MWT Example

- 6 Minute Walk Distance (6MWD): 800 feet
  - Average walking speed (mph)? 1.5
  - Estimated MET level? ≅2.2
  - 85% of this MET level?1.87
  - Determine a corresponding treadmill walking speed:(Table 1) _____ mph

FYI: ADL's = 2.5-3.0 METs
≅ 2.0-2.5mph

6 MWT Example

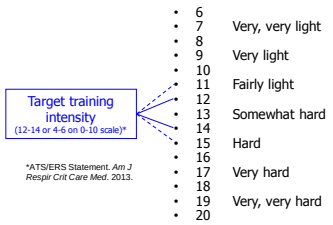
- Alternative strategy for determining training walking speed:
  - 6MWD: 800 feet
  - Speed conversion for determining average walking speed (mph): (____feet/second) x 0.68
    - (800 feet/360 seconds) x 0.68 = 1.5 mph (or use conversion table)
  - 80% x 1.5 mph = 1.2 mph

Other mechanisms to guide exercise prescription for "intensity"

- **Intensity**:
  - RPE (6-20)[1]: 12-14
  - Borg CR-10 Scale© (0-10)[1,2]: 4-6
    - Or other valid/reliable dyspnea scale

[1]Spruit M, et al. An official ATS/ERS statement: key concepts and advances in pulmonary rehabilitation. *Am J Respir Crit Care Med* 2013 Oct 15;188(8):e13-64.
[2]Borg, G., 1998, B.K. Pedersen, B. Saltin, 2006

Rating of Perceived Exertion (RPE)



*ATS/ERS Statement. *Am J Respir Crit Care Med*. 2013.

Borg G. Borg's Perceived Exertion and Pain Scales. Champaign, IL. Human Kinetics, 1998.
Noble BJ, Borg GAV, Jacobs I, et al. A category-ratio perceived exertion scale: relationship to blood and muscle lactates and heart rate. *Med Sci Sports Exerc* 1983; 15:523-528).

Additional intensity considerations:

- Use disease-specific symptoms to guide
  - Exercise at sub-symptom threshold for some conditions (e.g., PAH)
  - Ratings of perceived fatigue: e.g., CR-10 Scale (0-10)

- **Time**: 20-60 min·session^{-1}
  - Interval training can be considered if can't tolerate continuous at a given intensity
    - exercise:rest:exercise:rest
    - alternating higher and lower intensity intervals
  - PR: 8-12 weeks → lifelong

- **Type**: Dynamic with primary focus on large muscle groups of lower body
  - e.g., walking, cycling (or similar), rowing, steps, elliptical
  - Some evidence for upper extremity (e.g., arm ergometry)

Endurance Exercise Training Example

Multiple Types: diversifies training benefits, potentially allows for greater volume of exercise to be tolerated within a session

- Walking x 20-30 minutes
- Seated combined arm/leg stepping ergometer or cycling x 10 minutes
- Unsupported arm exercise/ Arm Ergometry x 5 minutes
- Step x 5 minutes

20-60 min·session^{-1}: patient-dependent.
Include low intensity warm-up and cool-down (especially important for asthma).

- **Progression**: Currently, no standardized published guidelines. Recommendations/considerations:
  - Individualize based on health and fitness status and responses from previous session(s). Titrate to symptoms.
  - RPE=12-14; CR-10 Scale (0-10)=4-6
  - Use exercise test target intensity training goals (METs), ceiling HR (peak observed HR on exercise test), exercise HR's, RPE, RPD, s/sx's to guide
  - Frequency, intensity, time, type
    - Initial focus typically on "time"

Summary of Endurance Exercise Training Prescription Guidelines for PR[1]

- **Frequency**: 3-5 times per week
- **Intensity**: initial intensity > 60% maximal work rate, progressing to ≥ 80% maximal work rate (If 6MWT: use method described previously)
  - Borg RPE (6-20)[1]: 12-14
  - Borg CR-10 Scale© (0-10)[1,2]: 4-6
- **Time**: 20-60 minutes per session
- **Type**: Rhythmic, dynamic exercises involving large muscle groups (e.g., walking and cycling)
- **Progression**: Titrate to symptoms (12-14 on 6-20 RPE Scale and 4-6 on Borg CR 0-10 Scale© or other reliable 0-10 scale) and target MET training level.

[1]Spruit M, et al. An official ATS/ERS statement: key concepts and advances in pulmonary rehabilitation. *Am J Respir Crit Care Med* 2013 Oct 15;188(8):e13-64.
[2]Borg, G., 1998, B.K. Pedersen, B. Saltin, 2006

Resistance Training Prescription Guidelines (Strong evidence)

General Concepts: Inverse relationship between resistance intensity and number of reps
For strength: greater resistance, lower number of reps (e.g., 8-12 reps)
For endurance: lower resistance, higher reps (e.g., 10-15 reps)

Summary of Published Resistance Training Guidelines for PR[1,2,3]

- **Frequency**: Each major muscle group, 2-3 d·wk^{-1} (48 hr between bouts)
- **Intensity**: Variable depending on individual and desired outcomes
  - For improving strength for older, deconditioned adults or those just beginning a resistance program: 40-50% 1-RM (very light to light intensity; resistance to allow for 10-15 reps; perceptual ratings of exertion on 0-10 point scale for light intensity=5-6.
  - For moderate-higher fit individuals: ~60-70% 1-RM to allow for 8-12 reps
- **Time (sets and reps)**: Variable depending on the individual
  - For older and/or novice exercisers just starting: ≥ 1 set of 10-15 reps for strength; 15-25 reps for endurance (<50% 1RM)
  - Goal: 2-4 sets of 8-12 reps per set with ~2-3 minutes of rest in between sets
- **Type:** Target at least large muscle groups of upper/lower body.
  - Type should be graded in its application, safe to use, has motivational appeal to participant, and something that can be continued with long term. variety of types of exercise equipment and/or body weight. Think "Functional"
- **Progression**: gradual progression of resistance, reps, sets and/or frequency

[1]ACSM's Guidelines for Exercise Testing and Prescription, 9th and 10th Ed, 2018 (p 162-168).
[2]ATS/ERS Statement. *Am J Respir Crit Care Med*, 2013
[3]AACVPR Guidelines for Pulmonary Rehab Programs, 4th ed. 2011

Practical Considerations

- Start with light-moderate resistance during initial learning phase of exercises
  - Minimize potential risk for injury and muscle soreness
- Gradually increase resistance as patient tolerates
- Other approaches may include performing high reps with low weights.

Functional Approach Sit to Stand

A

Sit on edge of chair with arms folded across chest (or straight out in front of body).

B

Stand up.
Focus on using your legs, not momentum.

C

Slowly return to seated position. Repeat.

Partial Squat/Knee Bend

A

Stand up straight while holding on to a firm surface, as shown above.

B

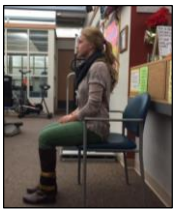
Slightly bend your knees, as if you were going to sit in a chair while holding on for support, as shown above.

C

Return to standing position. Repeat.

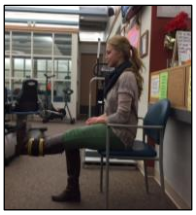
Seated Knee Extensions

A



Sit straight up in chair, back unsupported.
Weight strapped on patient's ankle.
Knee bent to 90 degrees, foot flat on floor.

B



Straighten knee while maintaining upright posture.
Pull "toes toward nose" (ankle dorsi flexion).
Pause and return to start position. Repeat.

Biceps Curls

A

Place band on floor underneath your feet.
Stand on center of band.
Hold one end of band in each hand.
Arms should be down by your sides.

B

Bend arms while keeping elbows tightly against your sides.
Slowly return to the start position.
Repeat.

Triceps Extensions

A

Grip band with both hands approximately 6-8 inches apart (leaving some slack).
Position hands in front of your chest as shown above (left hand above right hand).

B

Using right hand, pull band downward toward side.
Keep left hand still while holding band tightly.
Slowly return right hand to start position.
Repeat. When done with set, repeat sequence reversing hand position.

Single Arm Row

A

Hold middle part of band with hands approximately 4-6 inches apart and arms straight out in front of you, as shown above.

B

Using left arm, pull the band back toward your left armpit, as if you were using a bow and arrow, as shown above. Keep right arm still.
Return to start position slowly. Repeat
When done with set, repeat sequence using right arm.

Special Considerations: Resistance training in patients with PAH

- Light-intensity resistance training usually well tolerated
- Minimize significant increases in intrathoracic pressure that might decrease cardiac output
  - avoid Valsalva-type maneuver

ATS/ERS Statement. *Am J Resp Crit Care Med*, 2013.

As you know: Exercise intolerance is a hallmark feature of chronic lung disease.

Exercise conditions magnify the impact of underlying disease characteristics.

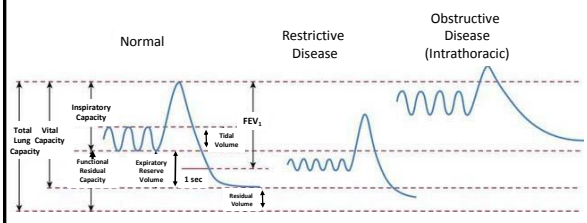
Disease Related Considerations for Exercise Intolerance:

- Pulmonary Limitations: Ventilatory and gas exchange abnormalities
- Cardiac and respiratory muscle dysfunction
- Skeletal muscle disuse and/or dysfunction
- Symptoms: Dyspnea, fatigue, anxiety
- Medication considerations

- ↓ physical activity→ physical deconditioning
  - Exercise training →↑exercise tolerance
  - "Trainability" is confounded if pulmonary function is limited

Overview of Pulmonary Function and Exercise

Pulmonary Function-Spirometry



Normal Pulmonary Responses to Exercise

$\uparrow \dot{V}E = \uparrow f_b \bullet \uparrow VT \rightarrow \uparrow \dot{V}D + \uparrow \dot{V}A$

$\dot{V}E$: minute ventilation
f_b: breathing frequency
VT: Tidal Volume
$\dot{V}D$: dead space ventilation
$\dot{V}A$: alveolar ventilation

Effects of Changes in Breathing Patterns

- $\uparrow f_b \rightarrow \uparrow \dot{V}D + \dot{V}A$ (less effective)
- $\uparrow VT \rightarrow \uparrow \dot{V}A$ (more effective)

Exercise in Normal Healthy People

- Pulmonary function is not a limiting factor:
  - Adequate ventilation and gas exchange
    - normal SpO2 (≅100%) at max exercise intensities
  - At max exercise: $\dot{V}E$ is ≤ 65% MVV.*
    - ≥35% breathing reserve
  - Normal ventilation/perfusion ratio

*MVV = Maximal volume of air that can be inhaled/exhaled during a max 12 sec PFT (expressed in L/minute values).

Pulmonary Responses to Exercise in Pulmonary Disease

- $\uparrow \dot{V}E = \uparrow\uparrow f_b \bullet \underset{\text{compromised}}{\dot{V}T} \rightarrow \uparrow\uparrow VD + \underset{\text{compromised}}{\dot{V}A}$
- Pulmonary function is a limiting factor
  - At peak exercise: $\dot{V}E \cong$ MVV (compromised)
  - ↓ $\dot{V}A$ and gas exchange →↓ SpO2
  - ↑ work of breathing
  - Compromised ventilation/perfusion in some

Disease-Specific Breathing Limitations During Exercise

"I can't get enough air in."

- Obstructive Lung Disease: ↑airway resistance (obstruction) = ↓ air flow
  - ↑air trapping (↑FRC*)—dynamic hyperinflation
  - ↓IC**=↓TV (compensate by ↑↑f_b)
- Restrictive Lung Disease: ↓lung volumes[1]
  - ↓IC =↓TV (compensate by ↑↑f_b)

[1](Neuromuscular diseases are complex and have different and/or multifactorial causes for restrictive physiology)

*FRC: Functional residual capacity
**IC: Inspiratory capacity

Exercise Limitations in Pulmonary Arterial Hypertension (PAH)

- Progressive elevation of pulmonary vascular resistance in small pulmonary arteries and arterioles
- As disease progresses: high flow/low resistance system → low flow/high resistance system:
  →Progressive dyspnea, severe activity limitation, eventual death due to right heart failure
  - Many recent advances in PH-related medications
  - Lung transplant may be the only definitive option for some
- Other considerations:
  - Gas exchange abnormalities, physical inactivity, skeletal muscle dysfunction/deconditioning, fatigue and other symptoms (syncope)
  - ↓ Exercise tolerance → ↓ survival in PAH patients

ATS/ERS, *Am J Respir Crit Care Med*, 2013
Advances in PH Journal, 2010

Pulmonary Arterial Hypertension (PAH)
PR Exercise Prescription/Training Considerations

- Optimal exercise training regimen: currently unknown.
- Some studies show exercise is well-tolerated: sub-maximal intensities
- Exercise training focus: keep people as functional as possible
- Prescribe exercise as tolerated, using symptoms to guide
- Exercise training can be maximized with optimal medical management (≥3mo). Patient should be aligned with a specialist.

ATS/ERS, *Am J Respir Crit Care Med*, 2013.
Chan et al. *Chest* 2013. Mereles et al. *Circulation* 2006., Grunig et al. *Eur Resp J* 2012.

Pulmonary Arterial Hypertension (PAH)
PR Exercise Prescription/Training *Considerations*, NOT ABSOLUTES
Patient-Dependent

- **FITT-Pro**: 3-5d·wk^{-1}, low to moderate intensity is usually safest RPE=11-13, sub-symptom threshold, 20-30min·d^{-1} (consider low intensity, shorter duration intervals may be better tolerated), walking if tolerated (seated modes may be better tolerated), may need to include energy conservation strategies
- Supplemental O2 "try" to maintain SpO2≥90%
  - Hypoxemia→ ↑ pulmonary vascular resistance=↑ PA pressure→ ↑ risk for arrhythmias or circulatory collapse
  - Monitor symptoms, not just saturations. If hypoxemia + symptoms, stop exercise.
  - Consider maintaining SpO2 > 85% in some patients who are asymptomatic
- Monitor for symptoms: ↑ fatigue, reported symptoms, or other clinical signs of disease worsening. Work closely with heart failure/PH MD specialist.
- Monitor BP: if a decrease in SBP with exercise, stop exercise. Systolic BP should be >90-100.

Other general considerations to maximize exercise training and outcomes:

- Flexibility in our PR program structure
- Optimal medical management
- Maximize disease self-management strategies

Supplemental O2 Considerations

- Use supplemental O2 to enable exercise training
- General guide: maintain SpO2≥89% (e.g., 89-94%)
- COPD:
  - Some evidence supports use of supplemental O2 during exercise training who don't experience significant hypoxemia[1-3]
  - O2 therapy has been shown to improve activity tolerance but limited evidence regarding increased lifespan or QOL
- Restrictive lung disease (ILD)
  - ↓ DLCO: May have high supplemental O2 requirements
  - Exercise induced hypoxemia may limit exercise tolerance
  - NIPPV may be beneficial for some people
- PAH
  - Hypoxemia → increased pulmonary vascular resistance.
  - Emphasize adherence with supplemental O2; SpO2≥90%

[1]Nici L, Donner C, Wouters E, et al. ATS/ERS statement on pulmonary rehab. *Am J Respir Crit Care Med*. 2006;173:1390-1413.
[2]Emtner M, Porszasz J, Burns M, et al. Benefits of supplemental oxygen in exercise training in non-hypoxemic COPD patients. *Am J Respir Crit Care Med*. 1995;136:225-244.
[3]Puhan MA, Schunemann HJ, Frey M, et al. Value of supplemental interventions to enhance the effectiveness of physical exercise during respiratory rehabilitation in COPD: a systematic review. *Respir Res*. 2004;5:25

Clinical Considerations

- Pulse-oximeter: routinely used to assess for O2-Hgb saturation (SpO2).
- Doesn't give the whole picture

Monitoring Considerations[1]
1. Movement artifact
2. Probe size, type, and location
   - Accuracy: Forehead>finger (3rd or 4th) >earlobe
3. Sensor positioning
4. Probe off
5. Low perfusion and/or dysrhythmias

[1]Hillegas E, et al. Official guidelines from the Cardiovascular and Pulmonary Section. Supplemental oxygen utilization during physical therapy interventions. *Cardiopulm Phys Ther*. 2014;25(2):38-49.

Examples: ↓'ed Hgb concentration → may have normal SpO2.
↓'ed Hgb concentration → ↓O2 carrying capacity of blood →↓exercise tolerance.
False high SpO2 in smokers (unable to differentiate between O2-Hgb and CO-Hgb.

Adaptive Strategies

Adaptive Strategies

Endurance Exercise Training in People with Pulmonary Disease

- Does not usually improve pulmonary pathology
- ↑ oxidative capacity of skeletal muscle
- Exercise training can result in ↑ function without significant measurable gains in "fitness" ($\dot{V}O_2max$) as a result of improving:
  - Confidence, mobility, anxiety, improved breathing efficiency/effectiveness, desensitization to dyspnea, utilization of adaptive strategies, muscle recruitment efficiency
- Difference between "exercise capacity" and "functional status"

Interactive Mini Case Examples

Disease-specific considerations
Practical considerations

Example 1: COPD

- 74 yo woman with moderate COPD
  - FVC=99% predicted
  - FEV1=74% predicted
  - FEV1/FVC=56
  - IC=85% predicted
  - FRC=122% predicted
  - DLCO=26% predicted
- Primary complaint: "Dyspnea, decreased activity tolerance, fear"
- Activity profile: Very active up until 1 year ago
- Personal goal: Dance x 1 hour 2d·wk^{-1}, walk x 30 minutes at ≥2.5mph, go on annual family vacation in 4 months

Conducted as part of a pre-PR screening assessment prior to participation in the PR program.

Initial Clinical Symptom-Limited Treadmill GXT Results

Time (min)	Speed (mph)	Grade (%)	O2 (LPM)	SpO2 (%)	HR*	BP	RPE (6-20)	RPD (0-10)	Pain (0-10)	METs
0	----	----	0	96	60	106/60	---	0	0	
0-1	1.6	0	0	92	74					
1-2	1.6	0	0	89	80					
2-3	1.6	0	0	86	87	120/70	10	1	0	2.2
3-4	1.8	3	2	89	92					
4-5	1.8	3	2	90	93					
5-6	1.8	3	2	90	94	124/68	17	8	0	3.1

Peak MET level

Reason for stopping: "Dyspnea and leg fatigue."

*Atenolol: 50mg daily

Initial 6MWT Results

Conducted at time of first session of PR.

- 6MWD=1200 feet (366 m)
  - Average walking speed: 2.3 mph
  - Estimated corresponding MET level: ≅2.7 METs
  - Peak observed HR=89
  - Lowest SpO2=89% (2LPM O2)
  - BP at end: 128/86
  - RPE=13 "Somewhat hard"
  - RPD=3 "Moderate"

Exercise Prescription

- Using results from the 6MWT, let's design an endurance exercise training prescription for this patient using FITT-Pro parameters while keeping the patient's goals in mind.

Assume standard patient monitoring during PR sessions

- HR
- BP
- SpO2
- Signs/symptoms
- RPE
- RPD
- Pain
- Supplemental O2: ≥2LPM
  - e.g., MD order: "Titrate to maintain SpO2≥89%"

FITT-Pro

This should be included in the ITP.

- **Frequency**: 3d·wk^{-1} in PR setting + 2d·wk^{-1} independently within 1-2 weeks
- **Intensity** (initial): ≅85% of 6MWT METs (or 80% of speed): (2.7 METs x 0.85=2.3METs); RPE: 12-14, RPD: 4-6
- **Time**: 40-60min·session^{-1}
- **Type**: Treadmill, walking over ground, seated combined arm/leg stepping ergometer, arm ergometer, step, (or other similar types)
- **Progression**: titrate to symptoms (RPE: 12-14, RPD: 4-6); ongoing throughout program (time, then intensity); use exercise test info (peak GXT HR=exercise training ceiling HR), daily responses, program and patient goals to guide

PR Mid-Point Reassessment

(Update ITP every 30 days)

- Reassess exercise capacity
  - 6MWT
- Evaluate effectiveness of current training program
  - MID for improvement in 6MWD with PR for COPD: =30m (Holland et al, *Eur Respir J* 2014)
- Modify training prescription as appropriate
  - FITT-Pro; (goal: progression to ≥3METs)

- Initiate independent dancing 4th week:
  (patient-specific goal):
  - **Frequency**: 2 d·wk^{-1} in addition to attending PR sessions (5 d·wk^{-1}total)
  - **Intensity**: RPE=12-14; RPD=4-6 (or ≤5)
  - **Time**: 5-10 minute bouts with rest in between throughout hour.
  - **Progressively** increase dancing time from 5-10 min bouts to 15-20, etc, up to 60min (5min·wk^{-1})

Sample PR Exercise Session at 6 Weeks:

- Aerobic Exercise Training: ≈2.6-2.9METs
  - Treadmill: 30 min
    - Warm-up:1.8→2.0mph x 5min (RPE=11)
    - Training: 2.3-2.5mph x 20min (RPE=13-14)
    - Cool-down: 2.0→1.8mph x 5min (RPE=11)
  - Seated combined arm/leg stepping ergometer, or cycle: 10min (RPE=13-14)
  - Arm Ergometer: 5min (RPE=13)
  - Step (8 inch height): 5min (RPE=13-14)
- Resistance exercises: resistance bands, weights, own body weight (repetitive sit → stand), seated knee extensions

Final PR Reassessment
(ITP: final assessment & follow up plans required)

- Evaluate overall effectiveness of training program
- Reassess exercise capacity (6MWT)
  - 6MWD ≥ 30 m compared to baseline
  - Assess functional capacity/participation in PA
- Provide patient with training guidelines to continue with exercise long term
  - PR maintenance program + home based
  - Encourage increased participation in PA
    - Physical activity monitor, etc

Physical Activity (PA)

- Current evidence suggests lack of transfer of gains in exercise capacity into participation in daily life activities.
- Use of an activity monitor to directly measure PA has been shown to be a stronger predictor of survival than other outcomes
  - Lung function, 6MWD, cardiovascular status, PVD, BMI, dyspnea, health status, depression, and other systemic biomarkers
- Consider incorporating things into your program to encourage increased participation in and tracking participation of PA
  - Pedometers, daily activity diaries, activity trackers, accelerometer, smartphone app

AACVPR Expert Panel Review of: ATS/ERS Statement: Key Concepts and Advances in Pulmonary Rehabilitation. *Am J Respir Crit Care Med*, 188(8), e13-e64, 2013.

General Exercise Training Considerations for People with COPD

- Pursed-lips breathing
- Allow adequate rest in between modes
- Supplemental O2 (SpO2≥89%)
- Optimize medical management
  - Improved disease self-management strategies
- Pacing with activity, anxiety/panic control
- Low level patients: consider short duration repeated bouts with rest
- Consider interval training
- Resistance training, specific focus on legs

FYI: Evidence to support for some, but may not be appropriate for all.

High Intensity Interval Training in COPD[1-5]

- >70-90% peak work rate when used as an interval training approach/format (30-180 sec) interspersed with rest ratios of 1:1 or 1:2 [1-5]

[1]Beauchamp MK, Nonoyama M, Goldstein RS, et al. Interval versus continuous training in individuals with chronic obstructive pulmonary disease—a systematic review. *Thorax*. 2010;65(2):157-64.
[2]Kortianou EZ, Nasis IG, Spetsioti ST, Daskalakis AM, Vogiatzis I. Effectiveness of interval exercise training in patients with COPD. *Cardiopulm Phys Ther J*. 2010;21(3):12-9).
[3]Langer D, Hendriks E, Burtin C, et al. A clinical practice guideline for physiotherapists treating patients with chronic obstructive pulmonary disease based on a systematic review of available evidence. *Clin Rehabil*. 2009;23(5):445-62.
[4]Mador MJ, Krawza M, Alhajhusian A, Khan AI, Shaffer M, Kufel TJ. Interval training versus continuous training in patients with chronic obstructive pulmonary disease. *J Cardiopulm Rehabil Prev*. 2009;29(2): 126-32.
[5]Vogiatzis I, Nanas S, Roussos C. Interval training as an alternative modality to continuous exercise in patients with COPD. Eur Respir J. 2002;20(1):12-9.

As time allows…..

Let's get real…

Example 2: Very Severe COPD

- 63 yo male with very severe COPD, being considered for lung transplant candidacy
  - FVC=49%, FEV1=17%, FEV1/FVC=35%
  - BMI=20.6kg/m2
  - 6LPM O2 at rest and 8 with activity
  - Initial 6MWT: 6MWD=94 feet (28.7m)
- Is this person "rehabable?"
- What do you do?

Exercise Prescription

- **Frequency**: 5d·wk^{-1}
- **Intensity**: titrate to tolerance.
  - Consider using resting HR+20bpm, SpO2≥89%, RPE=12-14; RPD≤5
- **Time**: 20-30 min·day^{-1}
  - Short bouts with rest; multiple bouts·day^{-1}
- **Type**: over ground walking with rollator/4-wheeled walker, focus on seated stepping machine initially (legs only)
- **Progression**: slow; titrate to sx's (RPE=12-14; RPD≤5)
- Resistance exercises: seated knee extensions, repetitive sit to stand, biceps curls

Progression:

Recall: Initial 6MWD = 94 feet (28.7m) and required 8LPM O2

- 1 month PR:
  - 6MWD: 483 feet (147m), 12LPM O2
- 2.5 month PR:
  - 6MWD: 516 feet (157m), 12LPM O2
- 6 month PR + phase III:
  - 6MWD: 536 feet (163m), 15LPM O2 (1mph; 1.8METs)

Showing some "rehabability" but lung function continues to decline and limited potential for significant further improvement without transplant.

- 1 year post (B) lung transplant
  - 6MWD: 2130 feet (649m) ≅4mph, 4METs

Note: After transplant, diagnosis is now "post lung transplant." No longer COPD.

Example 3: Cystic Fibrosis (CF)

- 46 yo male with end-stage CF awaiting lung transplant
  - FVC=56, FEV1=30, BMI=21kg/m2
- 6MWD: 1313 feet (400m), 6LPM O2
  - Despite PR:↓6MWD: 292m at 2mo, then 147m at 3mo (8LPM O2) (≅0.9mph, 1.7METs)
- **FITT-Pro**: 5-7d·wk^{-1}, RPE=11-13, RPD≤5; 30min·d^{-1}, combination walking + seated mode; titrate to sx's
  - Exercise goals: maximize function within limitations
  - Minimize physical deconditioning from inactivity

Post Lung Transplantation (LT) Exercise Training Considerations

Post LT Exercise Considerations

- Lungs say, "Go!" Body says, "Whoa!"
- Lungs are no longer limiting factor
- Extreme physical deconditioning
- Exercise/rehab is key to successful outcomes
  - **FITT-Pro**: 5-7d·wk^{-1}, RPE: 12-14, x 30-60min·d^{-1}, progress to tolerance ("normal" exercise capacity)
  - Lower extremity functional resistance: e.g., repetitive sit to stand, seated knee extensions with ankle weights
  - Promote increased participation in PA over time
- Re-education on breathing and posture, upper extremity ROM
- Adherence to surgical resistance precautions

Summary of what we've covered thus far:

1. Identified the core components of exercise prescription and current evidence based guidelines
2. Discussed causes for exercise limitations in pulmonary disease and how pulmonary impairment affects exercise tolerance
3. Discussed disease-related conditions and strategies to optimize exercise training for those conditions
4. Applied concepts using case examples

Questions?

Additional examples if time allows…

Example 4: Restrictive Lung Disease

- 33 yo male with Interstitial Lung Disease (ILD)-Pulmonary Fibrosis. 1-year h/o decreasing activity tolerance and worsening dyspnea on exertion.
- BMI=21.4kg/m^2
- PFTs:
  - FVC=24% predicted
  - FEV1=24% predicted
  - FEV1/FVC=83
  - DLCO=24% predicted

Pre-PR Treadmill Clinical Symptom-Limited GXT Results

Time (min)	Speed (mph)	Grade (%)	O2 (LPM)	SpO2 (%)	HR	BP	RPE (6-20)	RPD (0-10)	Pain (0-10)	METs
0	----	----	0	100	79	100/62	---	0	0	
0-1	1.8	0	0							
1-2	1.8	0	0							
2-3	1.8	0	0	93	93	122/66	11	3	0	2.4
3-4	2.2	3	0							
4-5	2.2	3	0							
5-6	2.2	3	0	89	107	130/72	12	3	0	3.6
6-7	2.6	6	2	87	116					
7-8	2.6	6	2	91	120					
8-9	2.6	6	2	90	120	164/68	14	4	0	5.1
9-10	3.0	9	2							
10-11	3.0	9	4	87	132					
11-12	3.0	9	4	87	141	170/80	14	5	0	7.0
12-13	3.4	12	4	86						
13-14	3.4	12	4	85	155	176/80	16	8	0	~8.0

Reason for stopping: "Dyspnea." Peak estimated MET level

Restrictive Lung Disease-ILD

- Body says, "Go" but lungs say, "Whoa!"
- Exercise induced hypoxemia: hallmark feature.
- Supplemental O2 needs-often high
- PH likely co-exists
  - Monitor for "fatigue;" other PH-related sx's
- Rapid disease progression
- Transplant candidate?

- How might this person's program be different than someone with COPD?

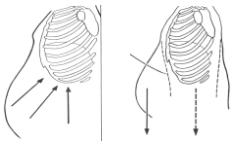
Exercise Training Considerations

- Goals of PR:
  - Maximize function, manage symptoms, evaluate O2 needs/equipment, psychosocial support
- Exercise strategies:
  - Provide adequate supplemental O2 to enable training
  - Intervals (not high intensity)
  - Shorter bouts or multiple bouts·day^{-1}
  - Seated exercise usually better tolerated for severe
  - Energy conservation and pacing strategies
  - Emphasize O2 therapy adherence

Restrictive Pulmonary Disease: Obesity Related

- Obstructive Sleep Apnea (OSA)
- Obesity Hypoventilation Syndrome (OHS)

Obesity and Breathing Mechanics



Reduced lung expansion → alveolar hypoventilation (↓TV).
Obesity Hypoventilation Syndrome (OHS)
90% also have OSA[1]

[1]Suratt PM and Findley LJ. Pathogenesis of obesity hypoventilation syndrome. © 2004 *UpToDate®*
(Bordow RA, Moser KM. Manual of Clinical Problems in Pulmonary Medicine. 4th ed. Boston, Little, Brown, 1996.)

- Exercise prescription and training considerations?

Example 5: 52 yo Male with Pulmonary Hypertension Secondary to ILD and Systemic Sclerosis

- 6MWD: 617 feet (187.5m)
  - Unable to walk continuously. Stopped twice d/t dyspnea (2min, 54sec). 15LPM O2. Low SpO2=80%. RPE=9. RPD=7.
  - 6MWT 4mo prior: 6MWD=820 feet (250m). 15LPM O2. Low SpO2=81%.
- Exercise prescription and training considerations?

Summary Statement

Exercise training programs can be enhanced by recognizing disease-related features, understanding basic principles of exercise training, and individualizing the exercise prescription accordingly to optimize the individual response as well as program outcomes.

"Art and Science"

Thank you!

kim-eppen@uiowa.edu

Additional Information
for your review on the following slides

Dosing and prescribing exercise is like dosing and prescribing medicine.

Individualized.

Art and science combined.
Rely on evidence-based guidelines when available.

The effects of engaging in exercise regularly may be as efficacious as some medications are for managing some health conditions.

When determining exercise intensity, use a combination of:

- Observed peak VO2 (and/or peak work rate)
- Functional exercise test (6MWT)
- Symptom scores (RPE and RPD)
- Patient responses to exercise
- Previous exercise history
- Disease-related considerations and comorbidities
- Individual goals and program goals

Terminology

- $\dot{V}O_2$: Oxygen uptake: volume of oxygen consumed per minute
- $\dot{V}O_{2max}$: Maximal oxygen uptake. Criterion measure for cardiorespiratory fitness (CRF).
  - Can be measured directly using sophisticated gas analysis equipment during an incremental exercise test or estimated using standardized metabolic prediction equations
- $\dot{V}O_{2peak}$: Peak oxygen uptake: peak volume of oxygen consumed per minute
- Peak work capacity or work rate: highest workload achieved on an incremental exercise test. Can be expressed as physical work (e.g. watts from a cycle ergometer test) or physiologic workload ($\dot{V}O_2$ expressed in mLO_2/min, mLO2/kg/min, or METs)
- MET: Metabolic equivalence of a task. Unit for expressing rate of energy expenditure (EE).
  - 1 MET = rate of EE of rest = 3.5mLO_2/kg/min
  - Estimating energy cost for activities: See Table 6.3, p 152: ACSMGETP 10th Ed. Metabolic calculations for the estimation of energy expenditure for various common physical activities.
  - Important to recognize the limitations of accuracy in persons with pulmonary disease