Role of Cardiopulmonary Exercise Testing in Exercise Prescription

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Role of Cardiopulmonary Exercise Testing in Exercise Prescription

- Clinical indications for CPX
- General principals of exercise prescription
- What are the advantages of CPX in exercise prescription?
- Other advantages of CPX in the context of exercise training
- General comment on physical activity and health
AHA/ACC Indications for CPX

- When a precise cardiopulmonary response to a therapeutic intervention is necessary
- When a research question is being addressed
- When the etiology of exercise limitation or dyspnea is uncertain
- Evaluation of exercise capacity in patients with heart failure to assist in the estimation of prognosis and assess the need for transplantation
- When assisting in the development of an appropriate exercise prescription for cardiac rehabilitation
General principals of exercise prescription
The FITT Principal:

- **Frequency**, **Intensity**, **Time**, **Type**
- **Frequency** – most days of the week
- **Intensity** – 50-80% of maximum capacity (usually using heart rate reserve)
- **Time** – minimum of 30 minutes
  - Moderate activity associated with numerous health benefits
- **Type** – any aerobic activity
  - Resistance training should be incorporated into all fitness programs, including cardiac rehab
Why is the exercise prescription important?

- An individualized exercise guideline encourages a person to be more physically active.
Effect of exercise Rx, clinician counseling on exercise

- Overweight adults who were advised by their physician to exercise were 5 times more likely to meet activity recommendations. *Weidinger Fam Practice 2008*
- Patients receiving counseling 50% more likely to increase physical activity pattern. *Kreuter et al Arch Fam Med 2000.*
- Providing pedometer increased steps walked/day by >2,000, ↑stairs climbed, ↑days/week walking >30 min, ↑frequency of exercise bouts. *Stovitz et al J Am Board Fam Pract 2005*
- Numerous studies have shown that physicians who are physically active themselves are more likely to counsel patients on the benefits of exercise. *Frank et al J Am Med Women's Assoc 2003; Abramson et al Clin J Sport Med 2000; Wee et al JAMA 1999*
- Three sessions of physician-delivered activity counseling by phone over 6 months resulted in greater physical activity. *Green et al Am J Prev Med 2002*
- Physician-provided exercise Rx, with written materials, results in significant increase in physical activity over 8 months. *Smith et al Br J Sports Med 2000*
- Activity counseling increased proportion of subjects meeting 30 min/5 days/week recommendation from 1 & 2% at baseline to 26 and 30% in men and women, respectively, at 2 years. *ACT study, JAMA, 2001*
- Two group counseling sessions increased physical activity in sedentary subjects by 70 min/week. *Brekke et al J AM Diet Assoc 2003*
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**Physician-provided exercise Rx, with written materials, results in significant increase in physical activity over 8 months. ***(Smith et al Br J Sports Med 34:262-267)*

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Why is the exercise prescription important?

- An individualized exercise guideline encourages a person to be more physically active.
- Helps ensure that activity is safe and appropriate for a given patient.
- However, rigid guidelines not necessary for most stable patients or the public.
What are the advantages of using CPX for exercise prescription?
What are the advantages of CPX in exercise prescription?

- More precise and reproducible measure of exercise capacity
  - Exercise prescription
  - Better measure of response to training
- More physiologic response to exercise
- More precise estimates of prognosis
What are the advantages of CPX in exercise prescription?

Precision and Reproducibility
Measured vs. Estimated Peak Mets Among Treadmill Referrals*

Measured METs (from measured VO\textsubscript{2})

Estimated METs (from work rate)

$r = 0.55$

$n = 1110$

$p < 0.0001$

10 METs

6-7 METs

10 METs
**VO₂ and Exercise Time with Serial Testing**

**Test 1**
- **VO₂**: 1119 ± 376 ml/min
- **Exercise Time**: 419 ± 140 sec

**Test 2**
- **VO₂**: 1105 ± 346 ml/min
- **Exercise Time**: 462 ± 130 sec

**Test 3**
- **VO₂**: 1123 ± 400 ml/min
- **Exercise Time**: 470 ± 131 sec

**VO\textsubscript{2} and Exercise Time with Serial Testing**

* Sullivan et. al., Chest 86:325
What are the advantages of CPX in exercise prescription?

- Precision and Reproducibility
- Exercise prescription and the ventilatory threshold
Ventilatory Threshold (V-slope method)

$\text{CO}_2$ from Krebs cycle stimulates ventilation

$\text{CO}_2$ from Krebs cycle and lactate buffering further stimulates ventilation
Exercise prescription and the ventilatory threshold

- Ventilation increases exponentially beyond VT
- Difficult to exercise for long beyond VT
- Good upper limit of exercise Rx
- Good marker of the “talk test”
- Well established training response when Ex Rx is linked to the VT
# Training at VT vs. % of Max

**VT** = individualized at VT

**HR Reserve** = standard training at HR Reserve

<table>
<thead>
<tr>
<th>Measure</th>
<th>Group</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>$VO_2^{max}$</td>
<td>VT</td>
<td>↑ 20%</td>
</tr>
<tr>
<td></td>
<td>HR reserve</td>
<td>↑ 10%</td>
</tr>
<tr>
<td>$VO_2@VT$</td>
<td>VT</td>
<td>↑ 22%</td>
</tr>
<tr>
<td></td>
<td>HR reserve</td>
<td>↑ 8%</td>
</tr>
<tr>
<td>$O_2^{pulse}$</td>
<td>VT</td>
<td>↑ 17%</td>
</tr>
<tr>
<td></td>
<td>HR Reserve</td>
<td>↑ 9%</td>
</tr>
</tbody>
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Vallet 1997 Eur Respir J 10:114-122 (COPD patients)
What are the advantages of CPX in exercise prescription?

- Precision and Reproducibility
- Exercise prescription and the ventilatory threshold
- VO$_2$ reserve
$VO_2$ Reserve = (Peak $VO_2$ - Rest $VO_2$) $\times$ (% intensity desired) + Rest $VO_2$

Considered by some to be the **gold standard**

- ACSM Position Stand on Quantity and Quality of Exercise
- Eur Assoc Cardiovascular Prevention Rehabilitation Standards on CPX, 2009
Advantages of CPX in exercise prescription

**VO₂ Reserve:**

- More closely reflects the range of metabolic rate than other methods
- Not subject to the vicissitudes of heart rate:
  - Variability
  - Hyperthermia & Dehydration
  - Fatigue
  - Medications
What are the advantages of CPX in exercise prescription?

- Precision and Reproducibility
- Exercise prescription and the ventilatory threshold
- VO$_2$ reserve
- Documenting training response with CPX
Effects of Training on Exercise Capacity

Milani, Lavie, Spiva. Am J Cardiol 75, 940-942
Exercise Training in AAA

**Estimated METs**
- Pre-Exercise: 5
- Post-Exercise: 7

**Exercise Time**
- Pre-Exercise: 8 minutes
- Post-Exercise: 10 minutes

**Peak VO2**
- Pre-Exercise: 20 ml/kg/min
- Post-Exercise: 22 ml/kg/min

Myers et al., submitted, 2011
Exercise training improves the VE/VCO$_2$ slope in CHF:

- **Coats et al. Circulation 85:2119, 1992**
  - $VE/VCO_2$ slope ↓ from 0.38 to 0.34 with 8 weeks of training

- **Davey et al. Br Heart J 68:473, 1992**
  - $VE/VCO_2$ slope ↓ from 0.39 vs 0.35 with 8 weeks training

- **Myers et al. Med Sci Sport Exerc 31:929, 1999**
  - $VE/VCO_2$ slope ↓ from 0.33 vs 0.27 with 8 weeks high intensity training

  - $VE/VCO_2$ slope ↓ from 0.33 vs 0.28 with 8 weeks training

  - 1.7 unit decrease in VE/VCO$_2$ slope in high risk women
Exercise training improves the OUES in CHF:

- Gademan et al. EJCVPR 15:140, 2008
  - *OUES increased 19% after 4 weeks of training*

- Myers et al. JCRP, in press, 2011
  - *OUES increased 12% after 8 weeks of high intensity training*

  - *OUES increased 14% after 4 weeks of training*

  - *OUES increased 6% after 6 months of training*
Exercise prescription and public health message regarding physical activity
Minimal recommendations for physical activity – WHO, CDC, AHA, ACSM, US Surgeon General’s Report, European Working Group*

“All individuals should attempt to accumulate 30 minutes of moderate activity on most, if not all, days of the week”

“Additional health benefits can be gained through greater amounts of physical activity…”

30 minutes daily activity ≈20 to 40% reduction in cardiovascular and all-cause morbidity/mortality

*Australia, Canada, Fiji, New Zealand, Germany, Singapore, the Philippines, Switzerland, which are generally based on the United States Surgeon General’s recommendations for physical activity
Prevalence of Physical Activity in the European Union

![Bar chart showing the prevalence of moderate physical activity days per week across European Union countries.](image-url)
“Are you eating properly and getting plenty of exercise?”
Exercise Prescription, Physical Activity and Health

- HR reserve
- Karvonen formula
- % VO₂
- VO₂ reserve
- Training zone
- Perceived exertion
- Talk test
- Training range
- Ventilatory threshold
- Interval training
- Fat burning zone
- Polar HR, pedometer, accelerometer

- Find an activity that’s enjoyable - more likely to adhere
- Compulsive monitoring, narrow window for exercise Rx can be a barrier
- All clinicians should counsel patients on physical activity
Summary

- **CPX permits a more precise and effective exercise prescription**
  - Estimated METs less reliable

- **CPX provides important insights into the training response**
  - More precise
  - More physiologic response to training

- **Physical activity counseling should be a part every clinical encounter**