Obesity and Lung Function: Understanding How Obesity Impacts Care

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Obesity

- Mechanical effects
- Inflammation

Dyspnea

Reduced Physical Activity
FRC = Functional Residual Capacity

- Reduced lung compliance
- Closure of dependent airways
- Reduced expiratory reserve
• Reduced lung compliance
  • ↑ elastic work
• Closure of dependent airways
  • Airway obstruction → ↑ resistive work

Reduced expiratory reserve → Ventilatory Constraints

Lorenzo S and Babb TG. Exercise Therapy in Adult Individuals with Obesity. Chapter 6. pp: 87-100
**Flow (L/s)**

**Without obesity**

- Max FV
- Peak
- Rest
- Reserve

**With Obesity**

- Expiratory flow limitation
- Ventilatory Constraints → Dyspnea
- Dynamic Hyperinflation
- Low FRC → ↓ expiratory reserve

**Volume (L)**
Mechanisms for Dyspnea on Exertion

• Low FRC
  • Work of breathing (Elastic and Resistive)
  • Ventilatory constraints

• Individuals with obesity are simply deconditioned

• Altered perception

• Inflammation
  • Airway obstruction
How do we diagnose “deconditioning”?

- **Cardiopulmonary exercise test:** One of the most useful measures is exercise capacity or VO$_{2\text{max}}$.
- **Common approach:** Quantify VO$_{2\text{max}}$ relative to body mass. 
  - ml per kg per min

Wasserman et al, Principles of Exercise Testing and Interpretation, 1987
Body Mass = Fat Mass + Lean Body Mass
Simply deconditioned?

• Quantifying cardiorespiratory fitness relative to body mass → ALWAYS shows that obese individuals are “unfit”

• Better approach: *relative to lean body mass*

Unpublished data from 53 children, 8-12yr
- On average, individuals with obesity similar cardiorespiratory fitness as those without
- AHA approach of using “ideal” body weight to predict VO$_{2_{\text{max}}}$
Mechanisms for Dyspnea on Exertion

- Low FRC
  - Work of breathing (Elastic and Resistive)
  - Ventilatory constraints
- Individuals with obesity are simply deconditioned
- Altered perception
- Inflammation
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?Weight Loss?
Exertional dyspnoea in obesity

Vipa Bernhardt¹ and Tony G. Babb²

Effect of weight loss on operational lung volumes and oxygen cost of breathing in obese women

DM Bhammar¹,², JL Stickford¹,³, V Bernhardt¹,⁴ and TG Babb¹

Weight loss reduces dyspnea on exertion in obese women☆

Vipa Bernhardt, Tony G. Babb☆

Weight loss reduces dyspnea on exertion and unpleasantness of dyspnea in obese men

Vipa Bernhardtᵃ,ᵇ, Dharini M. Bhammarᵃ,ᶜ, Rubria Marines-Priceᵃ,ᵈ, Tony G. Babbᵃ,⋆
Ratings of Perceived Breathlessness (RPB)
Borg 0 – 10 Scale

<table>
<thead>
<tr>
<th>Rating</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Nothing at all</td>
</tr>
<tr>
<td>0.5</td>
<td>Very, very weak (Just Noticeable)</td>
</tr>
<tr>
<td>1</td>
<td>Very Weak</td>
</tr>
<tr>
<td>2</td>
<td>Weak (Light)</td>
</tr>
<tr>
<td>3</td>
<td>Moderate</td>
</tr>
<tr>
<td>4</td>
<td>Somewhat Strong</td>
</tr>
<tr>
<td>5</td>
<td>Strong (Heavy)</td>
</tr>
<tr>
<td>6</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Very Strong</td>
</tr>
<tr>
<td>8</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Very, very strong (Almost max)</td>
</tr>
<tr>
<td></td>
<td>Maximal</td>
</tr>
</tbody>
</table>

6 min cycling
- 60 Watts (women)
- 90 Watts (men)

-DOE (i.e. no or mild breathlessness)

RPB=3

+DOE (i.e. strong breathlessness)
Dyspnea on Exertion in Obesity

Dyspnea on Exertion in Men with Obesity

Fig. 2. Weight loss before and after intervention. Filled bars, +DOE; open bars, -DOE.

(Bernhardt et al. RPN. 2019. 261: 55-61)
Dyspnea on Exertion in Women with Obesity

(Bernhardt and Babb. RPN. 2014. 86-92)
EILV (inspiratory reserve)

EELV (expiratory reserve)

Before Weight Loss

After Weight Loss

n=29

Oxygen cost of Breathing

Eucapnic Voluntary Hyperpnea

Cycling @ 60W

Reduction attributable to VO$_2$Resp

### Total Body VO$_2$ (ml/min)

<table>
<thead>
<tr>
<th></th>
<th>Before Wt. Loss</th>
<th>After Wt. Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>O$_2$ cost of breathing</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slope (ml/L)</td>
<td>2.52 ± 1.02</td>
<td>2.11 ± 0.72</td>
</tr>
<tr>
<td>Y Intercept (ml/min)</td>
<td>218.4 ± 36.8</td>
<td>210.9 ± 32.9</td>
</tr>
</tbody>
</table>

Aerobic exercise training without weight loss reduces dyspnea on exertion in obese women

Vipa Bernhardt\textsuperscript{a,b}, Jonathon L. Stickford\textsuperscript{a}, Dharini M. Bhammar\textsuperscript{a}, Tony G. Babb\textsuperscript{a,*}

**EXERCISE TRAINING**

[Graph showing RPB (Borg 0-10) pre and post exercise training.]

Pre: [Graph bar] Post: [Graph bar] (RPN. 2016. 64-70)

**COMBINED (Wt Loss and Ex Tr)**

[Graph showing RPB (Borg 0-10) pre and post combined weight loss and exercise training.]

Pre: [Graph bar] Post: [Graph bar] (Unpublished data)
Mechanical effects (Low FRC)

Obesity

Weight Loss

Exercise Training

? → Dyspnea ↓
Obesity + “Pulmonary Disease”

- COPD
- Asthma
- Obesity hypoventilation syndrome
- Pulmonary embolism
- Aspiration pneumonia
- Obstructive sleep apnea
Dyspnea on Exertion in [Asthma & Obesity]

Implications:
- Increased severity of symptoms
- Difficult to treat asthma phenotypes
- Potential misdiagnosis of asthma
Nevada INBRE IDEA Network of Biomedical Research Excellence

- Mechanisms & treatment of exercise-induced bronchoconstriction
- 8 – 12 yr old, mild asthma (FEV₁ > 75% predicted)
- Collaboration with Dr. Craig Nakamura

Spirometry, lung volumes, airway resistance, DLCO

Exercise capacity

Exercise challenge tests
- FeNO
- Spirometry
- Airway resistance

Interval warm-up

Work Rate (Watts)

Time (seconds)
Preliminary Data: One case

- 10 yr old; BMI 89th percentile
- FEV$_1$ = 101% pred
  - ↓5% after 4 actuations of albuterol
- Cardiorespiratory fitness: 112% predicted
Summary

• *Myth-buster:* Most otherwise-healthy patients with obesity are NOT deconditioned

• Obesity: “causal” role in inducing dyspnea & dyspnea on exertion

• Potential treatments for obesity-related dyspnea
  • Weight loss
  • Exercise training
  • Inspiratory muscle training
  • Pulmonary rehabilitation

• Obesity and Asthma Phenotype: needs more research