### Pulmonary Functions

#### Tests
- Static lung functions - volumes
- Dynamic lung functions - volume and velocity

#### Dynamic Tests
- Velocity dependent on
  - Airway resistance
  - Resistance of lung tissue to change in shape

#### Dynamic Functions
- Single forced expiration
  - FVC - total volume exhaled
  - FEV\(_{1.0}\) - volume exhaled in first second
  - FEV\(_{1.0}\)/FVC - Forced expiratory ratio (FER) \(\times \%
  - Peak expiratory flow rate (PEFR) - highest forced expiratory flow \(\times \) L/min
  - FEF\(_{25-75\%}\) - Forced expiratory flow rate
    - Average flow rate measured over the middle half of the expiration (related to FEV\(_{1.0}\))

#### Dynamic Functions
- Maximal Voluntary Ventilation (MVV)
  - Volume of air that could be moved during vigorous, deep breathing (extrapolated)
  - Test of ventilatory capacity
  - 140-160 L/min

#### Determinants of Lung Functions (prediction)
- Race
- Age
- Gender
- Height
Factors Affecting Performance on Pulmonary Tests
- Motivation given to subject
- Position - standing optimal
- Illness - cold, allergy, etc.

Types of Pulmonary Disorders
- Restrictive - low lung volumes
  - Pulmonary fibrosis
  - Kyphoscoliosis
  - FVC < 80% of predicted
  - FEV1.0/FVC > 70% (normal for lower lung volume)
  - Inspiration limited by reduced compliance or weak inspiratory muscles

Types of Pulmonary Disorders
- Obstructive - low flow rates
  - Asthma
  - Bronchitis
  - Emphysema
  - FEV1.0/FVC < 70%

Pulmonary Screening
- Check for signs of restrictive disease:
  - Msd FVC/Pred FVC < 80%
  - Predict FVC - equation - Chp 4
  - Example
    - 30 yr old, female, 64 inches, FVC = 3.20, FEV1.0 = 2.5 L
    - Predicted FVC = (0.0414 x ht (cm) - (0.0232 x 30) - 2.2
    - FVC = (0.0414 x 162.6) - (0.0232 x 30) - 2.2
    - Predicted FVC = 3.83 L
    - 3.2/3.83 = .84 X 100 = 84% - normal

Pulmonary Screening
- Check for signs of obstructive disease:
  - msd FEV1.0/ msd FVC < 70%
  - 2.5/3.2 = .78 X 100 = 78%
  - Normal
  - Ok, so recheck in ....... years

Example
- Asian male, age 35 years, 63 in. tall
- FVC = 2.1 L
- FEV1.0 = 1.33 L
- Restrictive disease:
  - Predicted = 3.89 X 0.85 = 3.31 L
  - 2.14/3.31 = 64% (refer < 80%)
- Obstructive disease:
  - 1.33/2.1 = 62% (refer < 70%)
Flow Volume Loops
- Subject inspires to total lung capacity and then exhales as hard as he can to residual volume.
- Flow rate is independent of effort over most of the lung volume.
- High volumes - expiratory flow rate increases with effort but at med and low volumes, flow rate plateaus.
- WHY?????
  - Compression of airways by intrathoracic pressure.

Asthma
- Reversible, bronchospasm triggered by allergy, exercise, infections or environmental irritants.
- EIA (Exercise Induced Asthma) - epithelial water loss and cooling of airways.
- S/S - Increased secretion of nasal mucous, dry, nonproductive cough, wheezing, SOB.
EIA
- Most problematic – cold, dry environments
- 1984 Olympics Games in LA
  - 11% US team – chronic EIA
  - Won 41 medals

Bronchitis
- Inflammatory disorder of small airways in lung
- Common in smokers
- Productive cough, wheezing, reduced arterial O₂ saturation and increased CO₂ due to hypoventilation

Emphysema
- Gradual destruction of lung alveolar cell units and connective tissue and airway inflammation
- Enlargement of alveoli
- Loss of supporting tissue
- Airway collapse during expiration
- Total lung volume increases
- Dyspnea on exertion
- Limited functional capacity
- Arterial Desaturation

**Table 8-17. Dyspnea Scale**

<table>
<thead>
<tr>
<th>Description</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nothing</td>
<td>0</td>
</tr>
<tr>
<td>Very, very slight</td>
<td>0.5</td>
</tr>
<tr>
<td>Very slight</td>
<td>1</td>
</tr>
<tr>
<td>Slight</td>
<td>2</td>
</tr>
<tr>
<td>Moderate</td>
<td>3</td>
</tr>
<tr>
<td>Somewhat severe</td>
<td>4</td>
</tr>
<tr>
<td>Severe</td>
<td>5</td>
</tr>
<tr>
<td>Very severe</td>
<td>6</td>
</tr>
<tr>
<td>Very, very severe</td>
<td>7</td>
</tr>
</tbody>
</table>

Upper Body Resistance Training
- Important part of rehabilitation
- High reps, low intensity for arms and shoulders
- Coordinate breathing with motion
- Higher ventilation rates with upper body exercise
- Increase muscular endurance, decrease dyspnea and increase ability to perform ADL

EIA in Children
- 5-10% youth age 5-21 years affected by asthma
- Urban > rural
- Death rate – 5,000 annually
- Substernal chest pain
- Unnecessary decrease in PA
- Due to own or parental anxiety
- Under-recognized
Testing Protocol
- Abrupt exercise with little or no warm-up
- Bruce or Balke protocols not acceptable
- Goal: 80-90% APMHR during first 2-3 min of test
- Maintain 6-8 min
- PFT - before and after (2,5,10,15,20 min)
  - FEV₁₀
  - FEF₂₅-₇₅%
  - PEFR
- Assess reversibility by two albuterol inhalations 2-3 min apart and repeat PFT in 15 min

Testing Protocol
- 10-20% reduction in PEFR = EIA
  - Severity determined by decrease in FEV₁₀
    - Mild: 15-20% decrease
    - Moderate: 20-40% decrease
    - Severe: >40% decrease

Management of EIA
- 2 puffs albuterol 10-15 min before exercise
- Protective effect lasts 3-4 hours
- Proper warm-up (sports specific)
  - Low to high intensity
  - 5-10 min
- Nose-breathe – minimize airway cooling and dehydration

Refractory Periods
- 40-50% patients with EIA
- Induce through structured warm-up
- Most severe symptoms occur in first 6-10 min
- Spontaneously resolve
- Warm-up induce refractory period of diminished symptoms for up to 2 hours

Medications
- Quick-relief
  - Short-acting β₂-agonists - relief of acute symptoms
    - Regularly scheduled use is not recommended
    - 80% of patients attenuates symptoms
    - Effectiveness diminishes with regular use
  - Systemic corticosteroids - not respond to inhaler

Medications
- Corticosteroids – inhaled
- Cromolyn sodium – anti-allergic medication
  - Stop inflammation in response to allergens
- Long-acting β₂-agonists (Salmeterol)
  - Not treat acute symptoms
  - Works for 10-12 hours
  - Prevents release of substances in the body that cause inflammation
  - Bronchodilator
Medications
- Leukotriene modifiers (Zafirlukast)
  - Inhibits leukotrienes - role in inflammation and constriction of airway muscles

Concerns
- Arterial desaturation - ≤88% supplemental oxygen to maintain
  - \( S_O_2 \) at 90% or more during exercise
- Dyspnea scale during GXT
- Pursed-Lips Breathing - exhale twice as long as inhale
  - Decreased frequency
  - Increased TV
  - Improved sense of control over breathing distress and oxygenation