CARDIO-RESPIRATORY EXERCISE FITNESS
What does it really mean?

Dr. K.D.C. Upendra Wijayasiri (MBBS (SL), Dip.Spo.Med (col))
Sports Physician,
Head - Sports Medicine Unit,
Colombo South Teaching Hospital,
Kalubowila.

T.P: 0712415354
upendraanu@yahoo.com / upendra.wija@gmail.com
How a player comes to top?

Training

Physical fitness

Mental fitness
Components of Physical Fitness

**Physical Fitness** is divided into five **Health-Related** and six **Skill-Related** components.

- Cardiorespiratory Fitness
- Muscular Strength
- Muscular Endurance
- Flexibility
- Body Composition
- Agility
- Balance
- Power
- Speed
- Coordination
- Reaction Time
CARDIO-RESPIRATORY EXERCISE FITNESS
Cardio-Respiratory fitness

Respiratory component
Cardio-Respiratory fitness
Cardiac component
Cardio- Respiratory fitness
Muscle cell component

Figure 1—Interplay between the cardiorespiratory system and skeletal muscle which determines both O2 supply and demand.
Cardio-Respiratory fitness
Mitochondrial component
CARDIO-RESPIRATORY EXERCISE FITNESS TESTING (CPET)
CPET - how do we measure it?

• By using a “cycle ergometer” (COSMED – Italy)
• Sports medicine unit, CSTH and Department of physiology, Faculty of medical sciences, USJP
• Elite athletes, Clinical patients
• Total duration 8-12 min
• Stages typically 1-3 min in length
• Exercise intensity increased by 25 – 50 W or <5-8% of $VO_2_{\text{max}}$ per stage, at least towards end of test
The CPET laboratory
Measurements during CPET

1. Work rate : METs, Watts
2. Metabolic exchange : VO$_{2\text{max}}$, VCO$_{2\text{max}}$, RER, AT, Blood lactate level
3. Cardiovascular : HR, ECG, BP
4. Respiratory : Pulmonary function tests
5. Respiratory gas exchange : SpO$_2$
6. Symptoms : dyspnea, fatigue, chest pain
Maximal $O_2$ uptake ($VO_2\text{max}$)

• The highest rate of whole-body oxygen uptake ($VO_2$) achievable during exercise that utilizes a large muscle mass (e.g., running).

• An intrinsic biological characteristic of an individual at any particular point in time.
# Sports classification on CVS demand

<table>
<thead>
<tr>
<th>Low (20% MVC)</th>
<th>Moderate (40%-70% O2max)</th>
<th>High (&gt;70% VO2max)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Low (&lt; 40% VO2max)</strong></td>
<td>Body building, wrestling</td>
<td>Cycling, triathlon, decathlon, rowing, boxing</td>
</tr>
<tr>
<td>Throwing events, gymnastics, martial arts, climbing</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Moderate (20-50% MVC)</strong></td>
<td>Sprint running, jumping, rugby, short distance swimming,</td>
<td>Middle distance running, basketball, middle distance swimming</td>
</tr>
<tr>
<td>Archery, diving, auto sports</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>High (&gt; 50% MVC)</strong></td>
<td>Table tennis, volley ball</td>
<td>Long distance running, race</td>
</tr>
<tr>
<td>Cricket, billiards, golf, riflery</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
VO$_2$\text{max} – why is it important?

- VO$_2$\text{max} is the best overall measure of cardiovascular fitness

- Sets the upper limit to the production of energy (ATP) via aerobic metabolism (i.e., mitochondrial respiration).

- Adequately high VO$_2$\text{max} is a necessary but not a sufficient condition to be an elite endurance athlete.
$\text{VO}_2\text{max}$ in different groups of athletes
**VO₂ max – what determines it?**

- The primary limiting factor to VO₂ max is maximal cardiac output, and in particular, **maximal stroke volume**.

\[
VO₂ max = (Hr_{max}) \times (Sv_{max}) \times (a-vO₂diff_{max})
\]
Relationship between $VO_{2\text{max}}$ and maximal cardiac output
Role of genetics in determining baseline $\text{VO}_2\text{max}$
Role of genetics in determining trainability of VO$_{2\text{max}}$

### VO2max - Elite Athletes

<table>
<thead>
<tr>
<th>VO2max (ml/kg/min)</th>
<th>Athlete</th>
<th>Sport</th>
</tr>
</thead>
<tbody>
<tr>
<td>96.0</td>
<td>Espen Harald Bjerke</td>
<td>Norwegian Cross-Country Skier</td>
</tr>
<tr>
<td>92.5</td>
<td>Greg LeMond</td>
<td>US Professional Cyclist</td>
</tr>
<tr>
<td>88.0</td>
<td>Miguel Indurain</td>
<td>Professional Cyclist</td>
</tr>
<tr>
<td>84.4</td>
<td>Steve Prefontaine</td>
<td>U.S. Runner</td>
</tr>
<tr>
<td>84.0</td>
<td>Lance Armstrong</td>
<td>Professional Cyclist</td>
</tr>
<tr>
<td>83.0</td>
<td>Christian Goy</td>
<td>NCAA 1-mile indoor champion</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>VO2max (ml/kg/min)</th>
<th>Athlete</th>
<th>Sport</th>
</tr>
</thead>
<tbody>
<tr>
<td>78.6</td>
<td>Joan Benoit Samuelson</td>
<td>1984 Olympic Marathon Champ</td>
</tr>
<tr>
<td>76.6</td>
<td>Benti Skari</td>
<td>XC Skier</td>
</tr>
<tr>
<td>73.3</td>
<td>Greta Waitz</td>
<td>Marathon Runner</td>
</tr>
<tr>
<td>71.2</td>
<td>Ingrid Kristiansen</td>
<td>Ex-Marathon world record holder</td>
</tr>
<tr>
<td>65.0</td>
<td>Laura Wheatley</td>
<td>Who’s that??</td>
</tr>
</tbody>
</table>
**VO$_2$max – how do you train it?**

- At least/especially in untrained persons, “ordinary” endurance exercise training, if of sufficient intensity (i.e., >50-60% of VO$_2$max), frequency, and duration will lead to an improvement in VO$_2$max, but

- As an individual becomes more fit, it becomes progressively harder and harder to elicit further improvement, necessitating that the exercise intensity be increased if any further gains are to be achieved.
Changes in VO$_2$max over time in a world class team pursuit cyclist

<table>
<thead>
<tr>
<th>Date</th>
<th>Phase of preparation</th>
<th>Mass (kg)</th>
<th>VO$_2$peak (L/min)</th>
<th>VO$_2$max (ml/kg/min)</th>
<th>Wmax (W)</th>
<th>Wmax (W/kg)</th>
<th>HRpeak (beats/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>September 1993</td>
<td>Start of general preparation</td>
<td>72.95</td>
<td>5.42</td>
<td>74.3</td>
<td>456</td>
<td>6.25</td>
<td>212</td>
</tr>
<tr>
<td>December 1993</td>
<td>After 4 months aerobic base training</td>
<td>71.30</td>
<td>5.69</td>
<td>79.8</td>
<td>482</td>
<td>6.76</td>
<td>209</td>
</tr>
<tr>
<td>May 1994</td>
<td>1 wk prior to National Championships</td>
<td>72.40</td>
<td>6.14</td>
<td>84.8</td>
<td>496</td>
<td>6.85</td>
<td>201</td>
</tr>
<tr>
<td>November 1995</td>
<td>After 3 months aerobic base training</td>
<td>72.50</td>
<td>5.81</td>
<td>80.1</td>
<td>488</td>
<td>6.73</td>
<td>206</td>
</tr>
<tr>
<td>December 1996</td>
<td>After 4 months aerobic base training</td>
<td>74.10</td>
<td>5.87</td>
<td>79.2</td>
<td>490</td>
<td>6.61</td>
<td>205</td>
</tr>
<tr>
<td>August 1997</td>
<td>2 wk prior to World Championships</td>
<td>71.70</td>
<td>6.24</td>
<td>87.0</td>
<td>508</td>
<td>7.08</td>
<td>205</td>
</tr>
<tr>
<td>May 1999</td>
<td>1 wk prior to National Championships</td>
<td>70.30</td>
<td>6.20</td>
<td>88.2</td>
<td>505</td>
<td>7.18</td>
<td>204</td>
</tr>
</tbody>
</table>

VO$_2$peak: peak oxygen uptake; W$_{max}$: maximal workload; HR$_{peak}$: peak heart rate.

VO2max and sports performance

The graph illustrates the relationship between running velocity (km/h) and oxygen uptake (ml/kg/min) for two athletes. Athlete A has a VO2max of 70-ml/kg/min, while Athlete B has a VO2max of 60-ml/kg/min. The graph shows that as running velocity increases, oxygen uptake also increases. The velocity at VO2max (95% VO2max for both) is indicated on the graph.
Training program:

• Running “all-out” for 40 min/d, 3 d/wk.

• Cycling (on an ergometer) 6 x 5 min on, 2 min off, 3 d/wk. Power during intervals set so that subject achieved VO$_2$max during each effort.

**VO₂max** increases with age, training distance and with training experience

- However, after attaining the plateau of VO₂max, the increases in performance can still be found in athletes.
Thank you!