The Exercise Prescription: The Basics to Get You Going

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STUDIES IN MUSCULAR ACTIVITY. III. Dynamical changes occurring in man at work\textsuperscript{1}.

BY A. V. BOCK, C. VANCAULAERT, D. B. DILL\textsuperscript{2}, A. FÖLLING AND L. M. HURXTHAL.

(From the Medical Laboratory of the Massachusetts General Hospital, Boston.)

\textbullet J Physiol 1928; 66:136
Exercise Response

After Wasserman, et al. 2000
Types of Training

• Static
• Dynamic
• High-Intensity Interval (HIT)
### Classification of training type by sport
(adapted from Mitchell et al. 2)

<table>
<thead>
<tr>
<th>Dynamic component</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Golf</td>
<td>Baseball</td>
<td>Hockey</td>
<td></td>
</tr>
<tr>
<td>Cricket</td>
<td>Fencing</td>
<td>Long distance running</td>
<td></td>
</tr>
<tr>
<td>Bowling</td>
<td>Volleyball</td>
<td>Football (soccer)</td>
<td></td>
</tr>
<tr>
<td>Archery</td>
<td>American football</td>
<td>Middle distance running</td>
<td></td>
</tr>
<tr>
<td>Diving</td>
<td>Jumping events</td>
<td>Swimming</td>
<td></td>
</tr>
<tr>
<td>Equestrian</td>
<td>Sprinting</td>
<td>Basketball</td>
<td></td>
</tr>
<tr>
<td>Throwing events</td>
<td>Rugby</td>
<td>Ice hockey</td>
<td></td>
</tr>
<tr>
<td>Weight lifting</td>
<td>Figure skating</td>
<td>Cross country skiing</td>
<td></td>
</tr>
<tr>
<td>Gymnastics</td>
<td>Downhill skiing</td>
<td>Cycling</td>
<td></td>
</tr>
<tr>
<td>Martial arts</td>
<td>Body building</td>
<td>Triathlon</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Snowboarding</td>
<td>Rowing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wrestling</td>
<td>Boxing</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Canoe/kayak</td>
<td></td>
</tr>
</tbody>
</table>
$\dot{V}O_2$ = $Qt (Ca - \ddot{v}O_2)$
VO₂max Trainability and High Intensity Interval Training in Humans: A Meta-Analysis.

- healthy sedentary/recreationally active humans
- <45 yrs old,
- training duration 6-13 weeks
- e3 days/week
- e10 minutes of high intensity work
- e1:1 work/rest ratio
VO₂max Trainability and High Intensity Interval Training in Humans: A Meta-Analysis.

Cardiac Output

\[
\dot{V}O_2 = Qt (Ca-\bar{v}O_2)
\]

Trained

Detrained

NI slope = 5-6 ml/ml
<table>
<thead>
<tr>
<th></th>
<th>Dynamic</th>
<th>Static</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac Output</td>
<td>↑↑</td>
<td></td>
</tr>
<tr>
<td>MAP</td>
<td>↑</td>
<td>↑↑</td>
</tr>
<tr>
<td>SVR</td>
<td>↓</td>
<td>↑↑</td>
</tr>
<tr>
<td>Load</td>
<td>Volume</td>
<td>Pressure</td>
</tr>
<tr>
<td>Remodeling</td>
<td>Eccentric</td>
<td>Concentric</td>
</tr>
<tr>
<td>Ventricular compliance</td>
<td>↑</td>
<td>↓</td>
</tr>
<tr>
<td>LVEF</td>
<td>0↓</td>
<td>0</td>
</tr>
</tbody>
</table>
Biventricular Filling Pressures as a Function of Training

Minute Ventilation

Minute Ventilation (MVV)

\[ \text{VE} \ (L/\text{min}) \]

\[ \text{VO}_2 \ (L/\text{min}) \]

Trained

Detrained

Reserve

MVV

40

140
Effects of high-intensity interval training on pulmonary function

<table>
<thead>
<tr>
<th></th>
<th>Pre-training</th>
<th>Post-training</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Endurance (n = 7)</td>
<td>HIT (n = 8)</td>
</tr>
<tr>
<td>PEF (l/s)</td>
<td>6.27 ± 2.13</td>
<td>6.14 ± 1.61</td>
</tr>
<tr>
<td>FEF&lt;sub&gt;25-75&lt;/sub&gt;% (l/s)</td>
<td>3.19 ± 0.83</td>
<td>3.66 ± 0.55</td>
</tr>
<tr>
<td>FVC (l)</td>
<td>3.44 ± 0.95</td>
<td>3.52 ± 0.71</td>
</tr>
<tr>
<td>FEV&lt;sub&gt;1&lt;/sub&gt; (l)</td>
<td>4.39 ± 1.27</td>
<td>4.24 ± 0.96</td>
</tr>
<tr>
<td>FEV&lt;sub&gt;1&lt;/sub&gt;/FVC (%)</td>
<td>78.7 ± 2.5</td>
<td>83.7 ± 5.1</td>
</tr>
</tbody>
</table>

Cali Dunham • Craig A. Harms
Eur J Appl Physiol (2012)
112:3061–3068
DOI 10.1007/s00421-011-2285-5
Respiratory Muscle Blood Flow Steal

Arterial Oxygenation

\[ \dot{V}O_2 = Q_t (C_a - \bar{V}O_2) \]

Endurance Athlete

Normal

\[ 100 \text{ ml/dl} \]

\[ 75 \text{ ml/dl} \]

\[ \dot{V}O_2 \text{ (L/min)} \]
Figure 1. Individual arterial blood gas response to maximal exercise test. 

\( P_{aO_2} \) (mmHg); \( P_{aCO_2} \) (mmHg); alveolar-to-arterial oxygen difference; \( S_{aO_2} \) (%); oxygen consumption.

Dominelli P B et al. J Physiol 2013;591:3017-3034
Distribution of Cardiac Output

Blood Flow (L/min)

Rest VO2max

Muscle
Other
Renal
Splanchnic
Coronary

High VEmax./MVV
Skeletal Muscle

\[ \dot{V}O_2 = \dot{Q}t \left( C_a - \bar{v}O_2 \right) \]

\( C\bar{v}O_2 \) (mL/dL)

\[ 15 \]

\[ 5 \]

\[ 1.0 \]

\[ 3.0 \]

Detraining

Normal
Muscle metabolic responses during high-intensity intermittent exercise measured by $^{31}$P-MRS

Tlim (s) 304 ± 68 ……………….. 847 ± 240

Cardiac output max and skeletal muscle oxygenation after 2 weeks of HIT

Muscle oxidative enzymes after low volume sprint interval and traditional endurance training in humans.

Muscle fuel oxidation after low volume sprint interval and traditional endurance training in humans.
Training Adaptations
Cardiac

- Good:
  - Increased QT via stroke volume
  - Increased LV EDV
  - LV EF same to lower
  - Filling pressures decreased
  - SVR decreased
Training Adaptations
Cardiac

- Bad:
  - Electrical remodeling
  - Arrhythmias
  - Orthostatic HoTN
  - ?RV fibrosis
Training Adaptations
Pulmonary

• **Good:**
  - Increased respiratory muscle strength
  - Decreased RM metaboreflex
  - Less respiratory muscle steal
  - Increased perfusion of limb muscle

• **Bad**
  - Arterial $O_2$ desaturation
Training Adaptations
Skeletal Muscle

- **Good:**
  - Increased mitochondria
  - Increased capillary density
  - Increased oxidative capacity
  - Fat > CHO
  - Increased endurance
Training Response

After Wasserman, et al 2000
Training Guidelines (FITT)

- training duration > 6 weeks
- 3-5 days/week
- e10 minutes of high intensity work
- e1:1 work/rest ratio
- <10h week?