METABOLIC COST OF EXPERIMENTAL EXERCISES

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INTRODUCTION

- 8 activities performed during 17 altitude decompression sickness (DCS) protocols at Brooks City-Base, TX from 1983-2005
- Determination of metabolic cost of activity during nearly all of those subject-exposures was not accomplished
  - Equipment, interest, and funding limitations
- Subject activities during each minute of exposure were documented and consistent
- Isometric leg, isometric arm, dynamic leg, and dynamic arm exercises were tested at an equivalent metabolic cost - No difference in DCS risk
  - Mode of activity not the major factor
BACKGROUND & METHODS

• Potential relationship between metabolic cost and DCS risk postulated late in the research
  – Approximation of metabolic cost vs. DCS incidence in 4 profiles
  – Same altitude, time at altitude, and prebreathe time (3 of 4 primary DCS risk factors)
  – Metabolic cost and DCS incidence appeared to be correlated
• Needed method for measuring metabolic cost
  – Ability to do the different activities consecutively w/o interruption
  – COSMED K4b² used by NASA for sub-maximal metabolic cost determinations
    » Breath-by-breath; $\text{VO}_2$; 30-sec averages
    » Seated rest control before each sequence of activity
SUBJECTS

- 22 [of the 30 planned] subjects performed the identical exposure activities at ground level in the same chamber used for the earlier altitude exposures.

- The protocol and informed consent were approved by the NASA JSC Committee for the Protection of Human Subjects and the Wright Patterson AFB Institutional Review Board.

<table>
<thead>
<tr>
<th>Age, y</th>
<th>Weight, kg</th>
<th>Height, in</th>
<th>Height, m</th>
<th>BMI</th>
<th>BF, %</th>
<th>VO2max, l/min</th>
<th>VO2max, ml/kg/min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject Mean</td>
<td>29.8</td>
<td>158.8</td>
<td>68.0</td>
<td>1.7</td>
<td>24.1</td>
<td>18.0</td>
<td>2.9</td>
</tr>
<tr>
<td>Database Mean</td>
<td>30.1</td>
<td>172.3</td>
<td>69.0</td>
<td>1.8</td>
<td>25.4</td>
<td>19.3</td>
<td>3.2</td>
</tr>
</tbody>
</table>
RESULTS

• Plotted vs. DCS during 4-h exposures to 30,000 ft following a 1-h prebreathe
• Parameters evaluated throughout each activity sequence
  – Mean $V_O_2$ (R<0.50)
  – Mean Increase in $V_O_2$ from seated rest control (R<0.43)
  – Mean % of $V_O_2_{peak}$ (R<0.50)
• Parameters evaluated during the highest 1-min of each activity sequence
  – Mean $V_O_2$ and Mean kcal/h (R<0.87)
  – Mean Increase in $V_O_2$ from seated rest control (R<0.86)
  – Mean % of $V_O_2_{peak}$ (R<0.90)
## CORRELATIONS

% DCS vs. Percentage of VO2peak represented by the Highest Metabolic Cost in any 1 min; N=22

\[ y = 0.0038x + 0.0552 \]

\[ R^2 = 0.804 \]

\[ R = 0.90 \]
DISCUSSION

• The correlation between DCS incidence and the highest 1-min metabolic cost or as a percentage of $\text{VO}_2\text{peak}$ being much better than that between DCS incidence and average metabolic cost or average percentage of $\text{VO}_2\text{peak}$ was unexpected.

• Possible reasons
  – Bubble formation resulting from more active muscle metabolism while decompressed
  – Muscle shear forces being greater during short-term relatively heavy exertion

• Possible implications
  – Measurement of $\text{VO}_2$ during a little as 1-min of an activity peak exertion may be a good DCS risk prediction tool based on % of $\text{VO}_2\text{peak}$
  – Beware of even short-term, high physical stress activity while decompressed
  – Plan for higher activity after additional exposure time (denitrogenation time)
PLANS

- The Brooks DCS Research database contains no exposures below 35,000 ft which required only seated rest and echo-imaging joint articulations.

- A prediction of significantly lower DCS risk for seated rest and echo-imaging joint articulations is implied by using data from the current research.

- Future research could include seated rest exposures and echo-imaging joint articulations at altitudes where analogous prebreathe and exposure durations could test the hypothesis that lower level (metabolic cost) activities would yield much less DCS risk.
  - 22,500, 25,000 ft, and 30,000 ft

- Update of the USAF Altitude DCS Risk Assessment Computer model may also be possible using the current data.

- Inclusion of these finding could improve DCS prediction using a NASA model.
CONCLUSIONS

- Correlation between average metabolic cost and DCS risk was poor
- There was a very good correlation between short-term higher level physical activity and DCS risk
  - Highest 1-min segment; Correlation = 0.90
- Prediction of DCS risk based on 1-min spikes in VO$_2$ may be a useful tool in planning decompression activity scenarios
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