Forearm muscle tissue re-oxygenation kinetics in male sport rock climbers

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Why assess oxygenation recovery in the forearms?

- Many markers of stress appear to be physiological not psychological

- Assess markers of oxidative recovery with respect to strength and endurance performance

- Underpinning physiology for strength and conditioning coaches

- Understanding muscle recovery is important for repeated bouts of climbing
Finger plate attached to strain gauge
“Open crimp” position with fingers flexed at proximal interphalangeal joint
Wrist plate
Steel supporting structure
NIRS optodes attached to forearm (without covering cloth)
Adjustable elbow rest

Point of set square placed on acromion process to check angle of upper arm
Set square
Finger force plate
Upper arm horizontally adducted 60° relative to shoulder girdle axis
Shoulder girdle of participant
Acromion process

LED Source
Photo Detector
Near-Infrared
Human Tissue

MacLeod et al., (2007)
MacLeod et al., (2007)

- Male on-sight 7a+

- Climbers had a significantly greater MVC than non-climbers.

- The force time integral was significantly greater in climbers vs. non-climbers during the intermittent but not sustained contraction.

- Re-oxygenation during 3s recovery periods explained 41% of the variance between groups.
Philippe et al., (2011)

Male on-sight 7c+, Female on-sight 7c

- Climbers had a significantly greater MVC, as did men vs. women.

- Climbers had a significantly greater force time integral compared to non-climbers for intermittent and sustained contractions.

- Climbers had a significantly faster re-oxygenation during 3s rest periods.
## Strength and endurance characteristics

Mean (SD), $F$ and $P$ values for forearm strength and endurance characteristics in all ability groups.

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Intermediate</th>
<th>Advanced</th>
<th>Elite</th>
<th>One-way ANOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td>F value</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(df 3,37)</td>
</tr>
<tr>
<td>Sustained Force</td>
<td>10799 (5882)</td>
<td>17319 (5933)</td>
<td>16826 (7435)</td>
<td>15605 (4830)</td>
<td>2.199</td>
</tr>
<tr>
<td>Integral</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intermittent</td>
<td>25524 (16000)</td>
<td>33717 (7646)</td>
<td>31990 (11463)</td>
<td>53252 (29981)*</td>
<td>3.853</td>
</tr>
<tr>
<td>Force Time</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integral</td>
<td>MVC (N)/body mass</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(kg)</td>
<td>3.2 (1)</td>
<td>3.4 (0.6)</td>
<td>4.2 (0.6)</td>
<td>5.9 (1.8)*, <strong>,</strong></td>
<td>10.986</td>
</tr>
</tbody>
</table>

NB: % variance is the estimated variance explained by the mean effects within each group for the named variable. NS is non-significant.
* Shows the group is significantly different ($p< 0.05$) from the control group
** Shows the group is significantly different ($p< 0.05$) from the intermediate group
*** Shows the group is significantly different ($p< 0.05$) from the advanced group
Time to recovery

Assessment by muscle group:
- Flexor digitorum profundus
- Flexor carpi radialis

Legend:
- Control
- Intermediate
- Advanced
- Elite
Time to half recovery

* Shows the group is significantly different ($p<0.05$) from the control group
** Shows the group is significantly different ($p<0.05$) from the intermediate group
*** Shows the group is significantly different ($p<0.05$) from the advanced group

- Flexor digitorum profundus
- Flexor carpi radialis
Per second recovery ($\frac{1}{2} T$)

* Shows the group is significantly different ($p< 0.05$) from the control group
** Shows the group is significantly different ($p< 0.05$) from the intermediate group
*** Shows the group is significantly different ($p< 0.05$) from the advanced group
Summary

• Higher level climbers have a greater oxidative capacity compared to non-climbers and lower level climbers.
• Oxidative capacity in the FDP and FCR may be trainable.
• Higher level climbers have a decreased time to half recovery.
• PCr re-synthesis may be faster in climbers compared to non-climbers.
Future studies

• To assess the effectiveness of different strength and conditioning programmes to oxidative capacity.
• Use NIRS to assess the effects of blood volume changes across groups.
• To assess mitochondrial function in the FDP and FCR in multiple ability groups.
• To use NIRS to observe blood flow and oxygenation kinetics under different forms of contractions using control, intermediate, advanced and elite groups.
References
