Internal responsiveness of two methods for assessing maximal strength and peak rate of force development in amateurs lead climbers

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Every instrument (i.e. measures or indicator tool) must possess some key attributes before can be used as dependent variable in a study:

1) Conceptual and measurement model
2) Validity
3) Reliability
4) Responsiveness
5) Interpretability
Strength measurement in sport climbing studies

General

Specific
dynamometers

handgrip

Grant et al. 1996

Watts et al. 2003

MacLeod et al. 2007

Background
<table>
<thead>
<tr>
<th>Attribute</th>
<th>Hand grip</th>
<th>Specific dynam.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conceptual model</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Validity</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Reliability</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Responsiveness</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>Interpretability</td>
<td>?</td>
<td>?</td>
</tr>
</tbody>
</table>
Internal responsiveness is the ability to detect changes in the variable measured over specific time frame \((Husted, 2000)\).
Isometric maximal voluntary contraction (MVC) of the finger flexors has been suggested to be a determinant in sport climbing performance.

(Fanchini et al, proceedings ECSS 2010)
Isometric maximal voluntary contraction (MVC) of the finger flexors has been suggested to be a determinant in sport climbing performance.

The peak of rate force development (pRFD) can be more appropriate than MVC for evaluating neuromuscular characteristics.

(Fanchini et al, proceeding ECSS 2010)

(Watts, 2004)
The aim of this study was to assess and compare the internal responsiveness of MVC and pRFD measured with a specific climbing dynamometer (SCD) and handgrip (HG) in amateur sport climbers.
Participants
(n=23 amateur)

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>32 ± 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height (cm)</td>
<td>177 ± 8</td>
</tr>
<tr>
<td>Weight (Kg)</td>
<td>67 ± 8</td>
</tr>
<tr>
<td>Experience (years)</td>
<td>10</td>
</tr>
</tbody>
</table>

Climbing ability (French scale)
“on-sight”
“after-works”
6a-8a
6b+-8b

Classified (Brent et al 2009)
intermediate - advanced

Table I. Climbing ability conversion table

<table>
<thead>
<tr>
<th>Climbing level</th>
<th>Study score</th>
<th>Sport grade</th>
<th>British technical grade</th>
<th>Fontainebleau bouldering grade</th>
<th>Yosemite decimal system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Novice</td>
<td>1</td>
<td>≤4+-</td>
<td>≤4b</td>
<td>≤4</td>
<td>≤5.8</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>4c</td>
<td></td>
<td>4+</td>
<td>5.9</td>
</tr>
<tr>
<td>Intermediate</td>
<td>3</td>
<td>5+</td>
<td>5a</td>
<td>5</td>
<td>5.10a</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>6a to 6a+</td>
<td>5b/5c</td>
<td>5+</td>
<td>5.10b to 5.10c</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>6b</td>
<td>5c</td>
<td>6a</td>
<td>5.10d</td>
</tr>
<tr>
<td>Advanced</td>
<td>6</td>
<td>6b+ to 6c+</td>
<td>6c/6a</td>
<td>6a+</td>
<td>5.11a to 5.11c</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>7a to 7b</td>
<td>6a/6b</td>
<td>6b to 6b+</td>
<td>5.11d to 5.12b</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>7b+ to 7c</td>
<td>6b/6c</td>
<td>6c to 6c+</td>
<td>5.12c to 5.12d</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>7c+</td>
<td>6c</td>
<td>7a to 7a+</td>
<td>5.13a</td>
</tr>
<tr>
<td>Elite</td>
<td>10</td>
<td>8a</td>
<td>6c/7a</td>
<td>7b to 7b+</td>
<td>5.13b</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>8a+ to 8b</td>
<td>6c/7a</td>
<td>7c to 7c+</td>
<td>5.13c to 5.13d</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>8b+ to 8c</td>
<td>7a/7b</td>
<td>8a to 8a+</td>
<td>5.14a to 5.14b</td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>8c+</td>
<td>7b</td>
<td>8b to 8b+</td>
<td>5.14c</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>≥9a</td>
<td>7b</td>
<td>8c to 8c+</td>
<td>≥5.14d</td>
</tr>
</tbody>
</table>

(Brent et al.2009)
## Measurement tools

![Parallelogram load cell](image)

## Reliability

<table>
<thead>
<tr>
<th></th>
<th>Typical error% (90% CI)</th>
<th>ICC (90% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Specific climbing dynamometer</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MVC</td>
<td>7 (5 to 10)</td>
<td>0.94 (0.85 to 0.97)</td>
</tr>
<tr>
<td>pRFD</td>
<td>16 (12 to 24)</td>
<td>0.83 (0.63 to 0.93)</td>
</tr>
<tr>
<td><strong>Handgrip</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MVC</td>
<td>5 (3 to 6)</td>
<td>0.95 (0.88 to 0.98)</td>
</tr>
<tr>
<td>pRFD</td>
<td>9 (7 to 13)</td>
<td>0.92 (0.80 to 0.96)</td>
</tr>
</tbody>
</table>

*Fanchini et al. 2011, Communication to 16th ECSS congress, Liverpool, UK*
Methods

Instructions

MVC
“as hard as possible”

pRFD
“as hard as quick as possible”
Methods

Design

PRE
2 SCD-MVC
2 SCD-pRFD
1 HG-MVC
1 HG-pRFD
(2 min recovery)

POST
2 SCD-MVC
2 SCD-pRFD
1 HG-MVC
1 HG-pRFD
(2 min recovery)
Position

SCD: subject was seated on a chair with forearm vertical to the base of dynamometer and elbow arranged at 90° with a strap secured at the level of arm.

“open-crimp position”
Position

SCD: subject was seated on a chair with forearm vertical to the base of dynamometer and elbow arranged at 90° with a strap secured at the level of arm.

HG: subject was seated on a chair with the elbow extended laterally to the body.

"open-crimp position"
Route characteristics

Overhanging wall
11m height
15m development
grade 7b+ (French scale)
N° hand holds 47
Assessment: International Route Setter
Climbing modality: “flash”
Statistical analysis

• Data were normalized to body mass and Log-transformed.

• The strain-gauge signal was smoothed by a digital zero-lag Butterworth filter, cut-off 15 hz (MATLAB 7.0). (Andersen & Aagaard, 2006).

• MVC (N/Kg) was defined as the highest peak torque.

• pRFD (Nm/Kg/s) was defined as the slope of the torque-time curve (i.e. D torque/D Time) from the onset of contraction (Andersen & Aagaard, 2006).

• Onset of muscle contraction was defined as the instant when torque exceeded the baseline by 2.5% of the MVC.
Methods

Statistical analysis

• Percentage changes after the route (90% CI).

• Internal responsiveness (±90%CI):

  Cohen’s effect size
  \[ ES = \frac{(\bar{X}_{\text{posttest}} - \bar{X}_{\text{pretest}})}{SD_{\text{baseline}}} = \frac{(\bar{X}_{\text{posttest}} - \bar{X}_{\text{pretest}})}{\sqrt{\sigma_p^2 + \sigma_e^2}} \]

  standardize response mean (SRM)
  \[ SRM = \frac{(\bar{X}_{\text{post}} - \bar{X}_{\text{pre}})}{SD_{\text{change}}} = \frac{(\bar{X}_{\text{post}} - \bar{X}_{\text{pre}})}{\sqrt{\sigma_p^2 \times r + 2\sigma_e^2}} \]

  signal-to-noise ratio (S/N)
  \[ ES_{SEM} = \frac{(\bar{X}_{\text{posttest}} - \bar{X}_{\text{pretest}})}{\sigma_e} \]

(Husted et al, 2000; Norman et al, 2007; Amman et al, 2009)
Results

Changes after-climbing

![Graph showing percentage changes in HG-pRFD, HG-MVC, SCD-pRFD, and SCD-MVC after climbing. The x-axis represents percentage changes (90% CI), and the y-axis represents the different measures. The graph indicates changes in performance metrics before and after the climbing activity.]
Results

Internal responsiveness
Cohen’s effect size
Internal responsiveness
standardize response mean

Results
Internal responsiveness
signal to noise ratio
The decline of all measurements confirmed the occurrence of muscle fatigue.

The SCD-pRFD showed higher ES and SRM.

The S/N for HG-MVC was higher compared to HG-pRFD due to its higher reliability (typical error as CV was 5 and 9%, respectively).

The pRFD can be more appropriate compared to MVC in the specific (SCD) assessment for investigating fatigue in climbing activity.

Since the SCD showed construct validity (i.e. performance as construct) [5] and face validity (as more closely mimic the climbing grip styles), the SCD-pRFD should be considered appropriate to investigate muscle fatigue in sport climbing.
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Acknowledgements:

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Thank you for the attention

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