Geometric Entropy During Rock Climbing – Lead vs Top-Rope Ascents


School of Health and Human Performance
Northern Michigan University
Marquette, Michigan USA
Contemporary Theoretical Performance Model

- High Strength: Mass
- Fast RFD in Muscle
- Anaerobic Power?
  Explosive (CrP) Power for some moves
- Hip & Shoulder Flexibility?
- Economy?
- Fatigue Resistance
- VO$_2$max
  40-50 ml·kg$^{-1}$·min$^{-1}$
- Fatigue Resistance
- Climbing-Specific
  ↑Muscle Capillarity?
<table>
<thead>
<tr>
<th></th>
<th>Ascent 1</th>
<th>Ascent 4</th>
<th>Ascent 6</th>
<th>Ascent 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>EE Climbing (kcal)</td>
<td>17.0 ±5.1</td>
<td>14.6 ±5.0</td>
<td>13.2 ±4.5*</td>
<td>11.5 ±3.2*#</td>
</tr>
<tr>
<td>EE Recovery (kcal)</td>
<td>31.0 ±4.7</td>
<td>34.7 ±6.5</td>
<td>33.2 ±5.8</td>
<td>32.2 ±4.7</td>
</tr>
<tr>
<td>EE Total (kcal)</td>
<td>48.0 ±8.2</td>
<td>49.3 ±11.1</td>
<td>46.4 ±10.0</td>
<td>43.7 ±6.3#</td>
</tr>
</tbody>
</table>

*Significantly different from Ascent 1.
#Significantly different from Ascent 4.

**Blue** – Line of Motion (LM)

**Red** – Convex Hull (c)

\[
GE = \ln \frac{2 \times LM}{c}
\]
• Artificial route, 10 m height, 5.10a/6a/18.
• Point at center of climber’s back digitized.
• 10 repetitions with 1 min rest between.
• GE decreased with repetition.
• GE plateau by rep 3.
<table>
<thead>
<tr>
<th></th>
<th>Ascent 1</th>
<th>Ascent 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geometric Entropy</td>
<td>1.142 ±0.138</td>
<td>0.930 ±0.139*</td>
</tr>
<tr>
<td>EE Climbing (kcal)</td>
<td>17.4 ±4.2</td>
<td>13.2 ±4.5*</td>
</tr>
</tbody>
</table>

*Indicates significantly different from Ascent 1, p<.01

A psychophysiologicaal comparison of on-sight lead and top rope ascents in advanced rock climbers

5.11a/6c/22

Groups matched for age, gender, height & weight

Fig. 3. Mean VO₂ averaged between clips for top rope and lead climbs.
Purpose

Compare the Line of Motion and degree of Entropy during ascents under top-rope and lead conditions.
Methods

- Six experienced climbers (4♂, 2♀)
- Lead ability 5.8-5.11/5a-6c/15-22.
- 3 sport style ascents on outdoor sandstone rock.
  - Ratings ≈ 1-2 below best RP via YDS
  - Top-Rope (TR1)
  - Balanced order Lead (LD) and Top-Rope (TR2)
Methods

- High definition digital video recorded at 30 Hz.
- Single marker at center back of climber’s harness was manually digitized at 6 Hz (MaxTRAQ 2D ver 2.2)
Methods

- Geometric Entropy (GE) was calculated according to Sibella. et al.\(^2\):
  \[ GE = \ln^*((2*LM)/CH) \]
  where LM is the line of motion and CH is the value of the convex hull about the LM.

- Within subjects repeated measures ANOVA with Bonferroni post hoc testing; significance set at <0.05.
↑ GE 0.225 in LD

↑ GE 0.027 in LD

5.10a/6a/18 - 20 m - 9 bolts
# Results

<table>
<thead>
<tr>
<th></th>
<th>TR1</th>
<th>LD</th>
<th>TR2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line of Motion</td>
<td>79.7 ± 3.8</td>
<td>81.5 ± 4.6</td>
<td>77.6 ± 3.0</td>
</tr>
<tr>
<td>Geometric Entropy</td>
<td>0.96 ± 0.04</td>
<td>1.02 ± 0.06</td>
<td>0.92 ± 0.03</td>
</tr>
<tr>
<td>Time (min)</td>
<td>2.53 ± 0.84</td>
<td>3.01 ± 0.55</td>
<td>2.41 ± 0.71</td>
</tr>
</tbody>
</table>

No significant differences across ascent conditions.
Conclusions

- Geometric entropy does not differ between Lead and Top-Rope ascent conditions.
- Other factors may exert influence.
  - Small sample size (5 of 6 had ↑GE in LD)
  - Difficulty of route relative to climber ability
    - ↑GE may be higher in more skilled climbers\(^1\)
      (Cordier, et al. - skilled -7b, average – 6b, route – 6a)
- Is Economy an important consideration?