The Validity, Viability & Tolerability of a Gravity Loading Countermeasure Skinsuit (GLCS) during Ambulation & Resistance Exercise

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Disclosure Information

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I have no financial relationships to disclose.

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• Health Mentor, Nuffield Health

I will not discuss off-label use and/or investigational use in my presentation
Background

- Microgravity exposure precipitates:
  - Fluid shifts
  - Progressive bone loss
  - Muscular atrophy

- These can lead to increased risk of injury, decrease operational functionality and produce safety issues
- Current countermeasures provide some protection from microgravity but are insufficient for long term exploration
- Need for novel, low resource countermeasures
Countermeasures

Exercise

Lower Body Negative Pressure

Pingvin suit

GLCS
Aims

- Determine viability of GLCS Gz Loading
- Assess subjectively and objectively the GLCS’s feasibility and tolerability during joint motion, ambulation and resistance exercise on Earth
Methods

Eight young healthy participants (♂=5, ♀=3; 28±6 yrs; 183±10 cm; and 77±8 kg) in both GYM & GLCS conditions.

From ankle-yoke line every vertical 1cm measured circumferentially to ensure correct loading & material strain.
Methods

Gz (Pressure) Loading (TekScan):
- Pressure sensors on the:
  - Sole of feet & shoulder
  - when standing & self-suspended

Joint (range of) motion (Bubble Inclinometer):
- Shoulder, knee & spinal (yoke & T12) flexion/extension,
- hip abduction/adduction
Methods

- **Ambulation:**
  - Sit & Reach test
  - Get Up & Go (3m) test

- **Resistance exercise (3 sets of 12 1RM):**
  - Shoulder press, squat, chest/leg press, seated row, calf raise

- **Subjective ratings:** RPE, thermal comfort, movement discomfort and body control during exercise
Results: Gz Loading

GLCS produced significant Gz loading when standing and self-suspended
Results: Joint (range of) Motion & Ambulation

<table>
<thead>
<tr>
<th></th>
<th>Shoulder Flexion (deg)</th>
<th>Shoulder Extension (deg)</th>
<th>Spinal Flexion at Yoke (deg)</th>
<th>Spinal Extension at Yoke (deg)</th>
<th>Spinal Flexion at T12 (deg)</th>
<th>Spinal Extension at T12 (deg)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GYM</strong></td>
<td>183 ± 6</td>
<td>65 ± 4</td>
<td>143 ± 5</td>
<td>33 ± 3</td>
<td>82 ± 3</td>
<td>33 ± 3</td>
</tr>
<tr>
<td><strong>GLCS</strong></td>
<td><strong>149 ± 8</strong>*</td>
<td>51 ± 9</td>
<td><strong>105 ± 7</strong>*</td>
<td><strong>21 ± 5.7</strong>*</td>
<td><strong>56 ± 3</strong>*</td>
<td><strong>11 ± 1</strong>*</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Hip Abduction (deg)</th>
<th>Hip Adduction (deg)</th>
<th>Knee Flexion (deg)</th>
<th>Knee Extension (deg)</th>
<th>Sit and Reach (cm)</th>
<th>Get up and Go (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GYM</strong></td>
<td>60 ± 7</td>
<td>26 ± 3</td>
<td>113 ± 4</td>
<td>12 ± 1</td>
<td>27.7 ± 3.2</td>
<td>4.9 ± 0.1</td>
</tr>
<tr>
<td><strong>GLCS</strong></td>
<td><strong>48 ± 6</strong>*</td>
<td>26 ± 5</td>
<td><strong>100 ± 3</strong>*</td>
<td><strong>11 ± 1</strong>*</td>
<td><strong>14.9 ± 2.6</strong>*</td>
<td><strong>5.6 ± 0.2</strong>*</td>
</tr>
</tbody>
</table>

* Significant difference (α=0.05)
Results: Resistance Exercise – Rep’s & Subjective Ratings

- No significant differences in Thermal Comfort were reported during exercise.
- Only shoulder press activity was objectively and subjectively affected.

<table>
<thead>
<tr>
<th>Shoulder Press</th>
<th>GYM</th>
<th>GLCS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rating of Perceived Exertion</td>
<td>15</td>
<td>16</td>
</tr>
<tr>
<td>(Borg Scale 6-20)</td>
<td>(13.8-16.5)</td>
<td>(15.4-18.4)*</td>
</tr>
<tr>
<td>No. of Reps completed</td>
<td>12±0</td>
<td>9±3*</td>
</tr>
<tr>
<td>(3rd set ± SD)</td>
<td></td>
<td>* Significant difference (α=0.05)</td>
</tr>
</tbody>
</table>
### Results: Resistance Exercise – Subjective Ratings

<table>
<thead>
<tr>
<th>Movement Discomfort (3rd set) (0-10 Scale)</th>
<th>Shoulder Press</th>
<th>Squat</th>
<th>Chest Press</th>
<th>Seated Row</th>
<th>Leg Press</th>
<th>Calf Raise</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GYM</strong></td>
<td>2(1.3-2.7)</td>
<td>2(1.0-3.0)</td>
<td>2(0.5-3.5)</td>
<td>2(0.8-3.2)</td>
<td>2(0.8-3.2)</td>
<td>2(0.8-3.2)</td>
</tr>
<tr>
<td><strong>GLCS</strong></td>
<td><strong>8(6.7-9.3)</strong>*</td>
<td><strong>7(5.5-8.5)</strong>*</td>
<td><strong>6(5.2-7.8)</strong>*</td>
<td><strong>6(4.2-6.8)</strong>*</td>
<td><strong>6(4.6-7.3)</strong>*</td>
<td><strong>5(4.2-5.8)</strong>*</td>
</tr>
<tr>
<td><strong>Body Control (3rd set) (0-10 Scale)</strong></td>
<td><strong>Shoulder Press</strong></td>
<td><strong>Squat</strong></td>
<td><strong>Chest Press</strong></td>
<td><strong>Seated Row</strong></td>
<td><strong>Leg Press</strong></td>
<td><strong>Calf Raise</strong></td>
</tr>
<tr>
<td><strong>GYM</strong></td>
<td>2(1.4-2.6)</td>
<td>2(1.6-2.4)</td>
<td>2(1.2-2.8)</td>
<td>2(1.2-2.8)</td>
<td>2(1.2-2.8)</td>
<td>2(1.0-3.0)</td>
</tr>
<tr>
<td><strong>GLCS</strong></td>
<td><strong>7(5.8-8.2)</strong>*</td>
<td><strong>6(5.1-6.9)</strong>*</td>
<td><strong>5(3.9-6.1)</strong>*</td>
<td><strong>5(4.0-6.0)</strong>*</td>
<td><strong>5(3.7-6.3)</strong>*</td>
<td><strong>5(5.7-4.3)</strong>*</td>
</tr>
</tbody>
</table>

* Significant difference (α=0.05)
Conclusions

- Subjects experienced some issues with suit donning
- GLCS provided ~0.8Gz additional on Earth that differed when self-suspended
- Ambulation, movement & resistance exercise were viable & tolerable without the severe discomfort reported in Pingvin suit
- However, same work load was reported as more challenging
- Potential as a ‘daily dose’ or adjunct to exercise countermeasure both in microgravity or terrestrially
- However, given movement discomfort & body control ratings, use as a ‘daily dose’ countermeasure needs investigation
Future work

- GLCS design improvements
- Effect of GLCS upon re-orientation fluid shifts

- Effect of ‘daily dose’ GLCS donning on the musculoskeletal system during daily activity and 6° head down tilt
Acknowledgements

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