Cardiovascular responses to heat acclimatisation in athletes with spinal cord injury

Cameron M. Gee; Melissa A. Lacroix; Wendy A. Pethick; Patrick Côté; Trent Stellingwerff; Christopher R. West
“Our observed increase in maximal oxygen uptake could be mediated by plasma volume expansion, improved myocardial efficiency, and increased ventricular compliance...”
Hypothesis: HA training in athletes with SCI will lead to (1) expansion in plasma volume, and (2) enhanced indices of resting cardiovascular function

**Discussion**

Mechanical effects, including SCI-induced reductions in circulating blood volume, loss of skeletal and respiratory muscle pumps, as well as sympathetic effects, including reductions in vascular tone and an absence of vasoconstriction below the level of injury, are responsible for reduction in venous return.

## Methods

### Participants:

<table>
<thead>
<tr>
<th>Participant</th>
<th>Sex</th>
<th>Age</th>
<th>Height (m)</th>
<th>Mass (kg)</th>
<th>TSI (months)</th>
<th>LOI</th>
<th>AIS</th>
<th>IWRF Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M</td>
<td>35</td>
<td>1.88</td>
<td>64</td>
<td>216</td>
<td>C7</td>
<td>A</td>
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<td>2</td>
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<td>C6</td>
<td>A</td>
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<td>T3</td>
<td>C</td>
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<td>67</td>
<td>134</td>
<td>C6</td>
<td>B</td>
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<td>1.90</td>
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<td>177</td>
<td>C5</td>
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<tr>
<td>6</td>
<td>M</td>
<td>32</td>
<td>1.85</td>
<td>58</td>
<td>192</td>
<td>C5</td>
<td>A</td>
<td>1.0</td>
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<tr>
<td>7</td>
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<tr>
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<tr>
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</tbody>
</table>

Mean±SD: 34.7±6.0 1.81±0.07 66.3±10.1 194±54

**Abbreviations:** TSI, Time Since Injury; LOI, Level of Injury; AIS, American Spinal Injury Association Impairment Scale (A=motor/sensory complete injury; B=motor complete/sensory incomplete; C=motor/sensory incomplete); IWRF, International Wheelchair Rugby Federation (classification range: 0.5-3.5).

### Training Intervention:

**5 day isothermic HA protocol,** following team session athletes completed 60 min circuit/interval training or cooling as necessary to maintain Tc at 38.5°C. HA followed normal team training session.

### Pre/Post Outcome Measures:

**Blood Profiles:** Hb, Hct %, ΔPV % (n=11)

**Cardiac Ultrasound:** HR, SV, VTI, Strain, Strain rate (n=5)

**During Training Outcome Measures:**

Tc, HR, Tcom (1-5 scale), Tsen (0-9 scale), RPE (6-20 scale)
## Results

<table>
<thead>
<tr>
<th>Day</th>
<th>Air Temperature (°C)</th>
<th>Relative Humidity (%)</th>
<th>HRavg (bpm)</th>
<th>HRmax (bpm)</th>
<th>Tcavg (°C)</th>
<th>Tcmax (°C)</th>
<th>Tcom</th>
<th>Tsen</th>
<th>RPE</th>
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<tbody>
<tr>
<td>1</td>
<td>31</td>
<td>31</td>
<td>125±7</td>
<td>139±10</td>
<td>38.3±0.5</td>
<td>39.1±0.8</td>
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<td>7.1±0.5</td>
<td>14.2±1.8</td>
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<td>26</td>
<td>125±14</td>
<td>131±16</td>
<td>38.4±0.4</td>
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<td>2.7±1.1</td>
<td>6.7±0.9</td>
<td>15.3±1.5</td>
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<td>13</td>
<td>119±15</td>
<td>129±15</td>
<td>38.4±0.2</td>
<td>38.8±0.4</td>
<td>3.2±0.6</td>
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<td>14.3±2.7</td>
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<tr>
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<td>38</td>
<td>14</td>
<td>123±11</td>
<td>135±14</td>
<td>38.4±0.3</td>
<td>38.7±0.4</td>
<td>3.0±0.8</td>
<td>7.0±1.0</td>
<td>15.4±2.2</td>
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<td>5</td>
<td>36</td>
<td>22</td>
<td>116±11</td>
<td>134±14</td>
<td>38.2±0.4</td>
<td>38.5±0.4</td>
<td>2.8±0.8*</td>
<td>6.7±0.9†</td>
<td>14.6±2.6</td>
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</tbody>
</table>

Mean±SD 36±5 21±8 121±12 134±14.0 38.3±0.4 38.7±0.5 2.9±0.8 6.9±0.8 14.7±2.2

*SE=0.35 compared to day 1; † SE=0.51 compared to day 1.

Abbreviations: HR, heart rate; Tc, core temperature; Tcom, thermal comfort; Tsen, thermal sensation; RPE, ratings of perceived exertion.

![Graph showing PV change (%)](image)

SE = 0.44
Results
Results

Basal clockwise rotation

Longitudinal strain

Radial strain

Circumferential strain

Apical counterclockwise rotation (as viewed from apex)
Results

- Twist increased from 10.3±4.9 to 12.4±2.9. SE = 0.52.

- Post values similar to that found by Stohr EJ, et al (2011) in 9 healthy active males (13.9 ± 3.9 deg.)
Conclusion

- First study to examine the feasibility of HA training in athletes with spinal cord injury
- A five-day isothermic HA intervention has the potential to improve indices of resting cardiac function which may be due to increases in plasma volume
- Potential non-sympathetically mediated mechanisms for an \( \uparrow \) in plasma volume due to \( \uparrow \) plasma aldosterone mediated sodium retention following an \( \uparrow \) in hormone secretion by pituitary (e.g. ACTH) and hypothalmus (e.g. ADH) and/or the oncotic effect of an \( \uparrow \) in intravascular proteins

Future Studies:
- Pre/post performance variable (e.g. repeat 20-metre sprints)
- Monitor training workload (e.g. circuits/lap completed per session)
- Determine optimal timeframe for HA in SCI.
- To understand mechanisms of HA in SCI by measuring circulating hormones in response to exercise & heat exposure (e.g. PA, Renin, ACTH, ADH)
Acknowledgements

- Melissa Lacroix
- Wendy Pethick
- Dr. Andy Van Neutegem
- Pat Cote
- Nancy Wong
- Marnie McRoberts
- Dr. Chris West