Knowledge Transfer from Space Medicine to Global Health on Earth

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Co-Founder & CMO, ISMC (USA)

www.thaisrussomano.com - www.innovaspace.org
Mercury, Gemini and Apollo Projects: pressure 5 psi / 100% O2
- cabin size and design of the life support system

Skylab Project: pressure 5 psi / 70% O2 and 30% N2
- safety and risk of lung atelectasia

Space Shuttle Program/ISS: pressure 14.7 psi (1 ATM, 760 mmHg), 20% O2 and 80% N2), temperature between 18 - 27 degrees Celsius, water vapour pressure 6.2 - 14 mmHg.
Space environment – Space Missions (LEO)

- Microgravity
- Radiation

The Human Mind in Space

Circadian Rhythm
Inner ear otoliths react differently to movements

Eyes become principal equilibrium organs

Modified sensibility causes confusion and disorientation

Body fluids shift from the lower extremities to the head

Radiations may increase cancer risks

Renal filtration flow increases. Bone losses cause renal lithiasis

Body fluids shift thin down legs

Immune system weakening

Blood plasma resorption inducing a decrease of red blood cell number and anemia at landing

Supporting bones and muscles atrophy

Touch and pressure receptors are no longer exposed to gravity
Knowledge, Products, Methods, Techniques, Processes

Transfer!
+40 years!!!!

Health and Medicine  
Transportation  
Public Safety  
Consumer Goods  
Energy and Environment  
Information Technology  
Industrial Productivity
Telemedicine & eHealth

Human Psychology, Physiology & Medicine

Development of Medical Equipment & Devices

Software, XAI, VR, AR & Health applications

Disease Investigation & Treatment

Exercise & Space Countermeasures

Genetics & Aging

Robotics, Robonauts & Robots as Doctors
CPR in MicroG: 3 methods
Tests in parabolic flights

Reverse bear hug

Hand stand

Evetts-Russomano
Evetts-Russomano MicroG CPR Method
Evetts-Russomano CPR Method – physically demanding

**Significantly different to +1Gz control at p<0.05, paired sample t-test**

**Significantly different to +1Gz control at p<0.001, paired sample t-test**

*Mean ± SD  * p < 0.001

**Rate of Perceived Exertion**

**Table:**

<table>
<thead>
<tr>
<th>Time (minutes)</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>+1Gz</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chest compression Depth (mm)</td>
<td>48.6 ± 0.48</td>
<td>48.4 ± 0.46</td>
<td>47.5 ± 0.40</td>
</tr>
<tr>
<td></td>
<td>103.7 ± 0.25</td>
<td>103.3 ± 0.24</td>
<td>102.2 ± 0.37</td>
</tr>
<tr>
<td></td>
<td>30.3 ± 0.10</td>
<td>30.5 ± 0.14</td>
<td>31.1 ± 0.11</td>
</tr>
<tr>
<td>Borg Scale (6-20)</td>
<td>9.1 ± 0.53</td>
<td>10.3 ± 0.60</td>
<td>10.8 ± 0.66</td>
</tr>
<tr>
<td>Arm Flexion (°)</td>
<td>1.19 ± 0.20</td>
<td>1.23 ± 0.19</td>
<td>1.33 ± 0.22</td>
</tr>
<tr>
<td></td>
<td>1.62 ± 0.19</td>
<td>1.47 ± 0.23</td>
<td>1.52 ± 0.22</td>
</tr>
<tr>
<td>Heart Rate (bpm)</td>
<td>110.9 ± 2.73</td>
<td>112.2 ± 3.57</td>
<td>114.8 ± 3.91</td>
</tr>
<tr>
<td>MicroG</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chest compression Depth (mm)</td>
<td>45.7 ± 0.53*</td>
<td>43.0 ± 1.14**</td>
<td>41.4 ± 1.26**</td>
</tr>
<tr>
<td></td>
<td>104.5 ± 1.13</td>
<td>105.2 ± 0.99*</td>
<td>102.4 ± 1.43*</td>
</tr>
<tr>
<td></td>
<td>30.2 ± 0.32</td>
<td>30.2 ± 0.36</td>
<td>30.1 ± 0.54</td>
</tr>
<tr>
<td>Borg Scale</td>
<td>13.3 ± 0.47**</td>
<td>16.1 ± 0.47**</td>
<td>17.9 ± 0.40**</td>
</tr>
<tr>
<td>Arm Flexion (°)</td>
<td>11.4 ± 1.85**</td>
<td>11.3 ± 1.86**</td>
<td>12.3 ± 1.76**</td>
</tr>
<tr>
<td></td>
<td>14.6 ± 1.99**</td>
<td>14.8 ± 2.07**</td>
<td>14.7 ± 1.85**</td>
</tr>
<tr>
<td>Heart Rate (bpm)</td>
<td>153.9 ± 3.48**</td>
<td>168.2 ± 3.18**</td>
<td>174.5 ± 2.79**</td>
</tr>
</tbody>
</table>
CPR in HypoG Simulation

Movie
## CPR in Simulated HypoG – Female Data

**n = 10**

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Planet X</th>
<th>Mars</th>
<th>Moon</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1G</strong> (9.81 m/s.s)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>0.7G</strong> (6.8 m/s.s)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>0.38G</strong> (3.71 m/s.s)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>0.16G</strong> (1.62 m/s.s)</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mean DCC (mm)</strong></td>
<td>44.6 ± 2.2</td>
<td>42.0 ± 4.5</td>
<td>36.2 ± 5.8</td>
<td>31.1 ± 6.4</td>
</tr>
<tr>
<td><strong>Mean FCC (crp/min)</strong></td>
<td>105.1 ± 2.3</td>
<td>104.8 ± 5.1</td>
<td>94.3 ± 23.5</td>
<td>99.2 ± 11.7</td>
</tr>
<tr>
<td><strong>Angle Variation (°)</strong></td>
<td>4.9 ± 1.0</td>
<td>8.9 ± 5.0</td>
<td>18.6 ± 9.8</td>
<td>20.7 ± 11.8</td>
</tr>
<tr>
<td><strong>Load Variation (Kg)</strong></td>
<td>0.0 ± 0.0</td>
<td>13.4 ± 2.0</td>
<td>20.4 ± 3.7</td>
<td>23.6 ± 6.3</td>
</tr>
</tbody>
</table>
## CPR in Simulated HypoG – Male Data

**n = 10**

<table>
<thead>
<tr>
<th>Male</th>
<th>Control</th>
<th>Planet X</th>
<th>Mars</th>
<th>Moon</th>
</tr>
</thead>
<tbody>
<tr>
<td>1G</td>
<td>9.81m/s.s</td>
<td>0.7G</td>
<td>6.8m/s.s</td>
<td>0.38G</td>
</tr>
<tr>
<td>Mean DCC (mm)</td>
<td>47.3 (±0.8)</td>
<td>45.8 (±2.1)</td>
<td>45.3 (±1.4)</td>
<td>44.6 (±1.2)</td>
</tr>
<tr>
<td>Mean FCC (crp/min)</td>
<td>105.3 (±3.1)</td>
<td>103.8 (±6.0)</td>
<td>105.6 (±4.6)</td>
<td>105.9 (±7.1)</td>
</tr>
<tr>
<td>Angle Variation (º)</td>
<td>4.2 (±1.7)</td>
<td>4.8 (±2.3)</td>
<td>11.3 (±4.5)</td>
<td>15.0 (±5.6)</td>
</tr>
<tr>
<td>Load Variation (Kg)</td>
<td>0.0</td>
<td>13.1 (±5.0)</td>
<td>25.0 (±9.9)</td>
<td>30.9 (±5.3)</td>
</tr>
</tbody>
</table>
A Preliminary Comparison Between Methods of Performing External Chest Compressions During Microgravity Simulation

Mehdi Kordi¹,², Ricardo B. Cardoso¹, and Thais Russomano¹,²

Aviation, Space, and Environmental Medicine • Vol. 82, No. 12 • December 2011

A comparison between the 2010 and 2005 basic life support guidelines during simulated hypogravity and microgravity

Thais Russomano¹,²*, Justin H Baers¹,², Rochelle Velho¹, Ricardo B Cardoso¹, Alexandra Ashcroft¹,², Lucas Rehnberg¹, Rodrigo D Gehrke¹, Mariana K P Dias¹, and Rafael R Baptista¹

Is Weight a Pivotal Factor for the Performance of External Chest Compressions on Earth and in Space

Justin Baers¹, Rochelle Velho¹, Alexandra Ashcroft¹, Lucas Rehnberg¹, Rafael Baptista¹, Thais Russomano¹,²

¹Microgravity Center, Pontifical Catholic University of Rio Grande do Sul, Porto Alegre, Brazil, ²Center of Human and Aerospace Physiological Sciences, School of Biomedical Sciences, Kings College London, London, United Kingdom
Free e-book linking to all the relevant literature on CPR in space and the terrestrial applications:

Spin-offs from Extraterrestrial CPR

- Small rescuer / weaker (child, female, old...) and a big patient

- Increased chest stiffness (diseases)

- Increased chest diameter (diseases, natural shape)
Van Gogh Project
<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Radial Artery Sample</th>
<th>Hyperemic Earlobe Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discomfort</td>
<td>Painful</td>
<td>Pain Free</td>
</tr>
<tr>
<td>Potential Complications</td>
<td>Hematoma</td>
<td>Hemorrhage</td>
</tr>
<tr>
<td></td>
<td>Hemorrhage</td>
<td>Cutaneous infection</td>
</tr>
<tr>
<td></td>
<td>Infection</td>
<td>Wrist pain</td>
</tr>
<tr>
<td>Ease of Use</td>
<td>Requires trained medical personnel</td>
<td>Performed by non-medical personnel.</td>
</tr>
<tr>
<td>Potential Usage</td>
<td>Hospitals research</td>
<td>Hospitals, Private Clinics, Rural Centers, Aero medical Transport, ISS, Other space missions</td>
</tr>
</tbody>
</table>
The Earlobe Arterialized Blood Collector (EABC) was developed to enable collection of arterialized blood from the earlobe of astronauts by non-medically trained personnel, whilst minimizing risks of environmental contamination, infection and pain.
Method of Blood Collection with EABC

1. Arterialization

2. Cleaning

3. Collection

4. Analysis
Volunteers had samples from the radial artery and the earlobe arterIALIZED blood collected simultaneously, after being in the HDT position and breathing for 15 min a 12.8% O\textsubscript{2} in N\textsubscript{2}. 
Blood Collection

EABC vs Blood from the arterial side of the fistula
Selected Publications - EABC

A Device for Sampling Arterialized Earlobe Blood in Austere Environments

Thais Russomano, Simon N. Evetts, Joao Castro, Marlise A. dos Santos, Jorge Cavillon, Dario F. C. Azevedo, John Whittle, Edward Coats, and John Ernsting

Aviation, Space, and Environmental Medicine • Vol. 77, No. 4 • April 2006

Assessment of an Earlobe Arterialized Blood Collector in Microgravity

T. Russomano1,2, J. Whittle2, G. Evetts3, E. Coats3, M. Vian1, R. Cardoso1, G. Dalmarco1, R. Cambraia1, and F. Falcao1

Aviation, Space, and Environmental Medicine • Vol. 80, No. 11 • November 2009

Clinical Validation of the Earlobe Arterialized Blood Collector

Felipe Falcao and Thais Russomano

Aviation, Space, and Environmental Medicine • Vol. 81, No. 11 • November 2010

Operational evaluation of the earlobe arterialized blood collector in critically ill patients

Sergi Vaquer1, Jordi Masip1, Gisela Gili1, Gemma Gomà1, Joan Carles Oliva1, Alexandre Frechette2, Simon Evetts2, Thais Russomano1 and Antonio Artigas1

Annals of Intensive Care 2014, 4(11)
http://www.annalsofintensivecare.com/content/4/1/11

Earlobe arterialized capillary blood gas analysis in the intensive care unit: a pilot study

Sergi Vaquer1, Jordi Masip1, Gisela Gili1, Gemma Gomà1, Joan Carles Oliva1, Alexandre Frechette2, Simon Evetts2, Thais Russomano1 and Antonio Artigas1
Van Gogh Project
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Video
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