The acute haemodynamic response to -6^{o} head-down tilt and thermoneutral head-out water immersion.

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Introduction

- Exposure to microgravity stimulates an immediate haemodynamic change (Buckey et al, 1993).
- Due to the experimental constraints associated with microgravity -6° head down tilt (HDT) and thermoneutral head out water immersion (HOWI) are commonly utilised.
- Both mimic the fluid centralisation elicited in microgravity.
- Previous research has shown no significant difference in the magnitude of cardiovascular response to both analogues (Shiraishi et al, 2002).

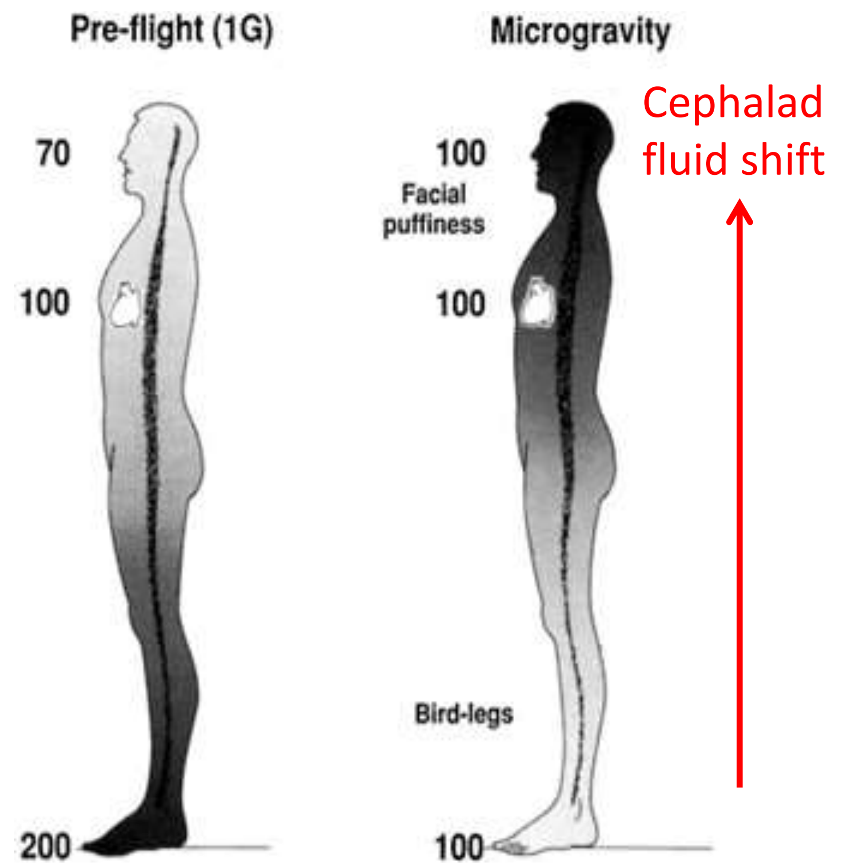

Figure 1. Mean arterial pressure and fluid distribution on Earth and in microgravity. Adapted from Hargens et al, (2009).

Aim

Compare the haemodynamic response to an acute 75 minute exposure to both thermoneutral head out water immersion and -6^{o} head down tilt

Hypothesis

- The majority of the initial haemodynamic response would occur within the first ten minutes of exposure to both analogues.
- HOWI would act as a greater stimulus for fluid centralisation leading to a cardiovascular response of greater magnitude

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Methods

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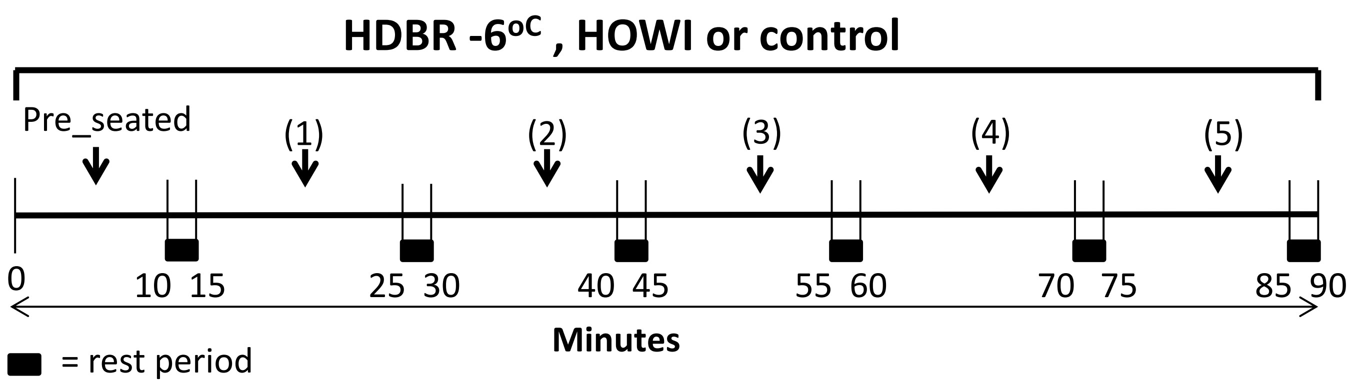
Participants

- 20 young male volunteers (age 24 ± 2.2 years; height 178 ± 4.4 cm; weight 74 ± 5.8 kg) participated in the study.

Experimental protocol



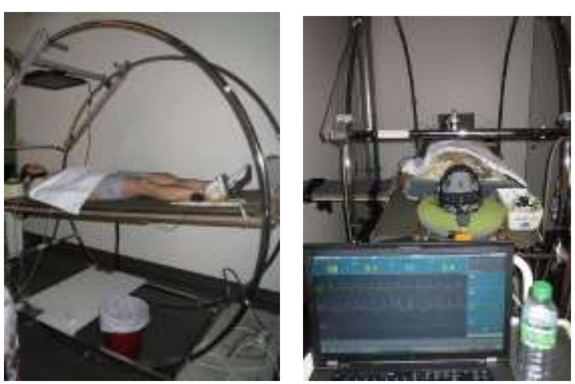


Figure 2. HDT


Figure 3. HOWI

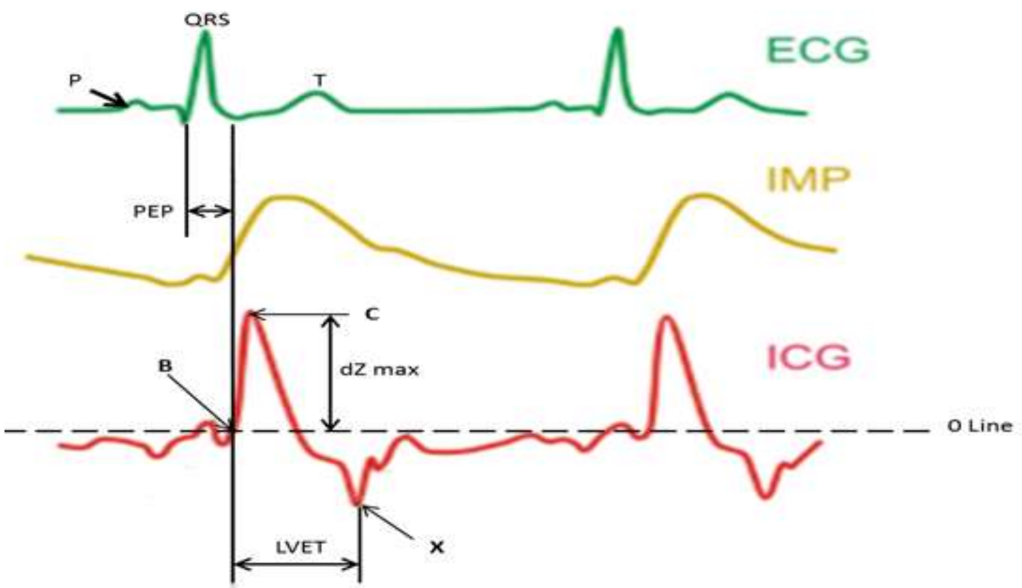
Data Analysis

- Beat to beat cardiovascular data was averaged over 10 minute periods.
- Stroke volume was measured using the Sramek-Bernstein equation (Bernstein, 1986)

$$SV = V_{EPT} \cdot \frac{dZmax}{Zo} \cdot LVET$$

- LVEDV was estimated using Capan's Equation

$$LVEDV = \frac{SV}{EF} \cdot 100$$



Statistical Analysis

- Two-way repeated measures ANOVA was performed to compare baseline values with the first and last ten minutes of each respective intervention and to compare the two analogues at the same experimental time point.
- Post hoc Holm-Sidak was used to correct for multiple comparisons.

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Results

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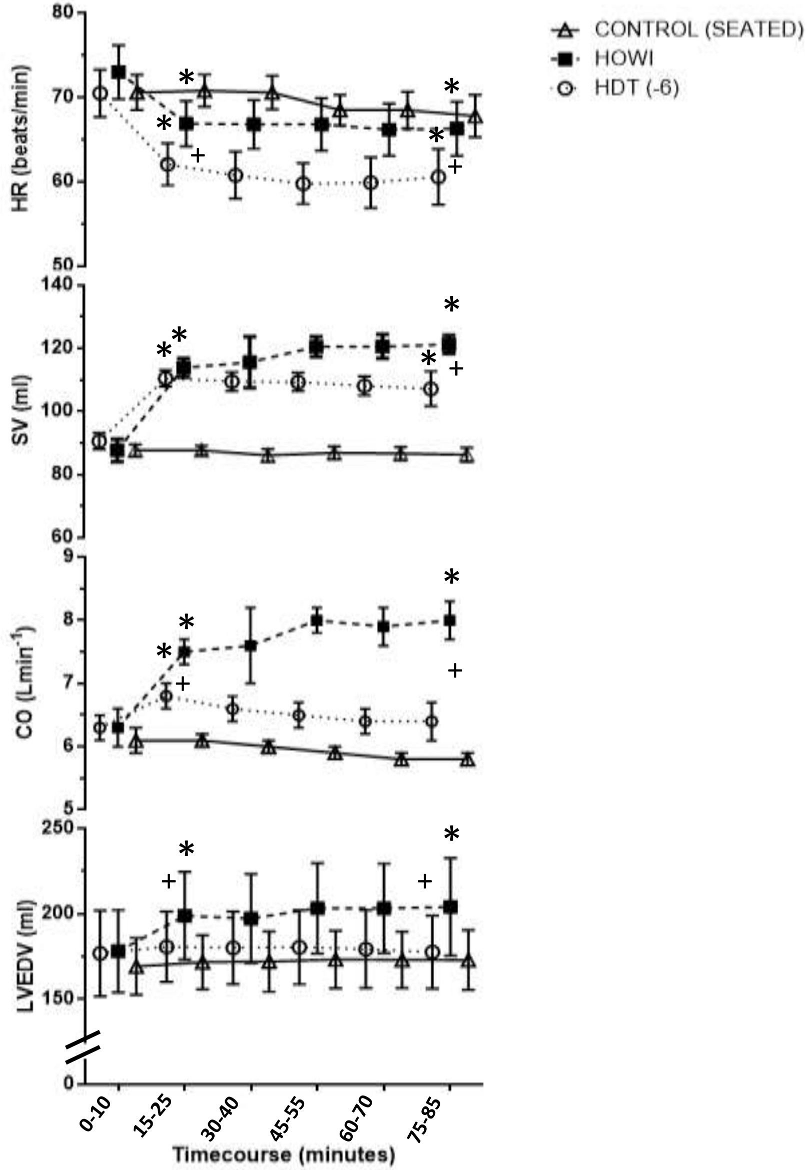

Data points represent mean ± SD of n=10 ($P < 0.05$). * represents significant difference (SD) from baseline. # represent SD from the first 10 minutes of exposure (15-25). + represents SD between interventions at the same point in time.

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Discussion

- Greater increase in LVEDV during HOWI suggests a greater increase in preload compared with HDT.
- SV and CO appear to plateau following the initial ten minutes of HDT. However, they continue to increase during HOWI.
- Mechanisms underlying the fluid shift are significantly different from those which occur in space.
- Impossible to mimic the paradoxical increase in cardiac dimensions and decrease in CVP elicited in microgravity.

Conclusion

- Both analogues stimulate an acute cardiovascular response.
- A significant proportion of the acute haemodynamic response occurs within the first ten minutes of exposure to each intervention.
- HOWI appears to stimulate a greater magnitude of cardiovascular response.

Future Perspectives

- Measure plasma noradrenaline , atrial natriuretic peptide and antidiuretic hormone.
- Investigate heart rate variability and blood pressure variability to determine the autonomic effect of these analogues.

Acknowledgements

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References

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Sramek-Berstein Equation

$$SV = V_{EPT} \cdot dZmaxZo \cdot LVET$$

V_{EPT} - Portion of the thorax which is electrically participating, calculated by

$$V_{EPT} = \delta\ {}^{L3}4.25 \quad , where\ \delta = BMIP\ (participant\ BMI) 24kgm\text{-}2\ (ideal\ BMI)$$

L = length of the thorax
calculated as 17% of height

(Gender, age and the ACM signal are also used to correct V_{EPT})

dZmax - Amplitude of the systolic peak of the ICG waveform, mathematically derived as dZ.

Zo – Transthoracic quasistatic base impedance.

LVET – Left ventricular ejection time (period between opening and closing of the aortic valve

IMMEDIATE EFFECTS OF MICROGRAVITY	IMMEDIATE EFFECTS OF HOWI	IMMEDIATE EFFECTS OF HDT
• Removal of hydrostatic pressure gradient • Increased central blood volume • Decreased pleural pressure • Increased thoracic volume • Increased vascular capacitance • Distension of cardiac chambers • Decrease in CVP • Increased SV and CO • Decreased SVR and HR	• Increased external hydrostatic pressure • Increased central blood volume • Increased pleural pressure • Cephalad movement of abdominal contents • Decreased peripheral vascular capacitance • Distension of cardiac chambers • Increased CVP • Increased SV and CO • Decreased SVR and HR	• Reduction of hydrostatic pressure gradient • Increased central blood volume • Increased pleural pressure • Cephalad movement of abdominal contents • Distension of cardiac chambers • Increased CVP • Increased SV and CO • Decreased SVR and HR