ACUTE CARDIOVASCULAR EFFECTS ACROSS SHORT-ARM CENTRIFUGE GRAVITY LEVELS AND EQUIVALENT TILT TABLE POSITIONS

Timo Frett[1], Inga Beccard[1], Laura de Boni[1], Rainer Herpers[2], Nils Bury[2], Jens Jordan[1,3] Jens Tank[1]

1 Institute of Aerospace Medicine, German Aerospace Center, Cologne, Germany
2 University of Applied Science, Siegburg, Germany
3 Head of the Institute of Aerospace Medicine, German Aerospace Center, Cologne, Germany

At +1Gz, head inward centrifugation increases heart rate and LF-SBP while reducing LF-BRS, showing distinct hemodynamic effects compared to tilt table positions and head outward centrifugation.

Introduction

Artificial gravity through short-arm human centrifugation (SAHC) has been suggested to counteract cardiovascular deconditioning in space by reestablishing a gravity-like caudal hydrostatic pressure column [1]. However, unlike standing on Earth, SAHC creates a force gradient, with substantially greater +Gz at the feet than at the head. The gradient increases with the square of the distance from center such that physiological gravity load at the level of the heart could lead to central hypovolemia and syncope, limiting SAHC safety in space.

Objectives

To compare cardiovascular responses to steep gravity gradients during SAHC with corresponding tilt table positions in a cross-over study.

Methodology

Cohort:

- 44 participants (22 m/f)

Protocol:

- **SAHC:** Outward (-Gz) and Inward (+Gz) with gravity levels randomized between 0g–1g (0.3g increments)
- **Tilt Table:** Head up and head down tilts. Angles randomized between 0°–45° (15° increments, head-up/down).

Measurements:

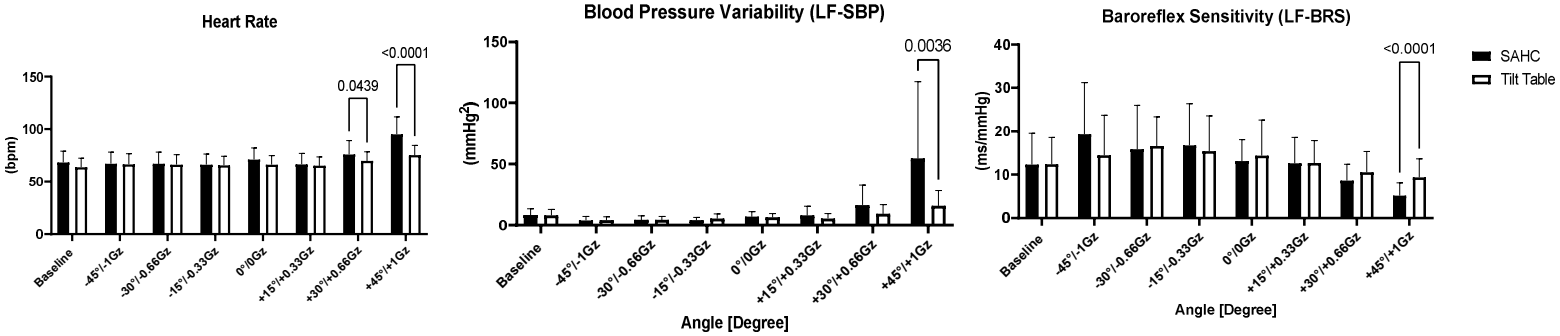
- Median heart rate, HR variability (RMSSD), systolic BP variability (LF-SBP), and baroreflex sensitivity (LF-BRS) from ECG and continuous BP readings

Statistical analysis:

- Linear mixed-effects model compared phases.
- P-values adjusted with Šidák's method for multiple comparisons.

Results

Up to -1/+1Gz or corresponding tilt table angles we observed no significant changes in heart rate, RMSDD, LF-SBP or LF-BRS. With increased head-inward (+Gz) centrifugation, we found a higher median heart rate (+0.6Gz p = 0.044)), +1Gz p < 0.0001)) and higher LF-SBP (+1Gz p = 0.0036) compared to head-up tilting, whereas LF-BRS was significantly decreased during centrifugation (+1Gz p < 0.0001). With the head outward position (-Gz), we observed no significant difference in heart rates, RMSSD, LF-SBP, whereas LF-BRS showed a significant (p=0.0257) increase compared to head down tilting. We found strong correlations of LF-BRS between SAHC positions (+Gz r = 0.98, p = 0.01; -Gz r = 0.92, p = 0.03) and head-up tilting.



Conclusion

Our study confirms the idea that artificial gravity through SAHC elicits a more pronounced cardiovascular autonomic response compared to standing on Earth. The finding, which may be partly explained by a larger acute hemodynamic burden and vestibular stimuli, could have a bearing on SAHC use as cardiovascular countermeasure.

Reference

[1] Linnarsson D, Hughson RL, Fraser K, Clément G, Karlsson LL, Mulder E, et al. Effects of an artificial gravity countermeasure on orthostatic tolerance, blood volumes and aerobic capacity after short-term bed rest (BR-AG1) J Appl Physiol. 2015;118:29–35.

Contact
E-mail: Timo.frett@dlr.de
Phone: +49 2203 6013458

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