BRAIN HEMODYNAMIC CHANGES MEASURED WITH NEAR-INFRARED SPECTROSCOPY DURING ALTERED GRAVITY. Thomas Zeffiro, Quan Zhang and Gary Strangman
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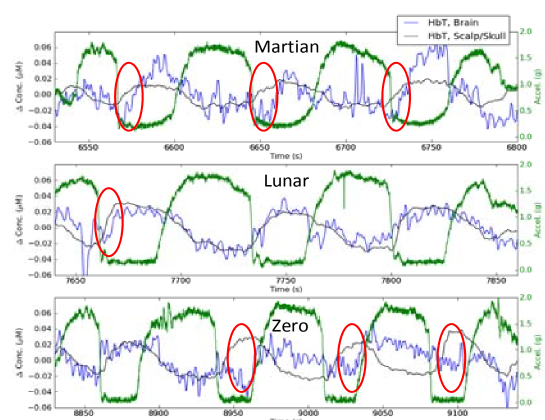
Introduction: During suborbital flights, rapidly changing gravitational forces are expected to significantly challenge the capabilities of the neurovascular system to sustain normal neurophysiological operations. While the brain has robust autoregulatory mechanisms to maintain stable perfusion, the degree to which exposure to hyper- or microgravity (μG) may compromise these mechanisms has not been extensively investigated and is not well understood. Prolonged μG is known to reduce hydrostatic gradients and cause cephalad fluid shifts that could interfere with accurate brain activity monitoring. These changes not only induce adaptive hemodynamic responses by the systemic circulation, but also influence cerebral perfusion pressure and blood flow. Our aim was to determine whether acute changes in gravity, and the attendant changes in brain perfusion, would permit sensitive detection of brain hemodynamics measured using near-infrared neuroimaging (NIN).

Methods: Using a novel mobile NIN device fabricated in our laboratory, we recorded continuous scalp and brain hemodynamic changes during a flight consisting of 20 parabolas, including simulations of Mars gravity, Lunar gravity and microgravity. Each parabola consisted of approximately 30 s of climb and 30 s of freefall. During the flight, the participant was seated upright, facing forward, with his head immobilized with a cervical collar for the first 16 parabolas, then floating freely for the final 4 parabolas.

Results: We recorded eight physiological data channels at 250Hz throughout the flight, including acceleration (Gx and Gz), cardiac electrical activity, respiration, and both peripheral and brain hemodynamics from dorsal prefrontal cortex. Hemodynamic changes associated with gravity alterations were similar in magnitude to those observed in our ongoing ground analog head-down tilt experiments. Following gravity transitions, we also observed differential regulation of brain relative to scalp blood volume.

Discussion: Gravitational variation over a range encountered during spaceflight resulted in clearly detectible modulations in human cerebral blood volume. Although these are the first such measurements accomplished in microgravity, mobile NIN may prove to be a practical means to achieve continuous monitoring of cerebral physiology during suborbital spaceflight. Its use could provide information pertaining to the integrity of cerebral autoregulation mechanisms in the face of phasic gravitational variations and could be of great practical value in routine physiological monitoring of individuals participating in commercial suborbital flights.

Participant wearing our NINscan mobile brain monitoring system during a period of microgravity. Successful continuous measurements of brain hemodynamics were made during 20 periods of reduced gravity.



Total hemoglobin (proportional to blood volume) for the near detector (black; sensitive to scalp and skull) and far detector (blue; additionally sensitive to brain tissue) plotted as a function of gravity loading (green). Red circles indicate periods where brain blood volume exhibited a lag relative to the blood volume of the scalp.