Acquisition of a Biomedical Database of Acute Responses to Space Flight During Commercial Personal Sub-Orbital Flights

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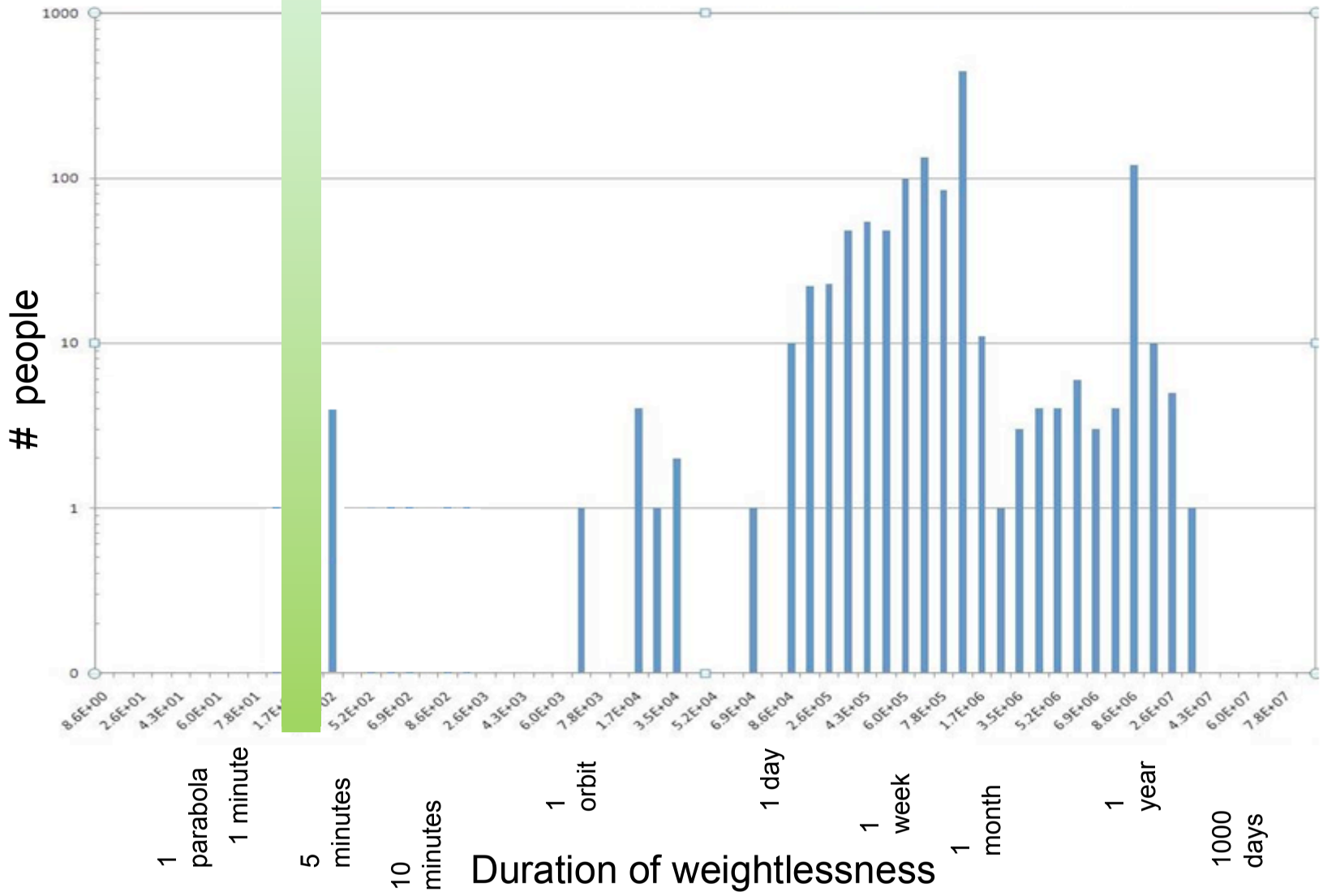
Disclaimer

Human Space Flight 0g Experience



Problem

- Currently, little data on initial physiological responses of diverse human population to g-transitions to and from weightlessness (and other space flight factors)

Opportunity

- Encourage participation by expected potentially large number (500-5,000 per year!) Commercial Space Flight Participants (CSFPs) on a standardized (±) flight profile, especially brief weightlessness
  - Participation by even a small percentage would provide significant database
  - Until recently, no published indication of planned capture of basic physiological data on CSFPs.

> "Every passenger is a research subject"
> Jon Clark, May 2008

Constraints on sub-orbital biomedical research

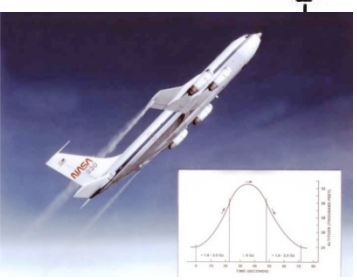
A colleague recently observed that…

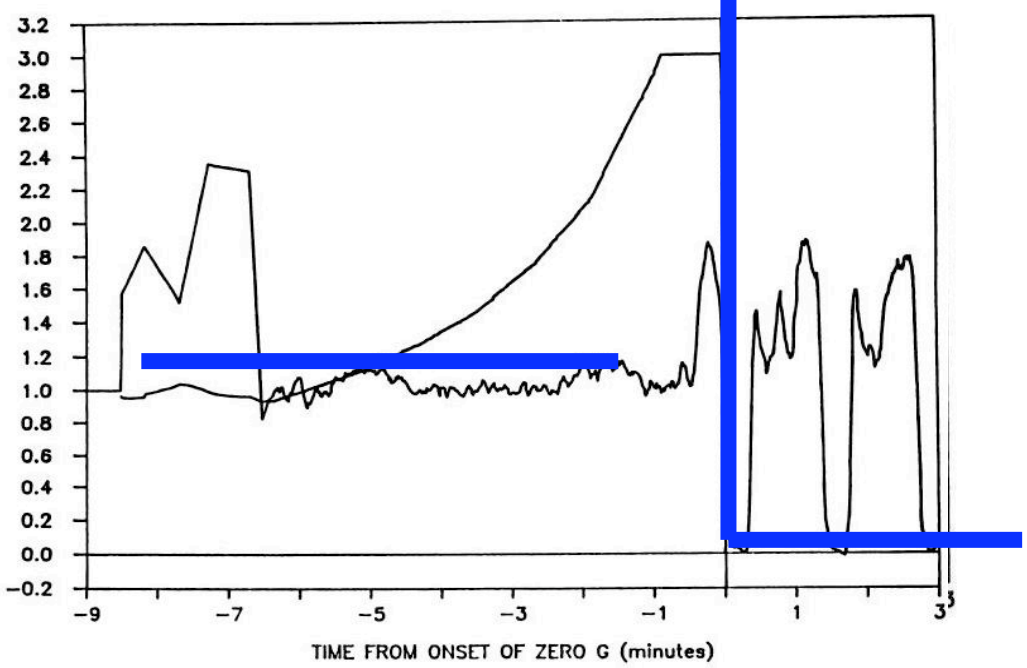
"The 'diverse' population will likely be skewed (at least initially) toward rich, old guys"

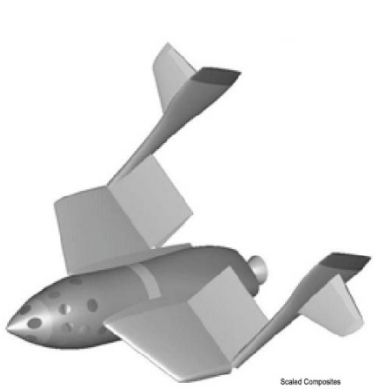
…and…

"If I only had 4 minutes to enjoy my $200K flight, I don't think I'd want to waste much of it performing an experiment."

Typical acceleration profiles





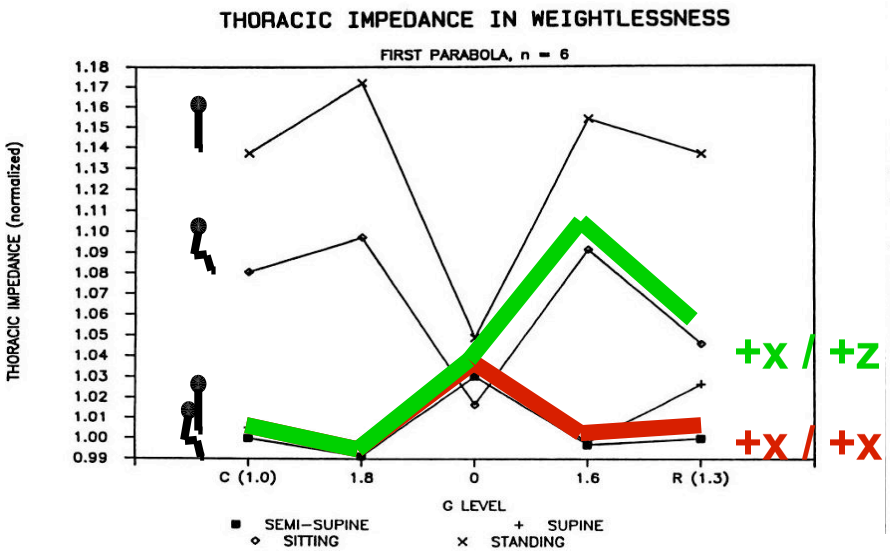


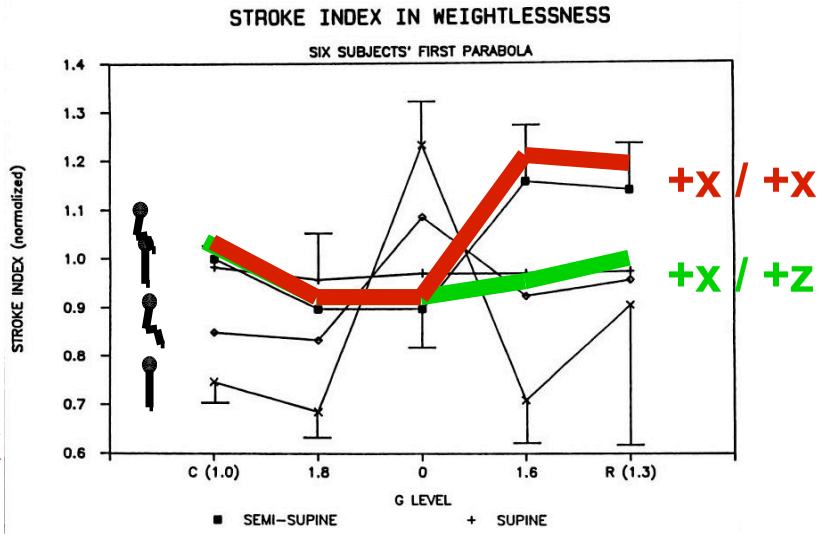
What measurements could compete with the view and the weightlessness?

Criteria for high-priority physiological parameters

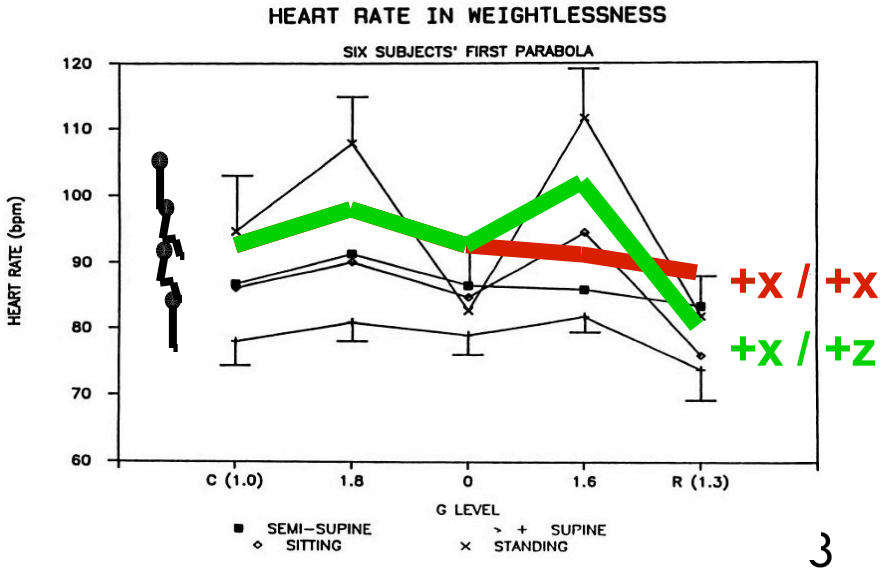
- Susceptible to dramatic change during suborbital space flight (high-g launch, brief weightlessness, high-g re-entry)
- Readily perceptible by participant
- Amenable to recording and display in personal interest package
- Clinically relevant either post-flight or during in-flight monitoring (*in situ* or remotely)
- Physiologically illuminating in context of database

Cardiovascular responses to g-transitions





Data from KC-135 parabolic flights. Cardiovascular data recorded in 4 postures: standing, seated, supine, semi-supine.



Cardiovascular, cardiopulmonary risk factors and operational covariates of specific interest

- *Not controllable, not modifiable risk factors*
  - Heredity
  - Gender
  - Age
- Controllable, modifiable risk factors
  - Smoking
  - High Blood Cholesterol
  - High Blood Pressure
  - Obesity (BMI)
  - Physical Inactivity
  - Stress & Behavior
  - Space flight history
  - Other?
- Operational, flight-related variables
  - +gx *vs.* +gz ascent body vectors
  - Pressure suit *vs.* shirt sleeves
  - Motion sick *vs.* not sick
  - +gx *vs.* +gz re-entry
  - Cabin temperature
  - Restrained *vs.* free-floating

Hypotheses of Interest

- Covariates will influence physiological responses to brief weightlessness, and to g-load after brief weightlessness
- Physiological responses will differ between populations exposed to different launch loads and profiles (e.g., different providers)
- Repeat flyers will respond to flight stresses differently than novice flyers (more…)

Hypotheses of Interest

- Repeated flight exposures will be associated with accommodation in acute responses, especially those requiring central processing
  - Sight-seers: 1-2 flights
  - Researchers: ~10 flights?
  - Flight crews (commercial providers' pilots): ~10s of flights?
    - Assumed available as comparison subjects

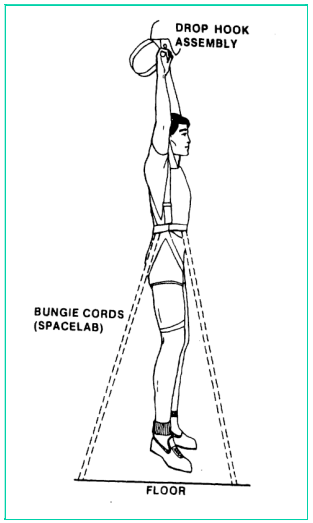
Astronauts and cosmonauts have exhibited less acute responses to repeated orbital flights in some areas (such as space motion sickness) but not in others (such as post-flight orthostatic hypotension)

Physiological responses to brief weightlessness and acceleration

Physiological System	Response to be measured and rationale	How to Assay?
Cardiovascular & Cardiopulmonary	*Yes*: Headward fluid shift will be detectable, and will distend thoracic vessels and sensors and initiate neural responses	Surface recording
Sensory-motor	*Yes*: Unloading of otolith sensors will be adequate to initiate neural reflex responses	Surface, voice & video recording
Human Behavior and Performance	*Yes*: Acute psychological and emotional responses will influence other parameters	Surface, voice & video recording
Musculoskeletal	*?*: Will exposure be too brief to initiate meaningful structural changes (but see sensory-motor)	Functional evaluation
Immunological, Endocrinological	*?*: Will exposure be too brief to initiate unequivocal response	Direct sampling (venous access; swabs?)

ca. 1990 low-profile measurements on Shuttle

- Response to g-transitions: 1g→3g → 0g → 2g → 1g
  - Cardiovascular
  - Sensory-motor

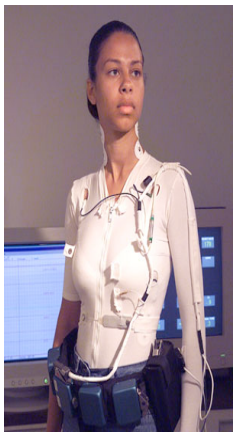


21st century body-worn instrumentation integrated into flight survival garments on sub-orbital flights

Response to g-transitions: 1g→5g → 0g → 5g → 1g

OpticHolter 2a (Strangman, MGH-HMD/NSBRI)

LifeShirt (VivoMetrics)



AFTE (Cowings, ARC; Jemison, Biosentient)

Typical lightweight in-cabin pressure garment: *Sokol* KV2 (Zvezda NPO, Moscow)

Helmut Hinghoffer-Szalkay: transiently extra-corporeal blood diversion for continuous density measurement, and sampling

Why *might* NASA support human research on sub-orbital flights?

- Training ground for next generation of flight surgeons and space life sciences researchers

- Hardware development, demonstration, and procedures validation in flight environment before orbital commitment

- Demonstrated spaceflight compatibility of a large, diverse population with a variety of pre-existing conditions may encourage diversification in astronaut recruitment and retention

- *Encourage* duplicate data
  - Independent confirmation of discoveries
    - Previously discouraged in space life sciences research
  - Distributed researchers may cover different regional operations

Next steps

- Encourage operators to accommodate data recording
- Identify willing suborbital volunteers
  - Everybody! (voluntarily, of course)
    - Celebrities, VIPs
    - Families (youngest to oldest)
    - Researchers
    - Pilots and flight crew
- Develop data recording system
  - Synergies with other users
  - Data recording continuously in the background, transparent to participant
    - Non-interference with work, play, sight-seeing
    - Document stressfulness of various individual activities
    - With large enough subject population, categorize responses to stressors in statistically valid manner
- Develop data archiving system

Every passenger will be an experiment—the only question is whether we or not collect the data!

Thank you!

Questions?