The Effects of Long Duration Head Down Tilt Bed Rest on Neurocognitive Performance: Extent, Longevity, & Neural Bases

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Background & Justification

• Spaceflight effects on gait, balance, & manual motor control have been well studied; some evidence for cognitive deficits

• Rodent cortical motor & sensory systems show neural structural alterations with spaceflight

• What about neural structural changes in humans?
Aims of the two projects

- **Aim 1** - Identify changes in brain structure, function, and network integrity as a function of prolonged head down tilt bed rest / spaceflight and characterize their time course.

- **Aim 2** - Specify relationships between structural and functional brain changes and performance and characterize their time course.
Evaluating neurocognitive changes occurring with bedrest

Conduct most behavioral & MRI assessments in ~last 5 days of BR, first session post BR = postural assessments only (SOT, FMT)
Pre & post flight; pre, during & post bedrest tests: MRI, DWI, fcMRI

Fling et al. 2013 Human Brain Mapping
Fling et al. 2012 Cerebral Cortex
Fling et al. 2011 Journal of Cognitive Neuroscience
Kwak et al. 2010 Frontiers in Systems Neuroscience
Langan et al. 2010 Frontiers in Systems Neuroscience
Fling et al. 2011 Frontiers in Neuroscience
Pre & post flight; pre, during & post bedrest tests: functional MRI

Task-based functional MRI (fMRI): brain networks engaged to perform various tasks

- Click / head tap induced VEMP (vestibular cortex mapping)
- Single & dual tasking of cognitive-motor tasks
- Sensorimotor adaptation task
- Spatial working memory task
- Foot tapping

Kwak et al. 2012 Behav Brain Research
Bo et al. 2011 Neuroimage
Anguera et al. 2010 Journal of Cognitive Neuroscience
Anguera et al. 2011 Journal of Cognitive Neuroscience
Pre & post flight; pre, during & post bedrest tests: behavior

- Spatial cognition, processing speed, bimanual coordination, rod and frame test, functional mobility test, dynamic posturography, click / head tap induced VEMP
Inflight tests: behavior

- Sensorimotor adaptation
- Spatial cognition
- Cognitive-motor dual tasking
Neuromapping data collection is still IN PROGRESS

• PRELIMINARY data to be presented today:
  • Balance (sensory organization equilibrium score)
  • Processing speed (digit symbol test performance)
  • Multiple metrics of brain structure
  • Multiple metrics of brain function
  • Single group over time, and subgroups stratified by exercise (Dr. Ploutz-Snyder study)
Bed rest impairs performance
Exercise helps, but it does not eliminate changes
Bed rest affects brain structure

Left column: gray matter volume increases (cool colors) and decreases (warm colors) with long duration head down tilt bed rest (n=10). Right column: recovery of changes post bed rest.
Parietal cortex gray matter & ventricular volume changes
Exercise helps, but it does not eliminate changes
Potential links between brain structural & behavioral changes

R=.37, Greater increases in parietal lobe volume are associated with greater declines in SOT score with bed rest.
Increases in third ventricular volume are correlated with decreases in card rotation & Purdue Pegboard performance.

Card Rotation (correct)

R - squared = 0.550 Beta volume = - 684.879 P volume = 0.035

Purdue Pegboard (time)

R - squared = 0.536 Beta volume = - 900.777 P volume = 0.039
Brain activity associated with foot movement increases with bed rest

- Average activation during foot movement
- Brain regions that increase activity with bed rest
Interpretations: preliminary

• Behavior, brain structure, & brain function change with bed rest
• Exercise reduces, but does not eliminate, these changes
• Mechanisms could include fluid shifts, neural plasticity due to altered sensory inputs, compensatory recruitment
Publication Plan

1) Effects of bed rest on cognitive & motor behavior, brain structure, & brain function (multiple papers depending upon outcomes)

2) Bed rest – exercise interactions, with Dr. Lori Ploutz-Snyder
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