Spaceflight Standard Measures

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Objectives

- To ensure that a minimal set of measures, relevant to human spaceflight risks, is consistently captured from crewmembers until the end of the ISS

- The data from these measures will be placed in an archive managed by HRP and made available to studies via data sharing agreements

- *Spaceflight Standard Measures* will constitute a database for:
  - Providing context for data acquired by concurrent experiments
  - Supporting or developing hypotheses
  - Evaluating the effectiveness of various in-flight countermeasure profiles
  - Comparing population responses to various mission durations (6 weeks, 6 months, 1 year)

HRP Identified Risks

Altered Gravity Level
- Vision alterations
- Renal stone formation
- Sensorimotor alterations
- Bone fracture
- Reduced muscle mass, strength
- Reduced aerobic capacity
- Adverse host-microorganism interactions
- Urinary retention
- Orthostatic intolerance
- Back pain
- Cardiac rhythm problems

Radiation
- Exposure to space radiation

Distance from Earth
- Limited in-flight medical capabilities
- Toxic medications

Isolation
- Adverse cognitive or behavioral conditions
- Performance & behavioral health decrements

Environment–Spacecraft Design
- Inadequate food/nutrition
- Human-system interaction
- Injury from dynamic loads
- Injury during EVA
- Celestial dust exposure
- Altered immune response
- Hypobaric hypoxia
- Sleep loss & work overload
- Decompression sickness
- Toxic exposure
- Hearing loss
- Sunlight exposure

Risks addressed by the *Spaceflight Standard Measures* project

Experiment Design Overview
6-month mission

Pre-flight	In-flight	Post-flight
Actigraphy w/ sleep logs (2 weeks each) (L-180, L-90)	Actigraphy (continuous)	Actigraphy w/ sleep logs (2 weeks) (R+0)
Personality Survey (anytime preflight)	Sleep Quality/Team Questionnaire (monthly)	Cellular Profile Survey (R+15)
Cognition (L-120 fam, L-90)	Cognition (FD30 & R-30)	Cognition (R+10, R+30)
Cellular Profile (ambient blood, saliva) (L-180, L-90)	Cellular Profile (ambient blood, saliva) (Early mission vehicle return, R-0)	Cellular Profile (ambient blood, saliva) (R+30)
Biochemical Markers (blood, urine) (L-180)	Biochemical Markers (blood only) (FD30, R-30)	Biochemical Markers (blood, urine) (R+30)
Microbiome (body, saliva, fecal) (L-90)	Microbiome (body, saliva, fecal) (FD30, R-30)	Microbiome (body, saliva, fecal) (R+30)
Carotid Intima-Media Thickness (cIMT) (L-180)	N/A	Carotid Intima-Media Thickness (cIMT) (R+5, R+30)
Sensorimotor Measures (L-180 , L-90)	N/A	Sensorimotor Measures (R+0 at landing site, R+0 at JSC, R+9)
Crew time: 6.83 hrs	Crew time: 15.25 hrs	Crew time: 5.25 hrs

Actigraphy

Actiwatch Spectrum
- Wrist watch worn snug against the non-dominant wrist
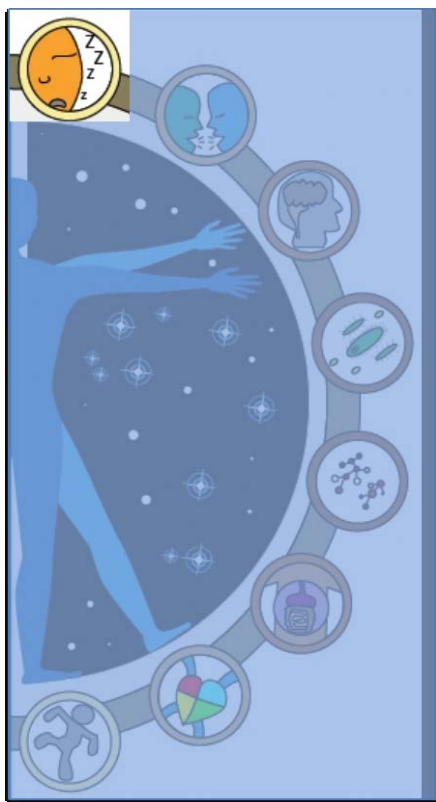- Tracks movement and light data

Questionnaire
- A brief post-sleep survey daily when actigraphy is collected on the ground
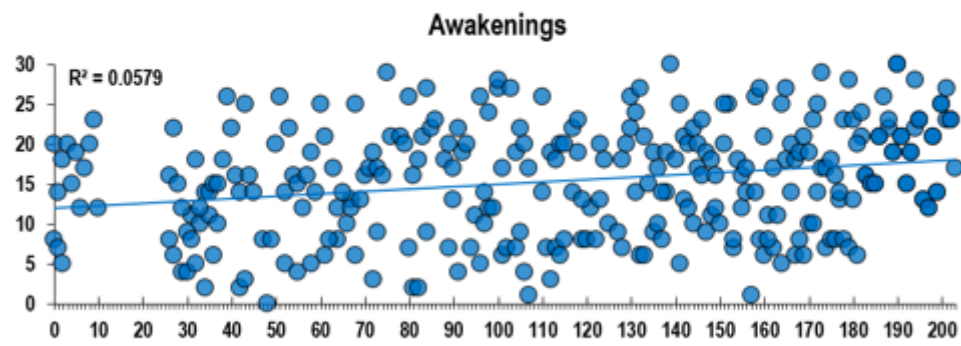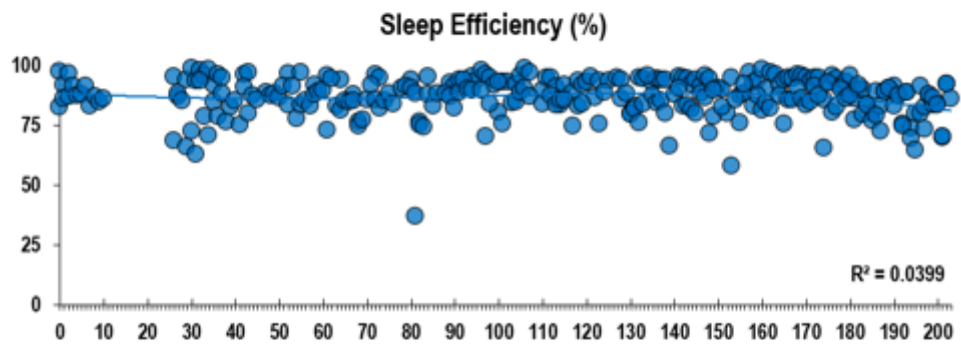
Tests Sessions
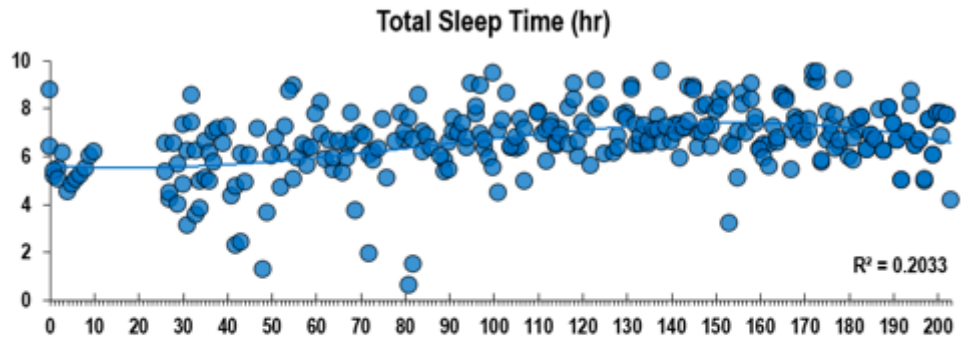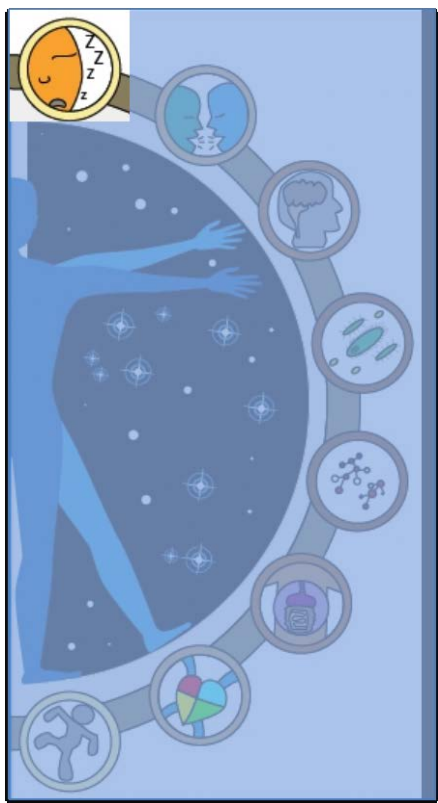- L-180, L-90: worn for two 2-week sessions
- FD1 to R-0: worn continuously
- R+0: worn for one 2-week session

Measures
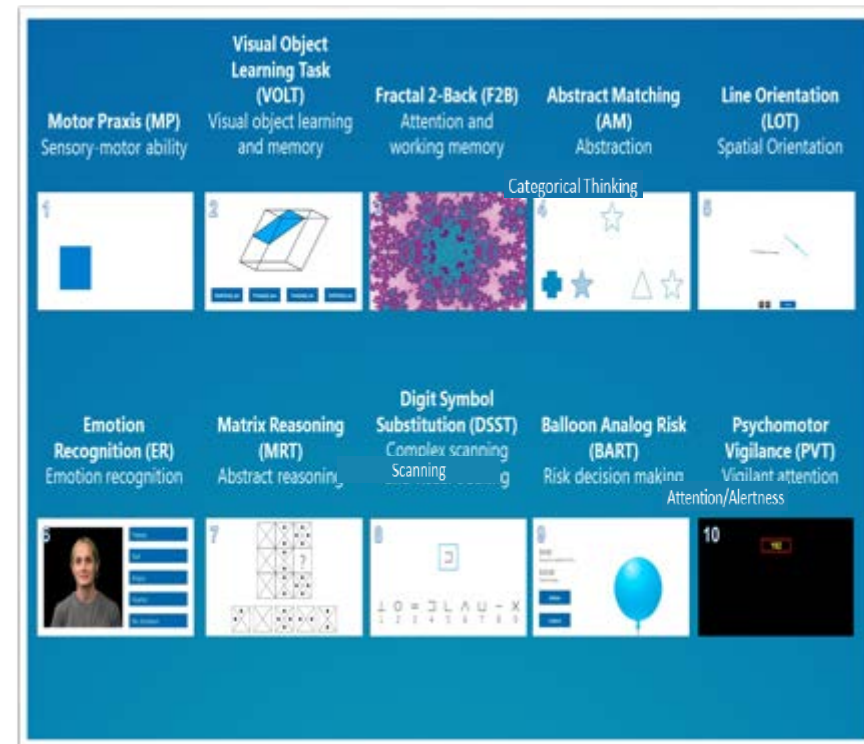- Activity level (per min)
- Light exposure

Actigraphy

Total Sleep Time (hr)

$R^2 = 0.2033$

Sleep Efficiency (%)

$R^2 = 0.0399$

Awakenings

$R^2 = 0.0579$

Flight Day

Personality Survey & Sleep Quality/Team Questionnaire

Personality Survey
- International Personality Item Pool, Neuroticism-Extraversion-Openness (IPIP-NEO)
- Paper-based survey

Sleep Quality/Team Questionnaire
- Completed in DCT in-flight

Tests Sessions
- Personality Survey – anytime pre-flight
- Sleep Quality/Team Questionnaire – monthly in-flight

Measures
- Sleep quantity and quality
- Mood
- Affect
- Team cohesion and performance
- Crew living/habitability

Cognition

A battery of 10 neurocognitive tests that cover a range of cognitive domains relevant for spaceflight

Test Sessions
- L-120, L-90
- FD30, R-30
- R+10, R+30

Measures
- Reaction time
- Learning
- Working memory
- Abstraction
- Spatial orientation
- Emotion recognition
- Abstract reasoning
- Visual tracking
- Risk decision making
- Attention

Cellular Profile

Blood Sample
- 2 tubes totaling 10 mL per session
- In-flight <u>live</u> blood cells quickly returned to ground

Saliva Collection
- One saliva sample per session (salivette)
- In-flight, stowed in MELFI

Cellular Profile Survey (post-flight only)
- A questionnaire about experiences during flight such as allergies, rashes, infections and wound healing

Test Sessions
- L-180, L-90
- ~FD30, R-30: Undock of return vehicle
- R+30

Measures
- Stress hormone levels
- Viral shedding
- Protein level
- Types of blood cells

Biochemical Markers

Blood Sample
- Ground: 3 tubes totaling 15.7 mL; collected early morning
- In-flight: 2 tubes totaling 15 mL per session

Urine Collection
- Ground only
- 24-hour urine collection–shared with medical collection when feasible

Questionnaire
- Ground only
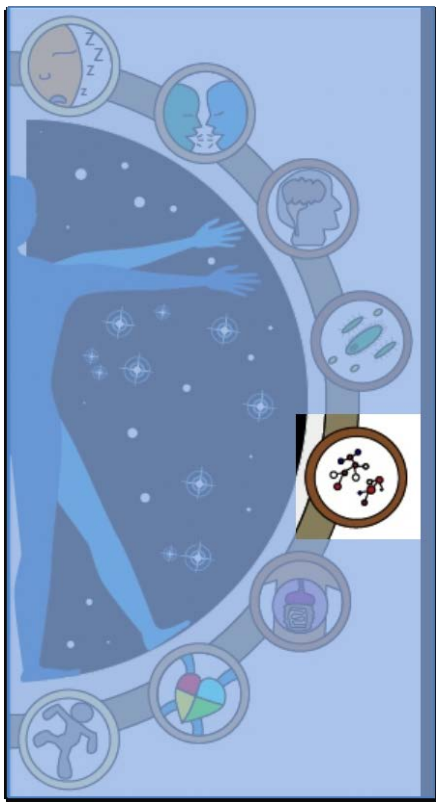- Exercise log completed at time of sample collection

Test Sessions
- L-180
- FD30, R-30
- R+30

Measures
- Complete blood count
- Comprehensive metabolic panel
- Comprehensive chemistry panel
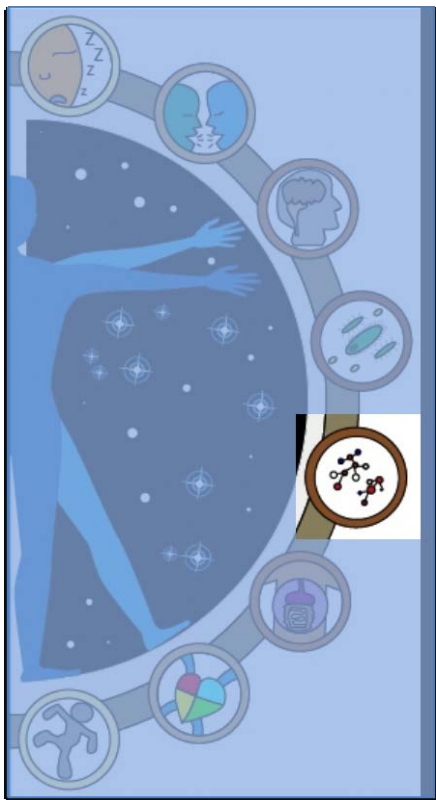
Biochemical Markers
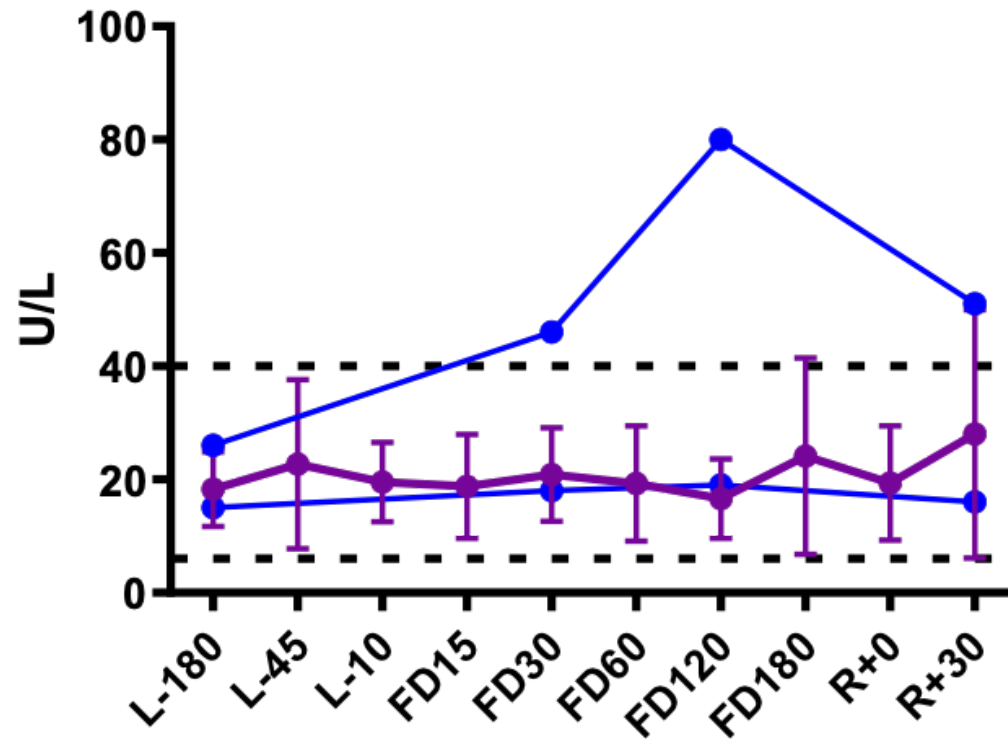
Liver enzyme alanine aminotransferase (ALT) from SSM subjects compared to 64 astronauts (purple line; mean ± SD)

Microbiome

Body Swabs
- Sample forearm, forehead, nostril, and control area using pre-moistened swabs
- Brief environment, health, and hygiene survey completed the day of body swab collection
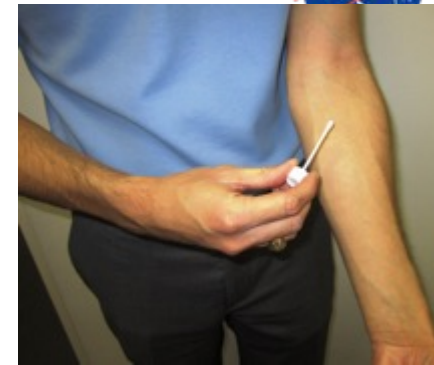
Saliva Collection
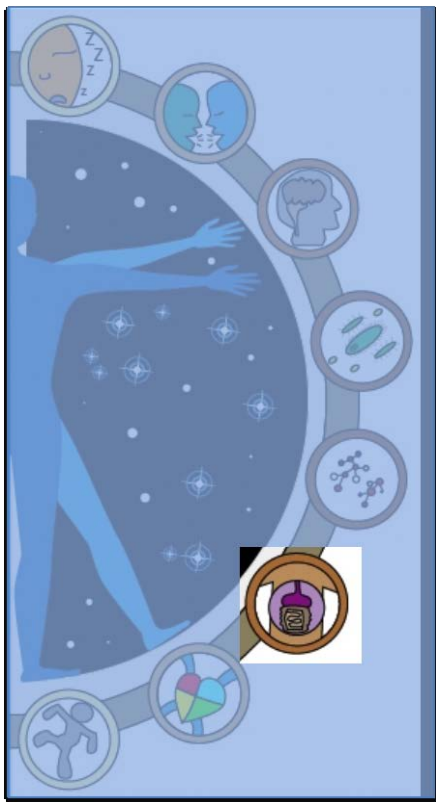- Sample every day for 4 days (salivette)

Fecal Sampling
- Ground: Human Stool Sampling Kit
- Flight: Swab to collect sample from WHC

Test Sessions
- L-90
- FD30, R-30
- R+30

Measures
- Types and concentrations of micro-organisms on the body

Carotid Intima-Media Thickness

Examination
- Ultrasound measure of carotid arterial wall thickness, which is an early indicator of vascular dysfunction (oxidative stress)
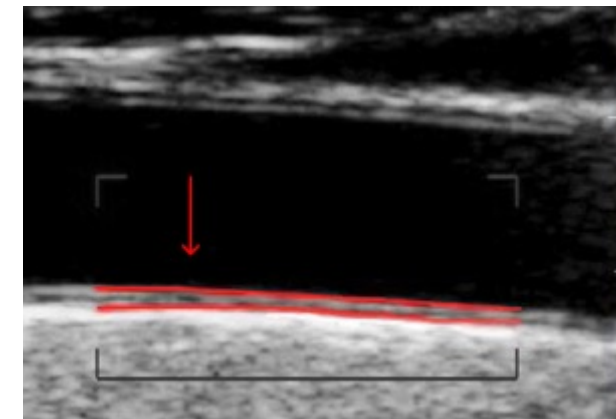
Questionnaire
- Short survey conducted during the test regarding exercise, diet, sleep

Test Sessions
- L-180
- R+5, R+30

Measures
- Thickness of the intima and media, the two inner layers of the carotid artery

Sensorimotor Measures

Sit-to-Stand Test
- Rise from a seated position
- Remain stationary for 10 sec

Tandem Walk Test
- Walk heel-to-toe with eyes open/closed

Recovery from Fall/Stand Test
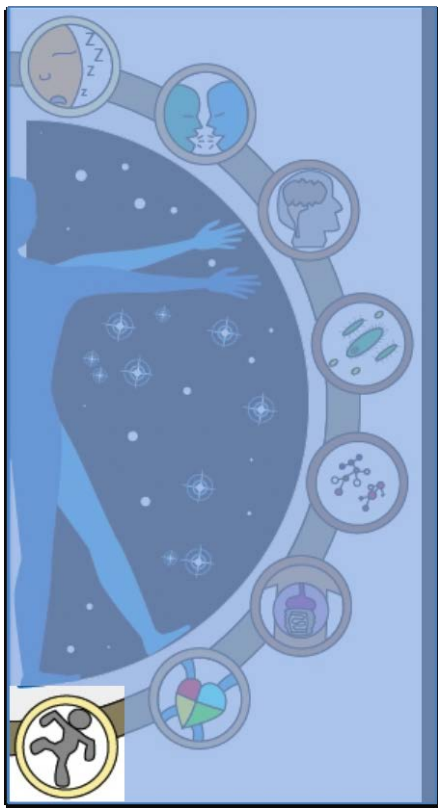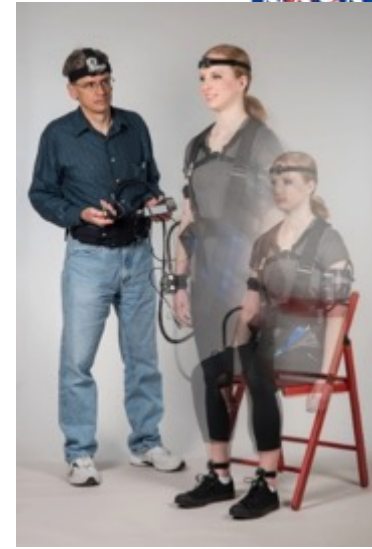- Rise from a prone position
- Remain stationary for 3 min

Motion Sickness Questionnaire

Test Sessions
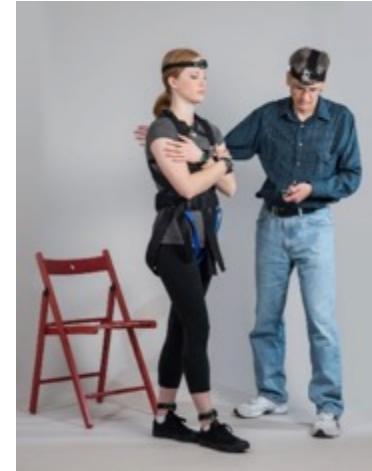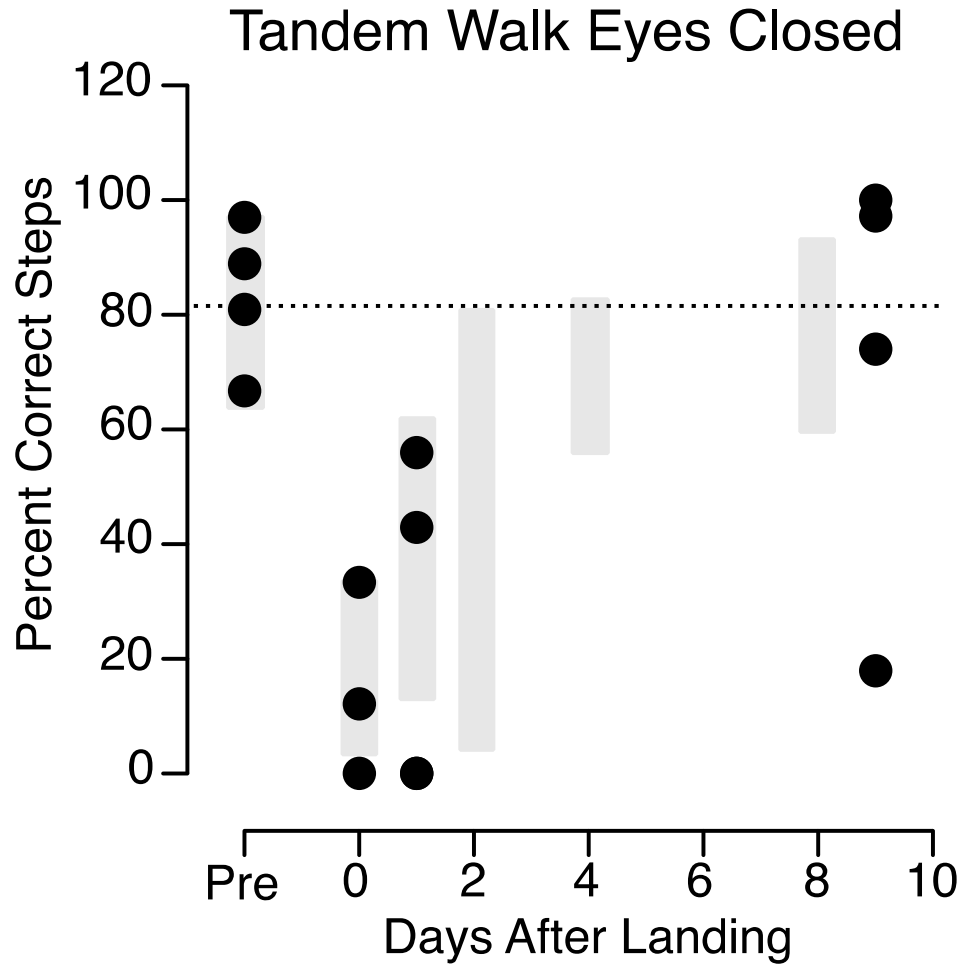- L-180, L-90
- R+0 at landing site, R+0 at JSC, R+9

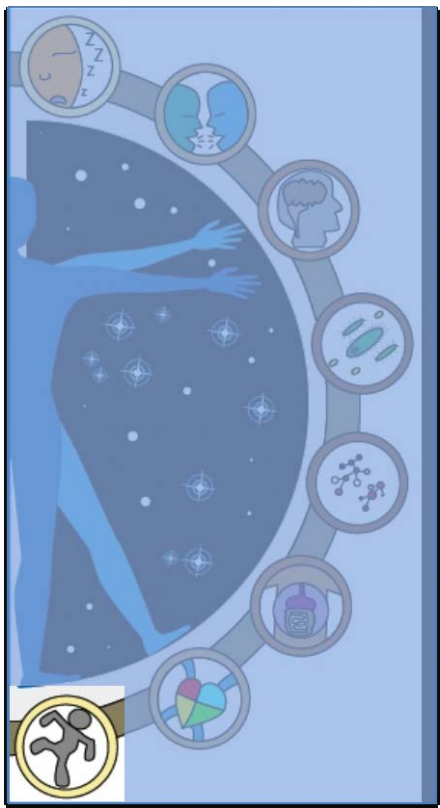Measures
- Body kinematics
- Balance
- Heart rate
- Blood pressure

Sensorimotor Measures

Tandem Walk Eyes Closed

Biochemical Analytes

- **Blood samples**
  - plasma allergy profile, plasma cytokine levels, VS cell expansion and cytotoxicity, T cell function, peripheral leukocyte distribution, and mitogen stimulated cytokine profiles, iCa, white blood cell count, neutrophils, lymphocytes, monocytes, eosinophils, basophils, red blood cell count, reticulocyte count, platelet count, mean platelet volume, and platelet distribution width
  - serum CO_2, BUN, bilirubin, glucose, serum 1,25-dihydroxyvitamin D, serum 25-hydroxyvitamin D, BSAP, calcium, ALT, AST, alkaline phosphatase, sodium, potassium, chloride, total protein, albumin, creatinine, osteocalcin, undercarboxylated osteocalcin, intact PTH, osteoprotegerin (OPG), osteoprotegerin ligand/RANKL, leptin, IGF-1, sclerostin, hepcidin, and N-terminal propeptide of type I procollagen (P1NP)
  - hemoglobin, hematocrit

- **Urine samples**
  - sodium, potassium, creatinine, pH, 24-hour volume, calcium, phosphorus, magnesium, uric acid, citrate, sulfate, calcium oxalate supersaturation, calcium phosphate supersaturation, sodium urate supersaturation, struvite supersaturation, uric acid supersaturation, and oxalate

- **Saliva samples**
  - viral DNA

- **Body and fecal samples**
  - bacterial DNA (gDNA, 16S rDNA)
  - microbial differences in community composition among group of samples