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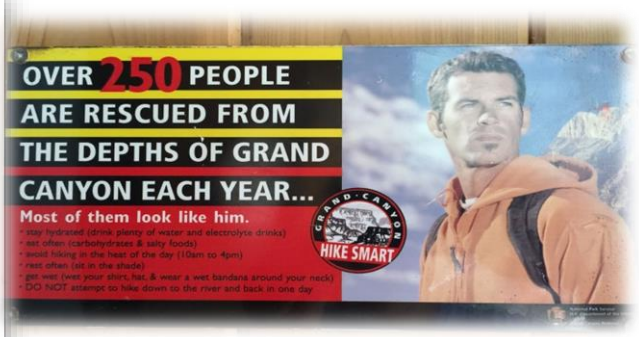

Rim-to-Rim Wearables At The Canyon for Health (R2R WATCH)

Presenter: Cliff Anderson-Bergman, PhD

Principal Investigator: Glory Aviña, PhD MBA

Sandia National Laboratories

U.S. DEPARTMENT OF ENERGY

National Nuclear Security Administration

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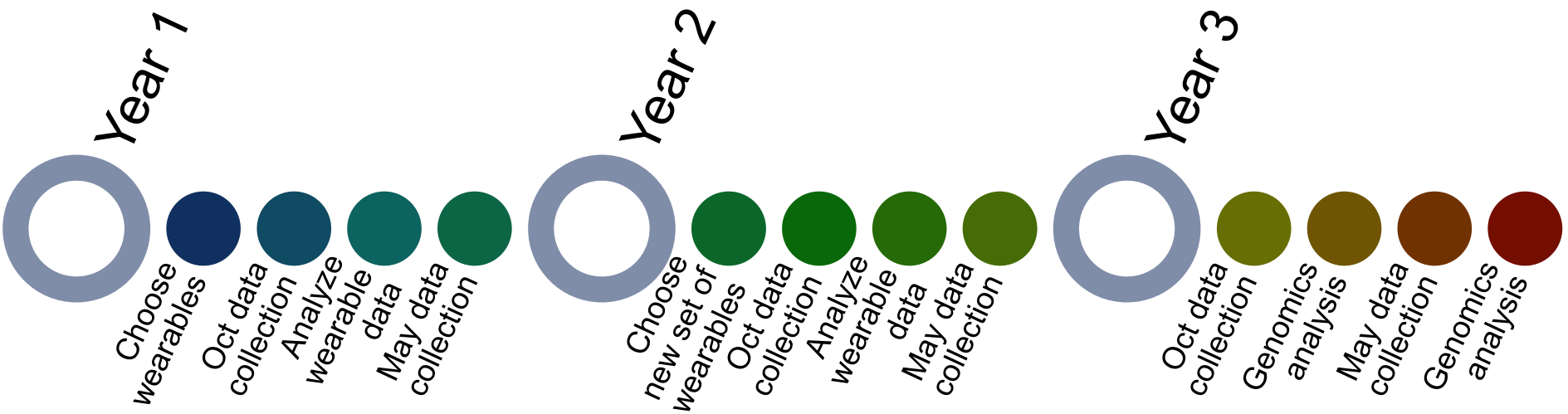
Purpose of this Study

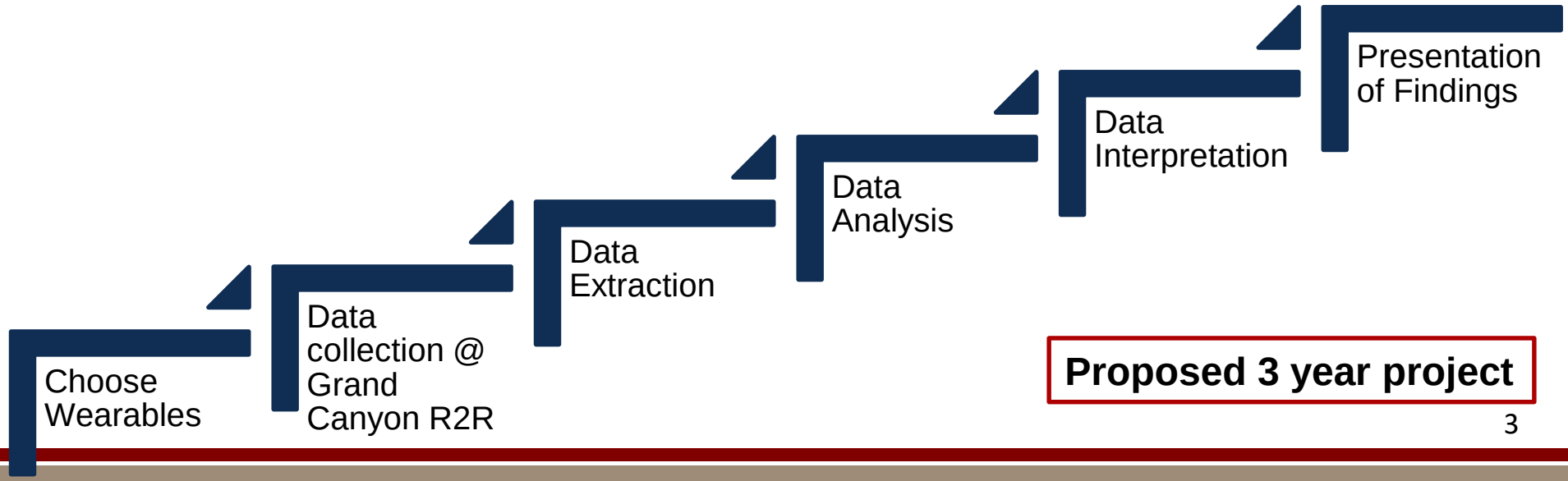
1) **Markers for Health:**
   identify physiological, cognitive markers most related to health and task performance

2) **Data Processing:**
   determine key methodologies for data processing from GOTS/COTS devices

3) **BSVE Integration:**
   integrate data into the Biosurveillance Ecosystem (BSVE)

Experimental Design





Proposed 3 year project

Interdisciplinary Approach

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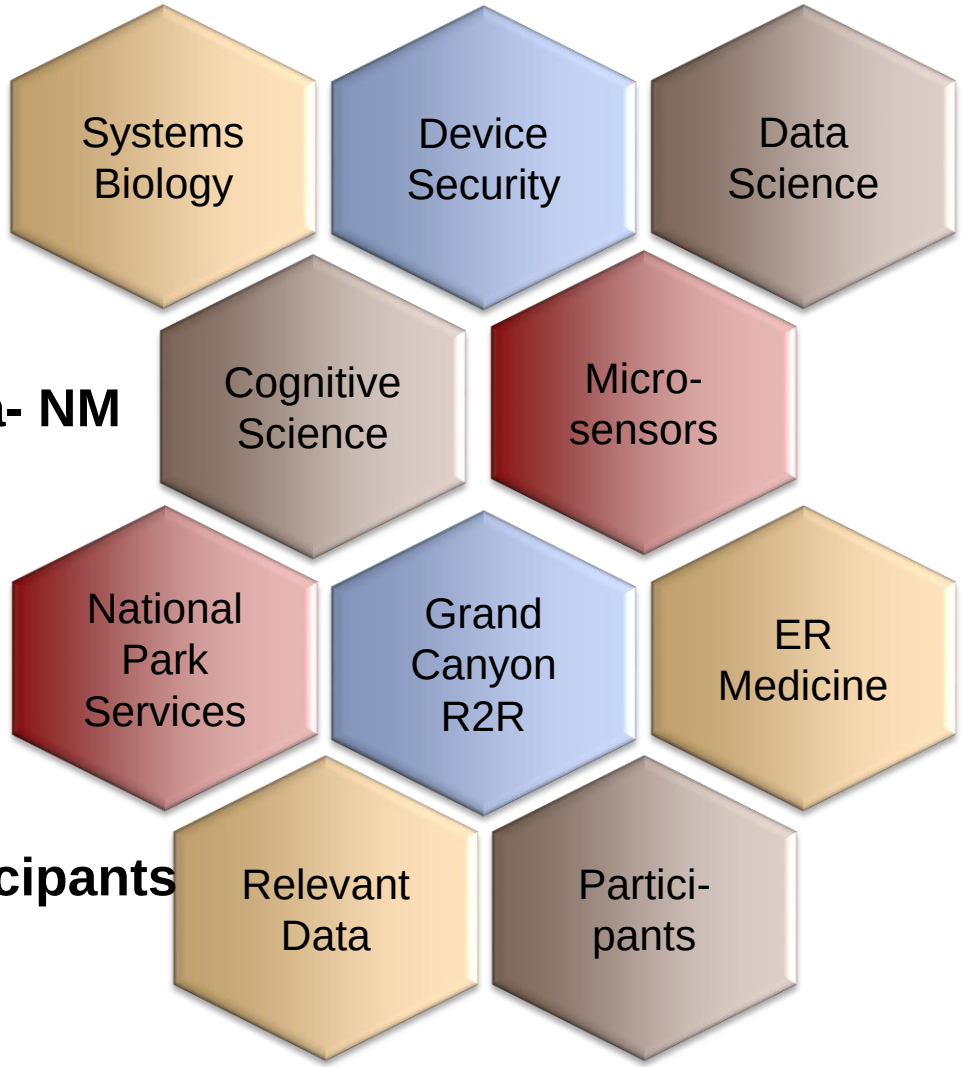

Sandia- CA

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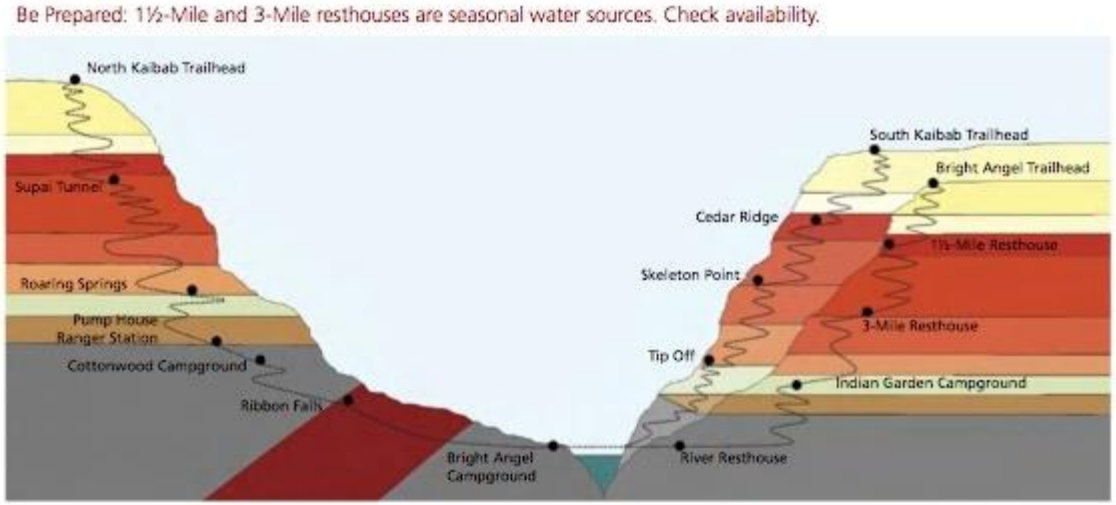
University of New Mexico

Military Participants

Grand Canyon Rim-2-Rim Hike

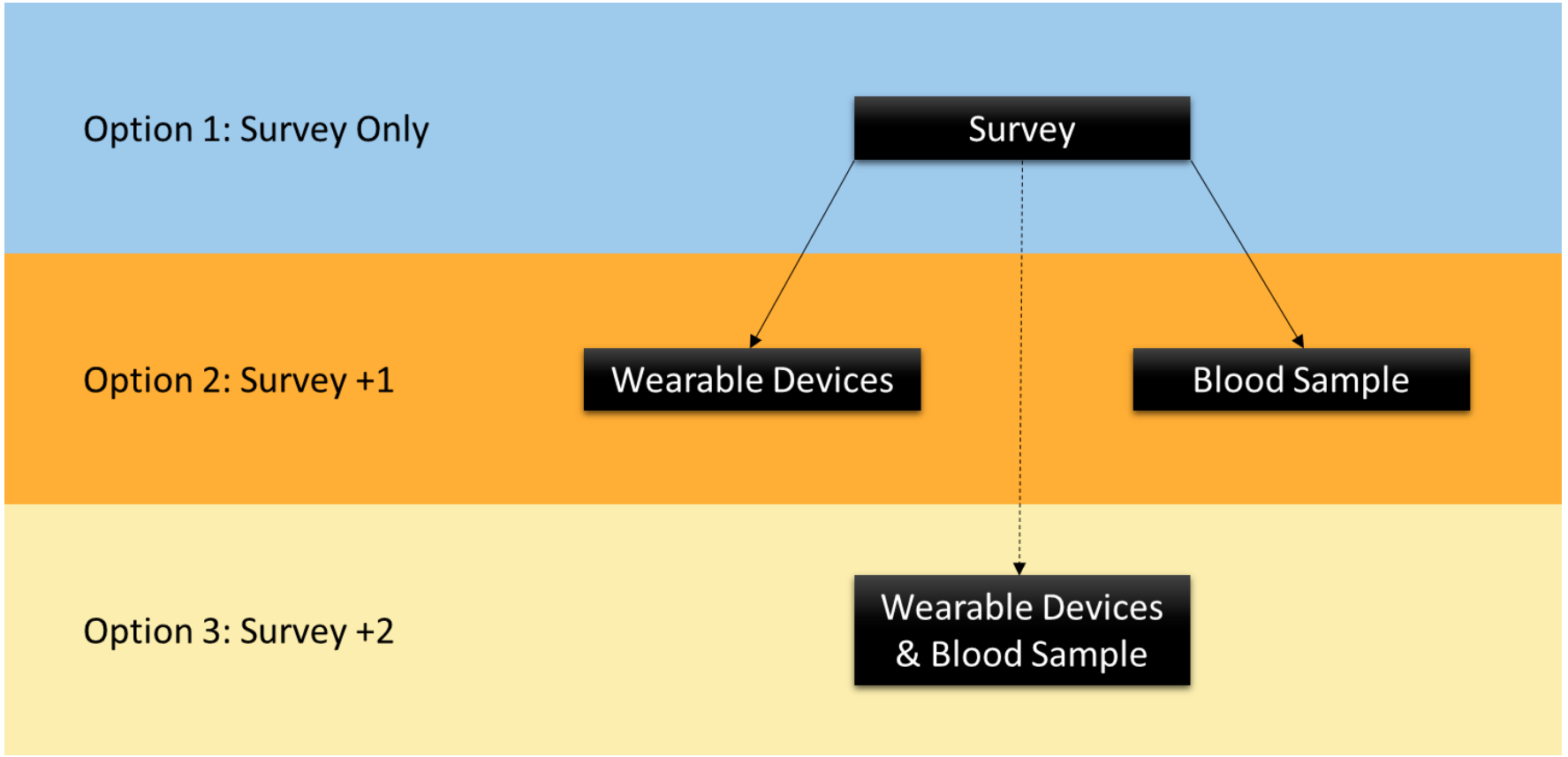
- Altitude and Temperature Change
- Extreme Environment
- Physical Strain
- 14.3 miles, 6,000 feet to the bottom
- 9.6 miles, 4,500 feet back to the South Rim

Figure 1. Signage at Bright Angel Trailhead, October 2015.



Source: https://www.nps.gov/grca/index.htm

Three tiers for R2R WATCH



R2R WATCH Team

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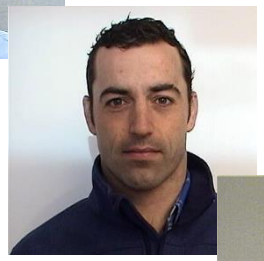
Clifford Anderson-Bergman, PhD (Org 8962), Statistician



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Kristin Divis, PhD (Org 1463), Cognitive Psychologist

Cathy Branda, PhD (Org 8920), Sr Manager, SNL Program Manager

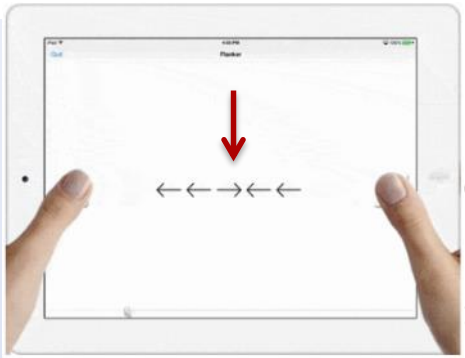
Patricia Benguerel (Org 8532), Project Controller

Victoria Newton (Org 10653), Project Support

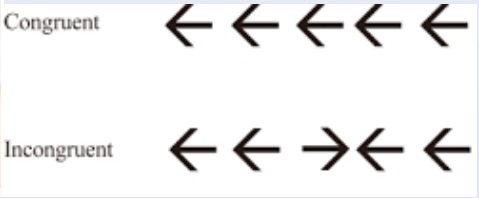
Collecting Physiological and Cognitive Data

Package	Cognitve Tests	GPS	Elevation	Heart rate (ECG)	Heart rate (Wrist)	Heart rate (Forehead)	Cadence (Wrist)	Cadence (Torso)	Temperature (Ambient)	Temperature (Direct Sun)	Temperature (Skin)	Humidity	Total	Qty
Advanced 1	iPod Touch 6	Fenix 3 HR	Fenix 3 HR	Wahoo TickrX	Fenix 3 HR	LifeBeam SmartHat	Fenix 3 HR	Wahoo TickrX	SensorPush	SensorPush	Tempe	SensorPush	**$1,115**	10
Advanced 2	iPod Touch 6	Spartan Ultra	Spartan Ultra	Smart Sensor	(None)	LifeBeam SmartHat	Spartan Ultra	(None)	SensorPush	SensorPush	(None)	SensorPush	**$1,165**	10
Basic 1	iPod Touch 6	Vivoactive HR	Vivoactive HR	(None)	Vivoactive HR	(None)	Vivoactive HR	(None)	SensorPush	(None)	(None)	SensorPush	**$515**	35
Basic 2	iPod Touch 6	eTrex 10 + 2AA	(None - 'floors')	(None)	Fitbit Charge HR	(None)	Fitbit Charge HR	(None)	SensorPush	(None)	(None)	SensorPush	**$485**	15

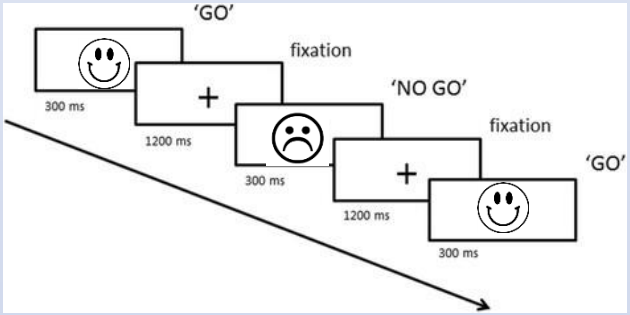
Collecting Physiological and Cognitive Data

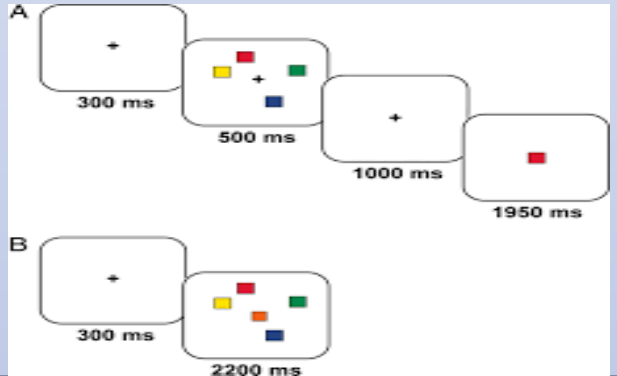


Flanker



Go/No-go





VSTM

Brain Baseline

- Attentional Blink
- Digit Span
- Digit Symbol Substitution
- Flanker
- N-Back
- Go/No-Go
- Posner Cueing
- Speed
- Spatial Working Memory
- Stroop
- Task Switching
- Trails A & B
- Visual Search
- Visual Short-Term Memory

Participants

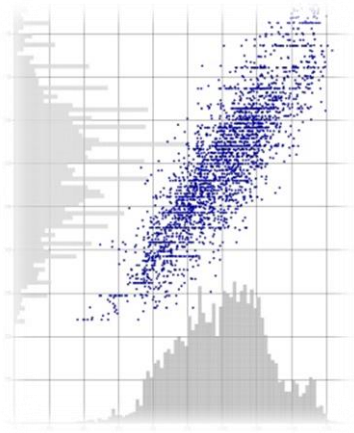
- **Voluntary hikers already doing Rim-to-Rim hike**
- **Military Personnel**

Figure 3a. Experienced hikers check-in to Rim-to-Rim study between 2 – 4am.
Figure 3b. Due to the length of the Rim-to-Rim hike, hikers hike down and up the canyon in the dark with headlamps.

Data

- **Data Extraction**

- **Device Security**



- **Data Analysis**
- **Data Interpretation**
- **Presentation of Findings**
  - Recommendations on Wearables
  - Statistical Findings

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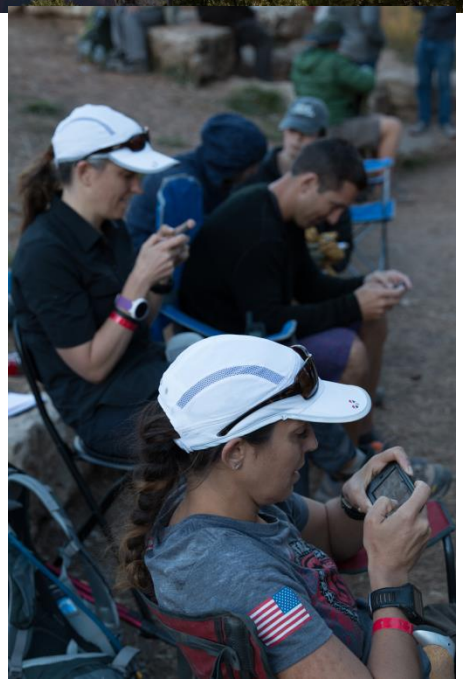
OCTOBER 2016 DATA COLLECTION

75 wearable devices packages
300+ wearable devices

Sandia National Laboratories Team

The University of New Mexico Health Sciences Center


RIM-TO-RIM RESEARCH STUDY
UNM
DEPARTMENT of EMERGENCY MEDICINE
GRAND CANYON




Post-Hike Basic Package 1 - Hot


08:24
26:06
21.53

Differences between Military & Civilians

	Military Personnel	Civilian
Count	12 hikers	38 hikers
Gender	50% male	50% male
Age	35.9 years *(stdev = 6.3)*	46.3 years *(stdev = 11.9)*
Elevation (residence)†	283.8 ft *(stdev = 209.0)*	1542.8 ft *(stdev = 2226.4)*
Weight*	169.4 lb *(stdev = 29.4)*	163.3 lb *(stdev = 23.6)*
SpO2*	95.0% *(stdev = 3.4)*	95.5% *(stdev = 3.1)*
Heart rate (standing)*	84.6 bpm *(stdev = 9.0)*	79.4 bpm *(stdev = 13.5)*
Heart rate (sitting)*	81.9 bpm *(stdev = 8.9)*	77.4 bpm *(stdev = 13.4)*
Sleep	5.9 hrs *(stdev = 1.1)*	5.9 hrs *(stdev = 1.4)*
Longest distance	33.4 mi *(stdev = 23.2)*	40.3 mi *(stdev = 26.7)*
Prev. completed R2R	8% yes	39% yes

†Elevation along the R2R trail ranges from 2400 to 8200 ft

**Prior to beginning hike*

Military vs Civilian: Cognitive Differences

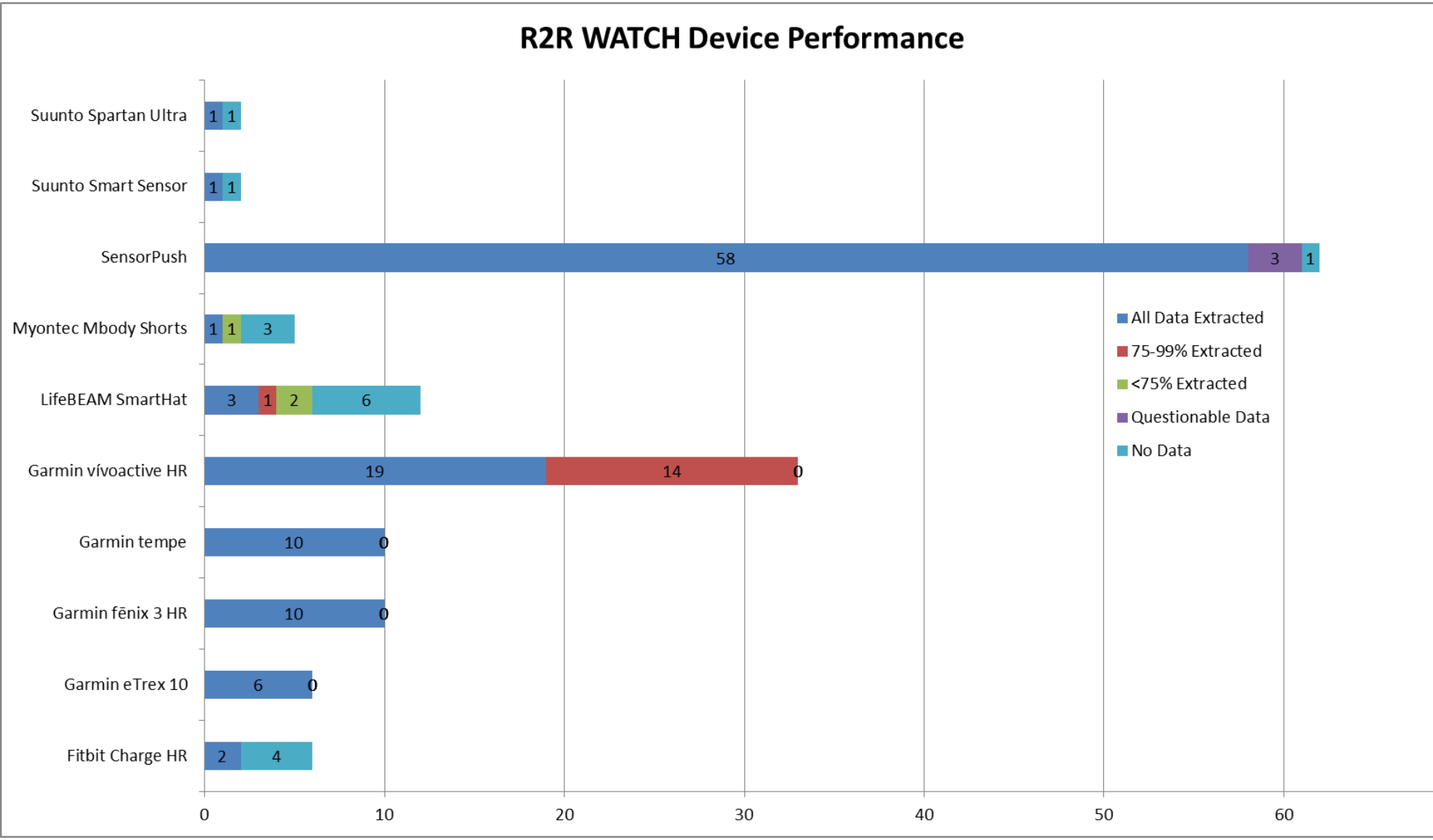
First Test		Military	Civilian
Go/No-go:	Time	527 ms (sd = 66)	554 ms (sd = 87)
	Accuracy	0.964 (sd = 0.061)	0.957 (sd = 0.070)
Flanker:	Time	594 ms (sd = 109)	592 ms (sd = 98)
	Accuracy	0.935 (sd = 0.140)	0.943 (sd = 0.107)
VSTM:	Time	1012 ms (sd = 206)	1139 ms (sd = 309)
	Accuracy	0.779 (sd = 0.082)	0.732 (sd = 0.093)

Last Test		Military	Civilian
Go/No-go:	Time	488 ms (sd = 92)	530 ms (sd = 71)
	Accuracy	0.940 (sd = 0.060)	0.949 (0.070)
Flanker:	Time	496 ms (sd = 64)	559 ms (sd = 71)
	Accuracy	0.975 (sd = 0.026)	0.956 (sd = 0.098)
VSTM:	Time	978 ms (sd = 411)	1088 (sd = 343)
	Accuracy	0.779 (sd = 0.082)	0.702 (sd = 0.106)

Military performed better in 10 / 12 measures

Military's advantage increased in later trials, especially with response time: Could be less fatigue or better learning

Overall Device Performance



Cognitive-HR Connection to examine fatigue

- Goal of Model 1: validate that BrainBaseline captures fatigue effect
- Take advantage of structure of experiment for robust measures
  - Know subjects start experiencing light fatigue hiking down the Canyon, heavy fatigue hiking back up the Canyon
  - Capture this in two variables: Percent descended, percent ascended
- Important to validate, but results do not extend to a non-controlled environment

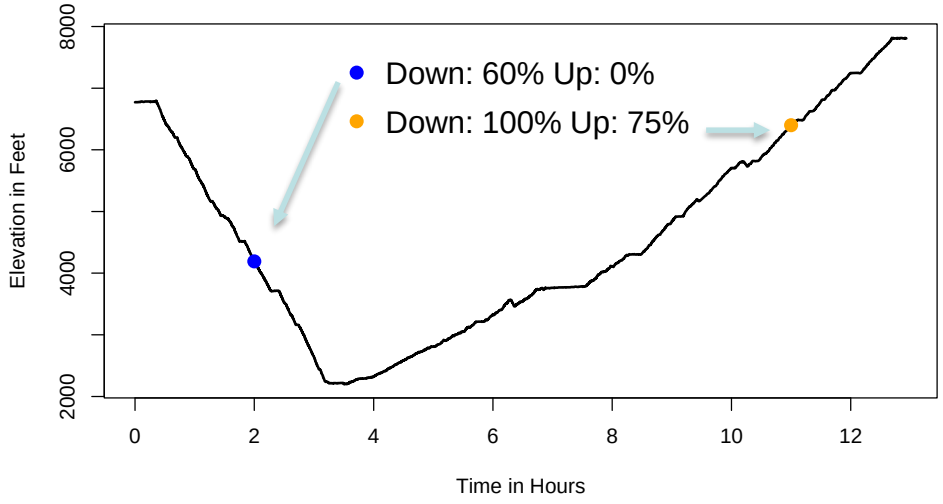


Table 2.

Estimated Effects on Response Time			
	Estimate	95% CI	P value
Flanker-congruent: Proportion up	72.1	(23.7, 120.6)	0.004
Flanker-congruent: Proportion down	-8.0	(-69.1, 53.1)	0.797
Flanker-incongruent: Proportion up	49.8	(-8.2, 107.9)	0.093
Flanker-incongruent: Proportion down	6.5	(-67.7, 80.8)	0.863
Go/no-go: Proportion up	27.7	(-23.6, 78.9)	0.290
Go/no-go: Proportion down	32.9	(-22.7, 88.5)	0.247
VSTM: Proportion up	206.8	(10.8, 402.9)	0.039
VSTM: Proportion down	225.2	(-33, 483.4)	0.087

Response time effects for the cognitive battery as a function of proportion up and down the canyon.

Table 3.

Estimated Effects on Accuracy			
	Estimate	95% CI	P value
Flanker: Proportion up	-0.003	(-0.052, 0.046)	0.9102
Flanker: Proportion down	-0.002	(-0.067, 0.063)	0.9562
Go/no-go: Proportion up	-0.047	(-0.088, -0.007)	0.0229
Go/no-go: Proportion down	-0.030	(-0.074, 0.015)	0.1878
VSTM: Proportion up	-0.124	(-0.184, -0.064)	0.0001
VSTM: Proportion down	-0.098	(-0.178, -0.019)	0.0155

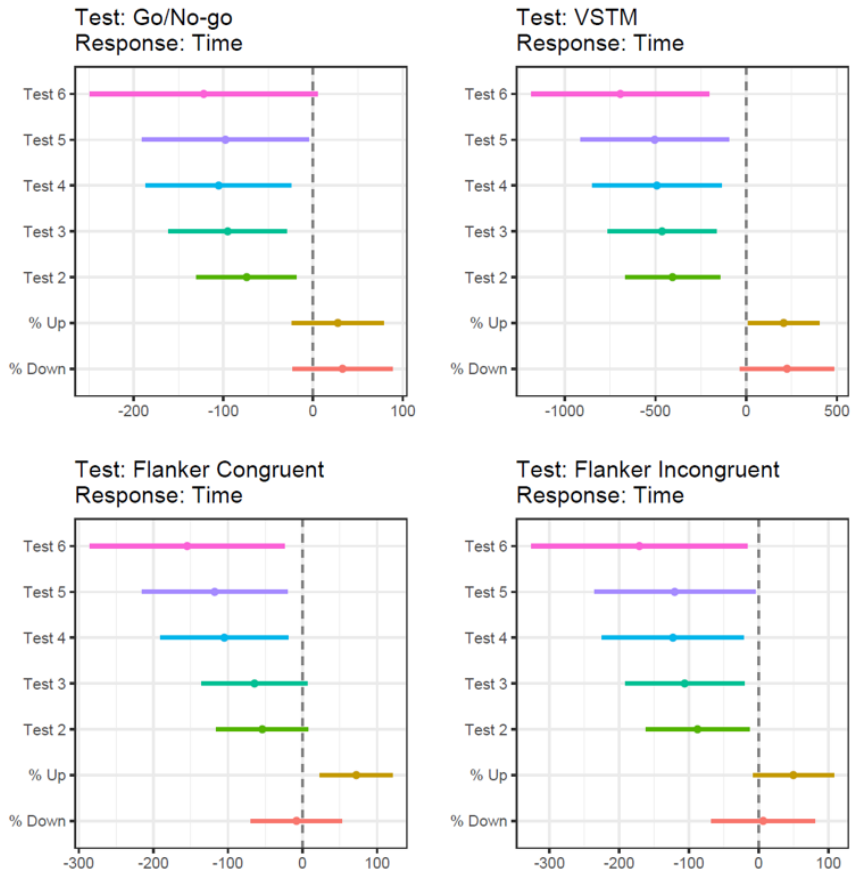
Accuracy effects for the cognitive battery as a function of proportion up and down the canyon.

Hypotheses

- Fatigue would have a positive effect on response time (increase)
- Fatigue would have a negative effect on accuracy (decrease)
- In 13/14 estimated effects, this trend was observed (p-value from sign test: 0.0009).
- **Brain Baseline scores decline as fatigue increases**

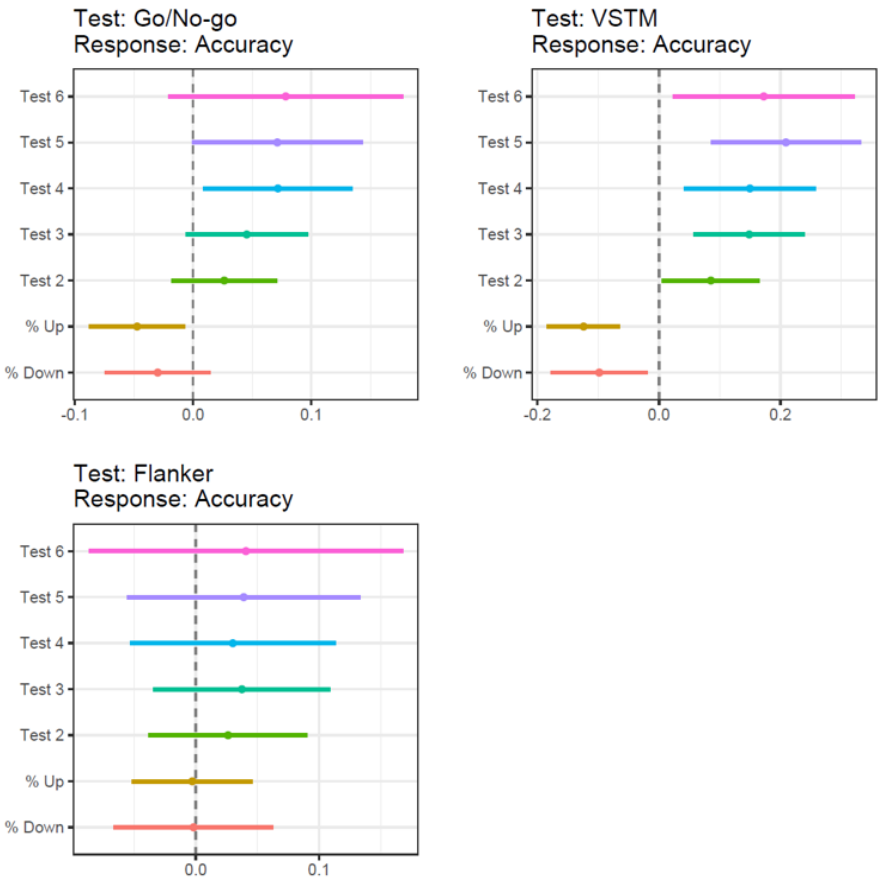
Brainbaseline-Fatigue Connection

Figure 2.



Response time effects for the cognitive battery as a function of proportion up and down the canyon, including learning effects.

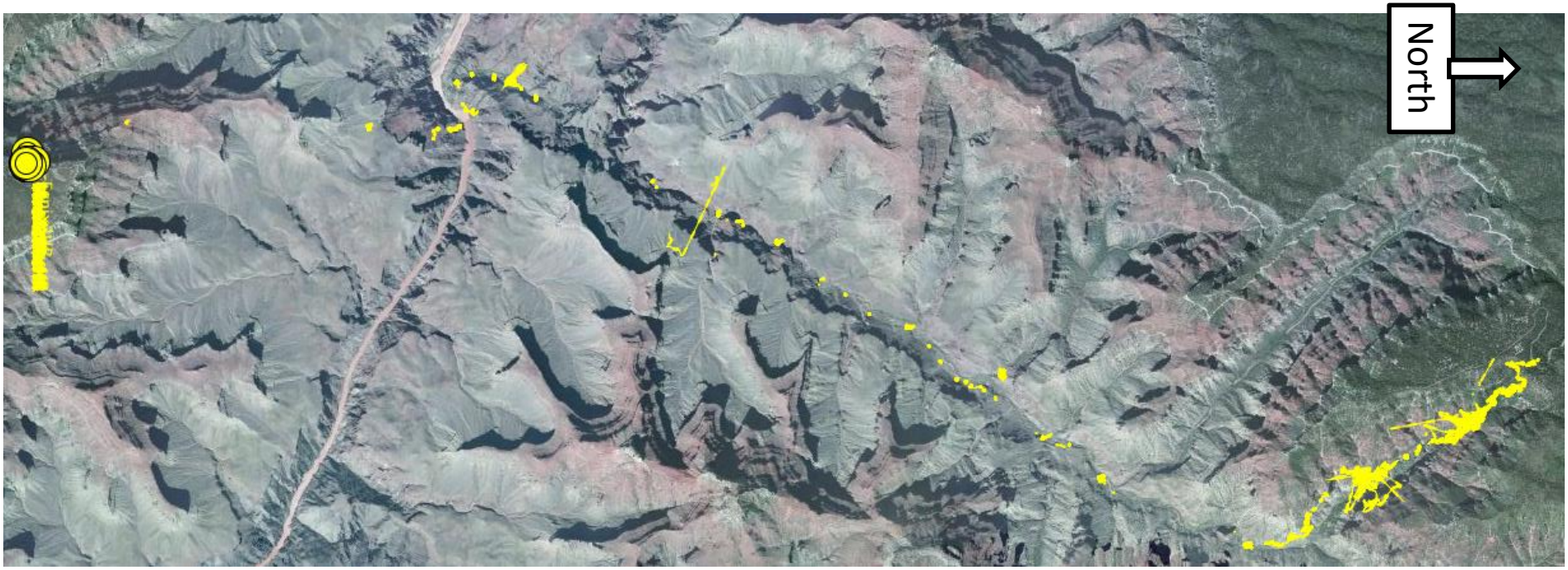
Figure 3.



Accuracy effects for the cognitive battery as a function of proportion up and down the canyon, including learning effects.

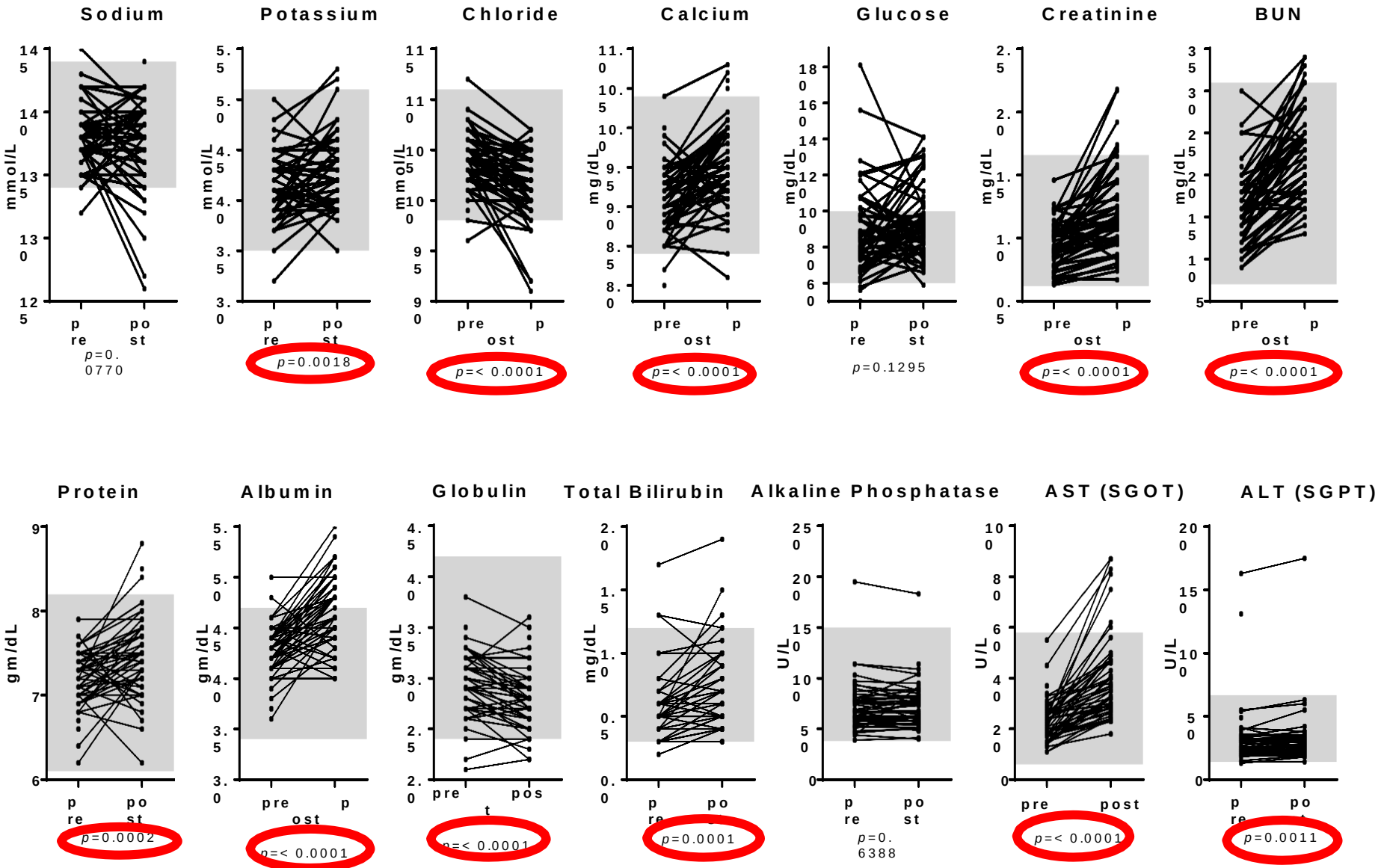
Hypothesis: heart rate responds more quickly to changes in workload as fatigue sets in

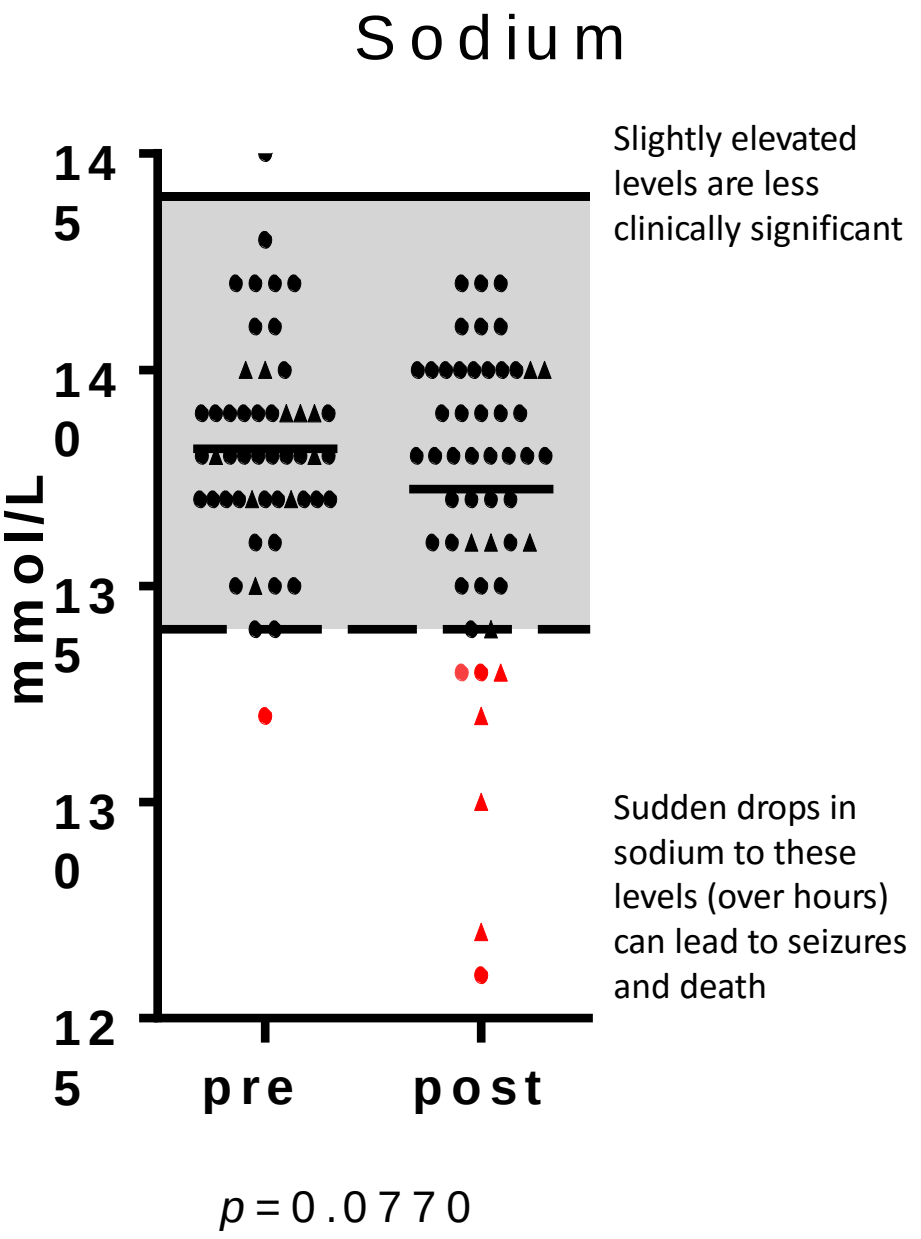
Detecting changes in workload - Breaks



- This is everywhere that somebody's pedometer (wrist-based accelerometer) read 0 for at least 80% of samples in any 5-minute period
- GPS was not used to detect breaks, only indicate where they were at the time
- This appears to be a reasonably promising, if crude, way to detect changes in workload
- But maybe it would be easier to just get a sample of more controlled data to start with

“Complete Metabolic Panel” – Standard Clinical Laboratory tests used commonly in most patients who receive blood tests. n = 51 matched samples, 60 total subjects *p* values from paired T-test between pre and post crossing samples. Red circles highlight significant differences.





Sodium levels did not change significantly as a population. This is in part because half of the subjects sodium concentrations increased, while the other half decreased. This is has important implications as decreases in sodium can lead to catastrophic outcomes including seizure, coma, and death. In less severe cases it can lead to nausea and declines in performance.

Previous literature implicates human behavioral factors like amounts of food and water ingestion as significant predictors. Molecular mechanisms through Arginine Vasopressin have also been implicated.

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THANK YOU

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