National Aeronautics and Space Administration

Evaluation of baroreflex effectiveness index during real and simulated microgravity: relation to orthostatic intolerance

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SPACE LIFE SCIENCES
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Introduction

- From Lexington, KY
- Studying Biomedical Engineering at the Georgia Institute of Technology, graduating in December 2013
- Previously conducted research with the University of Kentucky Biomedical Engineering department
  - Cardiovascular regulation during lower body negative pressure

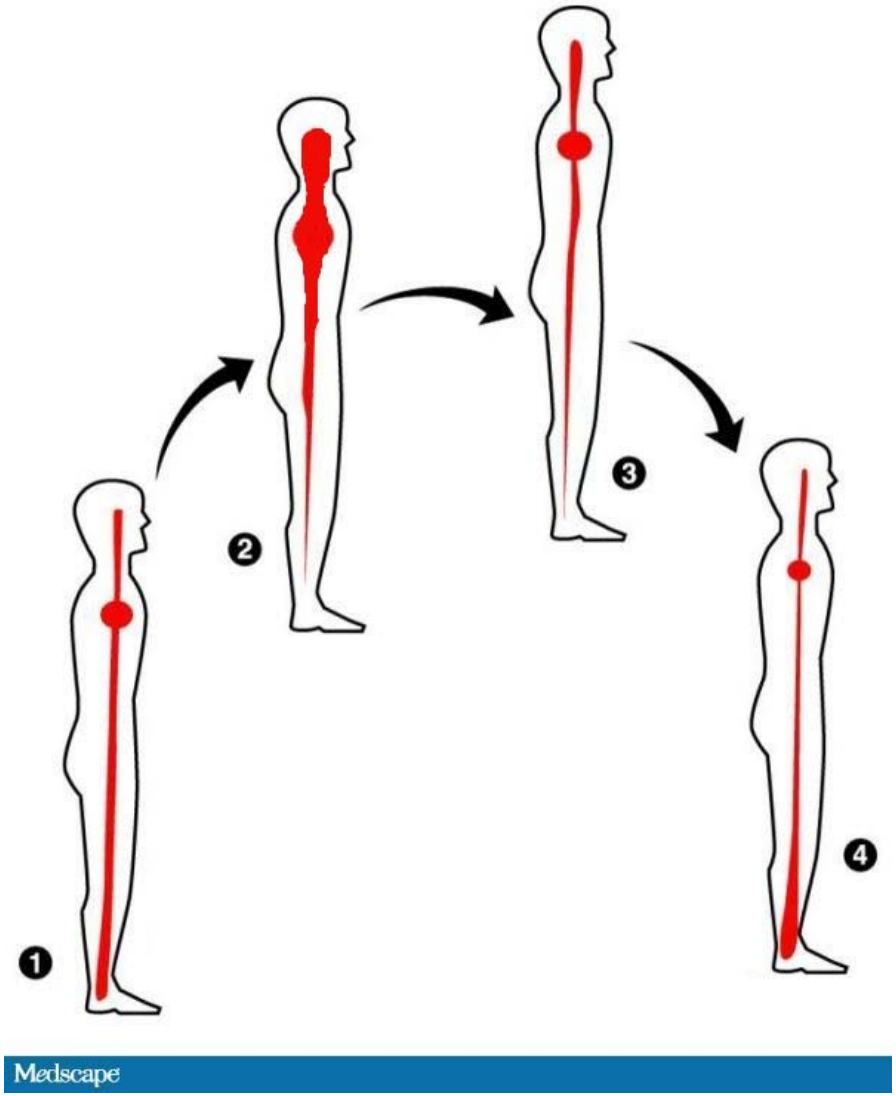
Objectives of Internship

- Gain valuable experience with spaceflight research and work outside an academic environment
- Assess baroreflex effectiveness index (BEI), a measure of the body's response to changes in blood pressure (BP), in:
  - Astronauts before and after space flight
  - Test subjects participating in models of space flight deconditioning
  - Relation to post space flight orthostatic intolerance (OI), inability to control BP after standing in gravity

Background: Fluid Shifts in Microgravity

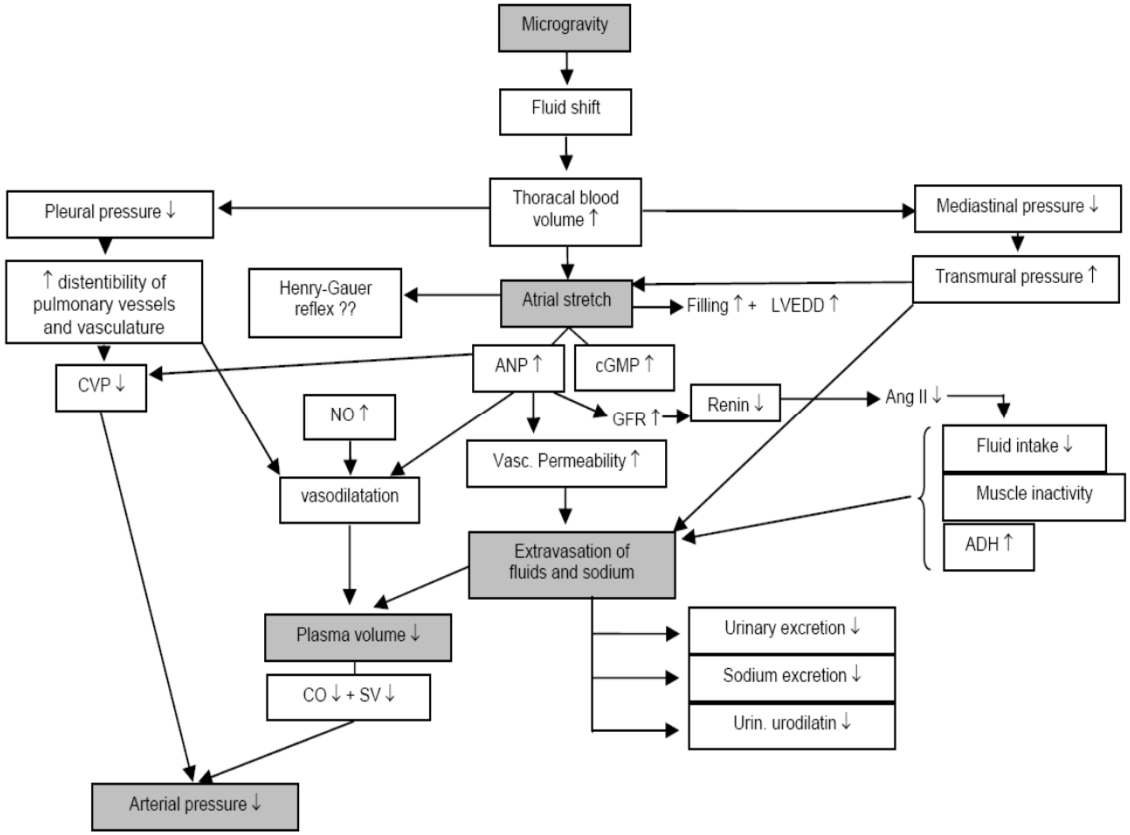
- Blood pressure monitored baroreceptors in arteries that relay signals to the brain
  - Adapting to microgravity retrains baroreceptors to work differently

1. Gravity on Earth causes blood to pool in lower body
2. Entering microgravity causes blood to redistribute to head and upper body
3. Adapting to microgravity causes blood volume to decrease
4. Re-entering Earth's gravity pulls fluid volume to legs



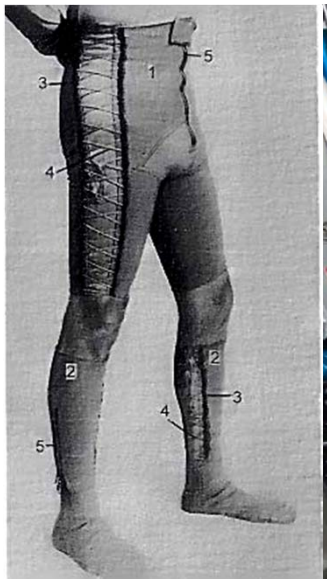
Background: Orthostatic Intolerance (OI)

- Microgravity can cause OI in astronauts returning to Earth
  - Fluid shifts
  - Neural, vascular, and cardiac changes in blood pressure control
  - Decrease in cardiac function related to duration of flight
- The inability to control blood pressure during gravitational stress (i.e. standing)
  - Heart Rate Increase
  - Presyncope (lightheadedness, loss of peripheral vision)
  - Syncope (fainting)



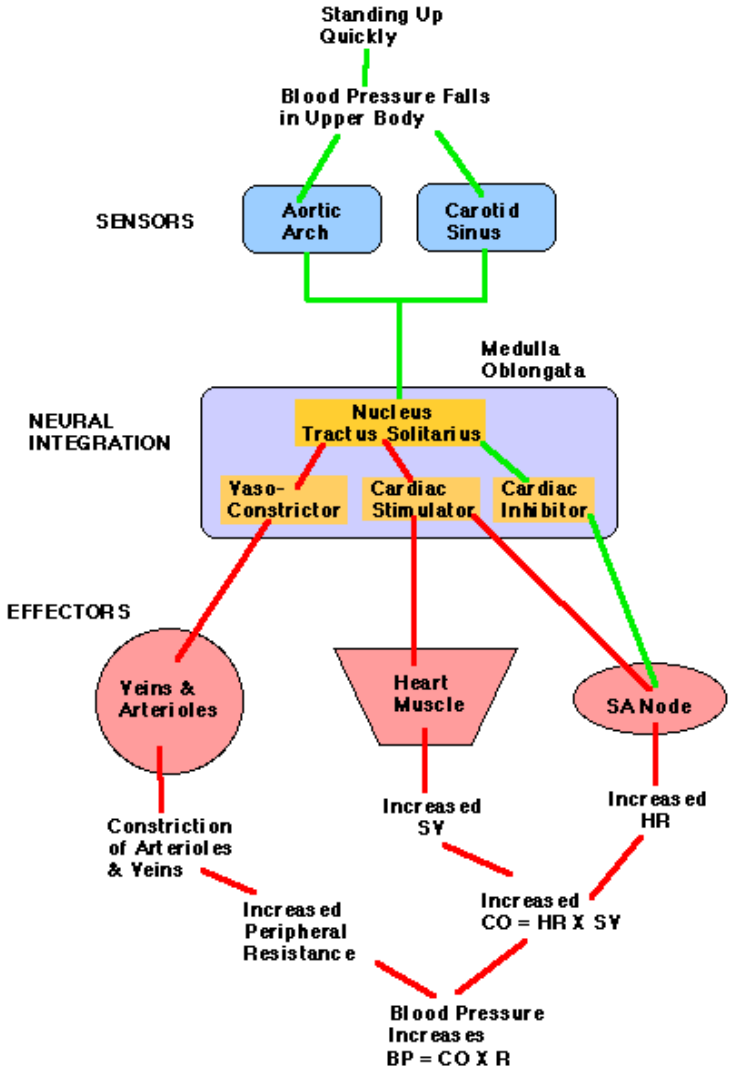
Background: Orthostatic Intolerance (OI)

- Health and safety concern for astronauts returning from long and short duration missions
  - Re-entry
  - Landing
  - Post-landing activities
  - Incidence of presyncope
    - STS missions: 20%
    - ISS missions: 60-80%
- Countermeasures are used to reduce OI symptoms
  - Fluid loading before re-entry
  - Exercise to maintain cardiac function
  - Compression Garments



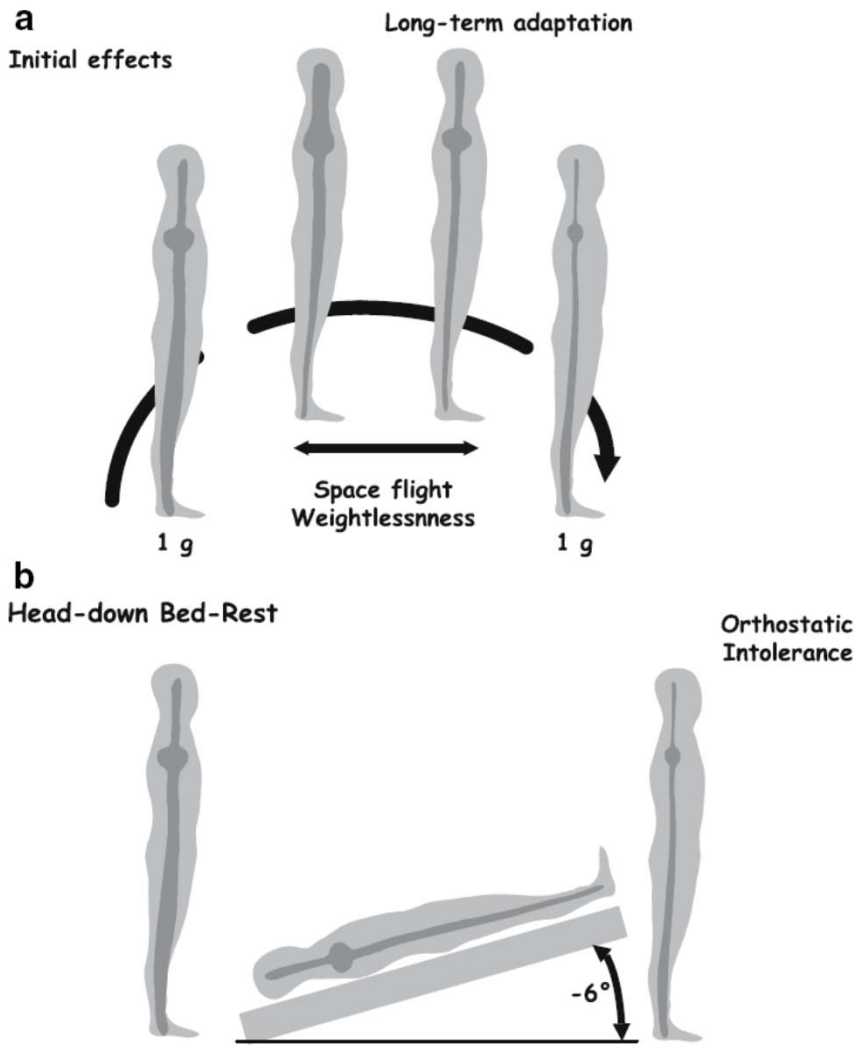
Background: Baroreflex

- Baroreceptor reflex (baroreflex) regulates blood pressure from baroreceptors sensing stretch in the carotid arteries and aorta
- Baroreflex effectiveness index (BEI) measures how frequently oscillations in blood pressure trigger an appropriate response in heart rate
  - How effective is this response to blood pressure change?
  - Has not yet been applied to at NASA to space flight research



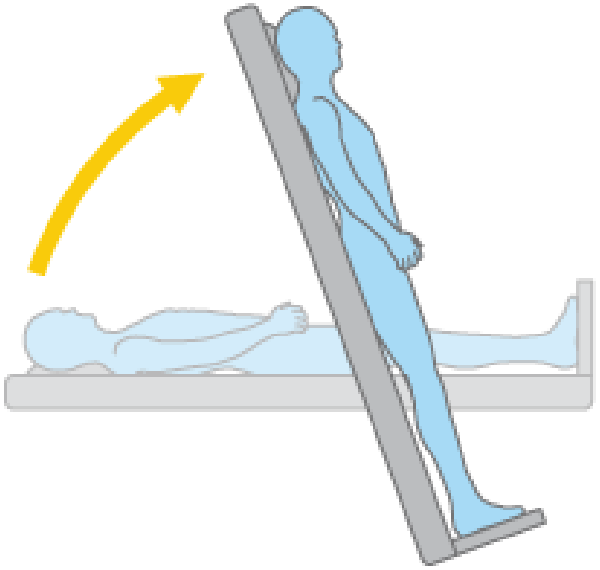
Background: Space Flight and Bed Rest

- Select individuals have the opportunity to participate in space flight
  - Small numbers for space flight (SF) studies
- Use analogues to simulate the effects on the body of space flight on Earth
  - 6º head down bed rest (BR)



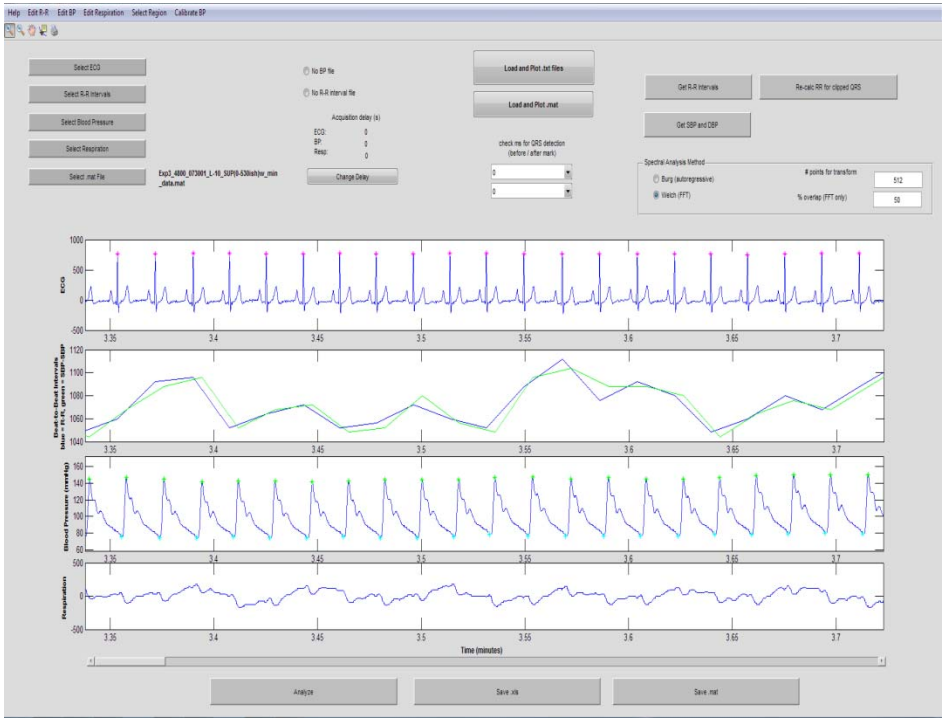
Methods

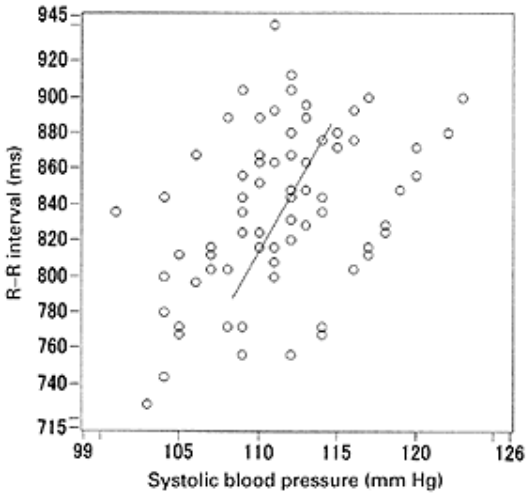
- Tests
  - Flight/Bed Rest Testing Days
    - L-10/BR-5 five to ten days before
    - R+0/BR+0 day of return or end of bed rest
  - Subjects were tested
    - Supine (laying down) for 2-5 minutes
    - Tilted to 80º on each of the testing days for 10-30 minutes or until symptoms of presyncope

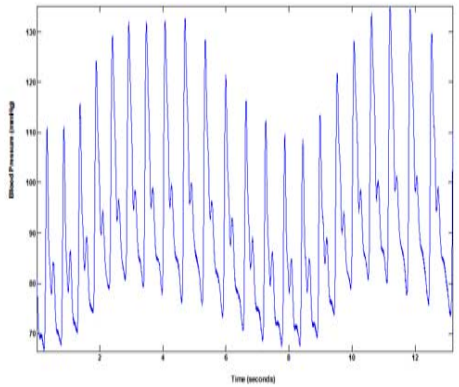


Methods

- Data Collected
  - Blood Pressure (Finometer, Finopress)
    - Systolic blood pressure (SBP)
  - Electrocardiogram (ECG)
    - R-R interval
- Data Analysis
  - NOTOCORD, MATLAB
  - $BEI = \frac{R{-}R\ intervals\ correlate\ with\ SBP\ ramps}{total\ SBP\ ramps}$
- Statistical Analysis
  - Student's t-test, two-way ANOVA
    - P<0.05 taken as significant
  - Simple linear regression, Survival Analysis
    - R^2 >0.9 taken as strong correlation

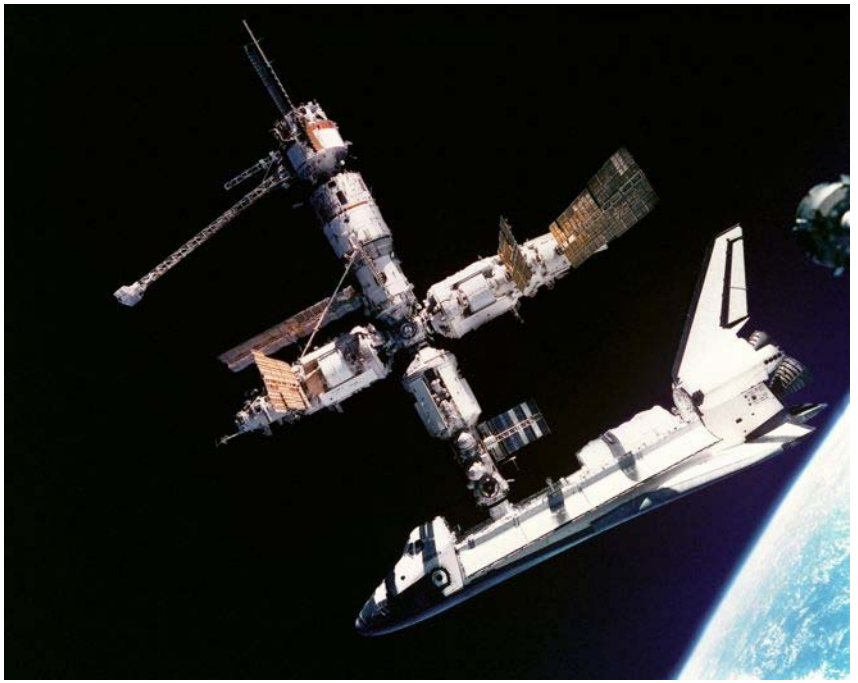






How does SF affect BEI?

- Space Flight
  - Short Duration (STS 116-118,120,122-124)
    - Two weeks
    - n=9
  - Long Duration (ISS Expeditions 1-15)
    - Up to six months
    - R+0 n=5
    - R+1 n=8



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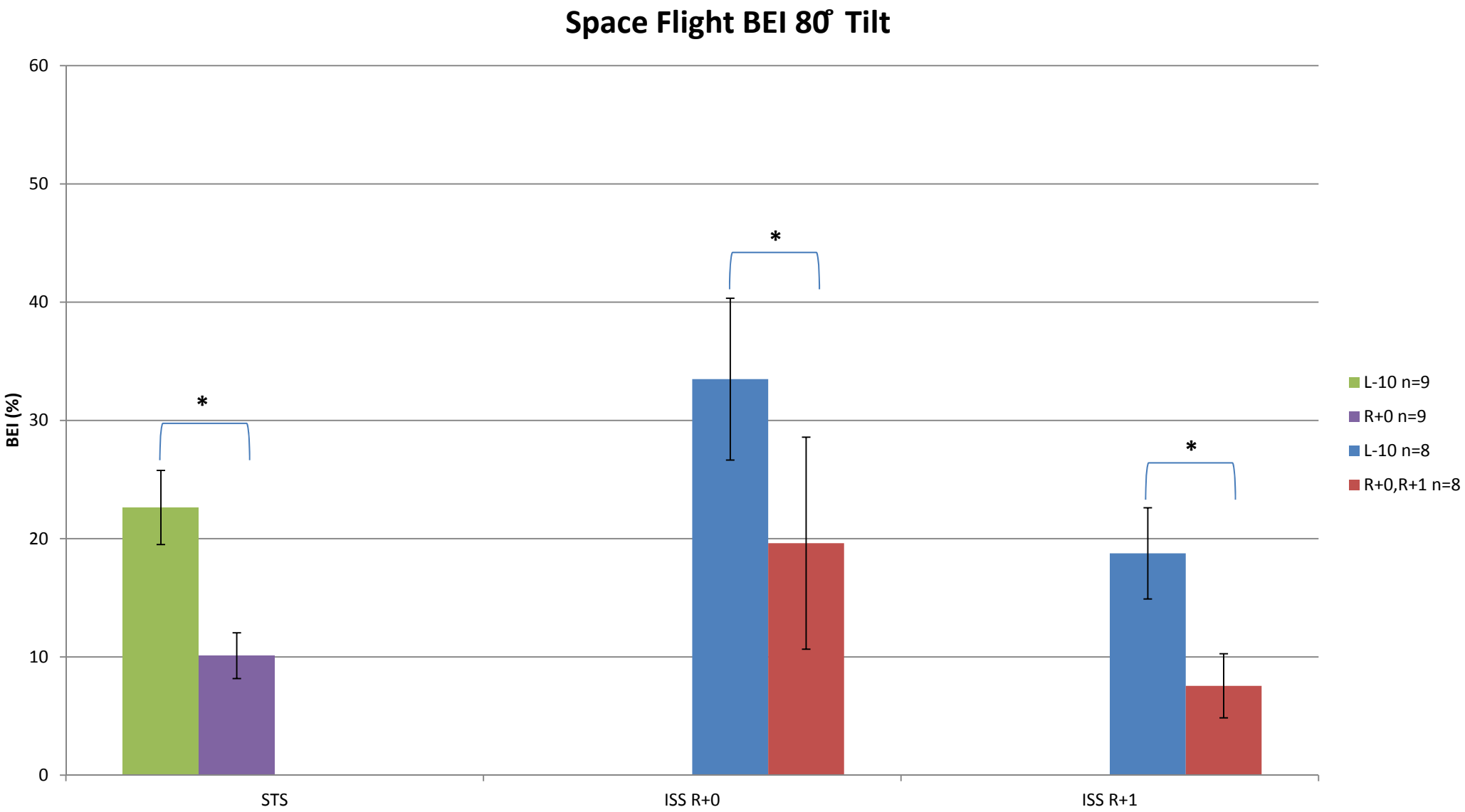
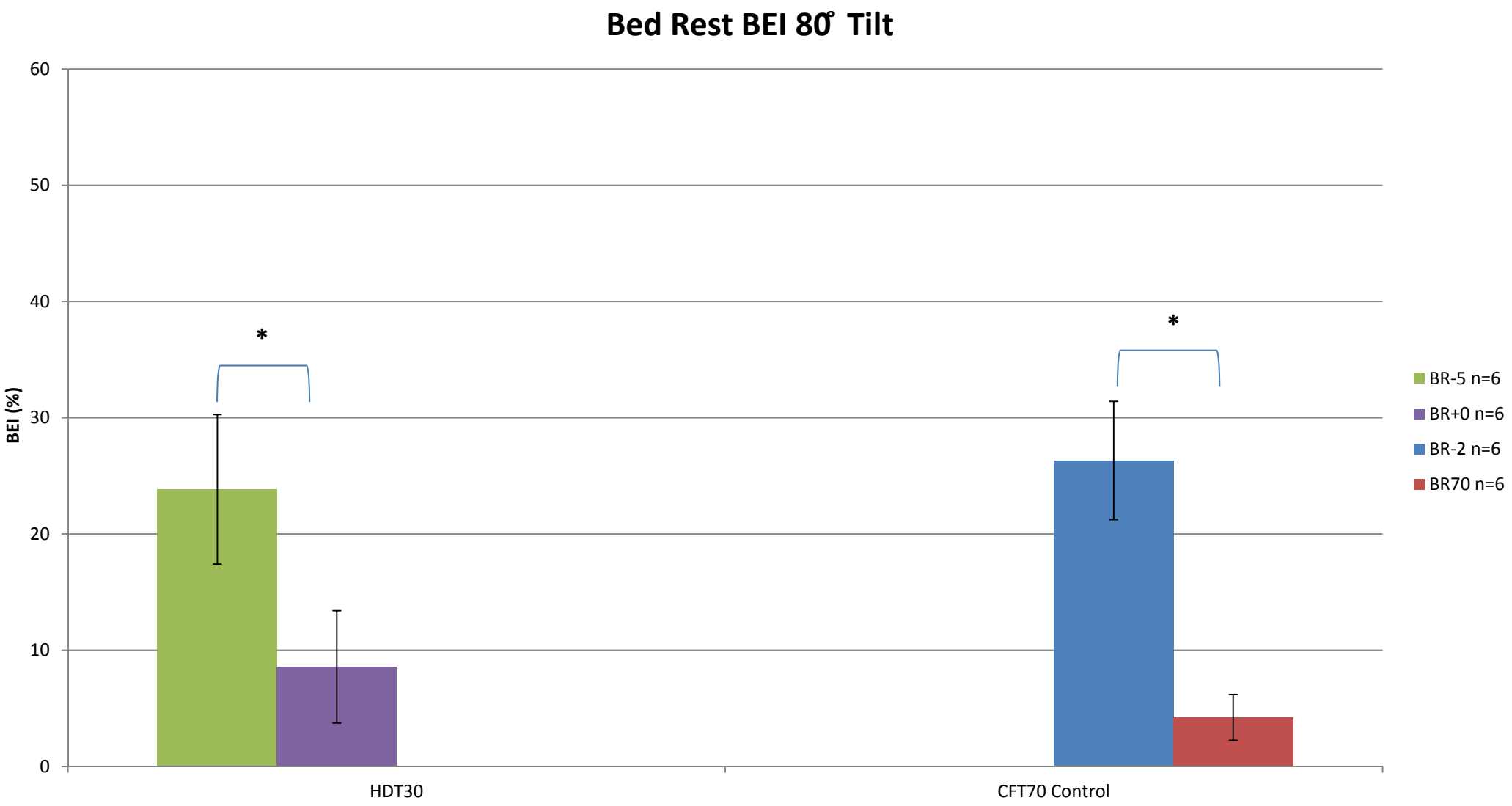


How does BR affect BEI?

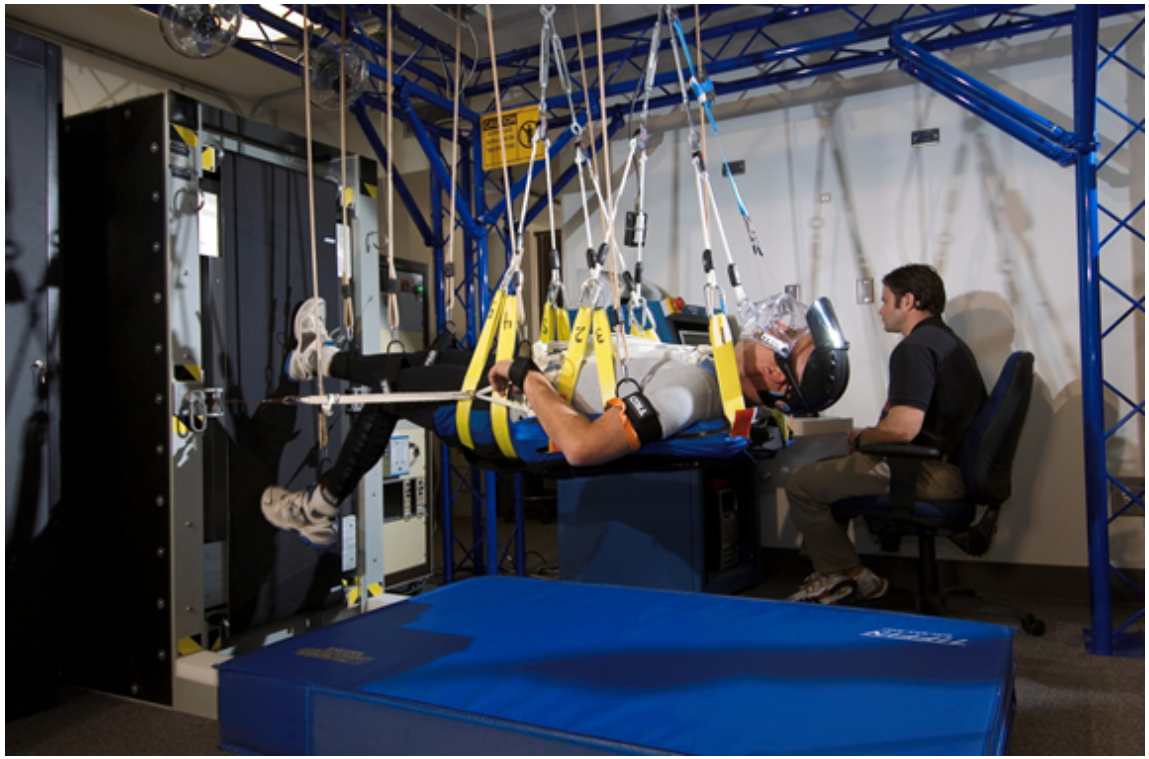
- Head Down Bed Rest
  - Short Duration (HDT30)
    - 30 days
    - n=7
  - Long Duration (CFT70)
    - 70 days
    - Control, n=6
    - Treatment (exercise) n=6

How does BR affect BEI?



How do countermeasures affect BEI?

- Head Down Bed Rest Countermeasures
  - Exercise (CFT70)
    - Control, n=6
    - Treatment, n=6



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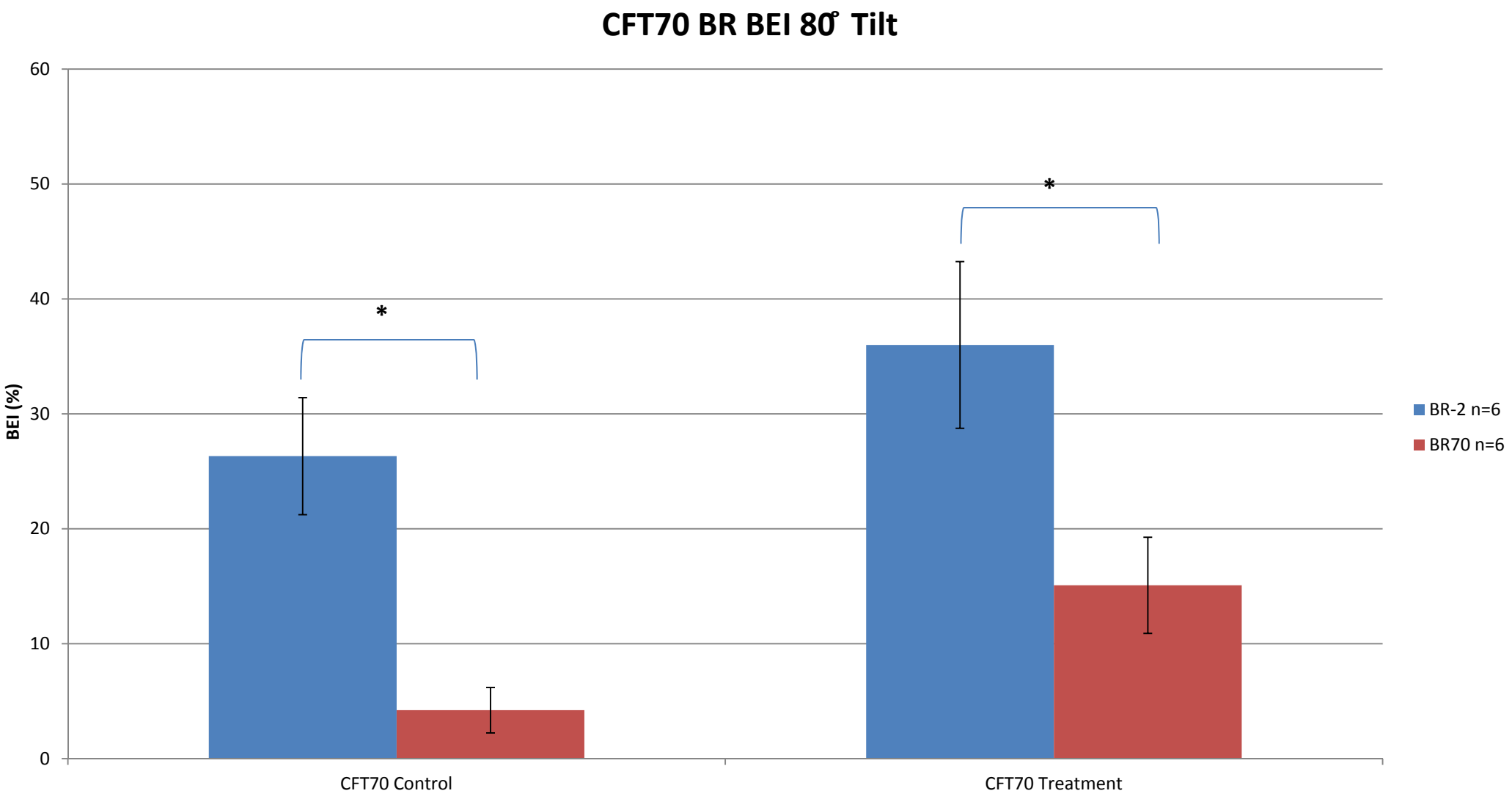
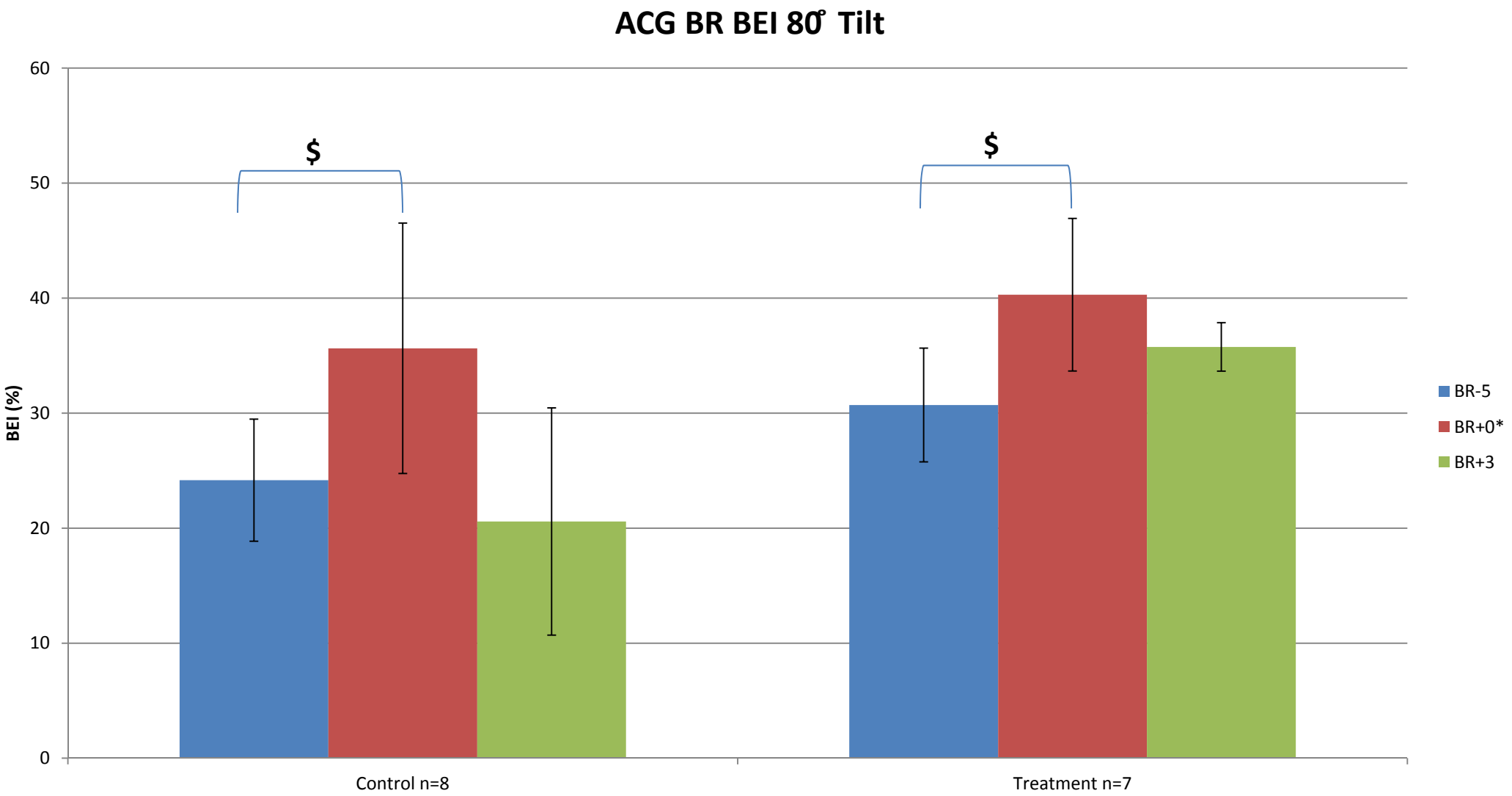


How do countermeasures affect BEI?

- Head Down Bed Rest Countermeasures
  - Compression Garments (ACG)
    - Control, n=8
    - Treatment, n=7

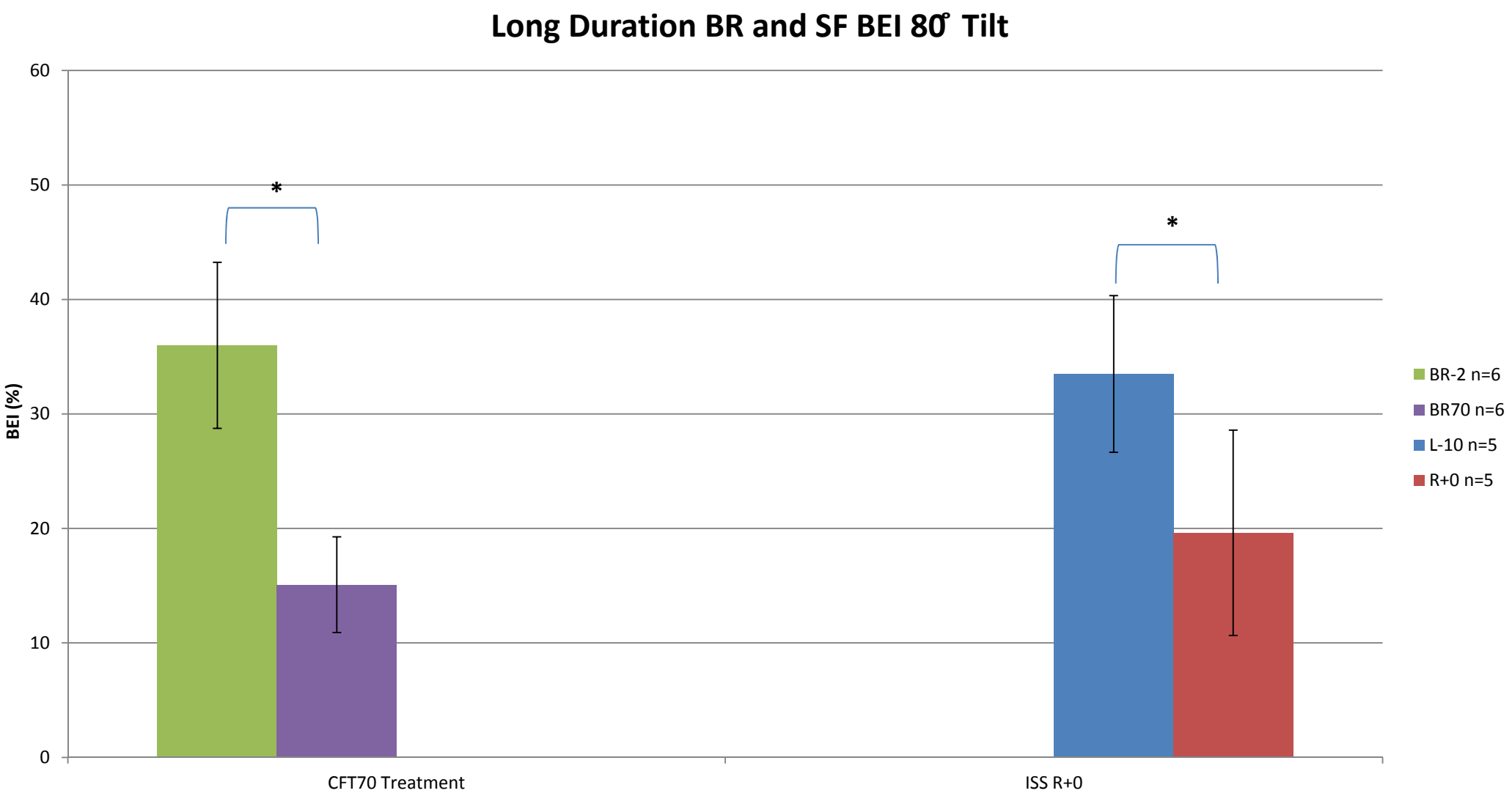
How do BR countermeasures affect BEI?



Is BR an effective model of SF?

- Studies
  - SF (ISS, STS)
    - R+0, n=6
  - BR (CFT70, HDT30)
    - Treatment, n=7
- Astronauts exercise 1.5 hours a day during flight
- CFT70 subjects exercised during bed rest

Is BR an effective model of SF?



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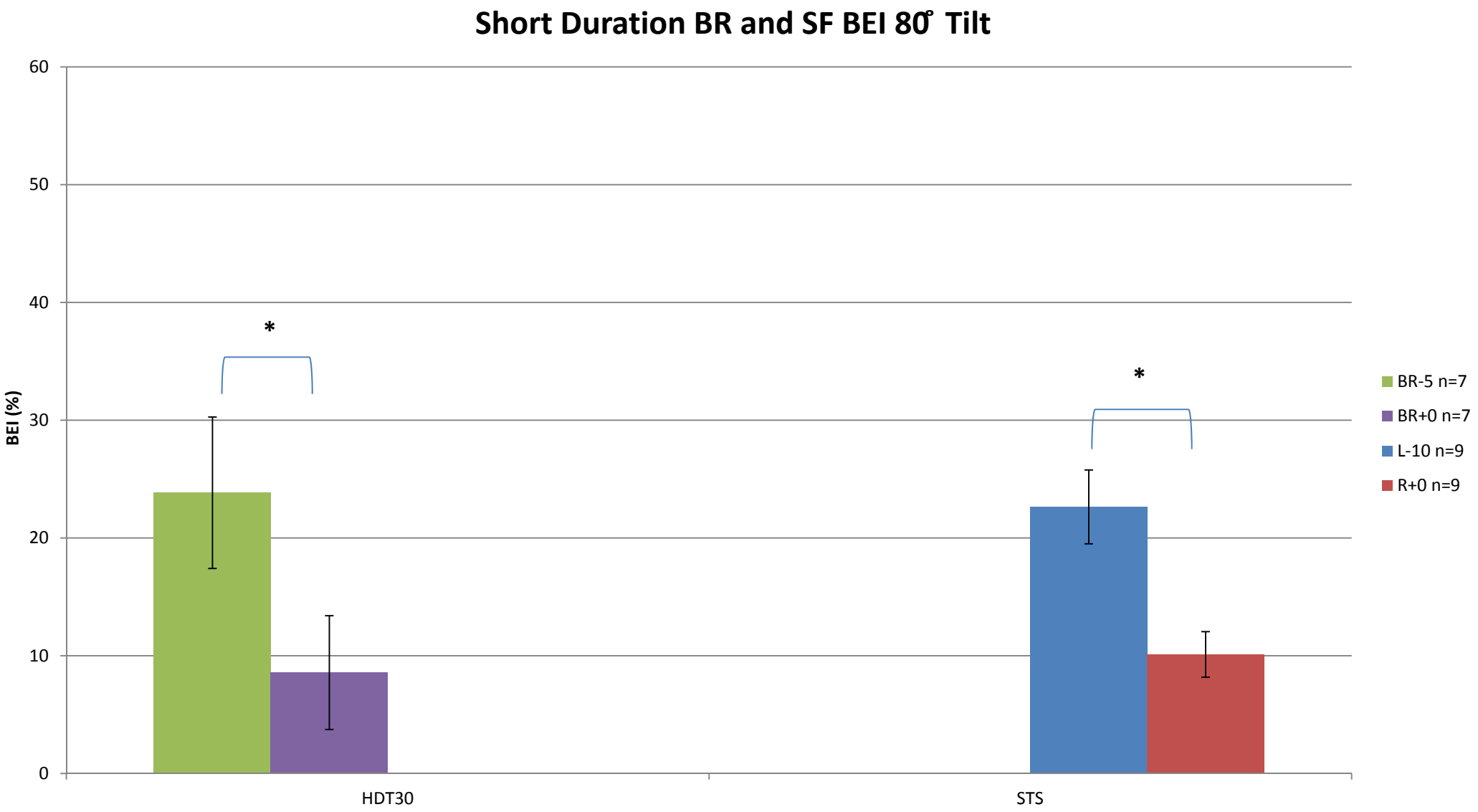
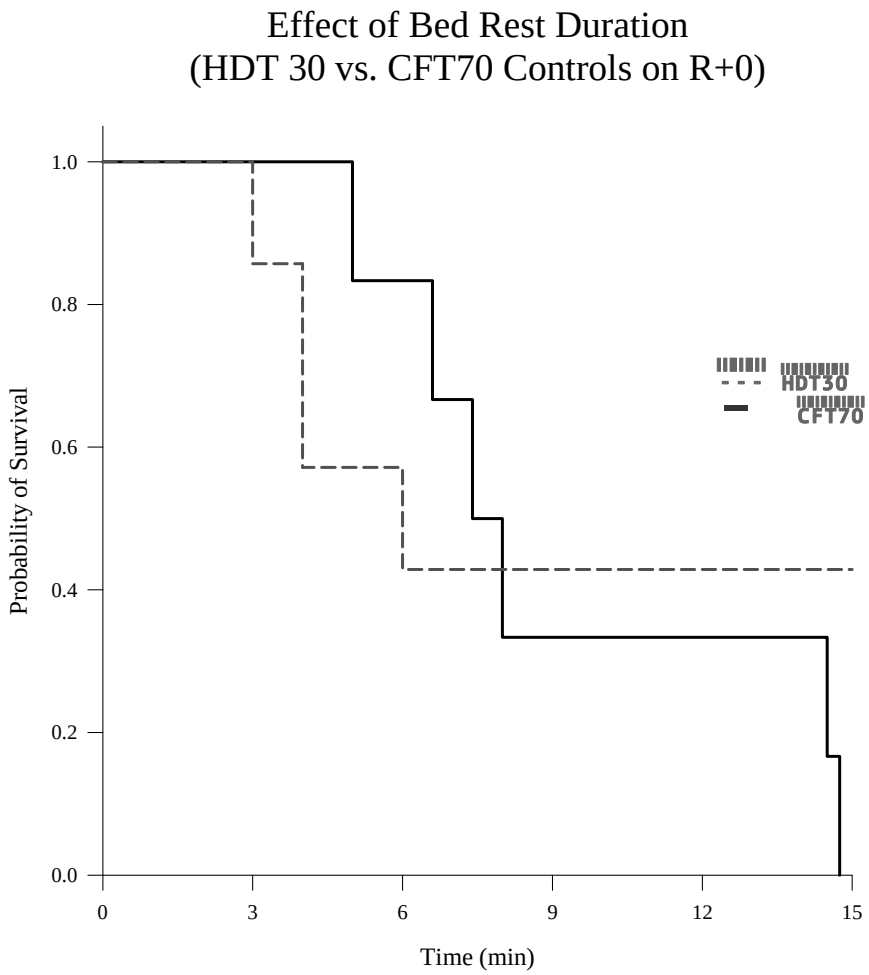
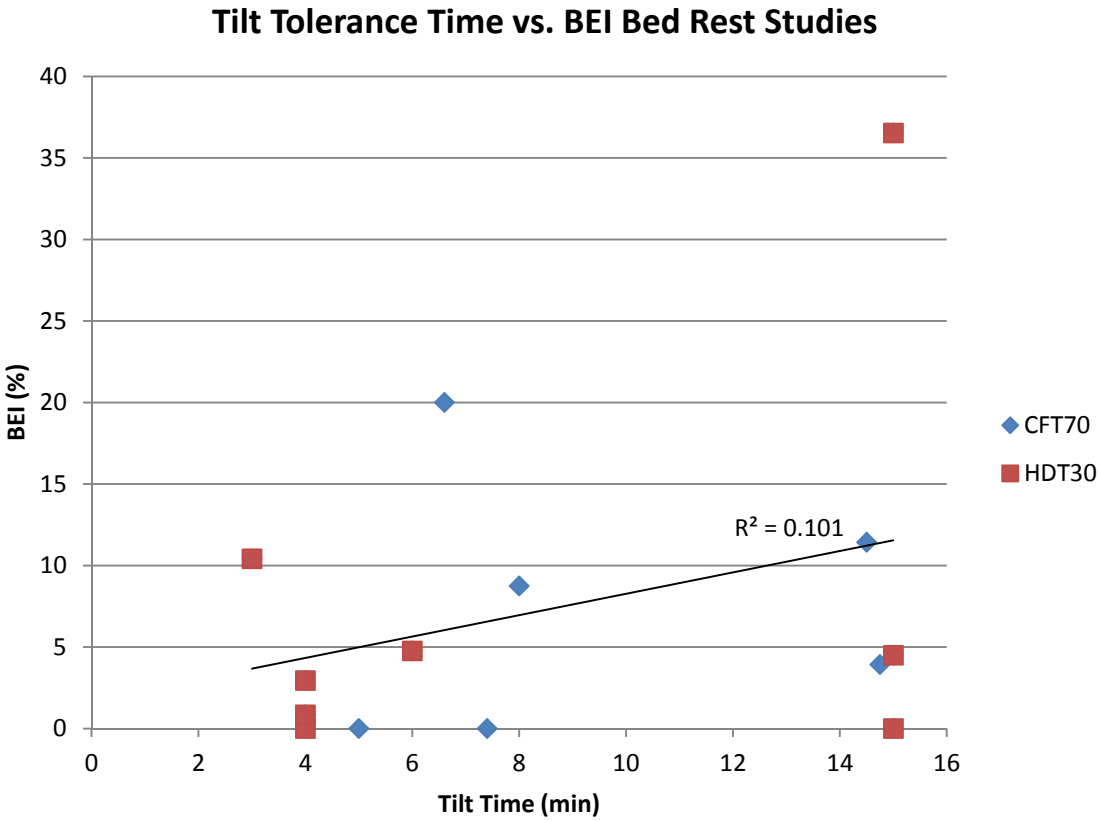


How does BEI relate to OI?





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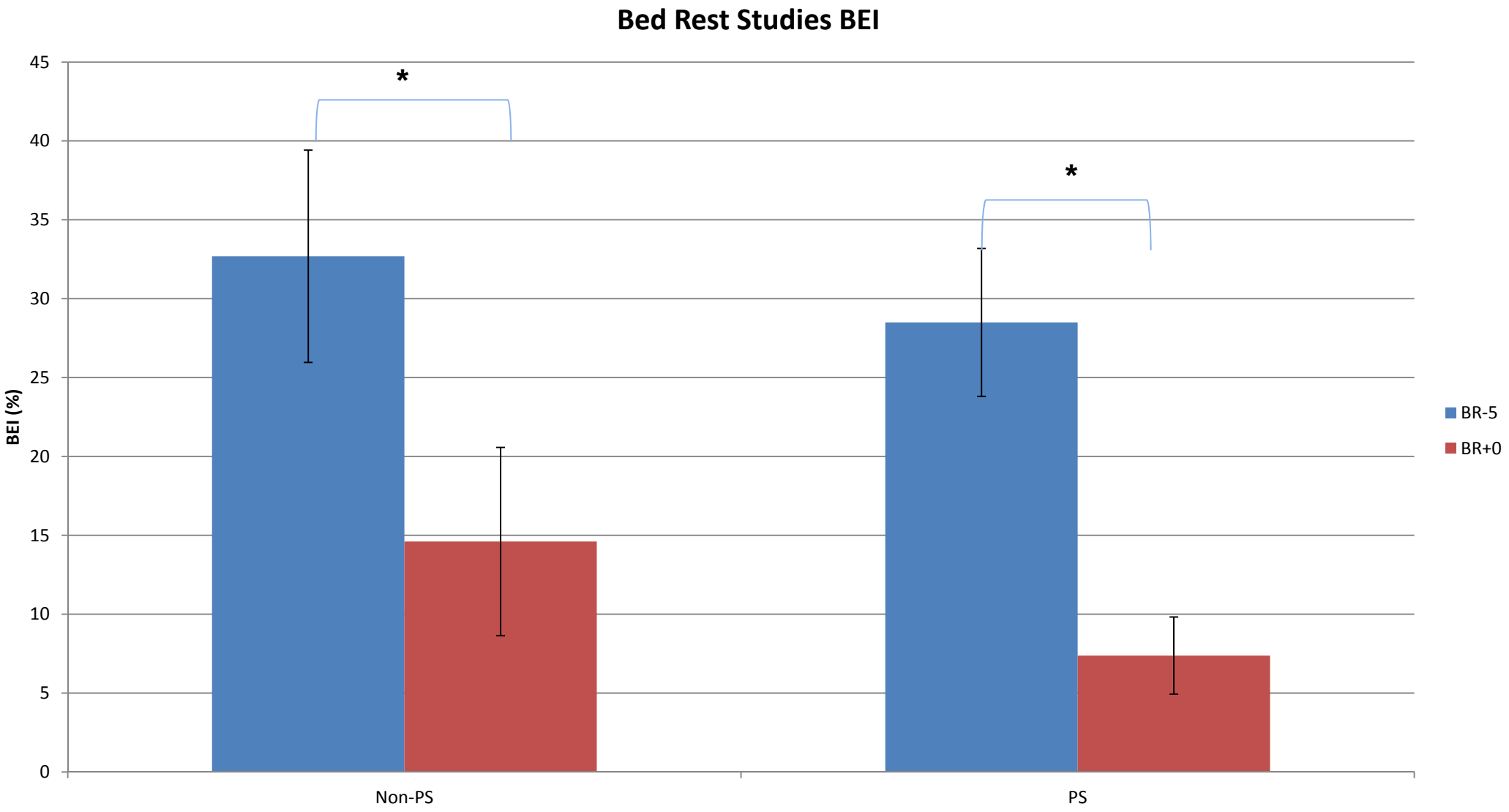

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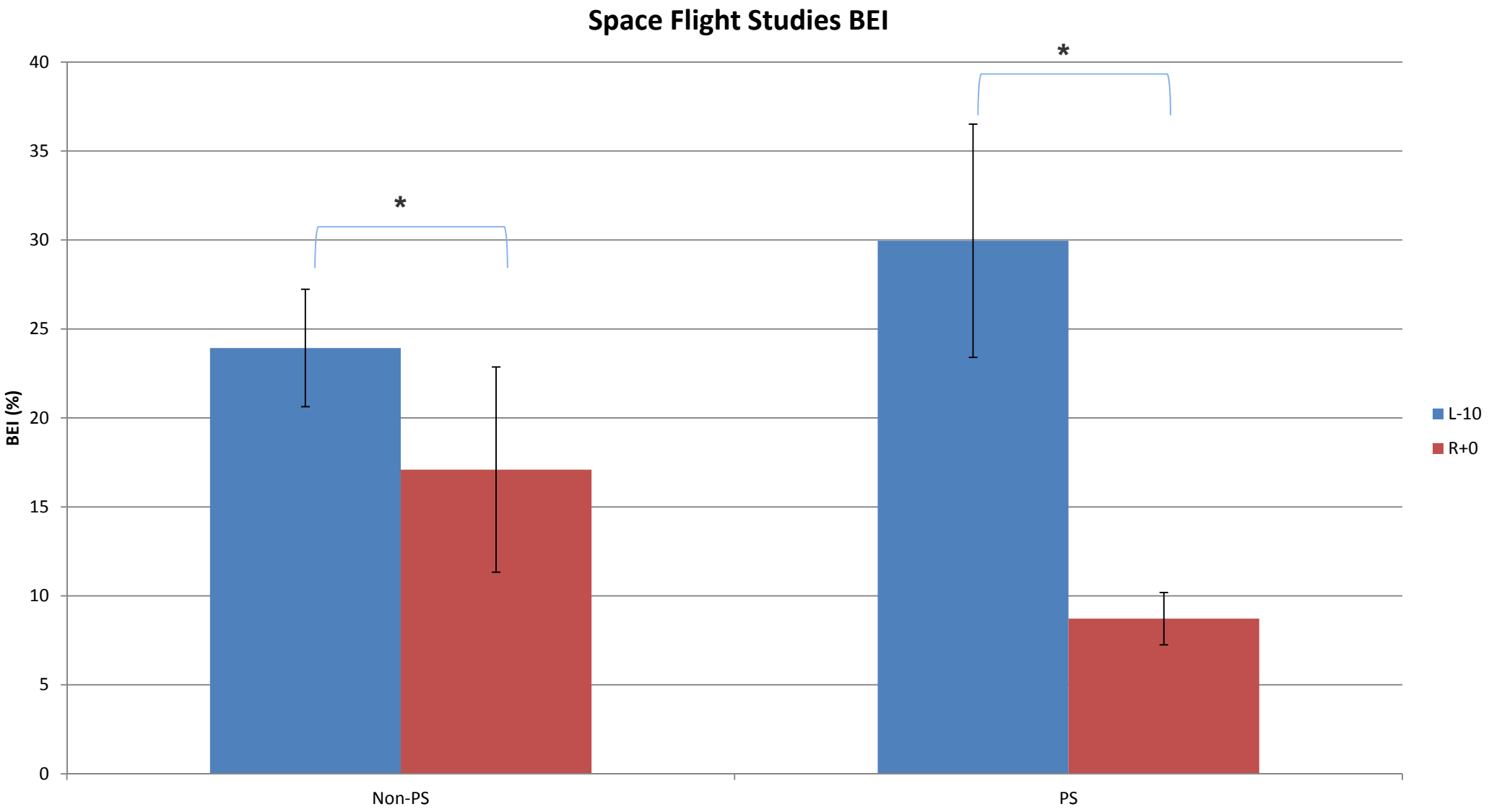

Conclusions

- Bed Rest and Space Flight cause a significant decrease in BEI
- BR causes similar changes to BEI as SF
- BEI may not correlate with subjects experiencing presyncope, but error is high and n is low
- Compression Garments have the potential to restore BEI after short duration BR, but do not prevent recovery

Future Plans

- Compare results with other baroreflex measures to better assess baroreflex function
- Compare BEI to other measures of baroreflex function and their relationship to OI
- Investigate gender effects on BEI in relation to OI
- Further testing of compression garment use to maintain BEI and decrease OI after long duration BR and SF
- Continue to work with the Cardiovascular Lab presenting this study at conferences with the goal of eventual publication

Acknowledgements

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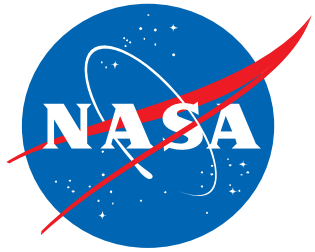
NASA