Model Flow Determination of Stroke Volume

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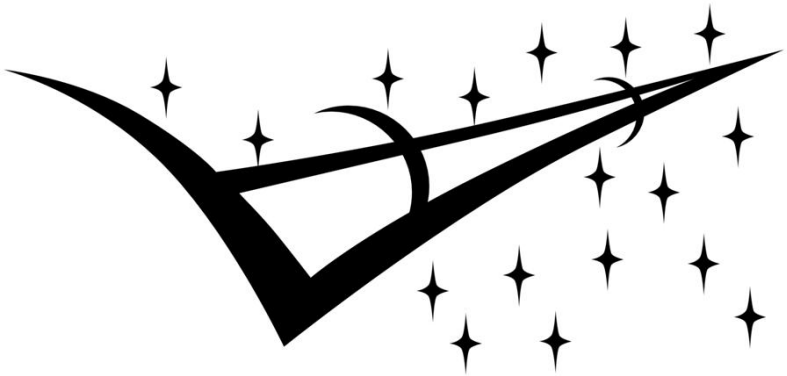
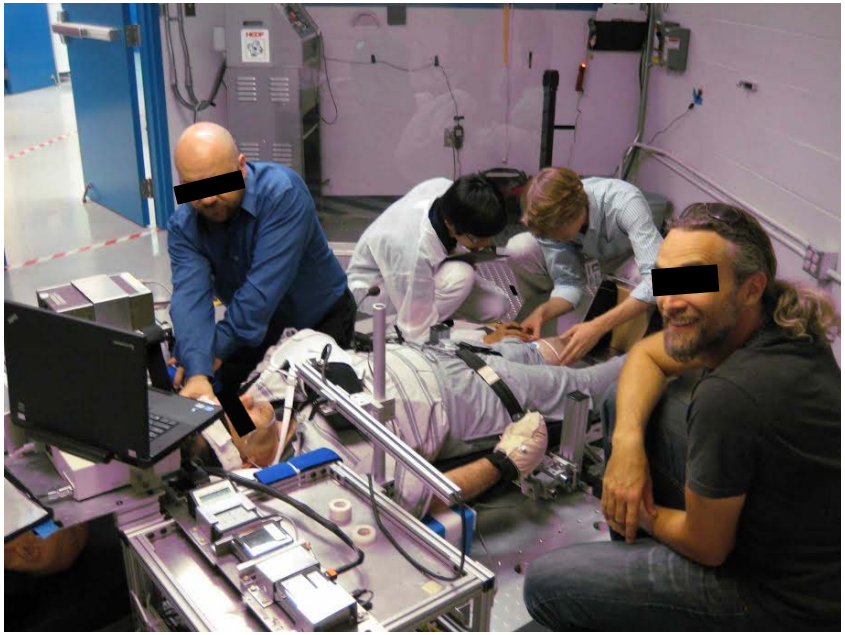
SPACE LIFE SCIENCES
SUMMER INSTITUTE



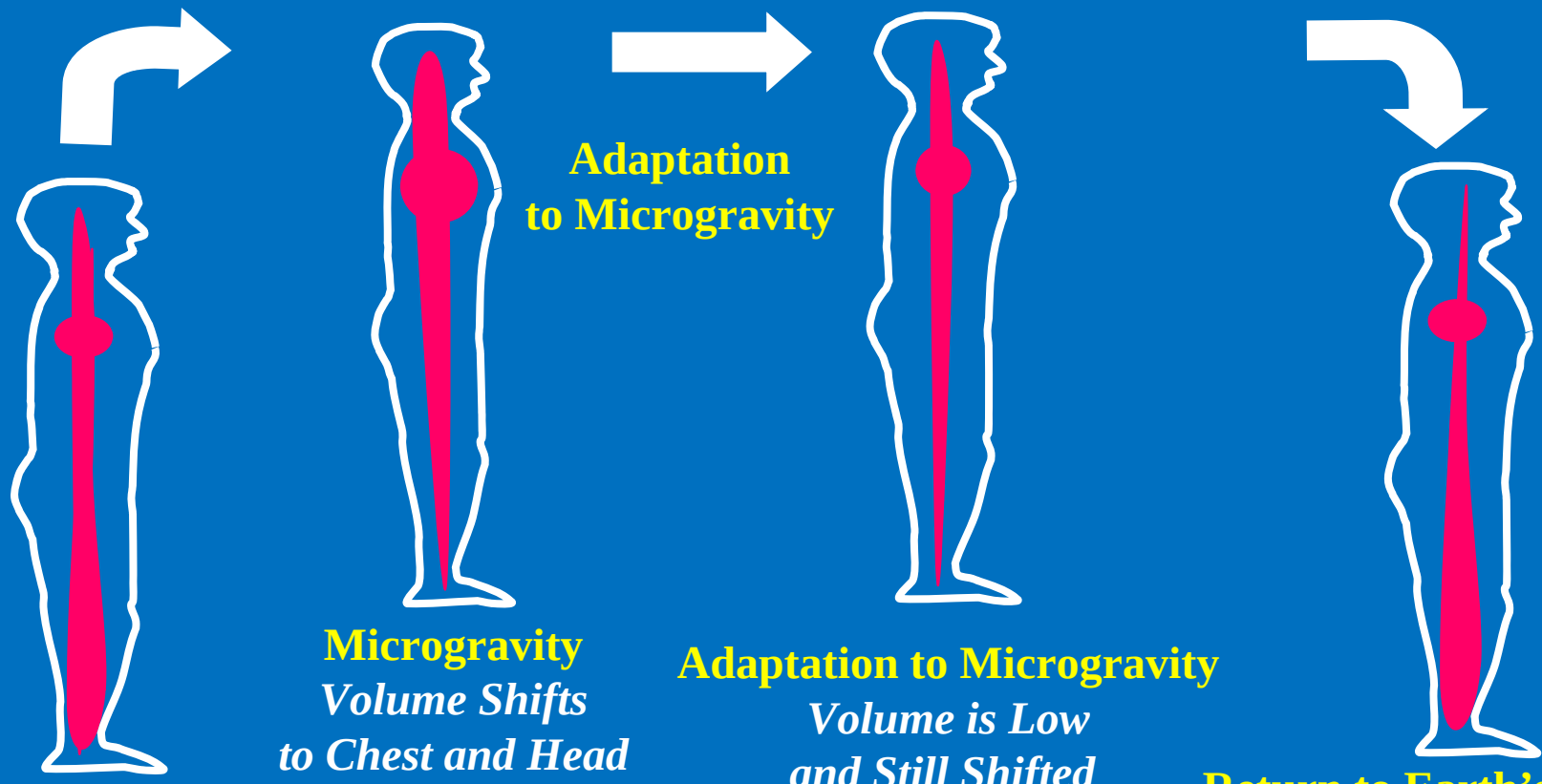
Introduction

- Education: Mechanical Engineering (BS, 2015) - University of Kentucky
- Research and Career Interests: Biomedical Engineering, Bioengineering, Aerospace Engineering
- Experience with NASA JSC CVL + UKY BME to evaluate countermeasures to cardiovascular deconditioning induced by prolonged exposure to spaceflight:
  - (1) AlterG
  - (2) Ames Human Performance Centrifuge



Orthostatic Intolerance

Inability to maintain blood pressure during upright posture



Earth's Gravity (1G)
Normal Volume

Microgravity
Volume Shifts to Chest and Head

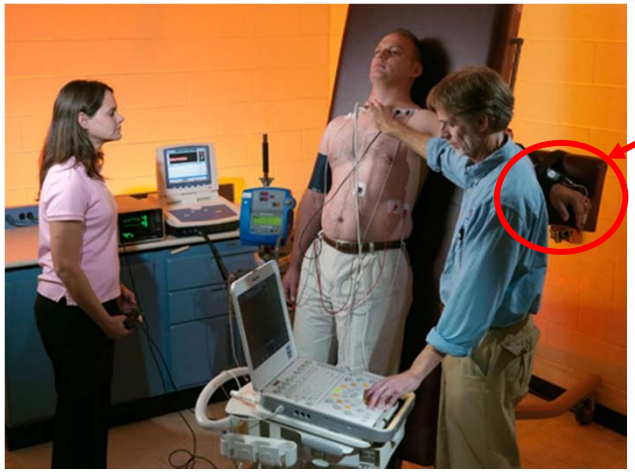
Adaptation to Microgravity

Adaptation to Microgravity
Volume is Low and Still Shifted to Chest and Head

Return to Earth's Gravity
Volume is Low and Now Shifts from Head to Legs
Possibility of Fainting!

Orthostatic Tolerance Test

TILT



Arm Position

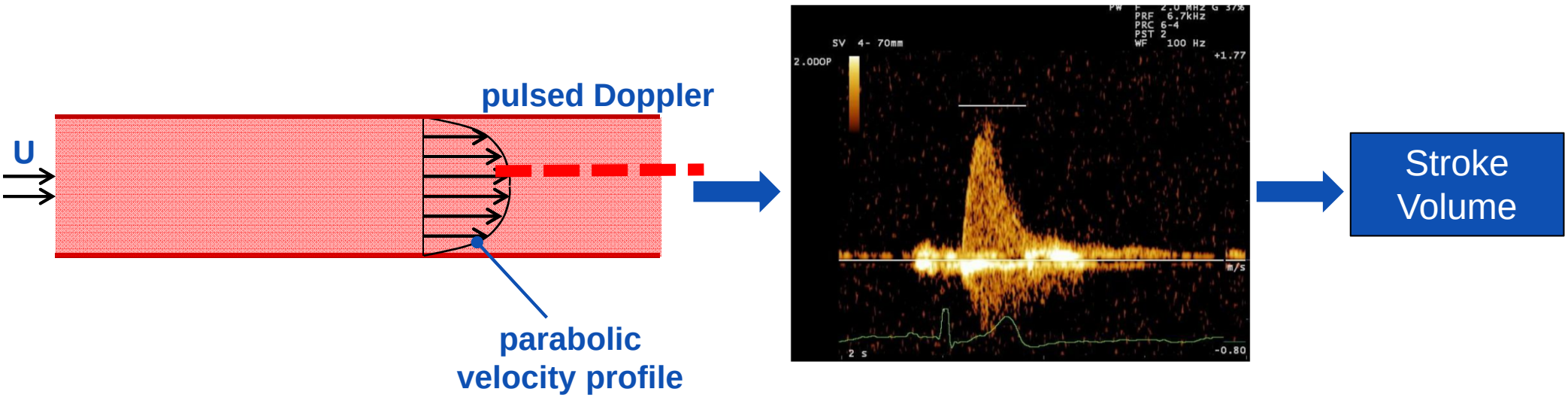
STAND

Doppler ultrasound

- Measures aortic blood flow velocity and diameter of the aorta to calculate stroke volume

Drawbacks:

- Requires a trained operator and expensive specialized equipment
- Each measurement typically incorporates a small sample of beats
- Difficulty in imaging certain subjects

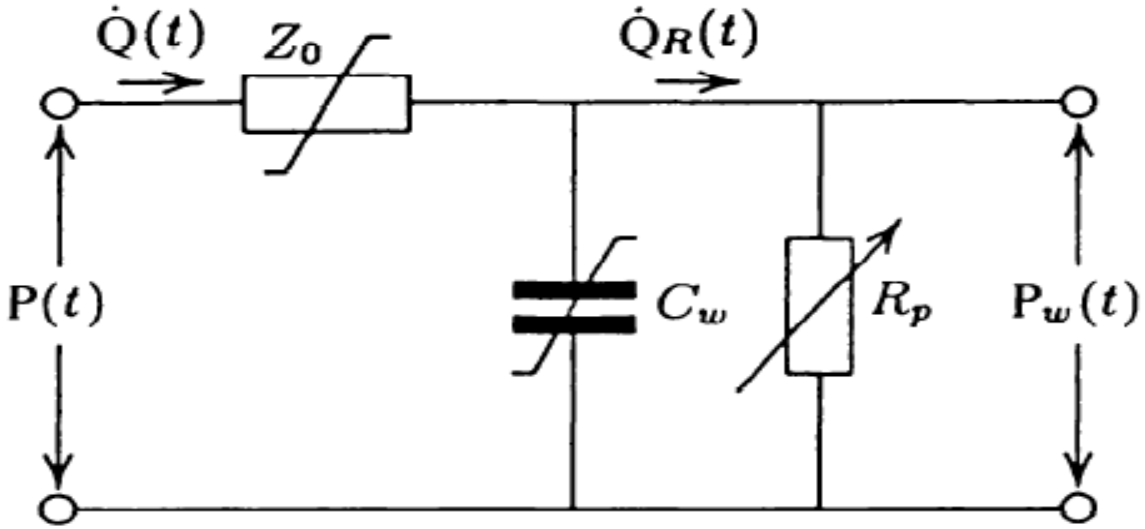


BeatScope Modelflow

- Continuous blood pressure waveform acquired using a finger cuff (finger plethysmography)
- Computes aortic flow pulsations from arterial pressure waveforms by simulating a model that incorporates assumptions of human morphology

FINOMETER

PORTAPRES



Three-element model used to compute aortic flow as proposed by Wesseling et al. Zo, characteristic impedance of proximal aorta; Cw, windkessel compliance of arterial system; Rp, total systemic peripheral resistance; Q(t), blood flow; P(t) arterial pressure waveform; Pw(t), windkessel pressure

Objectives of Internship

- To conceive, develop, and conduct a human subject research protocol to evaluate the use of Modelflow estimation of stroke volume during a stand or tilt test

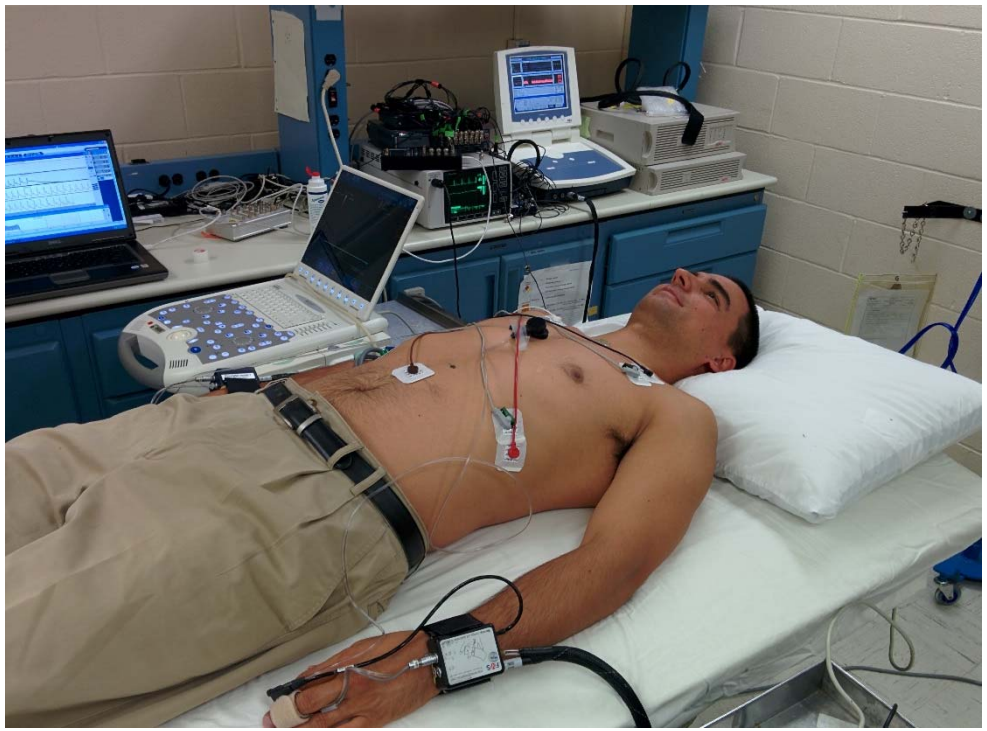
- Retrospective analysis to determine if Modelflow can be applied to previously collected data

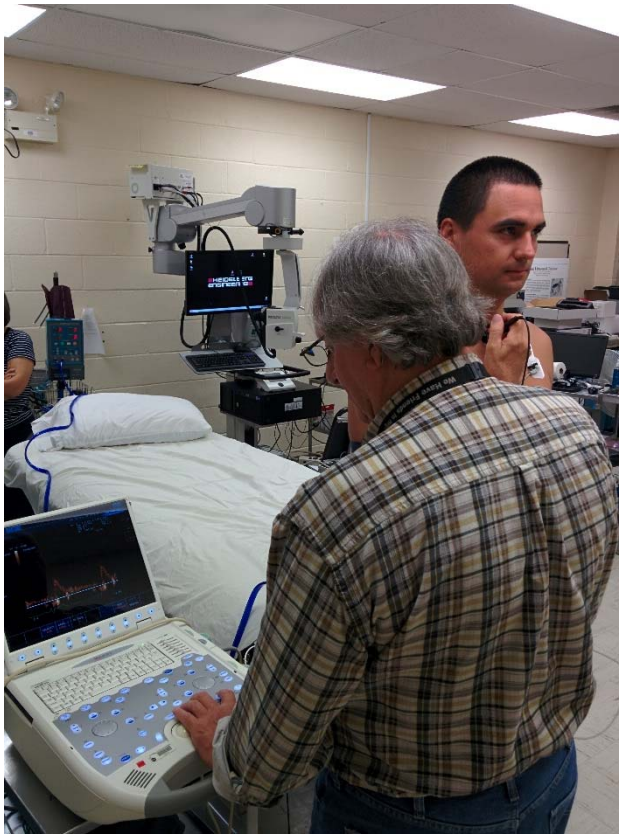
- Determine the possibility of analyzing future data in situations in which ultrasound measurements of stroke volume may not be possible, such as field testing

Protocol

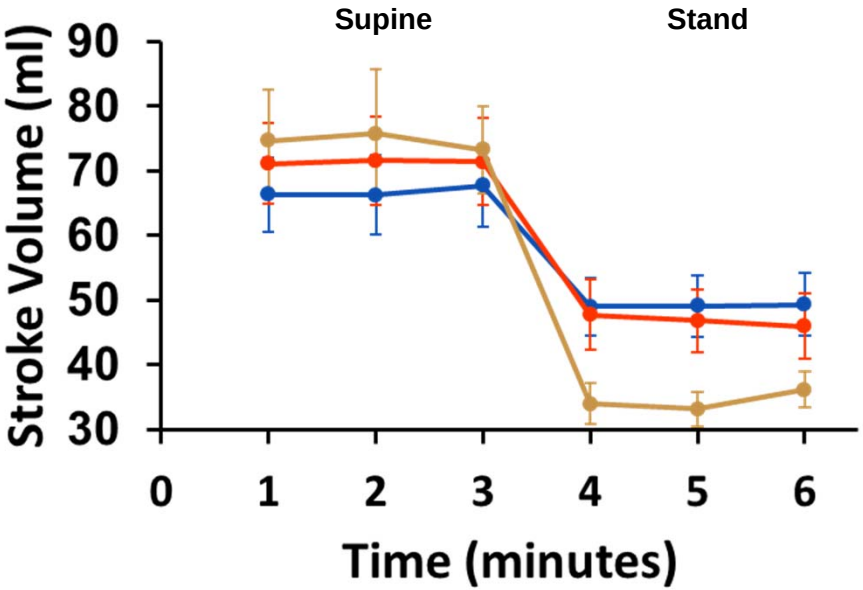
B	Dinamap
US	Ultrasound
FM	Right Arm Extended At Heart Level
PP	Left Arm Extended At Heart Level

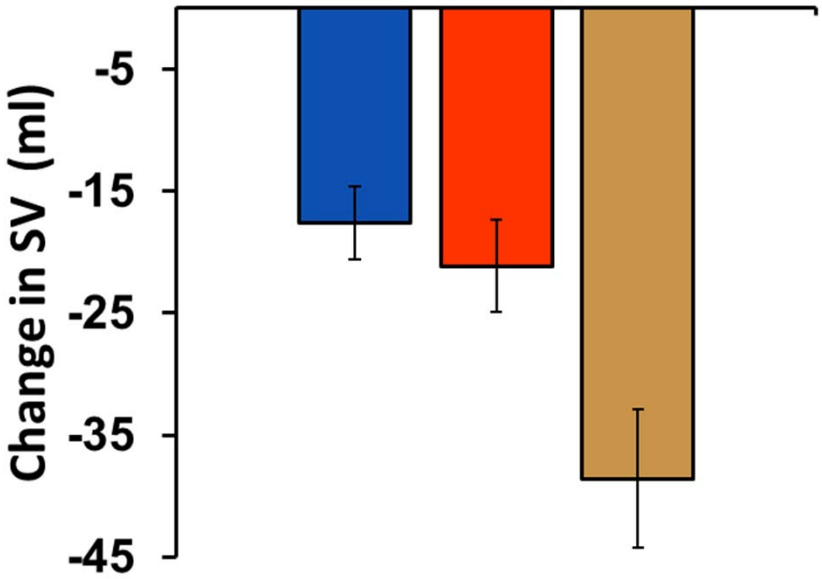
Supine							Stand						
	Baseline				B			Baseline				B	PP	B	FM	B
		US		US		US			US		US			US		US	
1	2	3	4	5	6	7	8	9	10	11	12	13				





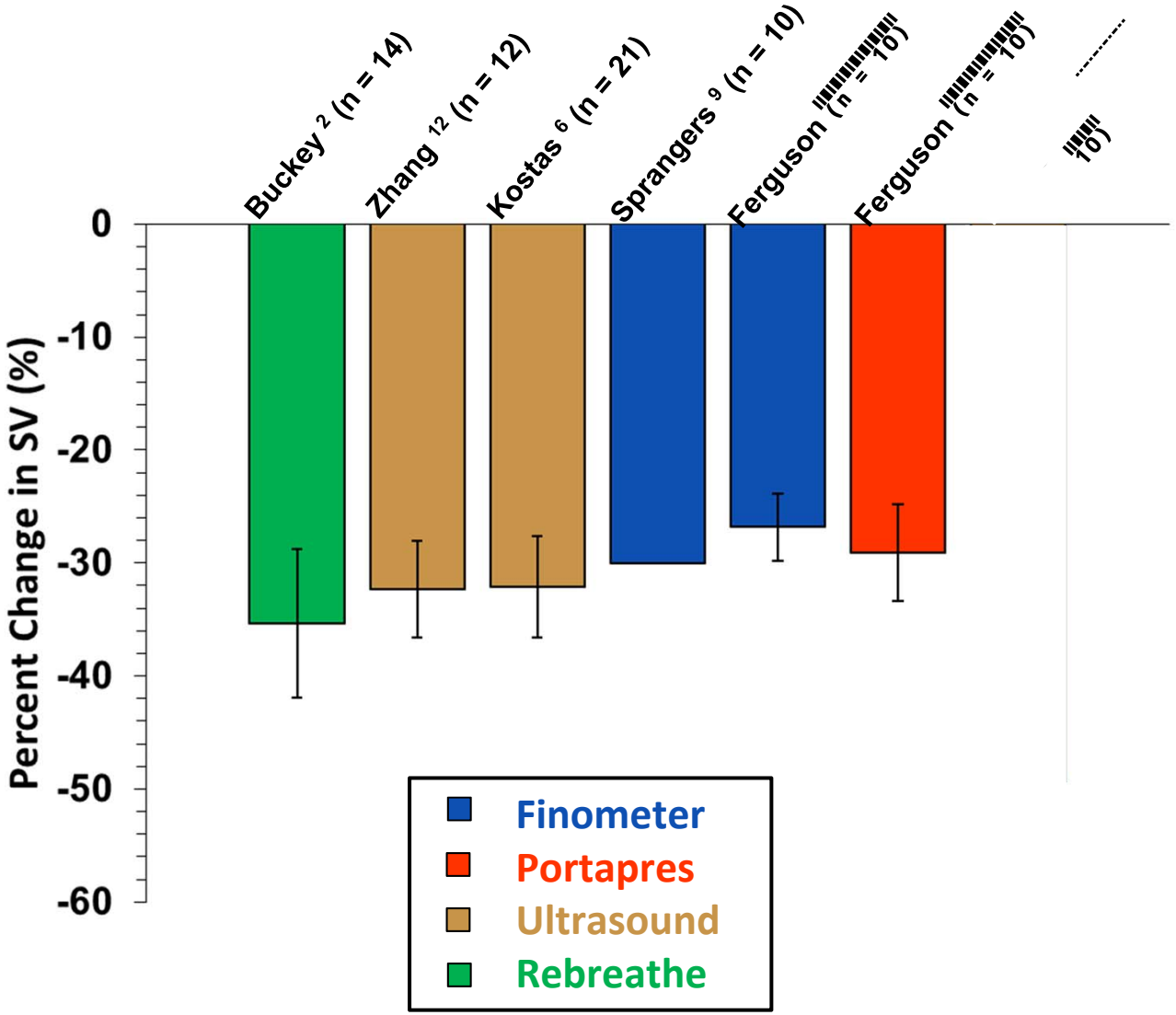
Results



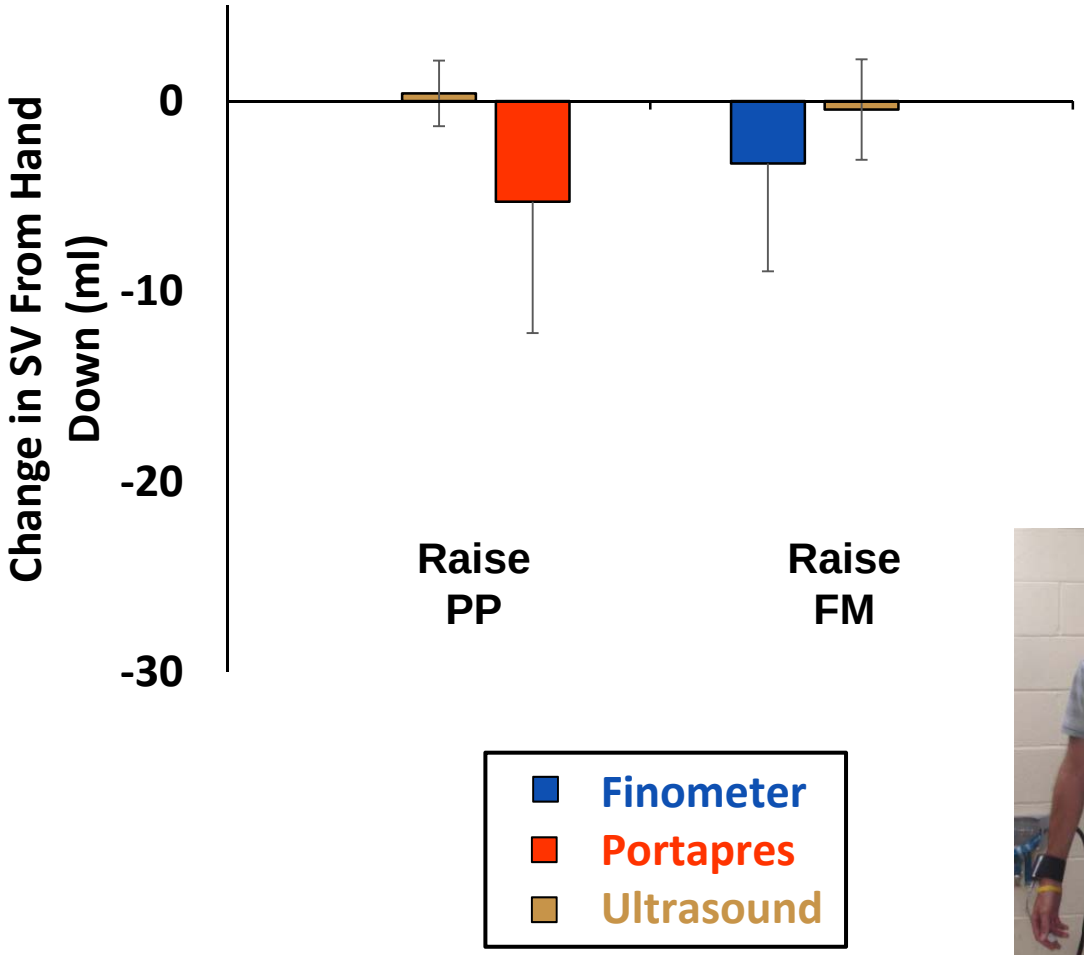


Finometer
Portapres
Ultrasound

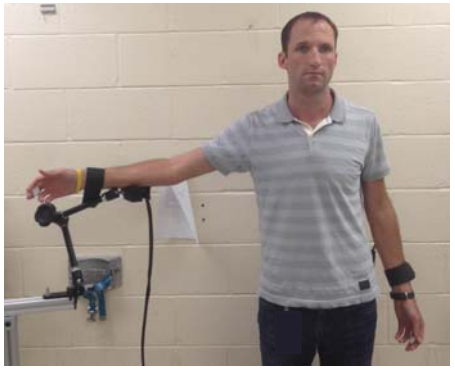
Results


Buckey [2] (n = 14)
Zhang [12] (n = 12)
Kostas [6] (n = 21)
Sprangers [9] (n = 10)
Ferguson (n = 10)
Ferguson (n = 10)
10)
0
-10
-20
-30
-40
-50
-60
Percent Change in SV (%)
Finometer
Portapres
Ultrasound
Rebreathe

Results

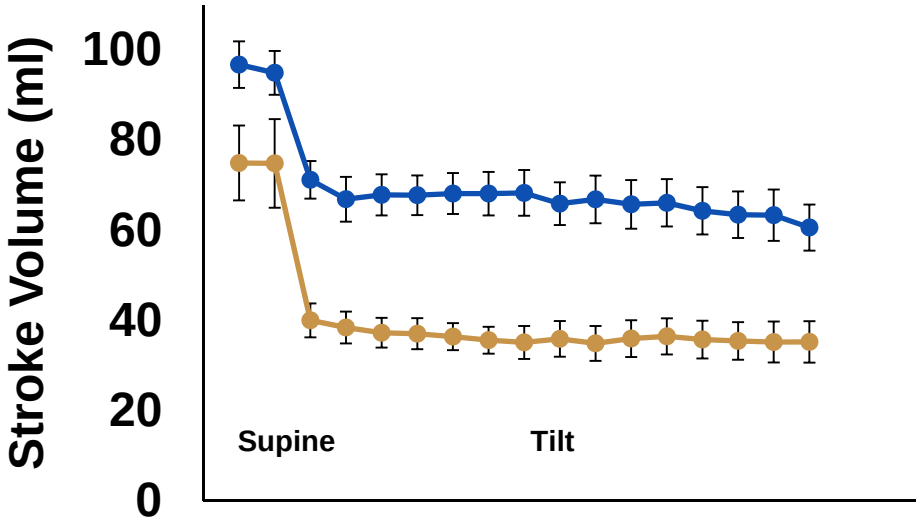


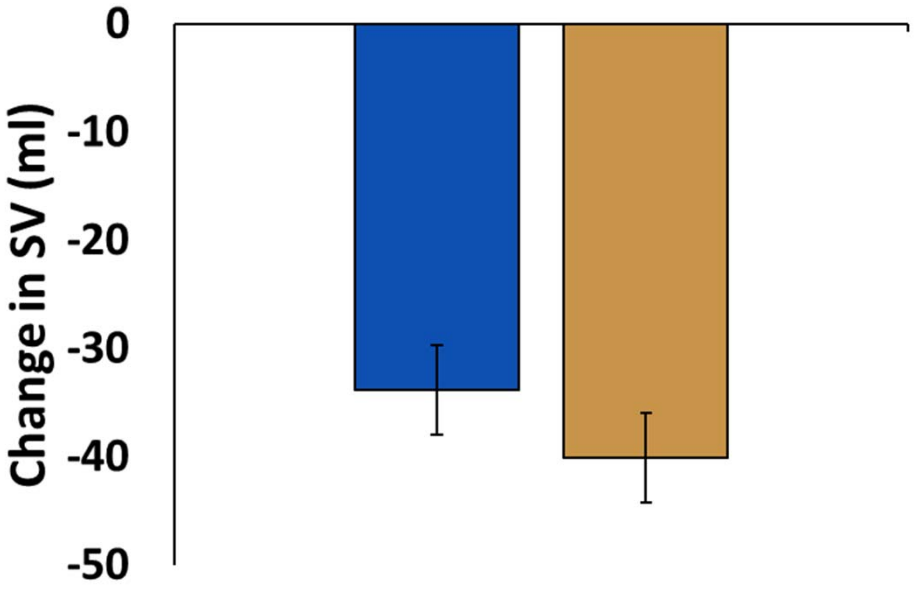
PORTAPRES



FINOMETER

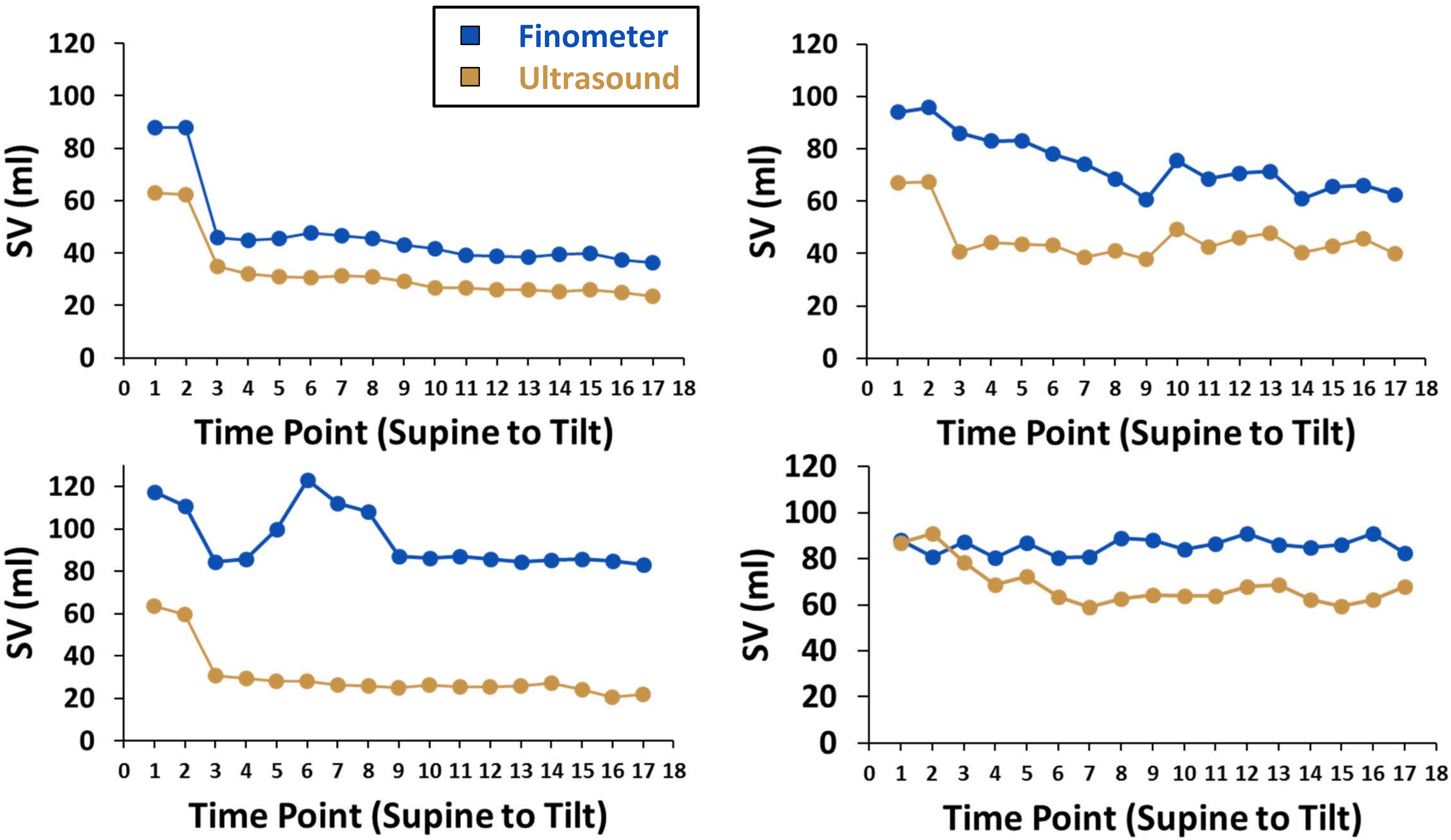
Retrospective Analysis





Finometer
Ultrasound

Individual Data



Discussion

Drawbacks and Limitations

- Modelflow may not accurately report absolute values of stroke volume
- Modelflow may not accurately report changes in stroke volume between postures
- The algorithm used by Modelflow estimates body surface area and aortic diameter
- Reliability of Modelflow computation of SV is dependent on its ability to track arterial pressure

Future Direction

- Identifying factors that contribute to differences between modelflow and ultrasound estimates
- Evaluate alternative inputs to the modelflow algorithm
- Investigate positional changes in finger cuff blood pressure acquisition

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Citations

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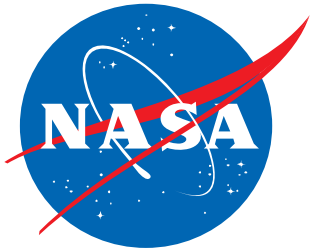
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