

Model Flow Determination of Stroke Volume

Connor R Ferguson

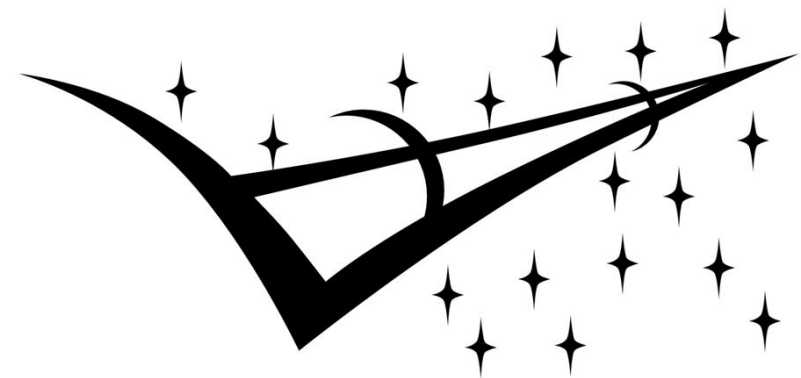
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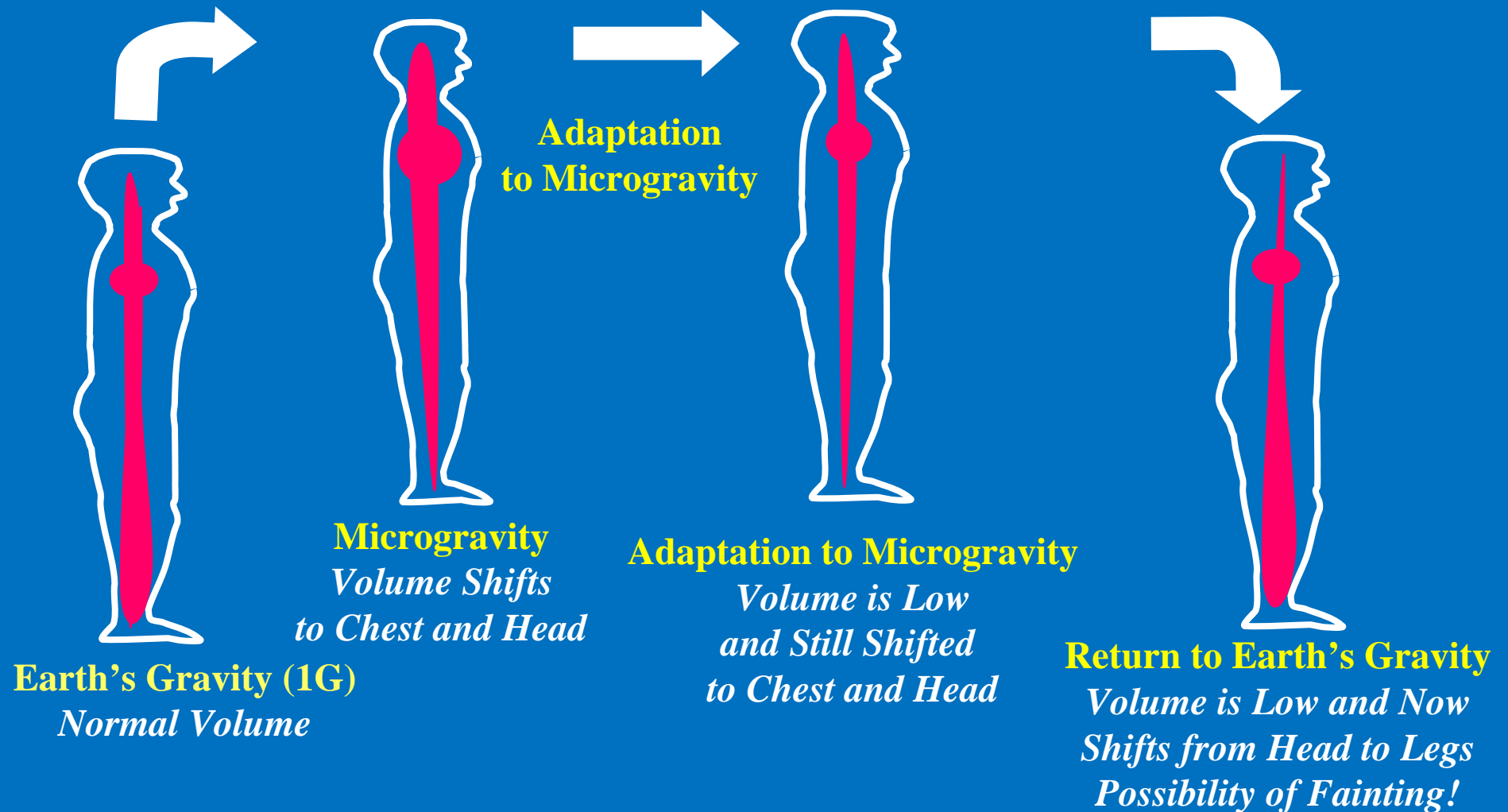
Introduction

- 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

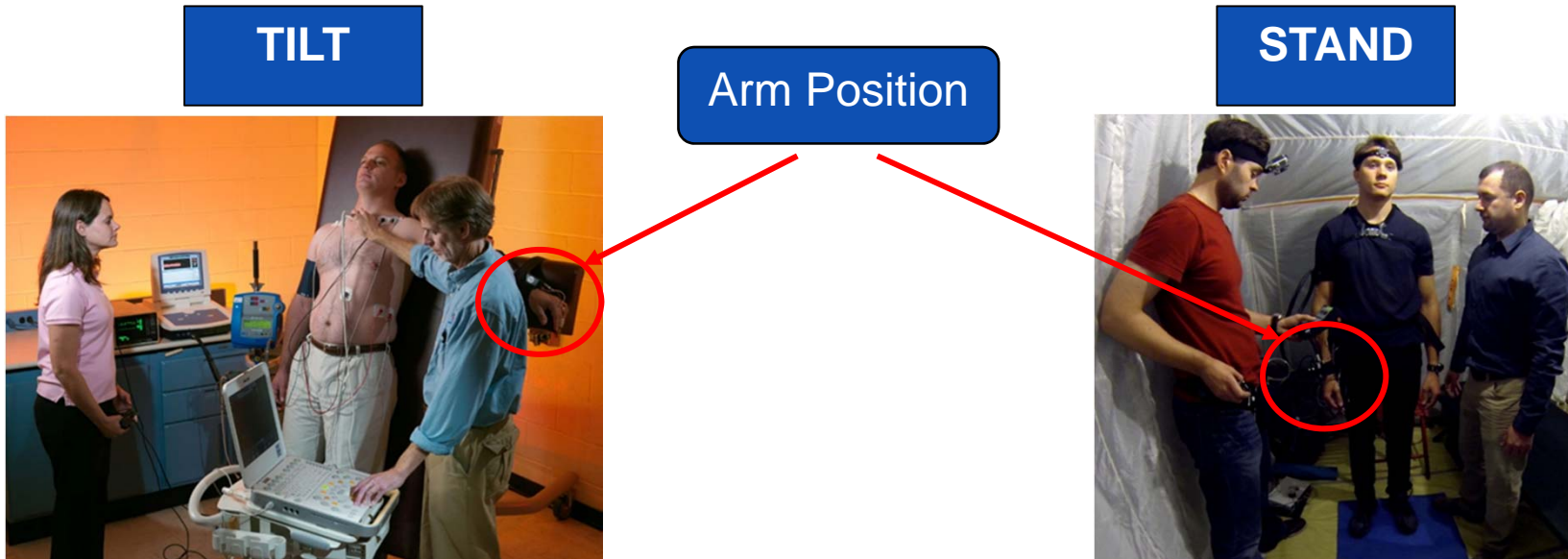


Orthostatic Intolerance

Inability to maintain blood pressure during upright posture



Orthostatic Tolerance Test

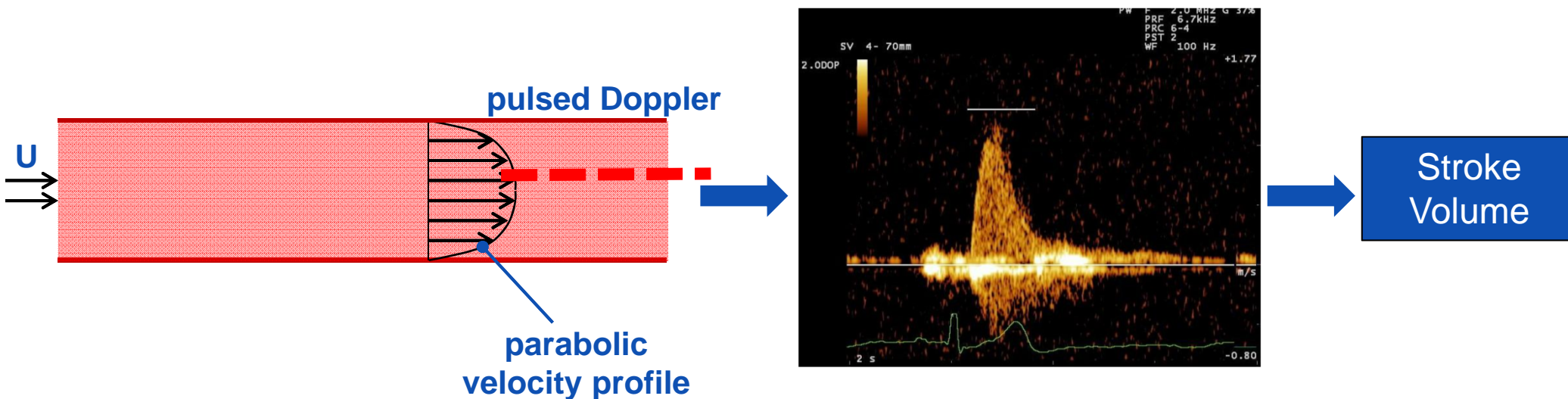


Doppler ultrasound

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

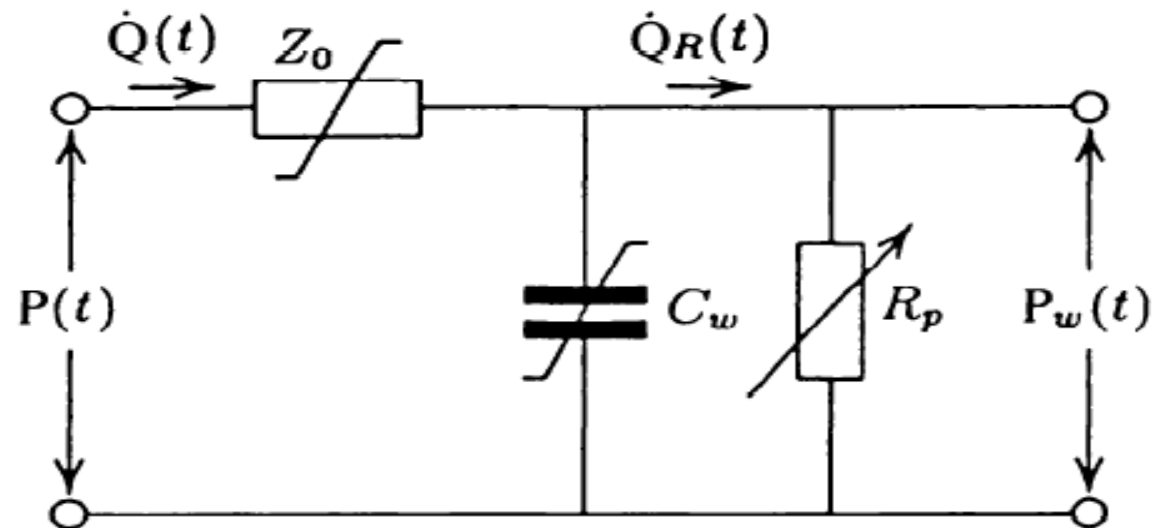
Drawbacks:

- ▢ 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



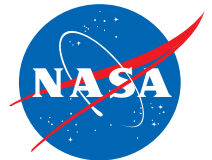
Three-element model used to compute aortic flow as proposed by Wesseling et al. Z_0 , characteristic impedance of proximal aorta; C_w , windkessel compliance of arterial system; R_p , total systemic peripheral resistance; $\dot{Q}(t)$, blood flow; $P(t)$ arterial pressure waveform; $P_w(t)$, windkessel 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

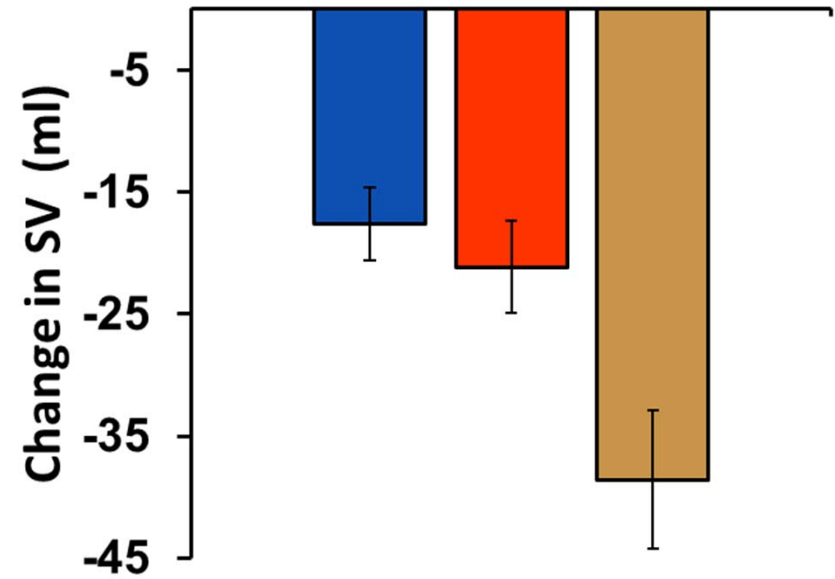
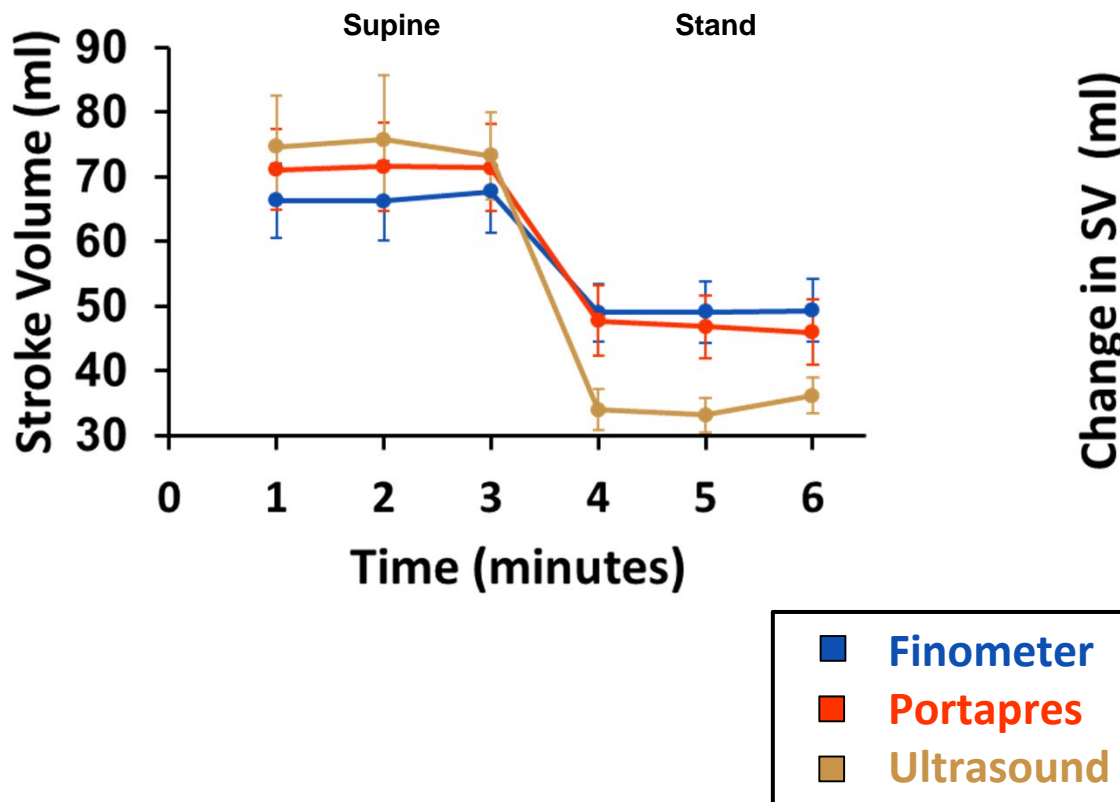


B	Dinamap
US	Ultrasound
FM	Right Arm Extended At Heart Level
PP	Left Arm Extended At Heart Level

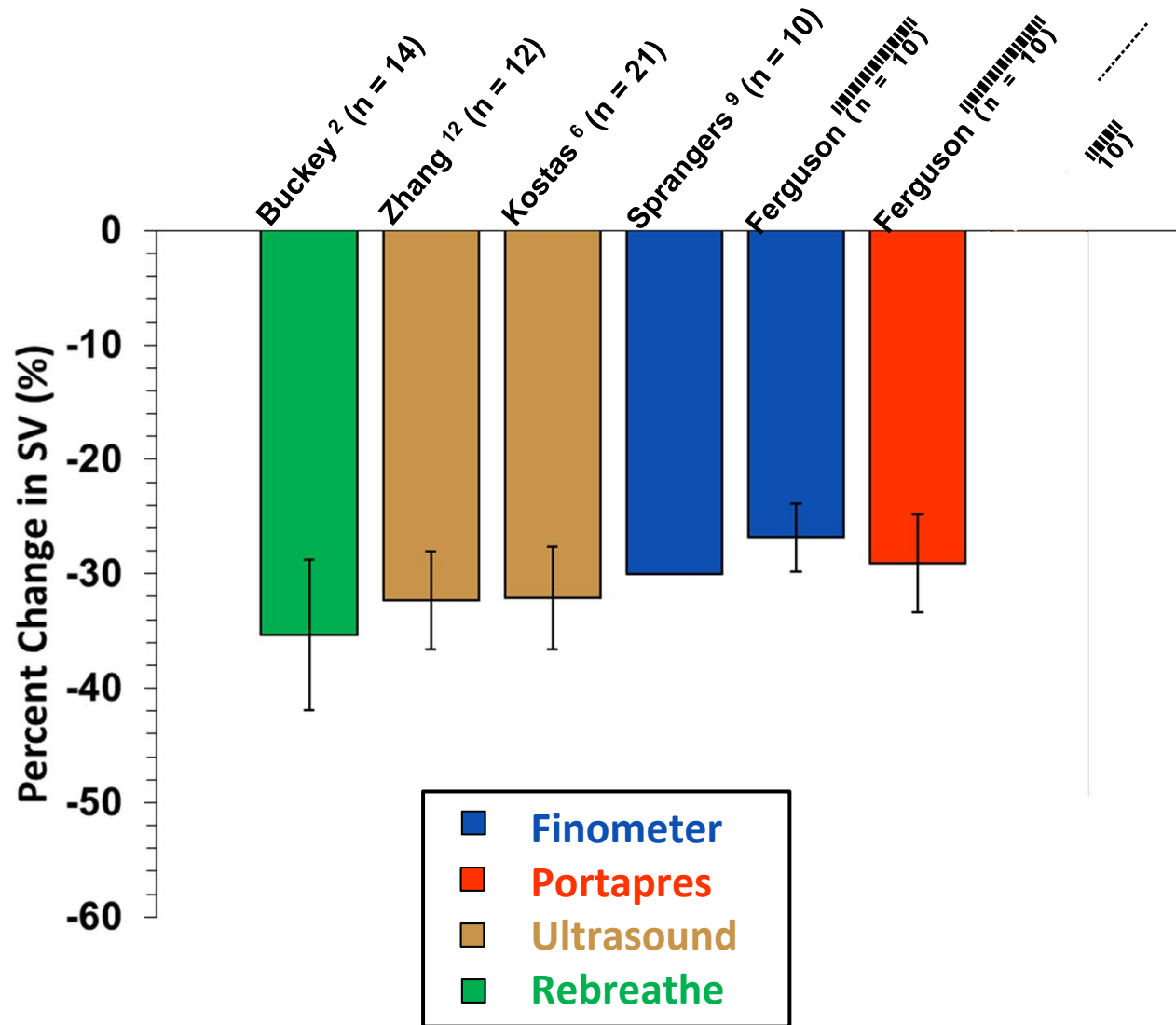
Supine					Stand										
		Baseline			B			Baseline			B	PP	B	FM	B
		US	US	US			US	US	US		US			US	
1	2	3	4	5	6	7	8	9	10	11	12	13			



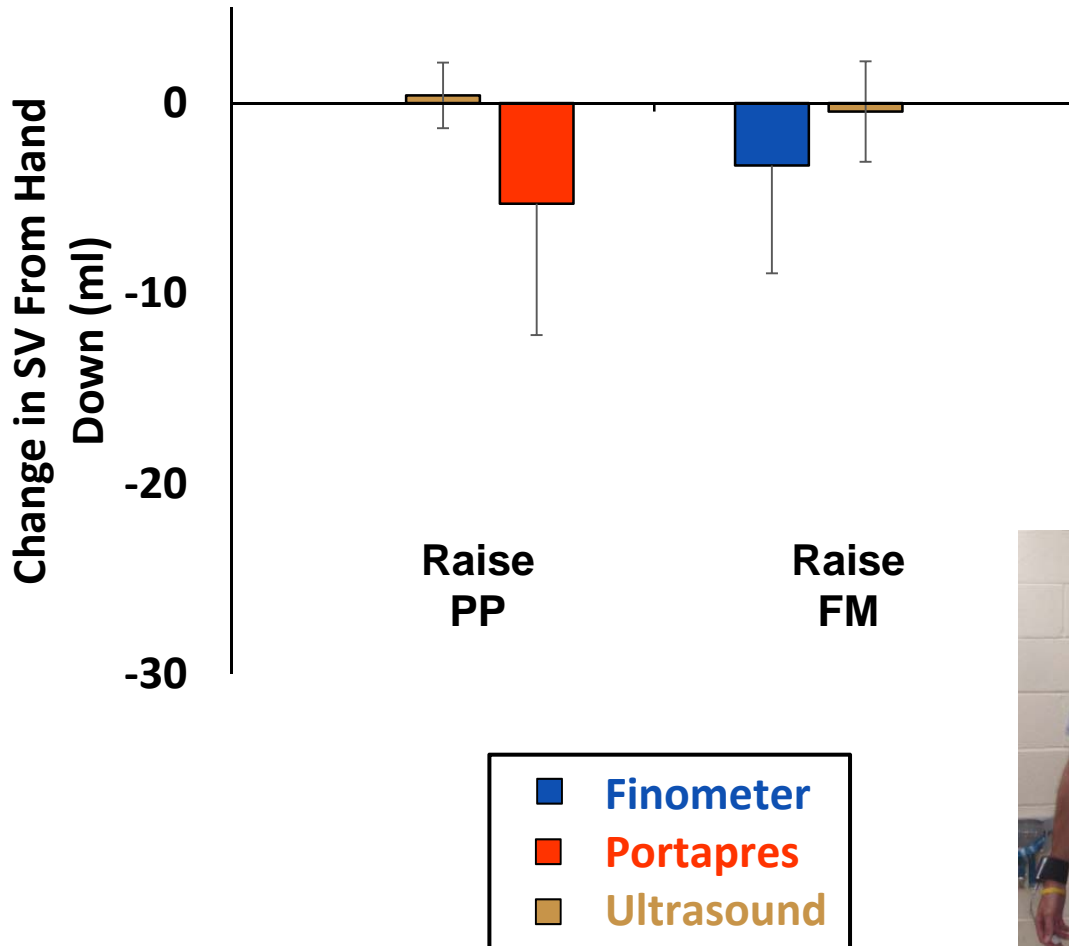
Results



Results



Results

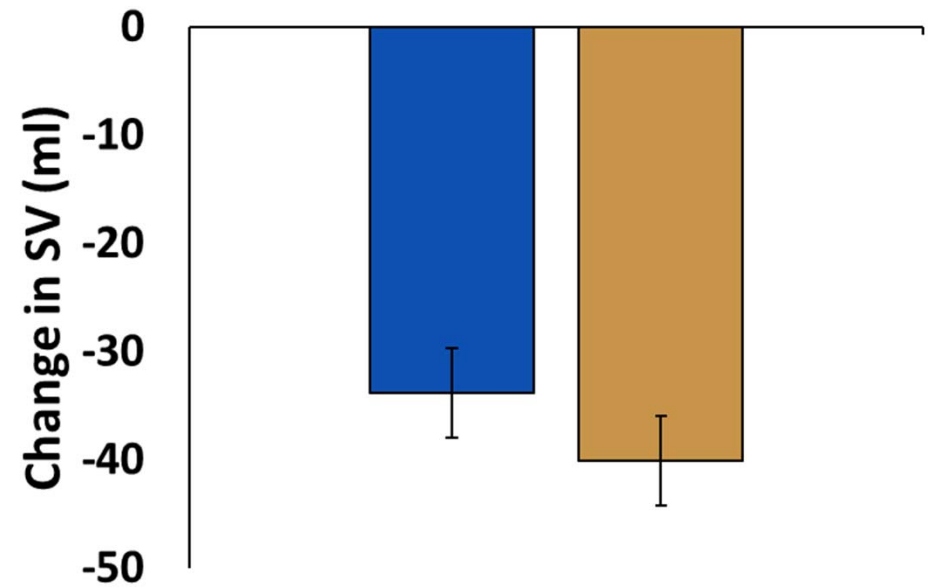
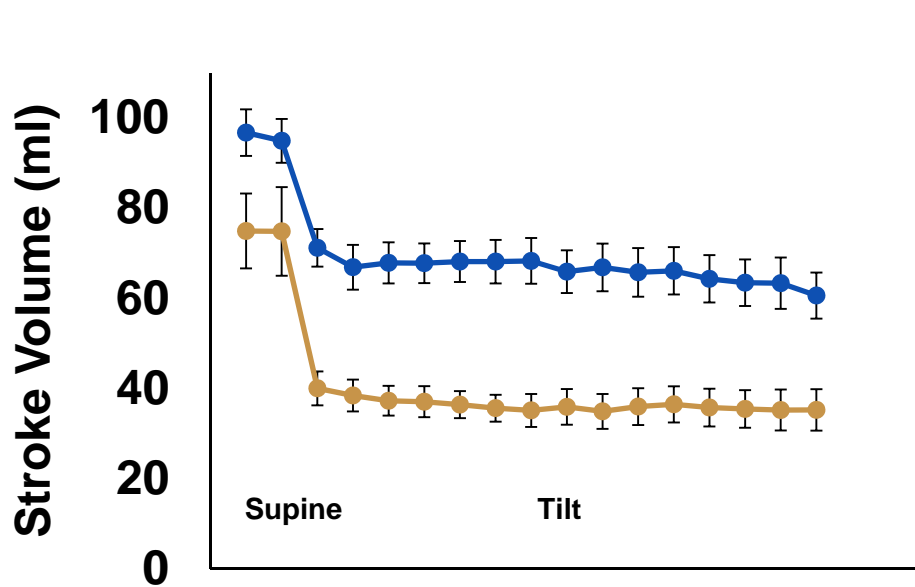
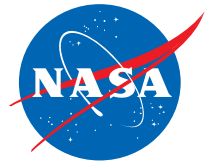


PORTAPRES

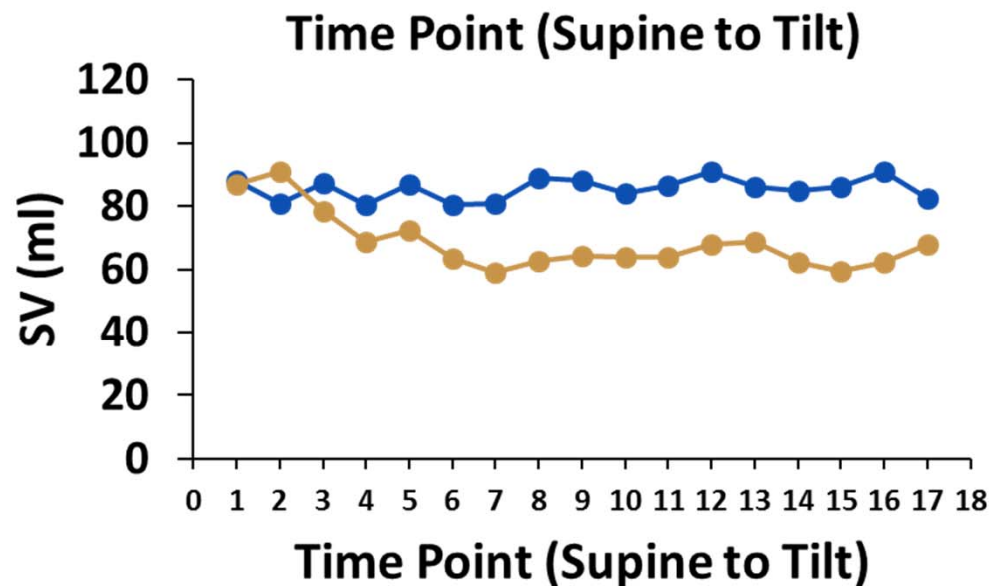
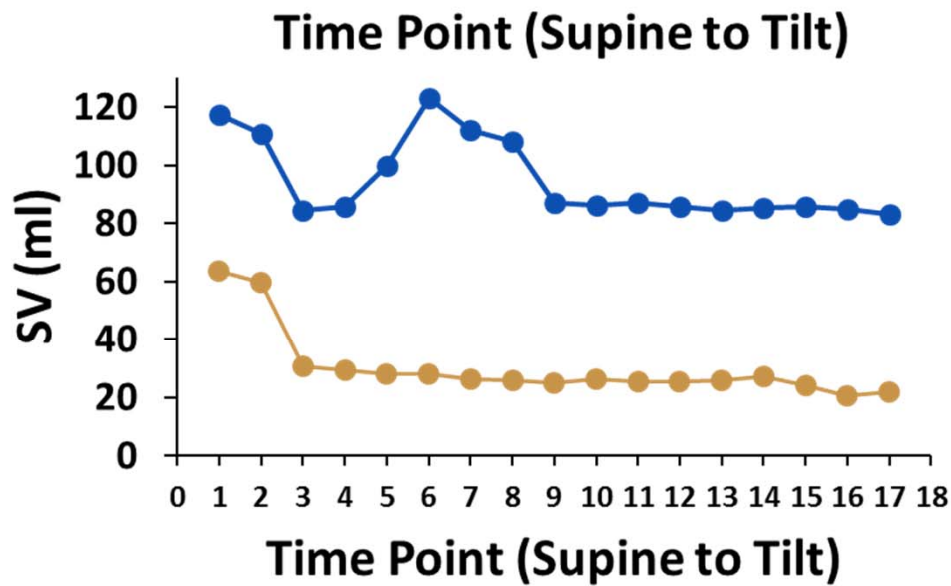
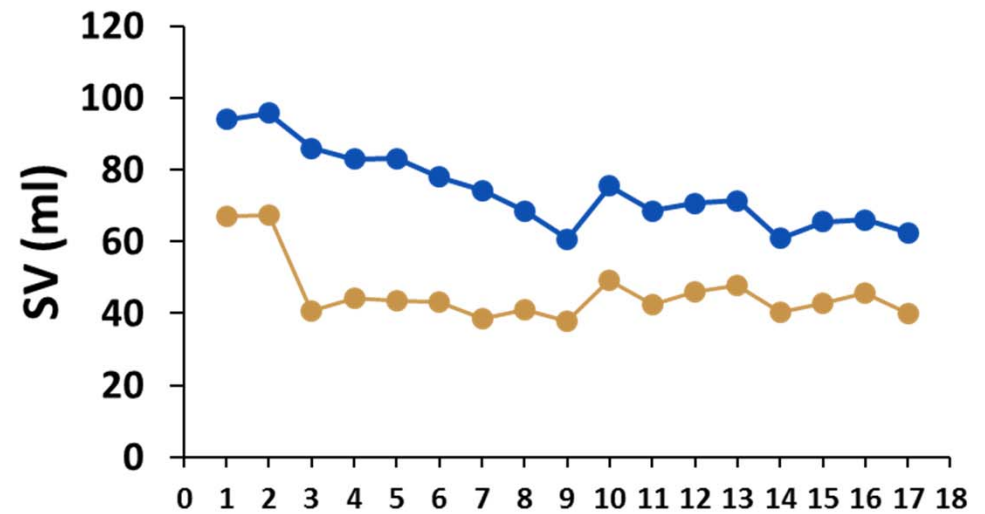
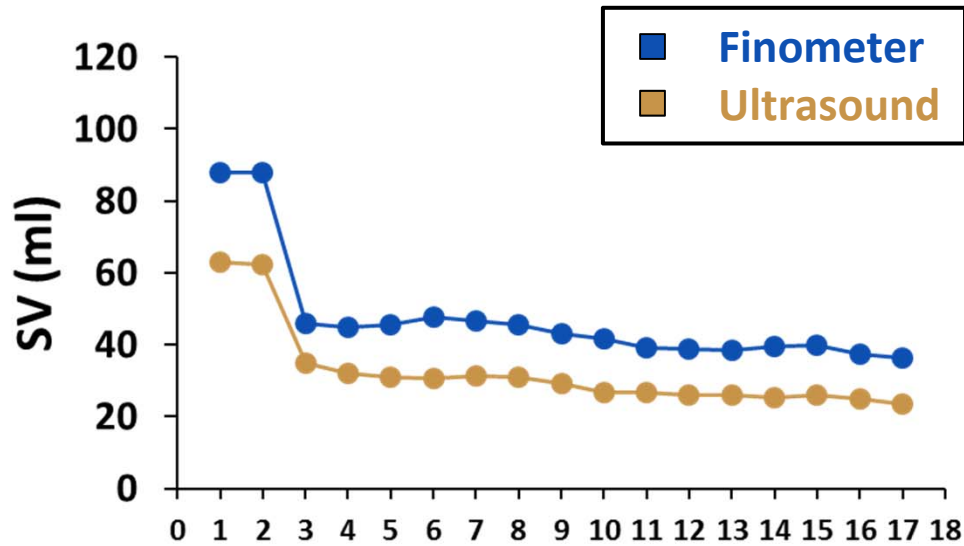


FINOMETER

Retrospective Analysis



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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