NONINVASIVE PULSE TRANSIT TIME MEASUREMENT FOR ARTERIAL STIFFNESS MONITORING IN MICROGRAVITY

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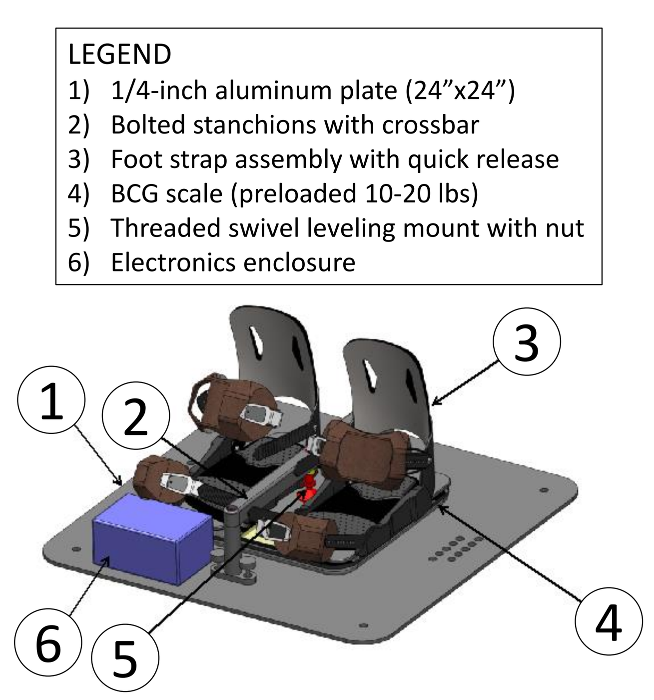
Abstract

The use of a noninvasive hemodynamic monitor to estimate arterial stiffness, by measurement of pulse transit time (PTT), was demonstrated in microgravity.

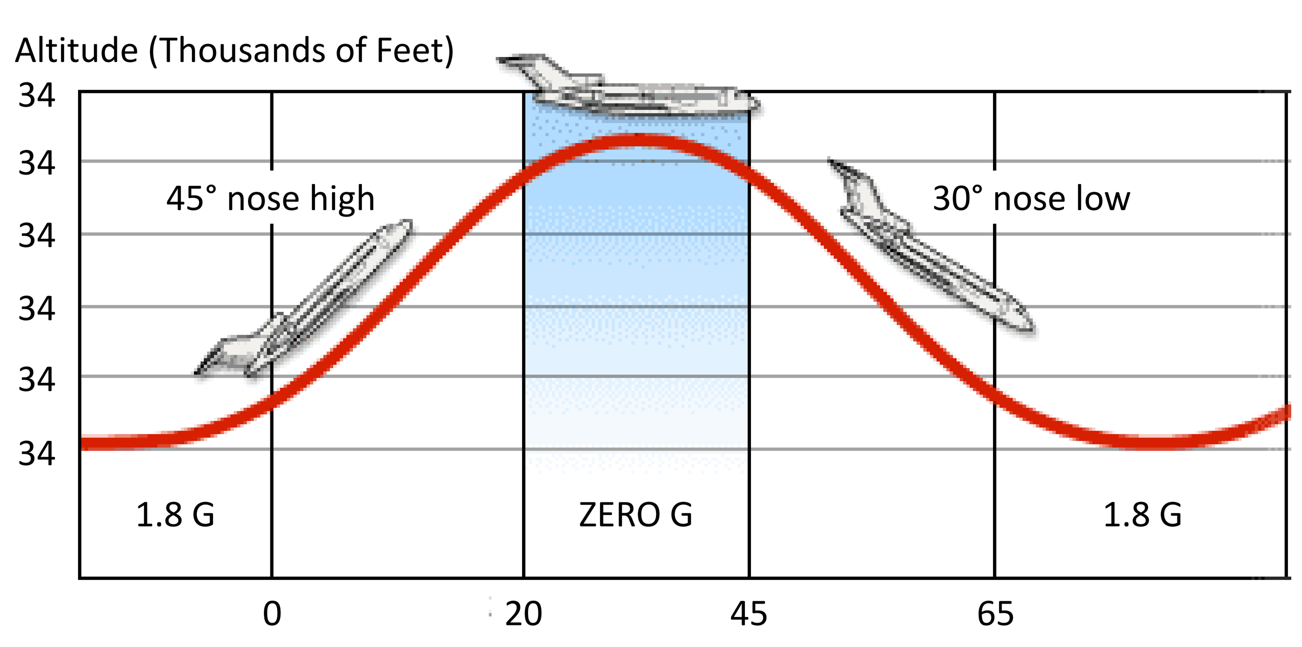
- PTT is calculated from features in the Ballistocardiogram (BCG) and photoplethysmogram (PPG) signal.
- 9 subjects were tested aboard a series of parabolic flights.
- An average of 60.2 ms PTT increase from ground to microgravity environments was shown (standard deviation = 32.9 ms).

Experiment Overview

Microgravity testing of the arterial stiffness monitor.

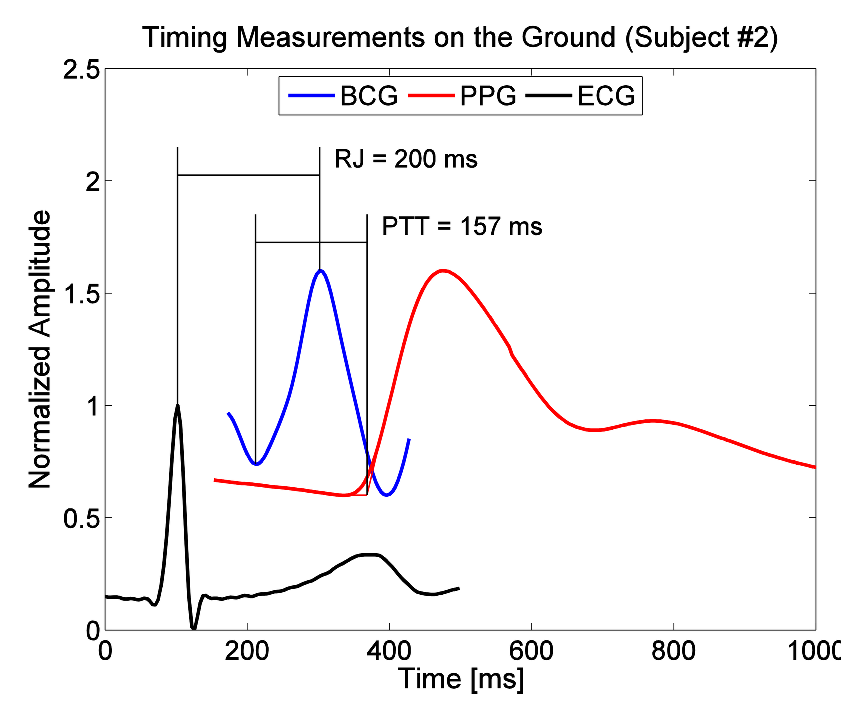


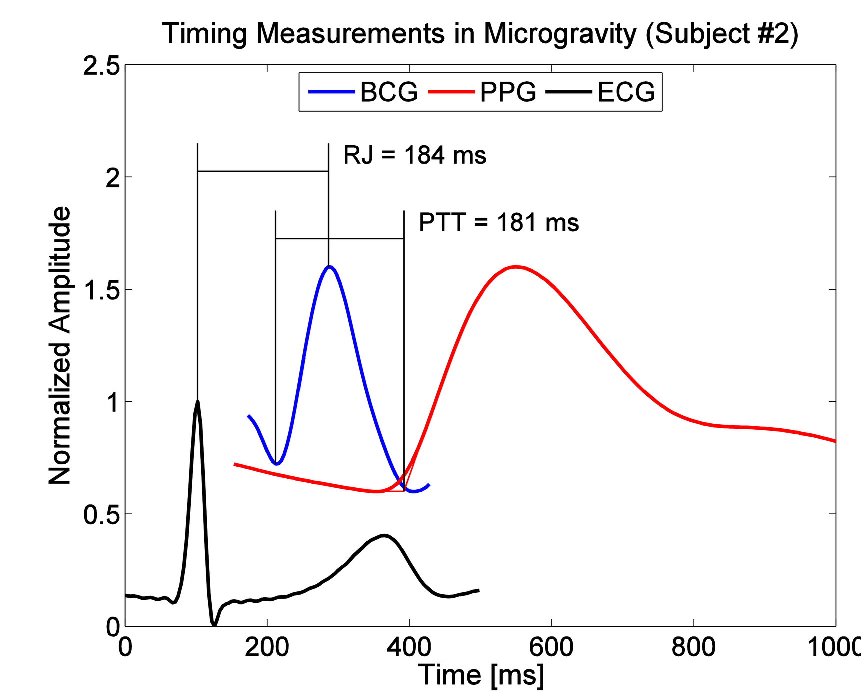
Subject's feet were equipped with a PPG sensor, then strapped into the monitor using boot bindings.



Parabolic maneuver performed during experiments.

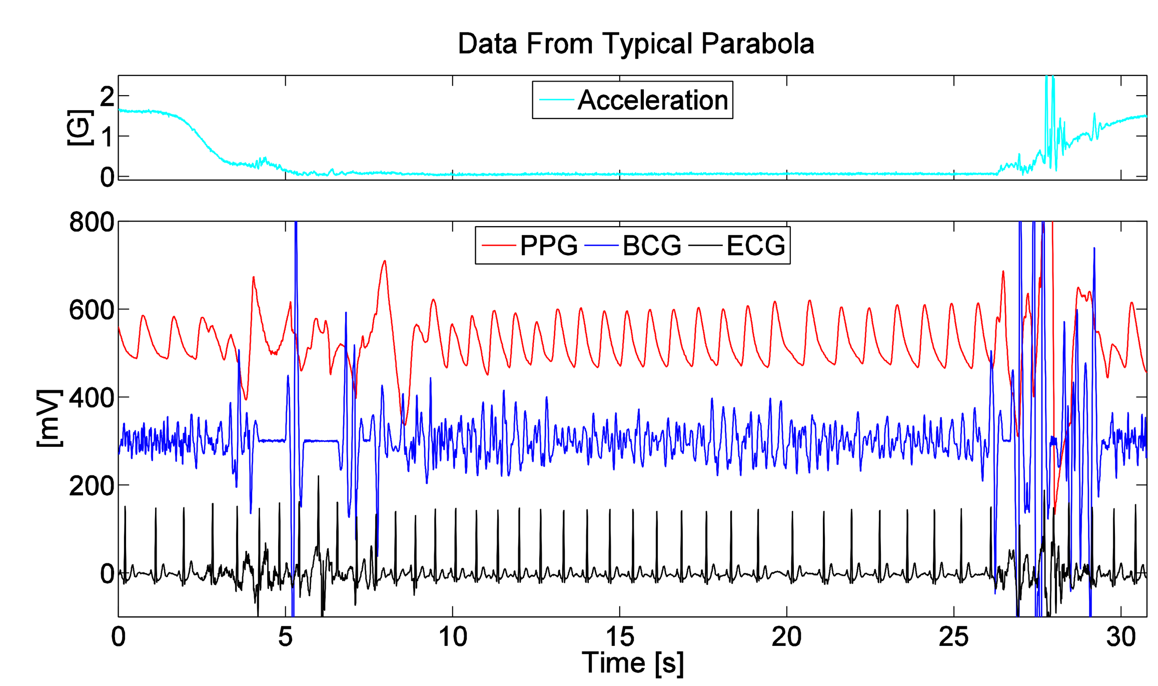
Noninvasive Arterial Stiffness Monitoring in Microgravity





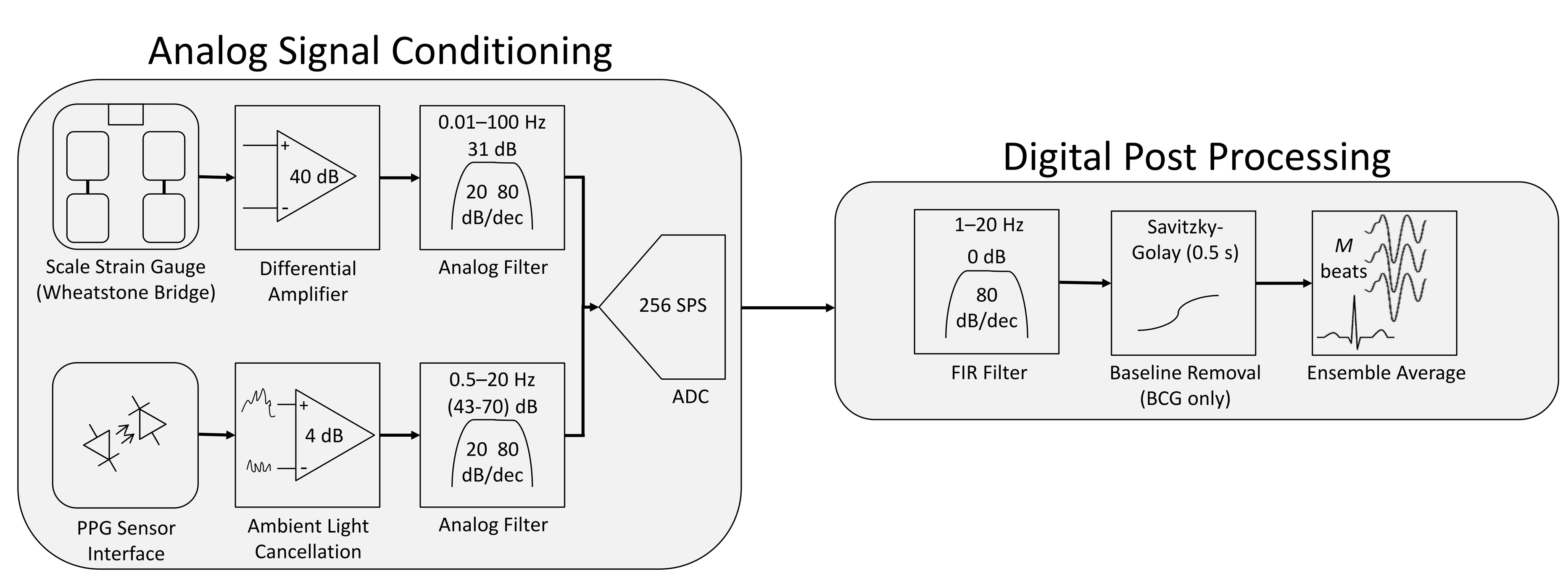
PTT and RJ Interval timings marked on the ground (left) and in microgravity (right).

Parabolic Dataset



Typical recording of PPG, BCG, and ECG signals (bottom) during a full parabolic microgravity maneuver from hypergravity to microgravity, and finally back to hypergravity again (top).

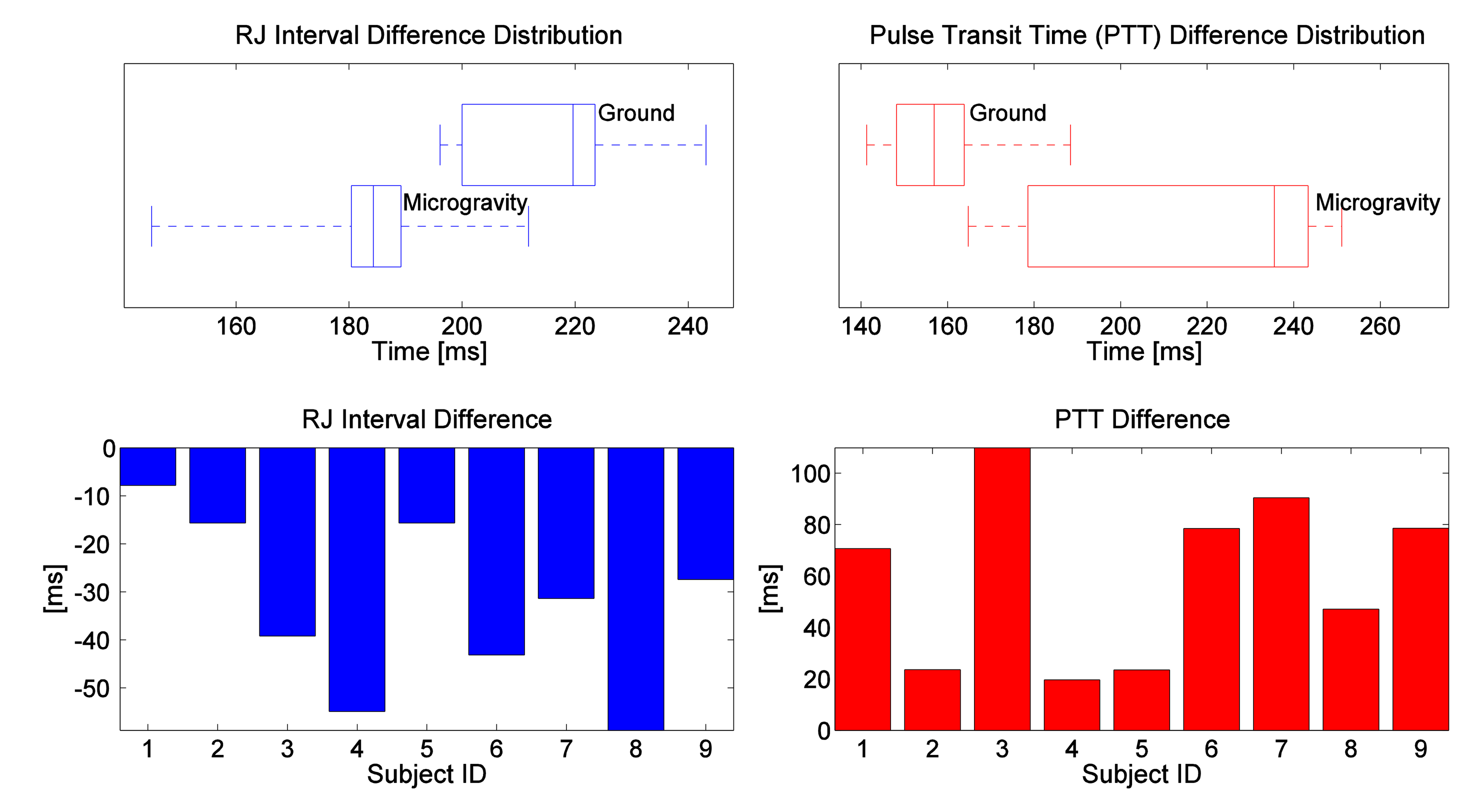
System Architecture



The analog signal chain (left) for BCG (top) and PPG (bottom) is contained in a custom-built wireless data logger worn on the subject and streamed to an onboard laptop. Post processing (right) was done with MATLAB.

Results

- PTT was increased from ground to microgravity by an average of 60.2 ms (Std. Dev. = 32.9 ms).
- The RJ interval was decreased from ground to microgravity by an average of 31.4 ms (Std. Dev. = 18.6 ms).



RJ Interval (left) and PTT (right) results comparing ground to microgravity measurements for all subjects.

Conclusion

These experiments validate the utility of the noninvasive hemodynamic monitor to estimate arterial stiffness in microgravity.

Key finding: consistent increase in PTT after transitioning from ground to microgravity ($P < 0.001$).

Possible explanations:

- Elimination of hydrostatic pressure
- Reduction of intrathoracic pressure
- Reduction of mean arterial pressure induced by vasodilation

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