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Wave reflection, assessed by pulse wave separation, is reduced under acute µ-g conditions in parabolic flight

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Introduction

Weightlessness during long-term space flight over 6-12 months leads to complex individual cardiovascular adaptation. The initial central blood volume expansion followed by a loss of plasma volume is accompanied by changes in vascular mechanoreceptor loads and responsiveness, altered autonomic reflex control of heart rate and blood pressure, and hormonal changes in the long run. Hence, function and structure of the heart and blood vessels may change. Hemodynamic data obtained during short- and long-term space flight may indicate that the adaptation process resembles ageing of the cardiovascular system characterized by decreased diastolic blood pressure, increased central sympathetic nerve traffic and increased arterial pulse wave velocity. Experiments during parabolic flights in supine position suggest, that stroke volume does not change during transitions between µ-g and 1-g.

We tested a novel method of pulse wave separation based on simple oscillometric brachial cuff waveform reading to investigate pulse wave reflection during acute weightlessness in healthy subjects. We hypothesized that the wave reflection magnitude (RM) remains unaltered during parabolic flights in supine position.

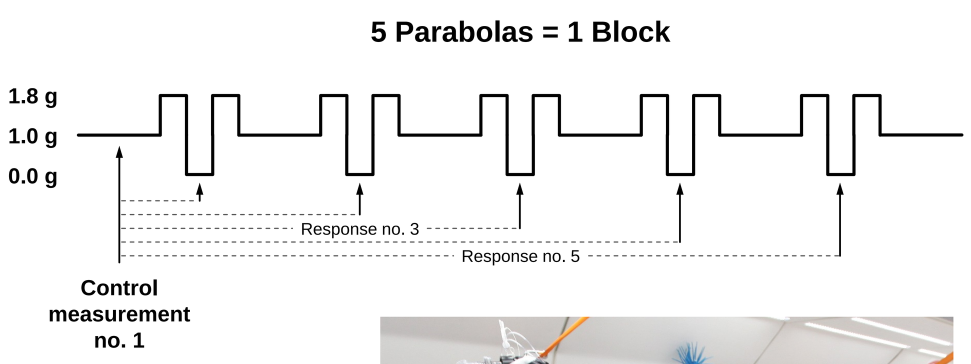
Methods

Subjects

- Healthy young subjects: 10 men, 5 women; 36±3 years; BMI 23±1 kg/m²

Study design

- Open, non-randomized, controlled
- 3 × 5 (15) responses per subject obtained in 3 blocks of 5 parabolas each:



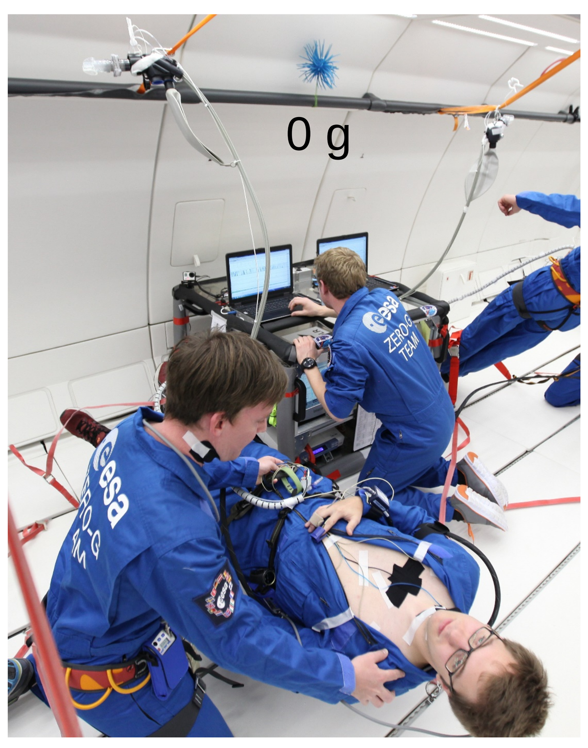


Fig. 1: Experimental setting

Methods

Measurements

- Heart rate (HR) from ECG, Biopac Systems Inc., USA.
- Arterial pressure (AP, photoplethysmography), Finometer midi, FMS, The Netherlands.
- Arterial pressure (AP, oscillometry), Modified Mobil-O-Graph, IEM, Germany.
- Arterial pressure pulse wave form analysis, ARCSolver algorithm, AIT, Austria.
- Cardiac output (CO, inert gas rebreathing), Innocor, Innovision, Denmark.

Fig. 2: Mobil-O-Graph for measurements of arterial pressure and pulse wave form

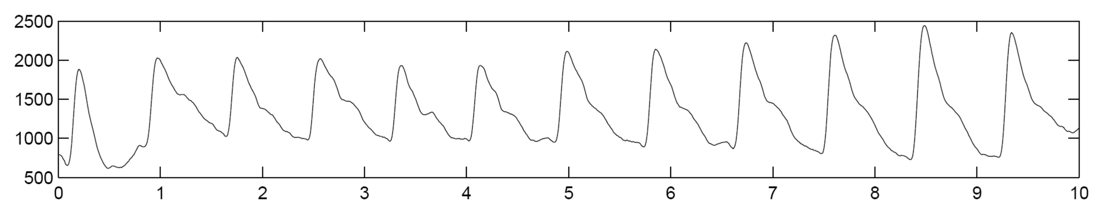


Fig. 3: Typical brachial pulse pressure wave form in supine rest (subject 0GM)

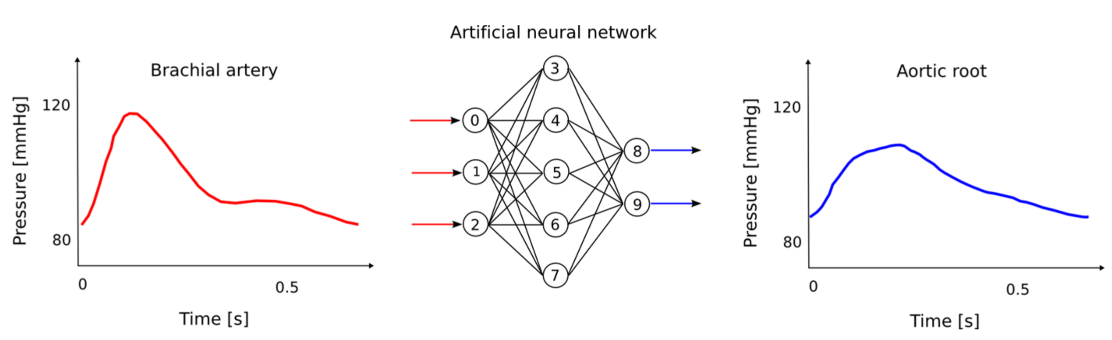
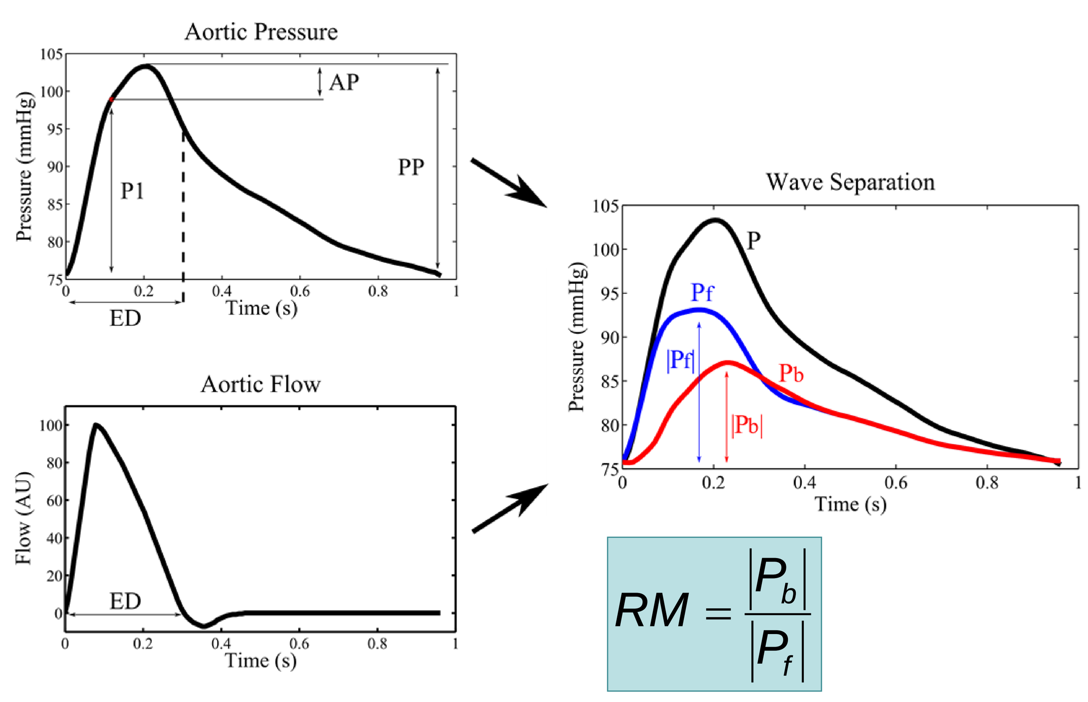


Fig. 4: Determination of central arterial pressure from the brachial wave form



$$RM = \frac{|P_b|}{|P_f|}$$

Fig. 5: Arterial pulse wave separation in forward (Pf) and backward (Pb) components

Results

Tab. 1: Hemodynamic parameters at 1 g and µ-g

Parameter		1 g	µg	p value
HR	[bpm]	62 ± 2	68 ± 2	<0.05
$SAP_{central}$	[mmHg]	119 ± 3	115 ± 3	<0.05
$DAP_{central}$	[mmHg]	80 ± 2	79 ± 2	0.44
CO	[l/min]	6.45 ± 1.47	7.53 ± 2.01	<0.001
RM	[%]	64.7 ± 1.6	59.9 ± 1.1	<0.001

HR: Heart rate
SAP/DAP: Systolic/diastolic arterial pressure
CO: Cardiac output, RM: Reflection magnitude

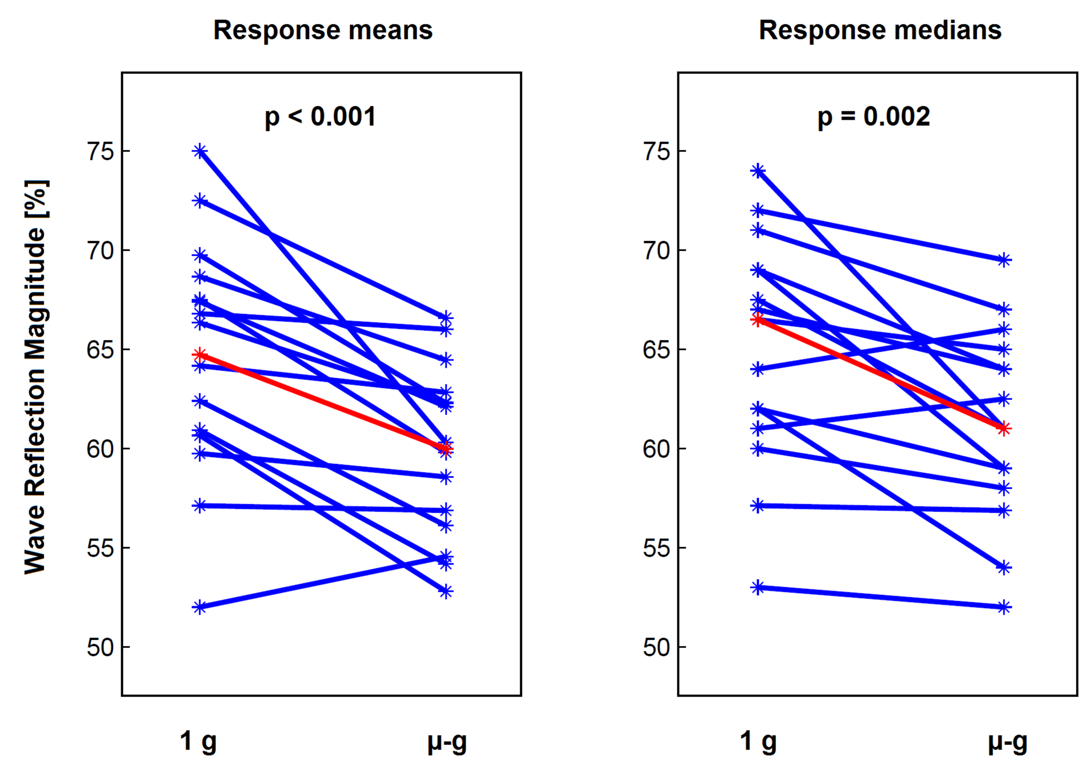


Fig. 2: Individual differences in pulse wave reflection magnitude between 1 g and µ-g

Summary

In supine position, acute transition from 1 g to µ-g causes the following hemodynamic changes:

- ⇧ Heart rate
- ⇧ Cardiac output
- ⇩ Pulse wave reflection magnitude.

Conclusion

The data suggest that 1-to-µ-g transition causes acute functional vascular changes caused by autonomic reflexes even in supine position.

Complete repeated measurements during long-term space flight without the limitations of profound acute hemodynamic changes during parabolas may be helpful to better distinguish functional from structural cardiovascular adaptations in astronauts.

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