DYNAMICS OF BLOOD PRESSURE, PULSE WAVE TRANSIT TIME AND SYSTOLIC TIME INTERVALS DURING ACUTE GRAVITY CHANGES INDUCED BY PARABOLIC FLIGHT

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ABSTRACT

To investigate cardiovascular adaptation to transient microgravity (μG), we measured RR intervals (RRI), arterial blood pressure (BP), pulse wave transit time (PTT) and systolic time intervals (STI) during parabolic flight. Our results demonstrate that during μG RRI, BP and PTT are subject to a rapid adaptation likely mediated by the baroreflex whereas STI changes with μG but does not present further adaptation.

1. INTRODUCTION

The suppression of all hydrostatic pressure gradients in weightlessness causes headward fluid shifts and a redistribution of blood, which causes an adaptation of the cardiovascular system to μG. Mechanisms of this adaptation are not fully understood, but they are supposed to be a major cause of orthostatic hypotension experienced by astronauts after spaceflight. We hypothesized that the changes of BP caused by transients in vertical acceleration (G_z) observed during parabolic flight would cause large changes in STI and PTT.

2. SUBJECTS AND MEASUREMENTS

Five healthy male subjects (means ± SD: age 31.8 ± 7.4 yr, weight 72.2 ± 4.5 kg, height 179.4 ± 4.3 cm) were monitored during ESA's 29th parabolic flight campaign. During 5 parabolas the subject was passively standing on a platform making a 60° angle with the floor of the airplane and breathed at a paced rhythm of 0.25Hz. ECG, impedance cardiogram, continuous finger blood pressure, finger photoplethysmographic pulse wave, abdominal respiratory movements and G_z were recorded at 1 kHz. Systolic and diastolic blood pressure were measured intermittently during 1G periods for calibration of continuous BP.

3. METHODS AND RESULTS

Heart beat interval (RRI), left ventricular pre-ejection period (PEP: time delay between the contraction of the heart and the opening of the aortic valve (AV)), PTT (time delay between opening of the AV and its arrival at the finger) and left ventricular ejection time (LVET) were measured as time differences between automatically detected cardiac events.

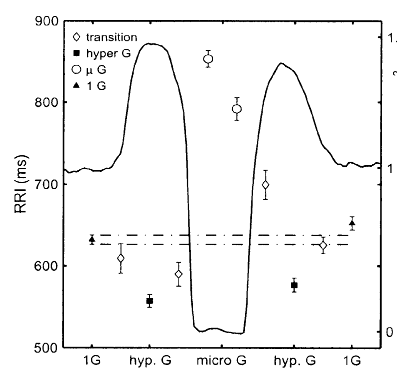

Figure 1. RR intervals during G_z transitions.

Grouping of data was performed in the following way: 1G - 30 seconds periods before and after the parabola where G < 1.1 g; Hyper G - periods of ~ 10 s with G > 1.5 g; μG - where G < 0.1 g. μG period was subdivided into first 10 s in μG and the remaining time. Remaining data corresponds to transition periods. These definitions were used to perform 2-way analysis of variance with G_z and subject as factor of variance and Bonferroni adjustment for multiple comparisons. Mean ± 95 % CI were computed for each group (see Figures).

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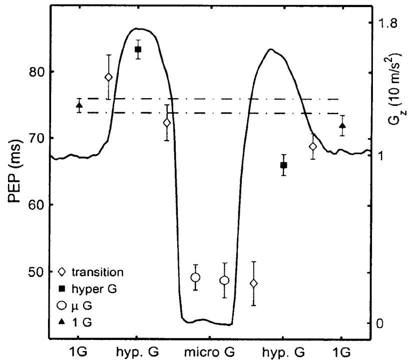

Figure 2. Pre-ejection period (PEP).

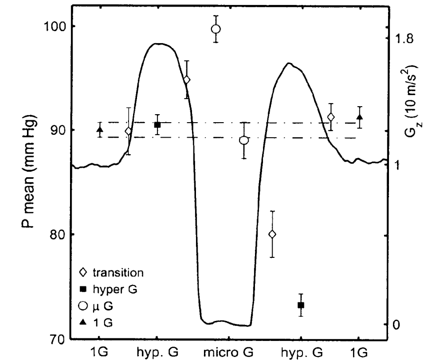

Figure 4. Mean blood pressure (BP).

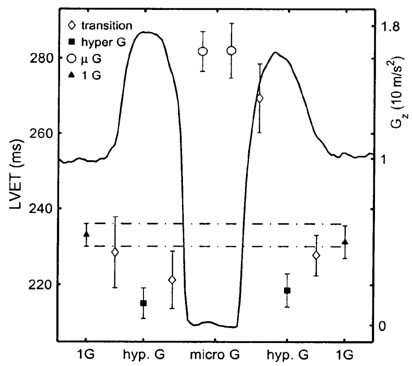

Figure 3. Left ventricular ejection time (LVET).

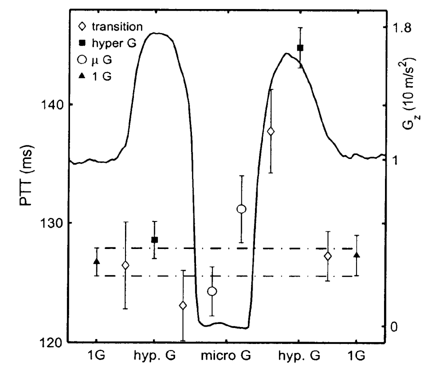

Figure 5. Pulse transit time (PTT).

At onset of μG, a nearly instantaneous response occurred: RRI, LVET and mean BP increased while PEP decreased and PTT remained at its 1 G level. During exposure to μG , PEP and LVET remained at their entry in μG values, no further adaptation was observed. A significant decrease is seen in RRI, and BP, consistent with the significant increase observed for PTT. Additionally, we observed that the transition between μG and hyper-gravity caused larger changes in mean BP and PTT than the transition from hyper-gravity to μG.

4. CONCLUSION

These results are in agreement with an increased preload volume of the heart. The increased LVET is an indirect evidence of increased stroke volume, which through Starling mechanisms is considered to be the cause of a shortening of the PEP (Myamoto, 1983) and to reflect a pure mechanical effect. For RRI, BP and PTT, the adaptation seen in μG is likely due to the baroreflex (Linnarson, 1996). The different dynamics of these parameters with $G_z$changes suggests that STI, PTT and BP transients reflect different mechanisms of adaptation to μG. The feasibility and relevance of these measurements in μG was demonstrated and monitoring these parameters during spaceflight may bring new clues to the understanding of orthostatic intolerance after space flight.

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