Gender Differences in Blood Pressure Control During 90-day Bedrest

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Introduction

Space-flight-induced physiological changes increase the risk of orthostatic hypotension on return to Earth, particularly for women. Orthostatic hypotension, or low blood pressure when sitting upright or standing, could impair a crew member's ability to perform routine or mission-critical tasks. The physiological mechanisms responsible for increased orthostatic hypotension in female astronauts are unclear. Several contributing factors to lower tolerance in women after space flight have been postulated, including a lower center of mass, higher circulating estrogen levels, and smaller and stiffer left ventricles.

We are currently studying the effects of gender on baroreflex sensitivity and orthostatic tolerance after bedrest, a well-accepted model of space flight deconditioning. The overall aim of this project is to examine factors that contribute to arterial blood pressure control in men and women, and to determine how men and women are affected during 90 days of 6-deg head-down-tilt bedrest. After space flight and bedrest, the capacity of the human body to regulate heart rate to compensate for sudden changes in blood pressure is decreased. Previous studies concentrate on a single blood pressure perturbation, such as a tilt test, bolus drug injections, or rapid neck chamber decompressions. By contrast, in this study we infused drugs that manipulated systemic vasoconstriction and vasodilation to produce changes in blood pressure to determine how well heart rate is regulated to compensate for these changes across the duration of bedrest.

Methods

Twenty-three volunteers (15 males, eight females) were tested 1 day before bedrest and then during near-bedrest days 30, 60, and 90. Normal saline was infused for 10 minutes followed by three 10-minute infusions of phenylephrine (PE) (a vasoconstrictor) of increasing concentrations (0.4, 0.8, and 1.6 $\mu g \cdot kg^{-1} \cdot min^{-1}$). After 20 minutes of rest with no infusions, saline was infused again for 10 minutes, followed by three 10-minute infusions of sodium nitroprusside (SNP) (a vasodilator) of increasing concentrations (0.4, 0.8, and 1.2 $\mu g \cdot kg^{-1} \cdot min^{-1}$). Electrocardiogram and blood pressure were measured continuously to examine heart rate responses to changes in blood pressure. Spectral and cross-spectral blood pressure and heart rate variability algorithms were used to assess the indices of autonomic balance and baroreflex sensitivity.

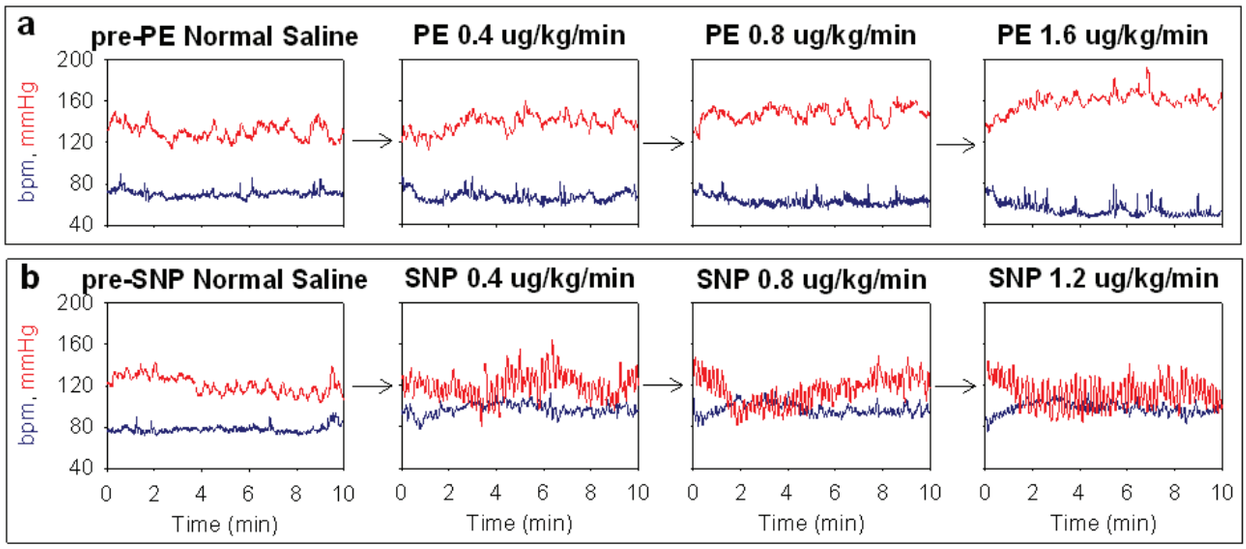

Fig. 1. *Heart rate (dark blue) and systolic blood pressure (red) response to drug infusions for one subject post-bedrest.*

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continued

Results

As expected, mean heart rate increased and mean resting blood pressure decreased with bedrest for all of the volunteers, and the women had lower blood pressure than the men. Cross-spectral phase changes indicated that women's heart rates responded slower than men's to both increases and decreases in blood pressure. During increasing concentrations of PE infusion, blood pressure increased and heart rate compensated by decreasing (figure 1a). During increasing concentrations of SNP infusions, blood pressure decreased and heart rate compensated by increasing (figure 1b). Spectral indices of heart rate variability indicate that heart rate control of blood pressure decreased throughout bedrest for both men and women, with a larger effect in women.

Conclusions

Post-space-flight orthostatic intolerance can be partially explained by the diminished capacity of heart rate to regulate changes in blood pressure. These preliminary results indicate that women experience a greater decrease in blood pressure control and a slower heart rate response during bedrest, both factors that would contribute to their higher incidence of orthostatic intolerance.

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