Effects of vibration and G-loading on heart rate, breathing rate, and response time

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I. Introduction
Aerospace and applied environments commonly expose pilots and astronauts to G-loading and vibration, alone and in combination, with well-known sensorimotor (Cohen, 1970) and performance consequences (Adelstein et al., 2008). Physiological variables such as heart rate (HR) and breathing rate (BR) have been shown to increase with G-loading (Yajima et al., 1994) and vibration (e.g. Guignard, 1965, 1985) alone. To examine the effects of G-loading and vibration, alone and in combination, we measured heart rate and breathing rate under aerospace-relevant conditions (G-loads of 1 Gx and 3.8 Gx; vibration of 0.5 gx at 8, 12, and 16 Hz).

II. Methods

Task parameters:
- G conditions: 1 Gx, 3.8 Gx
- Vibration conditions (0.5 gx): no vibration, 8 Hz, 12 Hz, 16 Hz

Participants:
- 10

Heart rate and breathing rate data were collected using a Zephyr bio-harness.

Task: Observers were asked to hold a switch at the end of the armrest and fixate a central red LED. After a randomized interval (200 - 700 ms), the LED extinguished and a target spot appeared at a random location on the touch panel and was visible for 133 ms (closed-loop) and until observers touched the panel (open-loop). Observers where asked to look at the point to the location where the spot had appeared.

Facilities:
- Fixed-based vibration platform (1 Gx)
- 20 G centrifuge (3.8 Gx)

The laboratory is equipped with a resonant vibration chair that can deliver single-frequency and complex broadband motion to seat occupants up to three degrees-of-freedom (vertical, pitch, and roll).

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The effects of vibration frequency on heart rate, breathing rate, and response time are less robust.

For all measures, we observed strong within-block effects, which would obscure any potential effect of vibration frequency.

Further analysis is necessary to compensate for the strong within-block effects.

III. Heart rate

We observed a significant main effect of G-loading (p<0.0001), no effect of vibration frequency (p>0.05), and no interaction (p>0.05).

IV. Breathing rate

We observed a significant main effect of G-loading (p<0.0001), a significant within-block effect (p<0.05), and no interaction (p>0.05).

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V. Response time

We observed a significant main effect of G-loading (p<0.0001), no effect of vibration frequency (p>0.05), and no interaction (p>0.05).

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VI. Conclusions

G-loading had a strong effect on heart rate, breathing rate, and response time.

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For all measures, we observed strong within-block effects, which would obscure any potential effect of vibration frequency.

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References


This material is based upon work supported by the National Space Biomedical Research Institute.