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 g at 8, 12, and 16 Hz).

II. Methods

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

Participants: 10 healthy, right-handed volunteers, aged 20-32 years.

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

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

The laboratory is equipped with a recumbent vibration platform (1 Gx), a fixed-based vibration platform (1 Gx), and a 20 G centrifuge (3.8 Gx). A vibration chair within the 20 G centrifuge can deliver Gx vibration during centrifugation.

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).

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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IV. Breathing 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).

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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We observed a significant main effect of G-loading (p<0.0001), a significant within-block effect (p<0.0001), and significant interaction (p<0.001).

V. Response time

We observed a significant main effect of G-loading (p<0.0001), no effect of vibration frequency (p=0.5), and no interaction (p=0.05).

We observed a significant main effect of G-loading (p<0.0001), a significant within-block effect (p<0.0001), and significant interaction (p<0.001).

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).

VI. Conclusions

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

References


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