Impact of Bed Rest and Exercise
Jessica M. Scott,1 Timothy Matz,2 Timothy Caine,3 David S. Martin,2 Meghan Downes,4 Lori Ploutz-Snyder1
1Universities Space Research Association, Houston, TX, Houston, TX; 2METTech, Houston, TX; 3Wyle Integrated Science and Engineering Group, Houston, TX; 4University of Houston, Houston, TX.

Abstract

BACKGROUND: Current techniques used to assess cardiac function following spaceflight or head-down tilt bed rest (HDTBR) involve invasive and time-consuming procedures such as Swan-Ganz catheterization or cardiac magnetic resonance imaging. An alternative approach, echocardiography, can monitor cardiac morphology and function via sequential measurements of left ventricular (LV) mass and ejection fraction (EF). However, LV mass and EF are insensitive measures of early (subclinical) cardiac deconditioning, and a decrease in LV mass and EF become evident only once significant deconditioning has already occurred. The use of more sensitive and specific echocardiographic techniques such as speckle tracking imaging may address the current limitations of conventional cardiac imaging techniques to provide insight into the magnitude and time course of cardiac deconditioning.

METHODS: Speckle tracking assessment of longitudinal, radial, and circumferential strain and twist was used to evaluate the impact of 70 days of HDTBR (n=7) and HDTBR + exercise (n=11) on temporal changes in LV mechanics. Echocardiograms were performed pre (BR-2), during (BR31, 70), and following (BR+4hr) HDTBR. Multi-level modeling was used to evaluate the effect of HDTBR condition (Control, Exercise) on cardiac variables. RESULTS: Compared to BR-2, longitudinal (BR-2: -19.0 ± 1.8%; BR31: -15.9 ± 2.4%; BR70: -14.9 ± 2.4%; BR+4hr: -16.0 ± 2.5%) and radial (BR-2: 15.0 ± 1.9%; BR31: 12.3 ± 2.4%; BR70: 11.3 ± 2.2%; BR+4hr: 13.5 ± 2.5%) strains were significantly impaired during and following bed rest (p<0.05), while twist (BR-2: 18.0 ± 4.0°; BR31: 18.1 ± 3.8°; BR70: 17.0 ± 3.6°; BR+4hr: 18.1 ± 4.3°) was significantly decreased at BR70 (p<0.05). In contrast, exercise preserved LV mechanics for longitudinal strain (BR-2: -19.1 ± 1.5%; BR31: -19.0 ± 2.4%; BR70: -19.1 ± 2.7%; BR+4hr: -17.8 ± 2.1%), radial strain (BR-2: 13.8 ± 2.4%; BR31: 14.3 ± 2.4%; BR70: 14.4 ± 1.6%; BR+4hr: 14.4 ± 2.4), and twist (BR-2: 17.8 ± 3.6°; BR31: 18.0 ± 3.6°; BR70: 18.2 ± 5.9°; BR+4hr: 18.3 ± 2.4°). CONCLUSIONS: Speckle-tracking echocardiography provides important new insight into temporal changes in LV mechanics during disease and exercise training.

Introduction

• Current techniques used to assess cardiac function following spaceflight or head-down tilt bed rest (HDTBR) involve invasive and time-consuming procedures such as Swan-Ganz catheterization or cardiac magnetic resonance imaging.1,2
• An alternative approach, echocardiography, can monitor cardiac morphology and function via sequential measurements of left ventricular (LV) mass and ejection fraction (EF). However, LV mass and EF are insensitive measures of early (subclinical) cardiac deconditioning, and a decrease in LV mass and EF become evident only once significant deconditioning has already occurred.
• The use of more sensitive and specific echocardiographic techniques such as speckle tracking imaging may address the current limitations of conventional cardiac imaging techniques.
• Importantly, given that strain, strain rate, and torsion measurements are sensitive indicators of cardiac function in numerous populations,3 it is plausible that these indices may provide early detection of disease-induced myocardial dysfunction.

Results

• Controls: Compared to BR-2, longitudinal (BR-2: -19.0 ± 1.8%; BR31: -15.9 ± 2.4%; BR70: -14.9 ± 2.4%; BR+4hr: -14.8 ± 2.1%) and radial (BR-2: 15.0 ± 1.9%; BR31: 12.3 ± 2.4%; BR70: 11.3 ± 2.2%; BR+4hr: 12.4 ± 2.5%) strains were significantly impaired during and following bed rest (p<0.05), while twist (BR-2: 18.0 ± 4.0°; BR31: 18.1 ± 3.8°; BR70: 17.0 ± 3.6°; BR+4hr: 18.1 ± 4.3°) was decreased at BR70 (p<0.05).
• Exercisers: Exercise preserved LV mechanics for longitudinal strain (BR-2: -19.1 ± 1.5%; BR31: -19.0 ± 2.4%; BR70: -19.1 ± 2.7%; BR+4hr: -17.8 ± 2.1%), radial strain (BR-2: 13.8 ± 2.4%; BR31: 14.3 ± 2.4%; BR70: 14.4 ± 1.6%; BR+4hr: 14.4 ± 2.4), and twist (BR-2: 17.8 ± 3.6°; BR31: 18.0 ± 3.6°; BR70: 18.2 ± 5.9°; BR+4hr: 18.3 ± 2.4°).

Discussion

• Given that exercise preserved LV mechanics during disuse, serial evaluation of subclinical markers of cardiac dysfunction with speckle tracking echocardiography could provide critically important information for the design and optimization of in-flight exercise countermeasure programs.
• Future analysis will include indices of diastolic function, which could provide insight into the mechanisms underlying impaired aerobic capacity following disuse. Indeed, loss of early diastolic longitudinal relaxation and delayed untwisting have previously been shown to contribute to exercise limitations.3

Acknowledgements

Funding provided by NASA Human Research Program.

References