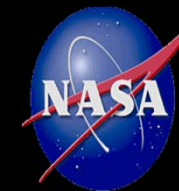


# TEMPORAL CHANGES IN LEFT VENTRICULAR MECHANICS: IMPACT OF BED REST AND EXERCISE

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## 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 ± 2.1%) 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%; BR 31: -19.0 ± 2.4%; BR70: -19.1 ± 2.7%; BR+4hr: -17.8 ± 2.1%), radial strain (BR-2: 13.8 ± 2.4; BR31: 14.7 ± 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 ± 4.2°). **CONCLUSIONS** Speckle-tracking echocardiography provides important new insight into temporal changes in LV mechanics during disuse 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.<sup>1,2</sup>
- 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.<sup>3</sup>
- Importantly, given that strain, strain rate, and torsion measurements are sensitive indicators of cardiac function numerous populations,<sup>4</sup> it is plausible that these indices may provide early detection of disuse-induced myocardial dysfunction.

## Purpose

- To examine the magnitude and time course of change of cardiac deconditioning during 70 days of bed rest.

## Methods

- 18 subjects completed 70 days of HDTBR; 11 were randomized to aerobic and resistance training, while 7 remained sedentary.
- Two-dimensional transthoracic short axis and apical four chamber views were acquired (Phillips iE33) pre (BR-2), during (BR31, 70), and following (BR+4hr) HDTBR.
- Speckle tracking (Q-Lab, Phillips) was used to assess longitudinal (Figure 1), radial, and circumferential strain and basal and apical rotation.
- Left ventricular torsion was calculated as the difference between the apical and basal rotations. Circumferential and radial strain data were averaged between the basal and apical slices.

## Statistical Analysis

- Multi-level modeling was used to evaluate the effect of HDTBR condition (Control, Exercise) on cardiac variables.
- All data were analyzed using SPSS (LEAD Technologies, Inc., US) and Excel 2007 (Microsoft Corp, Redmond, WA, USA).

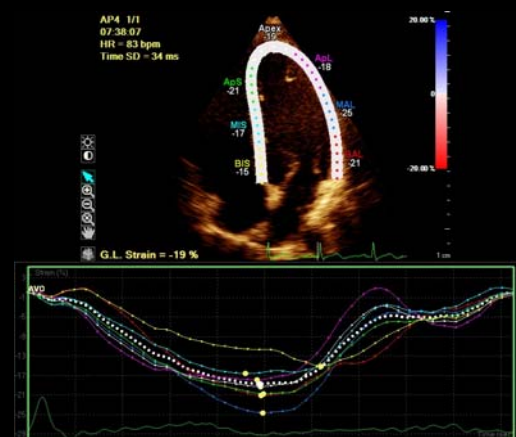


Figure 1. Example speckle tracking assessment of longitudinal strain.

## 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.
- Exercisers:** Exercise preserved LV mechanics for longitudinal strain (BR-2: -19.1 ± 1.5%; BR 31: -19.0 ± 2.4%; BR70: -19.1 ± 2.7%; BR+4hr: -17.8 ± 2.1%), radial strain (BR-2: 13.8 ± 2.4; BR31: 14.7 ± 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 ± 4.2°).

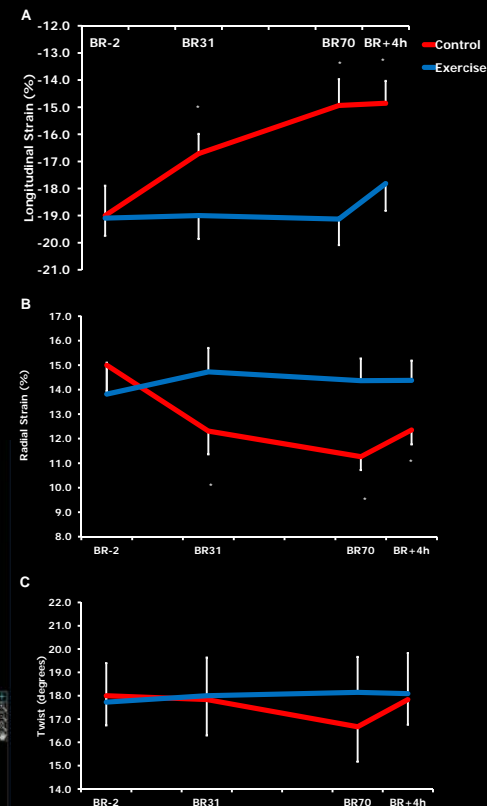


Figure 2. Time course of change A) longitudinal strain; B) radial strain; C) twist. · p <0.05 vs. BR-2.

## 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.<sup>5</sup>

## ACKNOWLEDGEMENTS:

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