

Analog Exercise Hardware to Implement a High Intensity Exercise Program during Bed Rest

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Background: In order to evaluate novel countermeasure protocols in a space flight analog prior to validation on the International Space Station (ISS), NASA's Human Research Program (HRP) is sponsoring a multi-investigator bedrest campaign that utilizes a combination of commercial and custom-made exercise training hardware to conduct daily resistive and aerobic exercise protocols. This paper will describe these pieces of hardware and how they are used to support current bedrest studies at NASA's Flight Analog Research Unit in Galveston, TX.

Discussion: To implement candidate exercise countermeasure studies during extended bed rest studies the following analog hardware are being utilized:

- **Stand alone Zero-Gravity Locomotion Simulator (sZLS)** – a custom built device by NASA, the sZLS allows bedrest subjects to remain supine as they run on a vertically-oriented treadmill (0-15 miles/hour). The treadmill includes a pneumatic subject loading device to provide variable body loading (0-100%) and a harness to keep the subject in contact with the motorized treadmill to provide a ground reaction force at their feet that is quantified by a Kistler Force Plate.
- **Supine Cycle Ergometer-** a commercially available supine cycle ergometer (Lode, Groningen, Netherlands) is used for all cycle ergometer sessions. The ergometer has adjustable shoulder supports and handgrips to help stabilize the subject during exercise.
- **Horizontal Squat Device (HSD)** – a custom built device by Quantum Fitness Corp (Stafford, TX), the HSD allows for squat exercises to be performed while lying in a supine position. The HSD can provide 0 to 600 pounds of force in selectable 5 lb increments, and allows hip translation in both the vertical and horizontal planes.
- **Prone Leg Curl** – a commercially available prone leg curl machine (Cybex International Inc., Medway, MA) is used to complete leg curl exercises.
- **Horizontal Leg Press** – a commercially available horizontal leg press (Quantum Fitness Corporation) is used for leg press and heel raise exercises. Minor modifications were made to the device including adding 200 lbs to the weight stack, raising the frame by 12 inches, making the footplate adjustable, and providing removable handles.

Conclusion: A combination of novel and commercial exercise hardware are used to mimic the exercise hardware capabilities aboard the ISS, allowing scientific investigation of new countermeasure protocols in a space flight analog prior to flight validation.