

CONTROLLED RESISTANCE EXERCISE DEVICE (C-RED)

David C. Paulus¹, Alton J. Reich², John K. DeWitt³, James E. Shaw², and Stelu S. Deaconu²

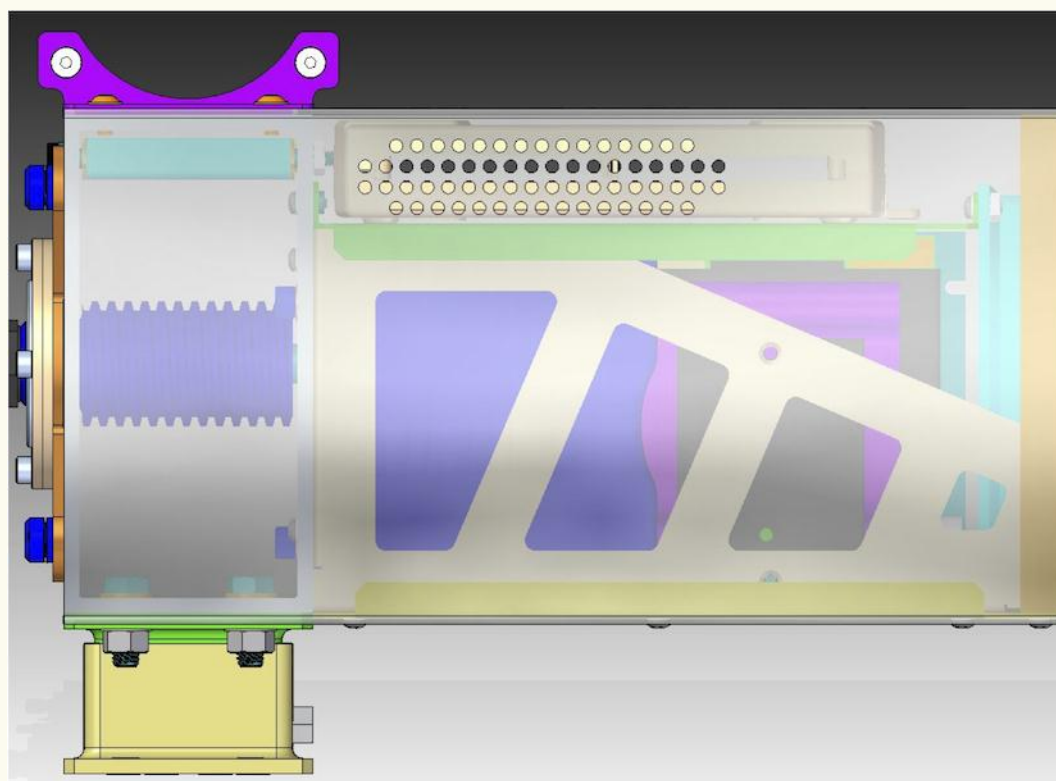
¹Paulus Consulting, LLC <paulus.consulting@gmail.com>, ²Streamline Automation, LLC <Alton.Reich@StreamlineAutomation.biz>, and ³Wyle Integrated Science and Engineering Group <john.k.dewitt@nasa.gov>

ABSTRACT

Spaceflight leads to muscle and bone atrophy, and isoinertial (free-weight) exercises provide a sufficient stimulus to elicit increases in both muscle strength and bone mineral density in earth-based studies. While exercise equipment is in use on the International Space Station for crew member health maintenance, current devices are too large to place in a transport vehicle or small spacecraft. Therefore, a portable computer controlled resistance exercise device is being developed for NASA that is able to simulate the inertial loading experienced when lifting a mass on earth. This portable device weighs less than 50 lb and can simulate the resistance of lifting and lowering more than 600 lb of free-weights. The objective is to allow crew members to perform resistance exercise with loads that have been shown to be necessary to maintain muscle and bone health. The device is reconfigurable and allows for the performance of typical free-weight exercises. Forces exerted, volume of work, range of motion, time-under-tension, and speed/ acceleration of movement are recorded and can be remotely monitored to track progress and modify individual protocols based on exercise session data.

SYSTEM DESIGN

The exercise device integrates the force generating components, controls, and data acquisition hardware into a very compact package. A load cell is integrated into the load path to enable closed-loop force feedback. The control software has modes for a constant target force, a calculated force target that includes inertial (acceleration) affects, and provisions for including eccentric overload.



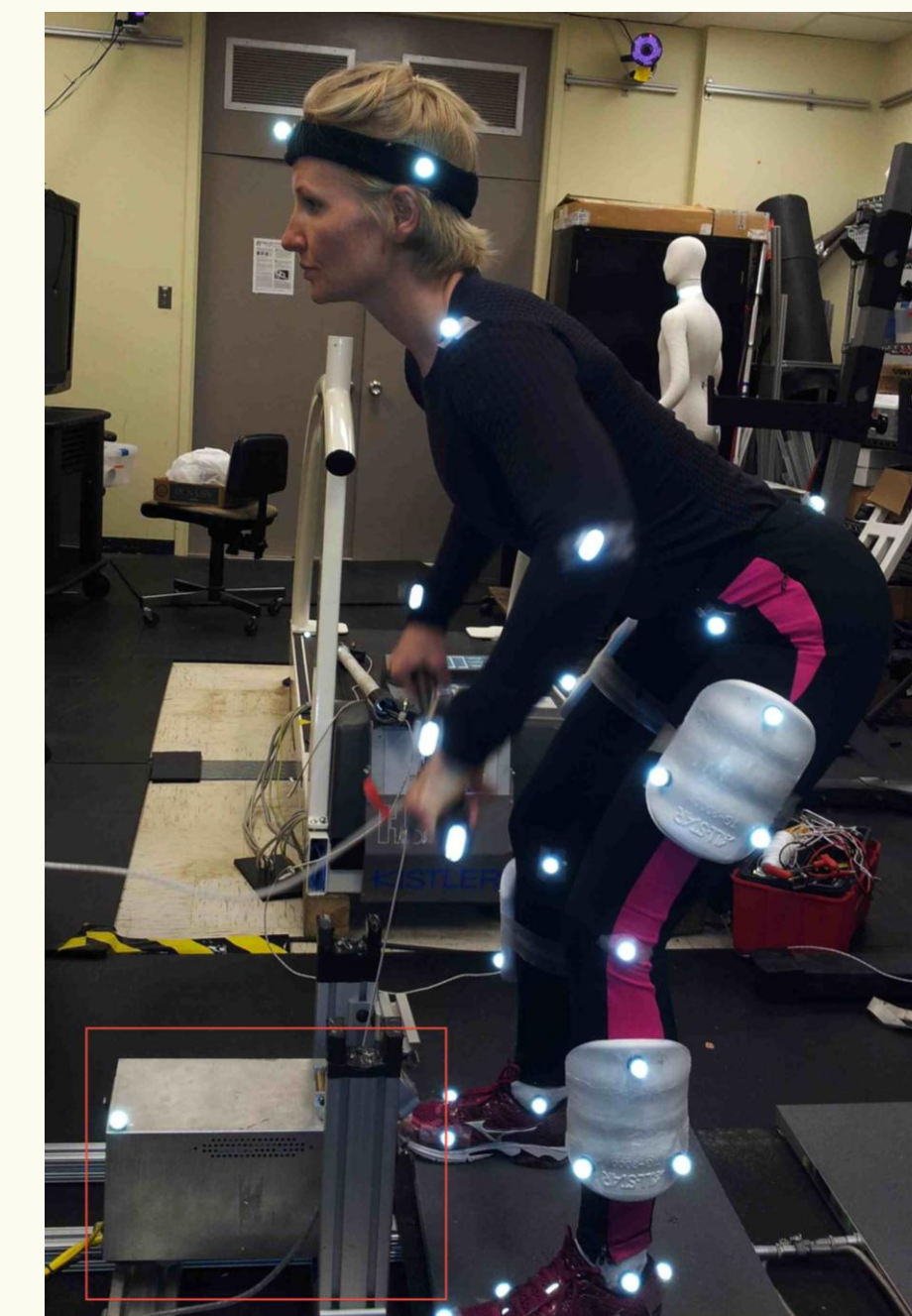
HUMAN SUBJECTS TESTING

Human subjects testing of the Controlled Resistance Exercise Device (C-RED) was performed at NASA-JSC with 9 subjects over a 3 day period. The exercises performed were selected to work the major muscle groups that are targeted to maintain muscle mass and bone density. They included squat, deadlift, bench press, shoulder press, upright row, and bicep curl. Loads during testing ranged from a low of 4 N (~1 lbf) to 1600 N (~360 lbf).

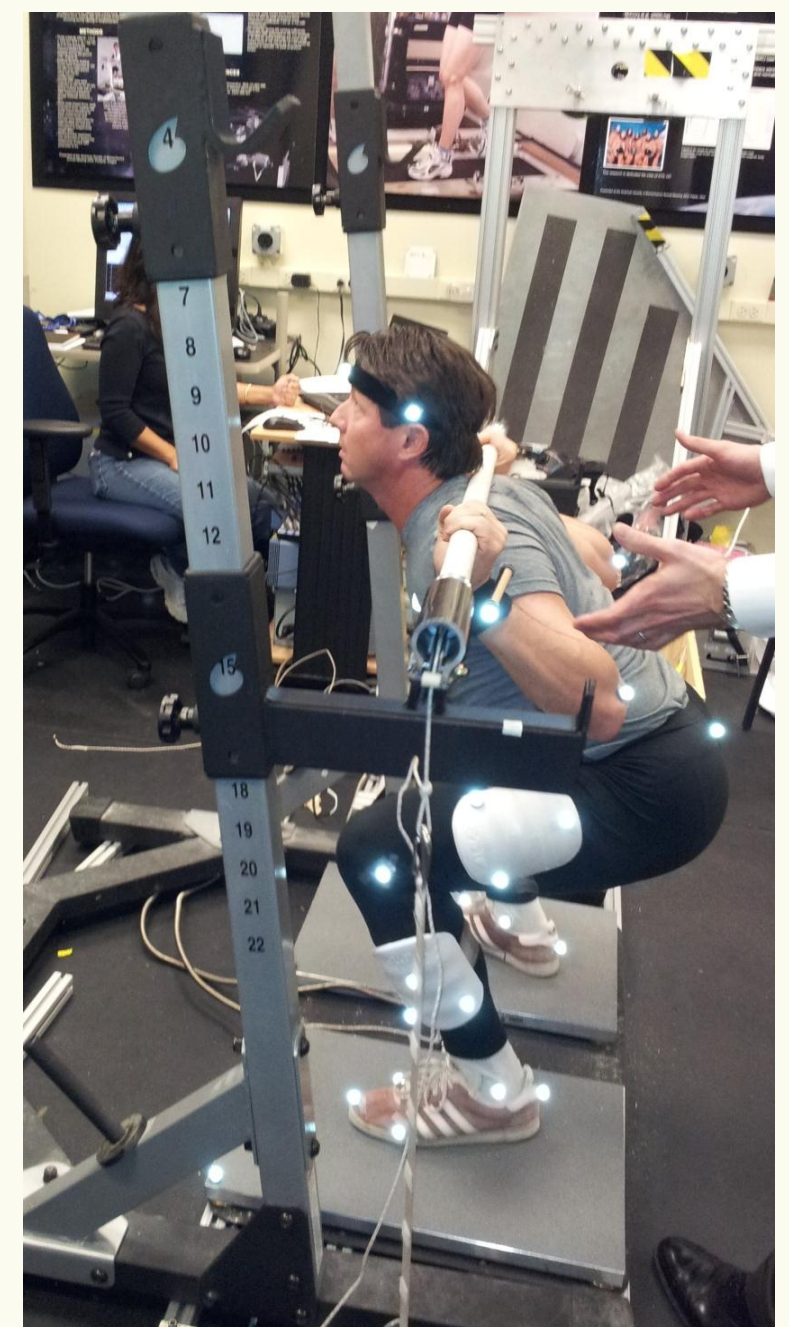
Deadlift Ground Reaction Force
C-RED Compared to ARED



S2 Bent Over Row



S1 Squat



S7 Deadlift – Load and Power

