

## Harness Station Development Test Objective (Harness SDTO)



*Astronaut Jeff Williams exercises on the ISS treadmill.*

A new exercise harness for crew members on the International Space Station (ISS) has been developed out of the Center for Space Medicine (CSM), a NASA Glenn/Cleveland Clinic collaboration. The CSM harness will be evaluated during on-orbit exercise in a Station Development Test Objective (SDTO). Treadmill exercise has been used on orbit since early space shuttle flights because it has the potential to simultaneously benefit the neurovestibular, musculoskeletal, and cardiovascular systems. Extensive effort has been put forth toward the development of exercise countermeasures, yet bone continues to be lost on current ISS missions and is a major concern for future exploration missions. A treadmill with vibration isolation (TVIS) has been a major component of the exercise hardware on the ISS. However, it has not proven to be a successful countermeasure. The key to the success of load-bearing exercise in space, such as treadmill running, is the application of loads to the crew member via a subject load device coupled to the body by a harness. ISS crew members frequently report discomfort from the current types of exercise harnesses, which makes the exercise protocols less effective. Experiments on the ISS have shown that this has resulted in low ground reaction forces on orbit (approximately 60 percent of 1-g loads), which is likely to be a major factor in the observed loss of bone mineral density in crew members. This project utilized valuable insights from the backpack industry for harness configuration and distributing loads to develop an improved harness for flight. The harness is designed to better distribute loads at the shoulders and hips and to accommodate for individual differences, including gender. The project resulted in the advancement of a new, more comfortable harness design that has been developed for flight testing on the ISS.



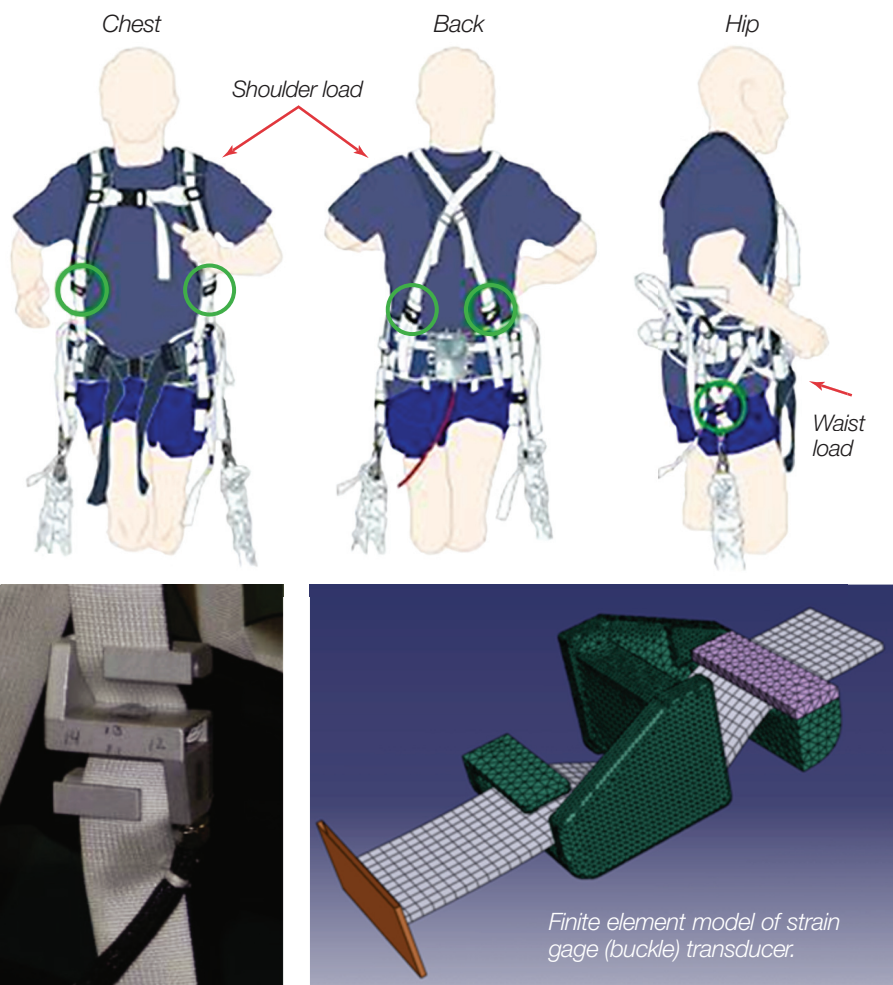
*CSM harness designed to improve comfort, loading, and adjustability.*

This Station Development Test Objective (SDTO) assesses whether crew members can exercise more comfortably and at higher loads using a new treadmill harness, as compared to the existing ISS treadmill harness. The hypotheses are as follows: (i) the CSM harness will provide greater overall comfort than the current ISS treadmill harness; (ii) crew members will be able to tolerate higher external loads from the subject load device; (iii) load distribution measurements collected with strain gauge instrumentation (buckle transducers) between shoulders and hips will correlate with subjective measures of comfort; and (iv) the CSM harness will provide more effective wear and adjustability (easier adjustments, and adjustments will stay fixed once they are set, breathable biocide outer fabric).

The SDTO research protocol is aimed at improving comfort, plus increasing consistent loading for crew members exercising on the ISS treadmill(s). The CSM harnesses will be instrumented to allow for objective correlation with subjective ratings of comfort. To provide a direct comparison with the ISS treadmill harness, the load distribution and subject load device applied to the ISS treadmill harness will also be measured. The ISS treadmill harnesses will be instrumented by the crew on-orbit during a one-time setup activity. Previously, measurement of inflight load distribution of the harness or the applied external load has not been performed—these objective data sets may be correlated with subjective comfort data for improved designs and for existing and advanced concept exercise countermeasures systems requiring crew member harnessing.

The sensors to measure load distribution were developed during pilot testing of the prototype harness. This load sensing methodology will be used during the flight experiment to obtain comparisons of load and comfort between the new CSM harness and the current U.S. ISS harness.

Development of optimized crew equipment for exercise is highly relevant to the ISS and Human Research Programs. The intended outcome of the SDTO is qualitative and



▲ Typical strain gage (buckle) transducer shown installed onto a harness strap to measure dynamic tension in the strap.

quantitative data to demonstrate that crew members prefer the fit and function of the CSM harness, and are able to tolerate higher subject loading during treadmill exercise aboard the ISS. Loading through the subject load system approaching 1-g-like loads (one bodyweight) is thought to be more effective for maintaining musculoskeletal health on-orbit. A second intended outcome is that the design and/or design elements identified as desirable improvements will be implemented as new operational hardware (harness/bungee) requirements for treadmill exercise. Furthermore, the crew member responses to directed questions relating to comfort, ease of use, wear, and durability will provide insight to improvements that may be made for future flight harness designs.

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