EVALUATION OF THE XSENS FORCE SHOE ON ISS

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BACKGROUND

The Advanced Resistive Exercise Device (ARED) offers crewmembers a wide range of resistance exercises but does not provide any type of load monitoring; any load data received are based on crew self-report of dialed in load. This lack of real-time ARED load monitoring severely limits research analysis. To address this issue, portable load monitoring technologies are being evaluated to act as a surrogate to ARED's failed instrumentation. The XSENS ForceShoe™ is a commercial portable load monitoring tool, and performed well in ground tests. The ForceShoe ™ was recently deployed on the International Space Station (ISS), and is being evaluated as a tool to monitor ARED loads.

METHODS

Subjects

Crewmembers assigned to ISS missions during Expeditions 40-44 were recruited for the evaluation. A minimum of two subjects are needed to complete the evaluation, and up to four may participate. To date, two subjects have participated in the evaluation. Written informed consent was obtained from each subject, and all procedures were approved by the NASA Johnson Space Center Institutional Review Board and the Multi-National Human Research Multilateral Review Board.

XSENS™ Force Shoes

The force shoes house six degrees-of-freedom (6-DOF) tri-axial force (Fx,y: ±130 lb_{force}, Fz: ±260 lb_{force}), and torque (Tx,y,z: ±177 lb-in) sensors. Data were collected at 50 Hz and transmitted to a laptop through a USB cable or Bluetooth connection. The resultant force was summed between left and right shoes for analysis.

Test Protocol

Subjects conducted a single familiarization session with the Force Shoes prior to flight. In-flight, data were collected with loads applied through the bungee assembly interface to the treadmill and on ARED. Static load measures taken with the bungee assembly were adjusted by adding and removing French clips at the treadmill harness interface. A series of static and dynamic loads were collected on ARED. Benchmark measures were collected at 100, 200, and 300 lb at the high and low bar positions. Incremental loads (25 lb) were collected over a target range of 0-500 lb. Load measures were collected in triplicate. Subjects were also asked to perform squat, deadlift, and bicep curl exercise. For consistency in load measures, the subjects were instructed to position the crank handle at the 12 O'clock position for each load adjustment. A cylinder evacuation was performed prior to each ARED session. Each Force Shoe™ session was video recorded.

RESULTS

Data were collected over a range of 0-325 lb at this point in the evaluation. Dynamic exercises were limited to deadlifts and bicep curls due to the low-traction interface between the Force Shoe™ and ARED platform. In bungee pull down measurements the within load repeatability standard deviation was 3% of the mean within a single test condition across loads between 40-160 lb and. Benchmark measures on ARED demonstrated <4% difference between high and low bar measures on two test days, and >4% on two other test days. Regardless, comparison of average repeated loads between two test sessions, where on average <4% and the within load repeatability standard deviation is 0.75% of the mean.

CONCLUSION

The XSENS Force Shoes™ perform as well in microgravity as they did in ground evaluations, and consistently measure repeated loads within a single session. The Force Shoes™ operated well in both wired and Bluetooth mode, which provides confidence that future Bluetooth devices flown to ISS will operate as expected. Analysis of Force Shoe™ data revealed an asymmetry in left to right foot loading, and will be investigated further. The XSENS Force Shoe appears to be a reliable tool for under foot load measurements for use in non-locomotor activity aboard ISS.