

ISS SQUAT AND DEADLIFT KINEMATICS ON THE ADVANCED RESISTIVE EXERCISE DEVICE

N. Newby¹, E. Caldwell¹, J. Sibonga², and L. Ploutz-Snyder³

¹ Wyle Science, Technology & Engineering Group, 1290 Hercules, Houston, TX 77058, ² NASA Johnson Space Center, Houston, TX, ³ Universities Space Research Association, Houston, TX

INTRODUCTION

Visual assessment of exercise form on the Advanced Resistive Exercise Device (ARED) on orbit is difficult due to the motion of the entire device on its Vibration Isolation System (VIS). The VIS allows for two degrees of device translational motion, and one degree of rotational motion. In order to minimize the forces that the VIS must damp in these planes of motion, the floor of the ARED moves as well during exercise to reduce changes in the center of mass of the system. To help trainers and other exercise personnel better assess squat and deadlift form a tool was developed that removes the VIS motion and creates a stick figure video of the exerciser. Another goal of the study was to determine whether any useful kinematic information could be obtained from just a single camera. Finally, the use of these data may aid in the interpretation of QCT hip structure data in response to ARED exercises performed in-flight.

METHODS

After obtaining informed consent, four International Space Station (ISS) crewmembers participated in this investigation. Exercise was videotaped using a single camera positioned to view the side of the crewmember during exercise on the ARED. One crewmember wore reflective tape on the toe, heel, ankle, knee, hip, and shoulder joints. This technique was not available for the other three crewmembers, so joint locations were assessed and digitized frame-by-frame by lab personnel. A custom Matlab program was used to assign two-dimensional coordinates to the joint locations throughout exercise. A second custom Matlab program was used to scale the data, calculate joint angles, estimate the foot center of pressure (COP), approximate normal and shear loads, and to create the VIS motion-corrected stick figure videos.

RESULTS

Kinematics for the squat and deadlift vary considerably for the four crewmembers in this investigation. Some have very shallow knee and hip angles, and others have quite large ranges of motion at these joints. Joint angle analysis showed that crewmembers do not return to a normal upright stance during squat, but remain somewhat bent at the hips. COP excursions were quite large during these exercises covering the entire length of the base of support in most cases. Anterior-posterior shear was very pronounced at the bottom of the squat and deadlift correlating with a COP shift to the toes at this part of the exercise. The stick figure videos showing a feet fixed reference frame have made it visually much easier for exercise personnel and trainers to assess exercise kinematics.

DISCUSSION

Not returning to fully upright, hips extended position during squat exercises could have implications for the amount of load that is transmitted axially along the skeleton. The estimated shear loads observed in these crewmembers, along with a concomitant reduction in normal force, may also affect bone loading. The increased shear is likely due to the surprisingly large deviations in COP. Since the footplate on ARED moves along an arced path, much of the squat and deadlift movement is occurring on a tilted foot surface. This leads to COP movements away from the heel. The combination of observed kinematics and estimated kinetics make squat and deadlift exercises on the ARED distinctly different from their ground-based counterparts.

CONCLUSION

This investigation showed that some useful exercise information can be obtained at low cost, using a single video camera that is readily available on ISS. Squat and deadlift kinematics on the ISS ARED differ from ground-based ARED exercise. The amount of COP shift during these exercises sometimes approaches the limit of stability leading to modifications in the kinematics. The COP movement and altered kinematics likely reduce the bone loading experienced during these exercises. Further, the stick figure videos may prove to be a useful tool in assisting trainers to identify exercise form and make suggestions for improvements.