Optimizing Astronaut Squat Exercise on the International Space Station, Year Three

Fregly, Christopher

Kim, Brandon

NASA has developed the Advanced Resistive Exercise Device (ARED) to help astronauts maintain lower body muscle mass on the International Space Station (ISS). While ARED squat exercise has been effective, NASA does not know if adjustments to the exercise could improve its effectiveness. We hypothesized that simple foot-related adjustments could alter muscle loading significantly during ARED squat exercise on the ISS. To test this hypothesis, we developed a multibody dynamic computer model of the ARED/astronaut system. Model inputs were ARED resistance loads and back, hip, knee, and ankle motions digitized from a NASA ISS YouTube video, while model outputs were reaction forces under the feet, ARED motion relative to the ISS, and muscle moments generated at the back, hips, knees, and ankles. We validated the model by reproducing muscle moments measured during ARED squat exercise on Earth. We used the model to investigate two foot-related adjustments on the ISS: 1) Forward-backward shift in center of pressure location (CoP) (±15 cm), and 2) Forward-backward shift in foot location (±15 cm). The digitized ankle and hip motions were offset by the minimum amounts necessary to simulate these new conditions. Changing the foot location had a much larger influence on muscle moments than did changing the CoP location. Shifting the feet forward on the ARED footplate increased knee moment and decreased hip and back moments significantly, while shifting them backward had the opposite effect. The optimal prescription may therefore be to perform ARED squat exercise twice with the feet in two different locations.

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