Influence of Load Profile on Biomechanics of the Squat and Deadlift

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Abstract:

Long duration space travel will expose astronauts to extended periods of reduced gravity. Since gravity is not present to assist loading, astronauts will use resistive and aerobic exercise regimes for the duration of the space flight to counteract the effect reduced gravity has on the body. Astronauts will exercise on a flywheel based device on the second Orion Exploration Mission (EM2). The effect that the flywheel load profile has on biomechanics is unknown when compared to free weights or a simulated free weight profile.

The purpose of this evaluation is to compare the differences in lower body kinematics and kinetics between the flywheel and free weight profile. Test subjects were instrumented with reflective markers for motion capture data collection while exercising on the Device for Aerobic and Resistive Training (DART) prototype developed by TDA Research, Inc. of Wheat Ridge, CO. Exercises performed were either the squat while wearing a harness or deadlift while grasping a T-bar,

both of which interfaced with the DART through a rope cable. The DART, a motorized device controlled via software, is capable of producing different load profiles. Profiles include simulated free weights with adjustable eccentric overload capability and flywheel. Test variables included the applied device load and the load profile, both set through the DART software interface. Motion capture data was collected with a 12 camera system (Smart-DX, BTS Bioengineering, Brooklyn, NY). Bilateral ground reaction force data were collected with force plates (P6000, BTS Bioengineering). DART cable force was recorded through an internal load cell. Data was collected from a total of four test subjects.

The three repetition maximum was determined for each test subject for both squat and deadlift. High, medium and low loads were determined based on this maximum. The test subject performed five repetitions of each exercise at each load and each test trial was repeated twice. Cadence was controlled during exercising. Biomechanical data were used to drive the models utilizing the OpenSim software platform. Subject specific models were scaled to match the anthropometrics of the test subjects and used to estimate the peak joint angle, joint range of motion, the peak joint moment and the joint moment impulse of the lower extremity joints and the lumbar joint.These are preliminary results because the data analysis is ongoing.

There was a lot of inter-subject variability, however, in general, there was a greater peak lumbar flexion angle for the flywheel squat exercise. There was a trend towards a greater range of motion at the hip for the squat exercise with free weight. There was also a greater hip extension, lumbar extension and ankle plantar flexion impulse moment during the squat exercise with free weight. During the deadlift exercise, the peak knee flexion angle and peak knee extension moment were greater when using the free weight profile.

For deadlift, the hip extension, lumbar extension and ankle plantar flexion impulse moment tended to be greater with the free weight profile. Overall, the kinematic and kinetic outcomes for the flywheel profile were either statistically the same as free weight profile in many cases, significantly reduced in a few cases, and rarely higher.

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