

Comparison of Knee and Ankle Dynamometry between NASA's X1 Exoskeleton and Biodex System 4

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INTRODUCTION: Pre- and post-flight dynamometry is performed on International Space Station crewmembers to characterize microgravity-induced strength changes. Strength is not assessed in flight due to hardware limitations and there is poor understanding of the time course of in-flight changes. **PURPOSE:** To assess the reliability of a prototype dynamometer, the X1 Exoskeleton (EXO) and its agreement with a Biodex System 4 (BIO). **METHODS:** Eight subjects (4 M/4 F) completed 2 counterbalanced testing sessions of knee extension/flexion (KE/KF), 1 with BIO and 1 with EXO, with repeated measures within each session in normal gravity. Test-retest reliability (test 1 and 2) and device agreement (BIO vs. EXO) were evaluated. Later, to assess device agreement for ankle plantarflexion (PF), 10 subjects (4 M/6 F) completed 3 test conditions (BIO, EXO, and BIOEXO); BIOEXO was a hybrid condition comprised of the Biodex dynamometer motor and the X1 footplate and ankle frame. Ankle comparisons were: BIO vs. BIOEXO (footplate differences), BIOEXO vs. EXO (motor differences), and BIO vs. EXO (all differences). Reliability for KE/KF was determined by intraclass correlation (ICC). Device agreement was assessed with: 1) repeated measures ANOVA, 2) a measure of concordance (ρ), and 3) average difference. **RESULTS:** ICCs for KE/KF were 0.99 for BIO and 0.96 to 0.99 for EXO. Agreement was high for KE (concordance: 0.86 to 0.95; average differences: -7 to +9 Nm) and low to moderate for KF (concordance: 0.64 to 0.78; average differences: -4 to -29 Nm, $P < 0.05$). BIO vs. BIOEXO PF concordance ranged from 0.89 to 0.92 and mean differences ranged from -9 to +3 Nm (BIO < BIOEXO). BIOEXO vs. EXO PF concordance ranged from 0.73 to 0.80 while mean differences were -18 to -36 Nm (BIOEXO < EXO, $P < 0.05$). PF concordance for BIO vs. EXO was slightly lower (0.61 to 0.84) and mean differences were greater (-27 to -33 Nm; BIO < EXO, $P < 0.05$). **CONCLUSION:** BIO and EXO were similarly reliable for KE and KF. KE measures produced high agreement between devices; KF did not. For ankle PF, torque differences due to the two footplates were small. However, the X1 motor reports greater torques than the Biodex motor during PF. This first prototype provides proof of concept for a reliable, robotic-based exoskeleton to perform portable dynamometry for large muscle groups of the lower body.