The Effect of Ankle Posture on Forces and Moments in an Anthropomorphic Test Device Tibia During Impact Tests

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Abstract

The Anthropomorphic Test Device (ATD) is an instrumented representation of a human used to evaluate the risk of injury during accidents. Impact tests of the lower leg are commonly conducted with the ankle in a single posture; it is unknown what effect initial ankle angle has on impact loading. The purpose of this study was to determine the effect of ATD ankle angle on the forces and moments measured in the lower leg.

Velocity-controlled impacts were applied to the heel of a Hybrid III ATD right lower leg (Humanetics Corp., Plymouth, MI, USA) that was installed in an axial orientation in a custom designed pneumatic impacting apparatus.1 Using a custom ankle positioning device, impacts were applied with the ankle in the following postures: i) flexion and extension (5o increments between 20o plantarflexion and 15o dorsiflexion); ii) eversion (5o) and inversion (10o and 20o). The ATD leg was subjected to three impacts of increasing velocity for each position. Five-axis load cells in the upper and lower tibia were sampled at 15 kHz during the impact.

Mean (SD) impact velocities were consistent for low (3.18 (0.05) m/s), medium (4.69 (0.07) m/s), and high (5.50 (0.16) m/s) velocities. Axial force (Fz) in the upper and lower leg tended to increase as the foot moved into dorsiflexion. Mx tended to increase with greater inversion in the upper leg but did not appear to vary in the lower leg.

Axial force (Fz) is used for industry safety ratings, and in this study it varied by up to 3kN over the range of flexion. This magnitude of change would have a significant effect on standard safety ratings.2 As ankle position affects the measured force, a neutral posture should be used during safety tests to match how current injury limits were developed.