

## **Response of Female and Male PMHS to Blast-Induced Vertical Accelerative Loading**

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Improvised explosive devices (IEDs) deliver a high energy blast to the underbody of military vehicles, exposing modern Warfighters to considerable risk during ground transport. Biomechanical data are required to develop an operationally relevant anthropomorphic test device (ATD) suited for the assessment of risk associated with the female Warfighter, or to map the injury prediction outputs of a male ATD to the female.

The objective of this study is to determine the origin of the differences between female and male impact and injury response, such as sex, morphology, anatomy, or tolerance. This study was conducted using the Accelerative Loading Fixture (ALF), which generates floor and seat loading conditions representative of the underbody blast (UBB) environment. The ALF consists of two rigid seats mounted to a platform that is accelerated upward within a superstructure frame. The platform is explosive-driven. A brake system arrests its motion as it passes through the apex of its travel. The floor and seat performance can be modulated independently. Twelve post-mortem human surrogates (PMHS) were tested in pairs, using two different floor conditions. The PMHS tested include 50<sup>th</sup> percentile males, and 5<sup>th</sup> and 75<sup>th</sup> percentile females. The PMHS were instrumented with strain gages, accelerometers, angular rate sensors, and video markers.

The data obtained include floor and seat acceleration and speed, generalized kinematics of the distal tibia and femur, sagittal perspective planar segment motion, and PMHS lower extremity damage results. The female and male tibia vertical acceleration responses are similar, with the females attaining greater acceleration earlier in the event. The female PMHS tibia (especially 5<sup>th</sup> percentile) attains greater peak vertical speed compared to males. Also, peak speed for the females is reached earlier in the event compared to males. Similar trends are observed for femur acceleration and speed, with the 5<sup>th</sup> percentile female reaching greater vertical acceleration and peak vertical speed earlier in the event. The femur response of the female is notably shorter in duration, but similar in shape to the male response. The female lower extremities initially rotate in the sagittal plane at a higher rate than the males.

For the lower-energy floor condition, no female nor male PMHS sustained damage to the lower extremities, with the exception of a minor talus chip observed in a 5<sup>th</sup> percentile female. For the higher-energy floor condition, differences were seen between 5<sup>th</sup> and 75<sup>th</sup> percentile females. In one test, a lighter female sustained a complete separation of the body of the right (outboard) talus, a pilon fracture to the left (inboard) tibia, a segmented bending fracture to the left femur, and bilateral crushed calcanei. In the same test, a large female sustained a crushed right calcaneus, a compression fracture to the left distal tibia, and a complete oblique fracture to the left distal fibula. In another test, a 50<sup>th</sup> percentile male sustained bilateral crushed calcanei and a spiral wedge fracture of the left femur, while a small female sustained bilateral crushed calcanei and a fracture through the posterior calcaneal articular surface of the talus.