Pelvic Response of a Total Human Body Finite Element (FE) Model During Simulated Under Body Blast (UBB) Impacts

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Abstract

Under Body Blasts (UBB) events in theater are the cause of many serious injuries sustained by the Warfighter to the pelvis, spine, and lower extremities. These injuries are often debilitating, resulting in increased healthcare expenses and a reduced quality of life. Injury prediction for UBB events continues to be a challenge due to the limited availability of UBB-specific test studies and injury criteria. This study focuses on the pelvic injury response of the 50th percentile male Global Human Body Models Consortium (GHBMC) Finite Element (FE) model. The input data used for this study was obtained from testing performed by the Biomechanics Product Team (BIO PT) for the Warrior Injury Assessment Manikin (WIAMan) development effort. The purpose of the WIAMan effort is to create a Soldier-representative, biomechanically-validated anthropomorphic test device (ATD) for use in live-fire test and evaluation and vehicle development efforts. Evaluation of GHBMC model fidelity and injury response is based on biofidelity targets (corridors) created using pelvis accelerations obtained from experimental testing of UBB-type loading using post mortem human subjects (PMHS).

Acceleration pulses obtained from accelerometers attached to the floor and seat of experimental test vehicle rigs were used to perform UBB FE simulations. Acceleration data from nodes in the S1 region of the pelvis of the GHBMC were extracted from the simulations. The extracted S1 acceleration data was compared to S1 data recorded from the experimental biofidelity corridors created from preliminary WIAMan experimental test data. Corridors were created using data filtered at 345, 1050, and 1750Hz. The corridors were generated using a standard approach determined by a Biofidelity Response Corridor working group. The approach aligns non-normalized signals using the Nusholtz method, transforms signals to principal component space using eigenvectors and eigenvalues, and generates ±1 and ±2 standard deviation equivalent corridors. The frequency values used to create these corridors were determined from preliminary work performed by the Signal Analysis Working Group (SAWG) for the WIAMan

project. The SAWG is investigating the adequate range of optimal filter frequencies for analysis of biomechanical signals. For this PMHS test data, 1050 Hz is the average frequency at which the change in frequency with respect to peak magnitude begins to level off for each data trace. The 345 and 1750Hz frequencies are the ±1 SD of the average frequency.

The FE S1 acceleration showed good correlation with the biofidelity corridors. An analysis was performed using an objective rating method (CORrelation and Analysis, CORA) using these corridor curves. The ±1 and ±2 SD curves were used for the inner and outer corridor limits, respectively. The average corridor curve was used as the cross-correlation reference. The CORA analysis showed good correlation (70% or higher) with an average of 70.7%, 83.5%, and 82.5% for the data filtered at 345, 1050, and 1750Hz, respectively. This data was acquired with the explicit purpose of developing an enhanced capability to predict the risk of injury for mounted soldiers who are subjected to the effects of UBB loading with the goal of enhanced vehicle and Soldier survivability.