Improvised explosive devices (IEDs) surfaced as a threat during the US military’s presence in Iraq and Afghanistan, contributing to 38% of the injuries sustained by wounded soldiers [1]. Underbody blasts (UBBs), where the IED detonates under a vehicle, impart massive amounts of energy through the floor and seatpan of the vehicle to a soldier’s lower extremities and pelvis, respectively. In UBB-related events, 8% of individuals wounded-in-action and 51% of individuals killed-in-action sustained pelvic injuries [2]. A tailored finite element model (FEM) of the pelvis designed for high-rate vertical loading can be used to better understand how the forces and moments from an UBB are translated from the seatpan through the body. As this tool is further developed, it can be used to assess differences in response due to varying postures, loadings, and countermeasures.

Currently, there is scarce data on the mechanical properties of the pelvis joints, particularly the sacroiliac joint (SIJ) and the pubic symphysis joint (PSJ), especially in loading conditions consistent with UBB. Based on previous experiences in laboratory testing and simulation, the properties of the SIJ and the PSJ were hypothesized to influence the load path and resultant forces and moments of the pelvis under high-rate vertical loading. This study examines the role of these two pelvis joints in UBB loading conditions by applying a sensitivity analysis on their material properties. The Global Human Body Models Consortium (GHBMC) 50th percentile male occupant model was modified to represent pelves from an experimental sled test series previously performed at UVA. The model includes the bony and soft tissues of the pelvis, potting on the sacrum, a load cell, and an impact plate. Both the PSJ and SIJ was comprised of two parts: the cartilage (modeled using visco-hyperelastic constitutive models) and the ligaments (modeled using elastic beams). Material parameters were varied by 10%, 50%, 200%, and 400% of their nominal values. The impact plate was prescribed the experimentally measured acceleration time-history, and 6 degree-of-freedom loads were measured at sacral load cell. Model results were compared to experimental test data using the correlation and analysis method (CORA) [3].

Preliminary results suggest that stiffening the SIJ and PSJ cartilage shear moduli above their nominal values resulted in improved overall CORA scores compared to the nominal model. However, the CORA scores for the more compliant SIJ and PSJ performed better compared to the nominal model for the flexion/extension moment (My) measurement, which is the important load mechanism that is eventually transmitted to the lumbar spine. This work highlights the importance of the SIJ and PSJ in the pelvis response to UBB, and demonstrates the need for future work in characterizing the material properties of these structures.
References