ABSTRACT
DESIGN OF NOVEL EXPERIMENTS AND ANALYSES FOR HEAD AND SPINE TRAUMA BIOMECHANICS

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Previous biomechanics research studies have used both whole-body and isolated postmortem human surrogate experiments to define human injury tolerances, advance safety in injury producing environments, and promulgate standards for design of injury mitigating systems. Recent developments in transportation and sports-related fields have led to an increasing need to determine tolerances for combined loading (multi-axis) scenarios. This dissertation demonstrates the efficacy of the novel experimental design and analysis to head and spine trauma in these modalities.

The first topic was the design of a novel experiment to examine the effect oblique loading on the tension tolerance of the lumbar spine. To examine this injury tolerance, isolated lumbosacral spine experiments were used with a custom six degree-of-freedom spinal alignment device. The isolated experiment injury matched previous whole-body tests and failure kinetics were obtained.

The second topic was the design of a novel experiment to measure the response of the head and neck to off axis moment loading at the occipital condyle joint. A dynamic rotational system applied angular displacement centered at the OC joint in an orientation that resulted in combined flexion-extension/lateral-bending/and axial rotation of the head. Region-specific anatomic kinetics were determined using load cells and a motion capture system.

The third topic was the design of a novel experiment model to assess the accuracy of wearable sensors for concussion research. The goal of this topic was to design a new technique which placed a custom sensor near the head-center-of-gravity in whole-body and isolated head/head-neck PMHS. Tests were conducted to benchmark current wearable sensors in the sport and military environments. The measured head kinematics from the in-PMHS sensor serves as the gold standard for these tests.

The fourth topic was design of a novel technique to compute three-dimensional time-varying global response kinematics of the head, spine, and pelvis in oblique frontal impacts. Collected data were combined to create three-dimensional temporal global kinematic corridors which are needed to validate current and future finite element models of the components/subsystems, human body models, and they can also be used for benchmarking different computational models.