Sensitivity of a Finite Element Head Model to Error in Head Acceleration Profiles as Measured by a Helmet-Based Accelerometer System for Ice Hockey

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I. INTRODUCTION

Global head kinematics with known injury outcomes can be input into finite element (FE) models of the head and brain to determine brain injury metrics associated with those outcomes. Helmet-based accelerometer systems such as the Head Impact Telemetry (HIT) System are one means by which to obtain global head kinematic data. However, such data are subject to measurement error [1]. This study assesses the influence of this error on brain injury metrics using the Simulated Injury Monitor (SIMon) FE head model.

II. METHODS

Head acceleration and velocity time histories from a validation study on the HIT System for ice hockey [1] were utilized as input into SIMon. Briefly, a 50th percentile Hybrid III ATD head and neck was fitted with a standard ice-hockey helmet equipped with the HIT system. The helmet was impacted with a linear impactor laterally at 5.0 m/s. In this analysis, for a single impact, three sets of time histories were used as input into the FE model: 1) linear accelerations and rotational velocities measured directly from the ATD, 2) HIT System-measured linear accelerations and rotational velocities calculated based on HIT System accelerations, and 3) HIT System data calibrated with previously developed power regression equations [1]. CSDM15 outputs were compared. Based on initial findings, the z-axis rotational velocity was set to zero and resulting CSDM15 outputs were compared.

III. INITIAL FINDINGS

Compared to the ATD data, CSDM was 105% and 941% greater for HIT System data and power regression-calibrated HIT data, respectively. With z-axis rotational velocity zeroed, the errors reduced to 29% and 39%, respectively.

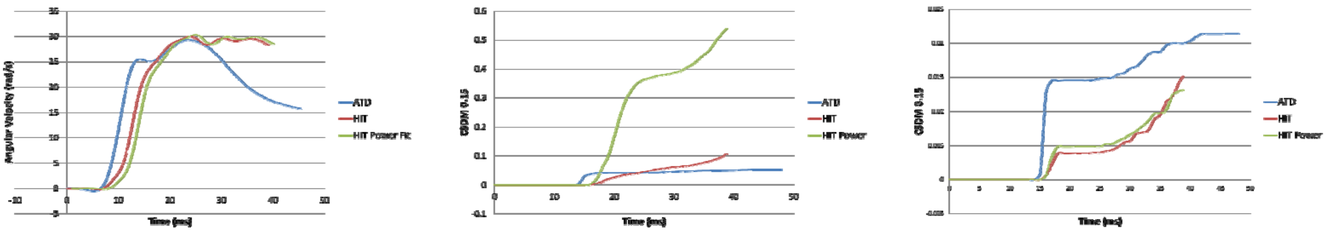

Figure 1: Angular velocity input for the main axis of rotation (left), CSDM calculations resulting from the three sets of input data (middle), and CSDM calculations when the z-axis rotational velocity is zeroed.

IV. DISCUSSION

These results suggest that similar maximum resultant accelerations and velocities do not necessarily correlate to similar injury risk measures. Much of the error in CSDM metric was driven by differences in z-axis rotational velocity between the ATD and HIT system. Although helmet-based accelerometer systems may accurately measure maximum resultant accelerations, advancements in such systems that more accurately measure rotational velocity are likely needed to use these data in FE based injury threshold development.

V. REFERENCES

[1] Allison et al., ASME Summer Bioengineering Conference, 2013.

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