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ESTIMATION OF 6 DEGREE OF FREEDOM ACCELERATIONS FROM HEAD IMPACT TELEMETRY SYSTEM OUTPUTS FOR COMPUTATIONAL MODELING

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Summary: Head impact exposure in contact sports has been extensively studied; however, the biomechanical basis of subconcussive head impacts is not well-understood.1,3,4,6–8 Finite element (FE) modeling may be used to further study this. FE simulation of head motion requires 6 degree of freedom (6DOF) curves defining the boundary conditions, which is not available from the Head Impact Telemetry (HIT) System, a common head impact sensor. The goal of this study was to develop a transformation algorithm to determine 6DOF acceleration curves based on the corresponding HITS output data.

The transformation algorithm was developed from a dataset of 14,767 head impacts collected with the HIT System. HITS output is limited to peak XYZ linear acceleration values, peak XY rotational acceleration values, a 40 ms linear resultant time trace, and azimuth and elevation of each impact. For this set of impacts, Simbex (Lebanon, NH) provided the 6DOF information.

The 6DOF data was used to calculate characteristic curves corresponding to impact location and polarity of XYZ accelerations peaks. First, the impacts were sorted into 1 of 192 impact regions defined by approximately equal divisions of azimuth and elevation, then classified by polarity of peak accelerations. Polarity was described by a 1x6 vector of positive or negative ones corresponding to the polarity of XYZ linear and rotational acceleration. Then, characteristic curves for each unique polarity combination were calculated by averaging aligned normalized acceleration curves. The characteristic curves for the region in Figure 1 are shown in Figure 2. 6DOF curves are generated for each impact by scaling the characteristic curves to the peak values output by the HIT System given the impact region and polarity.

The algorithm was validated against 50 random impacts by comparing predicted and true acceleration curves (Figure 3). CORA, an objective curve comparison metric, was used to quantify error.5 CORA scores were calculated for all 6 acceleration curves and averaged to get a single rating for each tested impact. The mean, minimum, and maximum CORA scores of the 50 validation impacts were 0.497, 0.267, and 0.733, respectively. These results demonstrate the algorithm accurately estimates 6DOF motion characteristics from 5DOF inputs.