Biofidelity Corridors of Powered Two-Wheeler Rider Kinematics from Full-Scale Crash Testing Using Post-Mortem Human Subjects

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Introduction:
Powered two-wheeler (PTW) riders face significant risks, with thousands succumbing to fatal accidents annually. Despite this, there is a lack of biofidelity data crucial for enhancing their safety. Previous analyses of crash databases and literature have identified common PTW crash configurations and injuries sustained. However, these studies lack essential kinematic data, injury timing, and mechanisms crucial for validating anthropomorphic test devices (ATDs) and human body models (HBMs). This study aims to bridge the gap by establishing biofidelity corridors from PTW to vehicle crash tests involving fully instrumented post-mortem human subjects (PMHS), marking the first analysis of its kind.

Methods:
Three tests were performed, each featuring a 50th percentile male PMHS instrumented with six-degree of freedom (6DOF) motion sensors, seated on a 2022 KTM 390 Duke. 6DOF sensors were placed on the nasal bone, sternum, C4, C6, T4, T12, and S1, in addition to left and right humeri, femora, and iliac wings to track occupant kinematics. The PTW traveled at 50 kph into the front passenger door of a 2011 Honda Accord offset by 30 degrees from perpendicular. All 6DOF data underwent transformation to an anatomical coordinate system, followed by filtering, averaging, and calculation of standard deviation to generate biofidelity corridors. These corridors capture occupant kinematics from 40ms before PTW impact to 200ms after.

Results:
The analysis unveiled commonalities in whole-body kinematics across tests. Severe injuries to the pelvis, thoracic cage, and T11 were consistent, resulting in similar Injury Severity Scores (ISS). Utilizing the linear acceleration and angular velocity data from the 6DOF corridors facilitated the review of kinematic responses associated with specific injuries. Corridors originating from the iliac wings and S1 demonstrated pelvis responses, which are critical to mimic the interaction of the pelvis with the fuel tank. Analysis of corridors from C4, C6, T4, and T12 revealed the spinal response, which aids in understanding the T11 failure.

Conclusions:
The study demonstrated high repeatability in full-scale PTW crash tests, with injuries exhibiting almost identical timing, types, and mechanisms. Similar global and local occupant kinematics enabled the creation of multiple biofidelity corridors covering all significant body regions. These corridors will aid in enhancing the biofidelity of ATDs and HBMs, which can then be used to evaluate potential safety equipment.