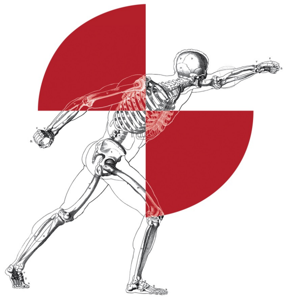

Biofidelity Corridors of Powered Two-Wheeler Rider Kinematics from Full-Scale Crash Testing Using Post-Mortem Human Subjects

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INTRODUCTION

- Annually, over 350,000 powered two-wheeler (PTW) riders succumb to fatal accidents worldwide [1], with 82,686 motorcyclist-related injuries and 5,932 fatalities reported in the US in 2021 [2].
- Previous analyses of crash data bases and literature have defined common crash configurations and injuries sustained.
- Currently, there is no anthropomorphic test device (ATD) or human body model (HBM) for PTW riders validated against post-mortem human subject (PMHS) data. These validated safety tools are critical to develop and evaluate protective systems for riders.
- **The objective of this study was to establish biofidelity response corridors from powered two-wheeler to vehicle crash tests using fully instrumented PMHS.**

METHODS

Experimental Methods

- Three 50th percentile male PMHS (Table 1) were instrumented with 6 degree of freedom (6DX) motion sensors and strain gages (Fig. 1).
- PMHS were positioned on the PTW (Fig. 2) and anatomical angles were recorded to quantify pre-test positioning.
- A 2022 KTM 390 Duke impacted a 2011 Honda Accord at a 30° offset with an impact velocity of 50 kph (Fig. 3).

Table 1: PMHS demographics

	Test 1	Test 2	Test 3	mean ± SD
Height (cm)	178	180	187	181.6 ± 4.7
Weight (kg)	73	68	73	71.3 ± 2.9
Age (years)	82	68	75	75 ± 7

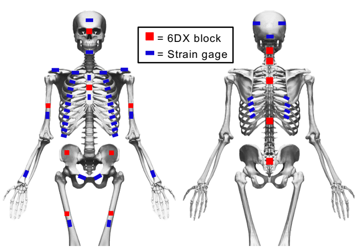

Figure 1: PMHS instrumentation

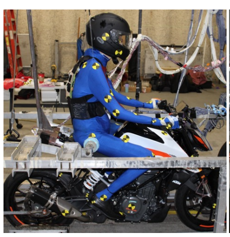

Figure 2: PMHS pre-test positioning (Test 3)

Figure 3: PTW impact with vehicle (Test 3)

Figure 4: PMHS thorax impact with vehicle (Test 3)

Data Processing

- 6DX motion sensor data were filtered then transformed using channel frequency classes (CFC) for each corridor following the process below:

Pre-test CT segmentation and points via Materialise Mimics → Create transformation matrix → Apply filtering and transform 6DX data to anatomical coordinate system (Fig. 5) → Align from peaks of interest and calculate corridors (mean ±1 SD)

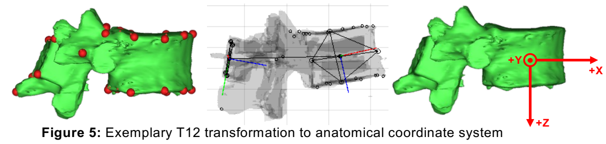

Figure 5: Exemplary T12 transformation to anatomical coordinate system

RESULTS

- 6DX motion sensor data were aligned to a common time based on peaks of interest, and a corridor was established using the mean ±1 standard deviation (Fig. 6).

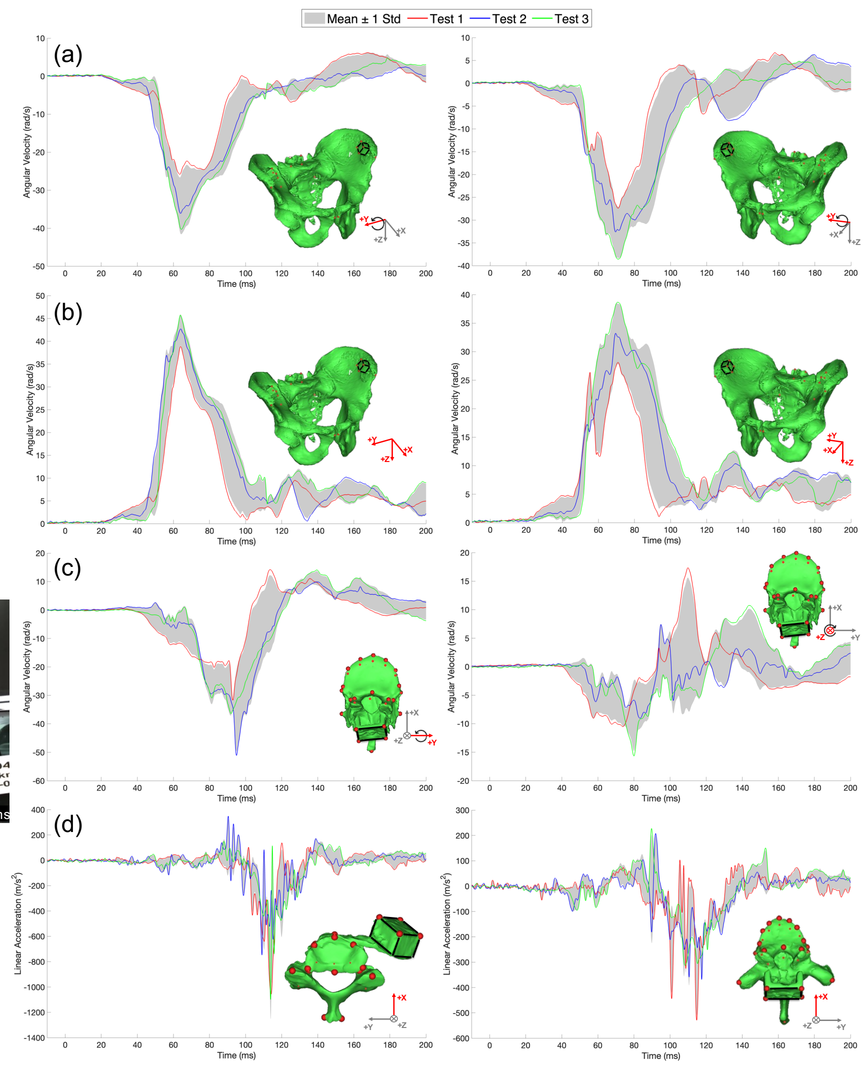

Figure 6: Time histories illustrating individual tests and corridors for (a) iliac wing y-axis angular velocity, (b) iliac wing resultant angular velocity, (c) T12 angular velocity, and (d) C6 & T4 linear acceleration

CONCLUSIONS

- The study effectively established biofidelity response corridors for all major body regions by utilizing an instrumented PMHS in a full-scaled PTW-to-vehicle crash scenario.
- All tests demonstrated a high level of repeatability in the test methodology, with injuries exhibiting nearly identical timing, types, and mechanisms, consistent with the literature [3,4,5].
- Future work will involve developing a simplified test methodology to refine the PMHS thoracic response and biofidelity corridors to improve safety tools and facilitate the advancement of protective systems.

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