Variation in Pedestrian Injury Response concerning Pre-impact Avoidance Maneuvers

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Introduction

- Previous studies on pedestrian injury biomechanics with finite element human body models (FE-HBMs) have primarily focused on a limited range of standard postures, such as standing or typical gaits.
- However, real-world field data suggest that pedestrians often attempt to avoid the imminent crash through various active maneuvers.
- The large variations in pre-collision postures can significantly impact the injury responses predicted by HBMs.
- Therefore, it is essential to quantitatively assess the difference through a systematic sensitivity study.

Objectives

- Quantitatively evaluate the differences in whole-body injury responses between HBMs in standard and collision-avoiding poses under a 40 km/h lateral impact.
- The analysis focuses on the similarities and differences in six representative injury metrics between the standard and collision-avoiding pedestrian groups.
- The findings are expected to offer constructive insights into real-world injuries and inform the development of future testing protocols.

Methodology

Virtual-Reality (VR) Experiment

- 34 experiments involving 19 volunteers were conducted.
- Identified 3 avoidance modes: forward avoidance, oblique stepping, and backward avoidance.

Model Generation

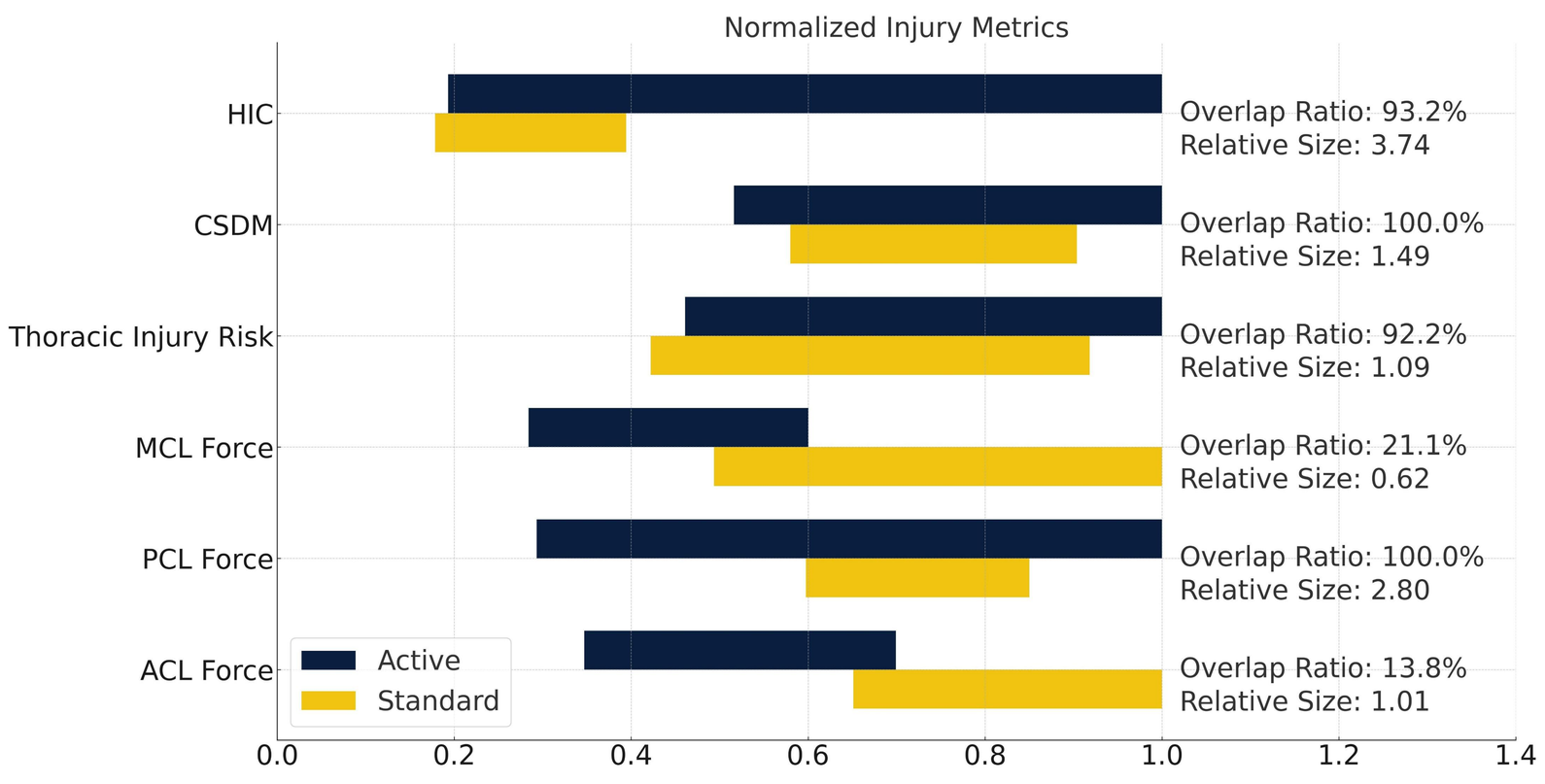
- The avoidance group included 15 posture-specific models (5 poses per mode).
- The standard group consisted of 7 models: a standing baseline and 6 gait stances.

Injury Outcome Analysis

- Mean $\pm$ standard deviation was used to report specific injury response ranges for both groups.
- Relative Size = (Avoidance range) / (Standard range)
- Overlap Ratio = (Shared injury range)/ (Standard range)

Preliminary Results

- Metrics with over 90% overlap include CSDM (100%), PCL force (100%), HIC (93%), and thoracic injury risk (92%). The relative range sizes are: CSDM = 1.49, PCL = 2.80, HIC = 3.74, and thoracic injury risk = 1.09.
- In contrast, the overlaps for MCL and ACL forces are limited at 21% and 14%, respectively, with relative range sizes of 0.62 and 1.01.
- Additionally, mean MCL and PCL forces in standard group (MCL = 2.0 kN, PCL = 1.4 kN) are significantly higher than those in avoidance group (MCL = 1.2 kN, PCL = 0.9 kN).



Current Conclusions

- The standard group shows inadequate capability to predict the ranges of HIC, CSDM and PCL force.
- THUMS in standard postures may overestimate MCL and ACL forces in real-world accidents.
- Future testing protocols should incorporate more realistic postures, which might be achieved through virtual testing using HBMs.

References

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