Assessment of Head-Ground Impact Patterns in Real World Pedestrian-Vehicle Collisions

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I. INTRODUCTION

Accident data show that pedestrian ground contact injuries are a significant problem. Understanding the relationship between vehicle shape and vehicle speed and subsequent pedestrian ground contact injuries is difficult, since small changes in initial impact configuration can result in dramatically different ground contact dynamics. Ground impact was studied by who used multibody modelling to predict different categories of pedestrian head-ground impact depending on the amount of whole body rotation of the pedestrian during the period of contact with the vehicle and subsequent movement prior to first contact with the ground [1]. However, the validity of the predictions was untested, since no validation data was available. This Short Communication uses videos of real-world pedestrian collisions to assess the ground impact categories proposed by [1].

II. METHODS

Twenty-eight real world pedestrian-vehicle collisions were sourced using online searches. The collisions were analysed through video footage illustrating pre-impact, vehicle impact, flight and ground impact phases, and these were used to estimate parameters essential for collision analysis. Vehicle type, vehicle braking, pedestrian walking speed, pedestrian height and orientation and position relative to the vehicle front were assessed by viewing of the collision footage. Vehicle speed was calculated through three methods: 1) Distance tracker Matlab code tracking vehicle movement and estimating vehicle speed; 2) Stopping distance formula ($v = \sqrt{2\mu g s}$) and 3) Throw distance equation for wrap-trajectory collisions from [2]. Head-ground vertical impact speed was also calculated through Matlab with the use of two frames just prior to ground impact and at ground impact. The real world collisions were categorised into one of the six impact mechanism categories from Crocetta et al. (2015) where possible, and were otherwise placed in an *Other* category. Comparisons between impact mechanism, head-ground impact speed, vehicle speed and ratio of vehicle bonnet leading edge height to pedestrian height (NBLEH) were made.

III. INITIAL FINDINGS

Twenty-one of the twenty-eight cases (75%) could be categorised as one of the ground contact mechanisms identified in [1], see Table I. Figure 1 shows the mean and standard deviation of head ground contact speed for the 21 cases and the corresponding distributions from the previously published multibody predictions [1]. No mechanism 5a/5b cases were observed.

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TABLE I

GROUND CONTACT MECHANISMS IDENTIFIED, SEE [1]

Mechanism	1	2	3	4	5a/b	Other
N	11	5	2	4	0	7

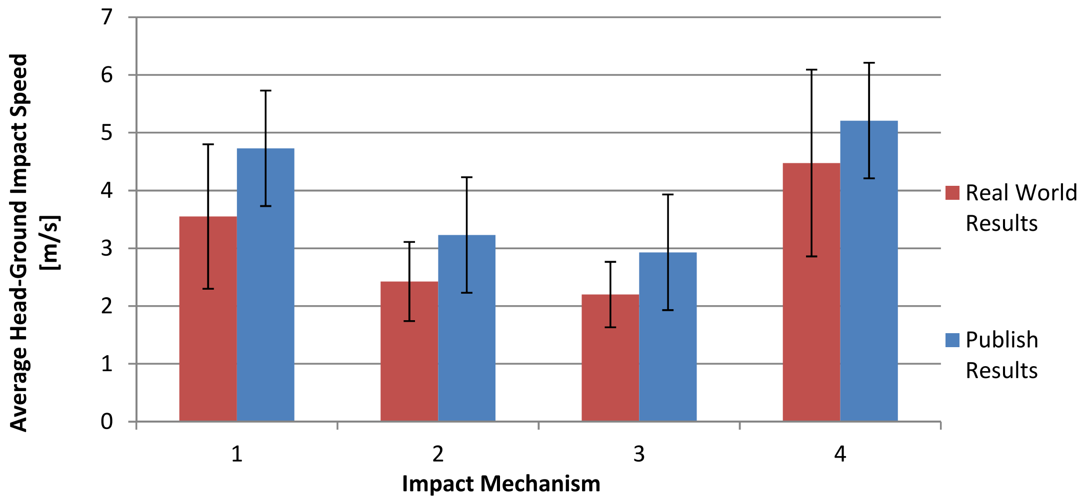

Fig. 1. Comparison of head-ground vertical impact speed from real world videos analysed and from previously published predictions [1].

IV. DISCUSSION

A substantial majority of cases matched one of the ground contact impact mechanisms presented in [1]. In the seven cases that did not match, this was mainly due to higher vehicle impact speeds than were included in the modelling study where the maximum was 40km/h, low effective vehicle braking leading to prolonged vehicle/pedestrian interaction or very low bonnet leading edge heights leading to more rotation. Figure 1 shows that, despite the limitations in the multibody modelling and the highly variable nature of pedestrian ground contact, the *trends* (mean and standard deviation) of pedestrian vertical head ground contact speed between the different categories observed in real-world cases was similar to the model predictions. However the average head-ground impact speeds are about 1m/s lower for all mechanisms in the real collisions compared to the models. These differences cannot generally be explained by higher vehicle impact speeds in the real-world cases, but may be due to energy absorption in the vehicle pedestrian impacts and the resulting maximum height the pedestrian's body is projected into the air, as this substantially influences the subsequent pedestrian ground contact speed. Further analysis is required to help to understand the influence of vehicle shape on pedestrian ground contact injuries, but the evidence provided here broadly supports the previous findings in [1] which suggest that there are identifiable patterns to pedestrian ground contact. Due to uncertainty in the reconstruction process, and challenges with the quality of the collision footage and the fact that all values used were estimates, the trends presented are of more significance than the absolute values.

V. References

[1] Crocetta et al., Accident Anal Prev, 2015.
[2] Simms and Wood, Pedestrian and Cyclist Impact: a Biomechanical Perspective, Springer 2009.