Pedestrian-ground contact injuries observed from German in-depth accident data

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I. INTRODUCTION

In the safety field of vehicle-pedestrian impact accidents, the vehicle front shape and Bonnet Leading Edge Height (BLEH) have been considered as influential factors for pedestrian-ground contact [1-4]. Simms *et al*. [2] reported that there was a positive correlation between BLEH and the head injury criteria (HIC) score obtained from ground contact. In addition, Crocetta *et al*. [1] defined different ground contact mechanisms with multibody models on the basis of the amount of predicted whole body rotation occurring prior to head contact with the ground. For wrap projection impact with whole body rotation between 90° and 180°, head-ground impact speeds increased with normalised BLEH (BLEH/pedestrian height). The aim of this study is to study the relationship between NBLEH (BLEH/hip height) and ground-related head injuries, assessed by Abbreviated Injury Scale (AIS) and based on a set of real world accident data.

II. METHODS

GIDAS Data

The German in-depth Accident Study (GIDAS) data (cases collected between 2000 and 2015) were used to analyze the nature of pedestrian-ground contact injuries. To evaluate the relationship between ground-related injury and NBLEH, the Blue Prints [5] and the EEVC WG17 [6] protocol were employed to measure the BLEH [7]. Hip heights for pedestrians were estimated from the known pedestrian height in GIDAS using standard anthropometric regression relationships [8].

Statistical Analysis

Data analysis was performed on SPSS software. The Shapiro-Wilk test was used to check whether the parameter NBLEH could be treated as normally distributed. For non-normal distributions, the Kruskal-Wallis Test was used to test for differences. Logistic regression and odds ratios (ORs) were used to assess the influence of NBLEH on AIS2+ ground contact head injury outcome, similar to previous studies [7][9]. An OR greater than or less than 1, respectively, indicated a rising or falling trend of injury odds, and Confidence Intervals (CI) at the 95% level were constructed.

III. INITIAL FINDINGS

Figure 1 shows the relation between NBLEH and AIS2, AIS3 and AIS4-5 head ground-related injuries (GRI). The average NBLEH increased from 0.89 for AIS2 to 0.95 for AIS3 and 1.01 for AIS4-5. The distributions are not normal, however, and the Kruskal-Wallis Test (Table I) shows that these differences are not statistically significant (P=0.366).

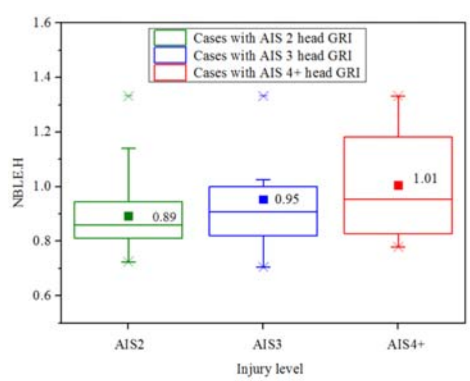

Fig. 1. Distribution of NBLEH for AIS2, AIS3 and AIS4-5 ground-related head injuries.

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TABLE I

KRUSKAL-WALLIS TEST RESULT OF NBLEH DISTRIBUTION FOR DIFFERENT GROUND-RELATED AIS LEVEL

Group	N	Median	Mean Rank	*P*-value of Kruskal Wallis Test
AIS2	24	0.86085	16.17	
AIS3	13	0.90855	20.08	0.366
AIS4+	4	0.95478	22.80	

In a further step, logistic regression was used to assess the potential relationship between ground-related injuries and NBLEH. Multicollinearity detection for the parameters of the potential model (speed, age and NBLEH versus AIS2+ ground-related head injuries) showed the VIF parameters were 1.041, 1.163 and 1.200, i.e. all less than 2.5, and the model could therefore be used for logistic regression analysis. Then ORs were used to assess the effects of NBLEH on AIS2+ ground-related head injury risk. Table II shows that ORs for both speed and age are greater than 1, i.e. they are significant, while the ORs for NBLEH range from 0.26 to 106 (i.e. not significant), showing logistic regression with NBLEH is not suitable to estimate the risk of AIS2+ ground-related head injuries.

TABLE II

LOGISTIC REGRESSION RESULTS FOR SPEED, AGE AND NBLEH VS GROUND-RELATED AIS2+ HEAD INJURIES

Parameter	Boundary values	β	*P*-value	OR (95% CI)
Constant	/	-6.534	/	/
Speed	3–116 km/h	0.025	**0.022**	1.025 (1.004–1.047)
Age	3–96 year	0.021	**0.007**	1.021 (1.006–1.037)
NBLEH	67–149%	1.664	0.277	5.283 (0.262–106.416)

IV. DISCUSSION

As Table I shows, although the median NBLEH does increase with increasing AIS level, this was not statistically significant. It is unclear whether a larger number of more severe cases would change this result (N=4 for AIS4-5). Furthermore, the ORs from a logistic regression of NBLEH as a predictor of AIS2+ ground-related head injuries showed no obvious effect (Table II). It is suggested that preventing the occurrences of ground contact injury may be a better way to reduce the ground contact injuries (a 2016 Google patent [10] addressed the concept), rather than optimizing vehicle front shape. Applying the ISO 2005 injury cost system [11] shows that, on average, 72% of pedestrian injury costs could be eliminated by preventing ground-related injuries in those cases with vehicle impact speeds less than 30 km/h. It was also noted that in 19/50 of these cases there were *only* ground-related injuries. Prevention of all ground-related injuries for vehicle impact speeds below 30 km/h would bring very substantial injury cost reductions.

V. REFERENCES

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