Motorcycle Helmets: The Population Diversity Influence on Head Injury Criterion Assessment.

Tomasz Bońkowski, Luděk Hynčík, Lukáš Šoltés

I. INTRODUCTION

The standardised tests [1] of helmets take the population diversity into account. It is done by using a wide range of head forms (A, E, J, M, O). However, during the full-body experimental and virtual testing of helmets [2], we are still limited by the available dummies and human body models [3], which do not represent the whole population. This study aims to find the differences in the Head Injury Criterion (HIC) assessment within the diverse population, during full-body virtual tests of the helmets.

II. METHODS

This study was conducted using ESI Virtual Performance Solutions 12.0 (Former Pamcrash). The Virthuman model [4-5] has been used as a human body model. The Virthuman is a hybrid (combination of FE and MBS) scalable (Fig. 1.) human body model for safety assessment [4]. VIRTHUMAN (male, 50 %, 1.77m and 72kg) [5] has been scaled up to 6 age ranges (16, 17, 18, 22, 26 and 34 years) and both genders. The choice of age ranges based on the analysis of the MAIDS database [6]. Each scaled VITHUMAN has been coupled with the FE model of T2 AGV helmet [7-8]. Due to the differences between the material law implementation in LS-Dyna [8] and VPS, the T2 AGV helmet has been remodelled in the VPS environment. The friction coefficient between the helmet and the VIRTHUMAN was set to 0.5 according to [9]. After coupling with the helmet, the VIRTHUMAN was positioned at angle of 15° between the model coronal plane and the ground [10], as shown in Figure 1. The initial velocity 7.5 m/s was adopted from the European Standard for helmet testing [1]. During the simulation, the acceleration of the head centre of gravity (COG) was monitored. According to the SAE J211-1 standard signal was filtered with the CFC 1000 filter.

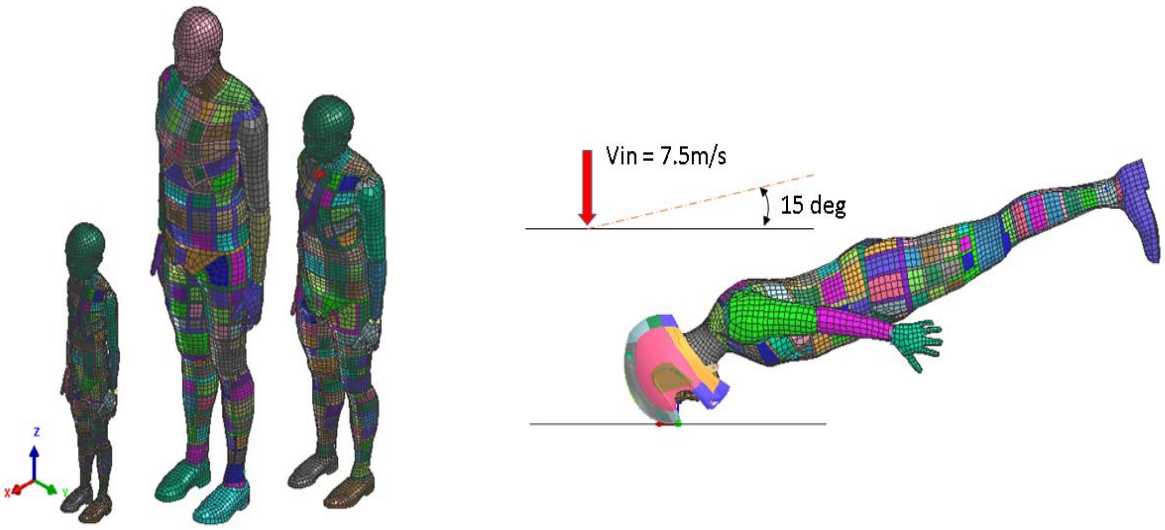

Figure 1. The VIRTHUMAN scaled to 6 years, male, 110 cm, 17 kg (3%), 40 years, male, 190 cm, 104 kg (99%), 70 years, female, 150 cm, 90 kg (10%) (left); the simulation setup (right).

T. Bońkowski is a PhD student (+420 37763 9181 / tomasz@ntis.zcu.cz) in Applied Mechanics in the Department of Mechanics, Faculty of Applied Sciences, at University of West Bohemia, Pilsen and a Marie Curie Research fellow (MOTORIST, n° 608092) in the European Centre of Excellence, NTIS - New Technologies for Information Society, Faculty of Applied Sciences, at University of West Bohemia, Pilsen, Czech Republic. L. Hynčík is an Assistant Professor and L. Šoltés is a Researcher in the European Centre of Excellence, NTIS - New Technologies for Information Society, Faculty of Applied Sciences, at University of West Bohemia in Pilsen, Czech Republic.

III. INITIAL FINDINGS

The differences in HIC with the time interval of 36 ms for scaled models are shown in Table I. The results shows that in each case the T2 AGV helmet could pass the ECE R22.05 certification threshold (maximum HIC not higher than 2400). However, only the cases with the male VIRTHUMAN came close to HIC threshold for serious head injuries (HIC = 1500). The assessment of HIC 36 for female VIRTHUMAN showed an increase in the range of 13.8 - 20.4 % compared to male VIRTHUMAN of the same age.

TABLE I
THE MASS, HEIGHT AND RESULTANT HIC 36 OF SCALED MODELS.

	Age [years]	**16**	**17**	**18**	**22**	**26**	**34**
	mass[kg]	56	59	58	61	59	62
Female	*height[m]*	1.64	1.66	1.66	1.67	1.66	1.65
	HIC 36	1811	1849	1819	1817	1799	1837
	mass[kg]	66	70	72	77	76	78
Male	*height[m]*	1.76	1.77	1.78	1.79	1.78	1.76
	HIC 36	1502	1471	1565	1522	1551	1519

IV. DISCUSSION

The coupled finite element (helmet) – hybrid (VIRTHUMAN) analysis was made to study the differences in HIC assessment among the diverse population. The head COG acceleration induced by the impact on the helmet was studied. The recorded acceleration was used to calculate the 36 ms HIC.

The results show that the used helmet can pass the ECE R22.05 certification for both genders. The assessment of HIC 36 did not show the significant differences among the same gender. However, the simulations show the disparity in HIC between the female and male. The HIC value for a female was 13.8 - 20.4 % bigger than male. This difference could be related to the smaller head diameter of VIRTHUMAN scaled to female dimensions.

This paper presents preliminary results on population diversity impact on HIC assessment. To draw the final conclusions, additional studies on helmets with smaller inside diameter should be continued.

V. ACKNOWLEDGEMENTS

The research leading to these results have received funding from the People Programme (Marie Curie Actions) of the European Union 7th Framework Programme FP7/2007-2013/ under REA grant agreement no. 608092. This work was supported by the internal grant project SGS-2016-059.

VI. REFERENCES

[1] ECE 22.05, E/ECE/324 & E/ECE/TRANS/505 Addendum 21, Regulation No. 22, Revision 4, 2002.
[2] Ghajari M et al, “MYMOSA D3.4”, http:// http://www.mymosa.eu. [Accessed on 2.03.2017]
[3] LSTC, “THUMS 4.0” http://www.lstc.com/thums. [Accessed on 1.03.2017]
[4] Vychytil J et al, SAE Tech. Paper, 2014.
[5] Hyncik L et al, SAE Tech. Paper, 2013.
[6] Bońkowski T et al, MOTORIST D3.1: Accident Statistics, 2015.
[7] Khosroshahi S.F et al, IRCOBI, 2016.
[8] Ghajari M et al, J Crashworthiness, 2011.
[9] Milne C et al, IRCOBI, 2013.
[10] Otte D et al, DATABASE COST 327 Accident Description and Analysis of Motorcycle Safety Helmets, 1999.