A Powered Two-Wheeler Crash Test Dummy

Jolyon Carroll, Bernard Been, Håkan Sundmark, Mark Burleigh, Bei Li

I. INTRODUCTION

This short communication provides the status of work-in-progress regarding a new dummy intended principally for use in testing powered two or three-wheelers (PTWs). As with the development of the Motorcyclist Anthropometric Test Device (MATD) [1] an updated modification of the Hybrid III is proposed. This is to promote more widespread evaluation of protective systems for PTW riders. Whilst a series of full-scale tests with the dummy are planned, this paper describes the status with the test tool, so far.

In 1989, the design and basic features of the first MATD were described [2]. The tool adopted for use in ISO 13232 [3], "research evaluation of rider crash protective devices fitted to motorcycles", remains in use within the research community. This proposal for a new PTW riding dummy takes a similar approach using a Hybrid III 50^{th} percentile male dummy with sit/stand (pedestrian) pelvis construction and femur flesh and standard, non-sliding, knees (without the sliding mechanism that facilitates tibia to femur displacement). To this same base dummy a reduced and minimum set of further modifications are made to allow simple and yet adequate representation of a PTW rider. Importantly, the development of the PTW riding dummy has paired physical and finite element models together, from the start, to support both physical and virtual testing in the future.

II. METHODS

Two elements comprise the method used in the development: the selection or design, fabrication and modelling of the dummy parts, and the use of the dummy in a test setup intended to represent a likely crash mode for PTWs.

Description of the Dummy

Mechanical requirements for the MATD are described in ISO 13232-3:2005, together with the rationale for their use. This was reviewed against newer dummy options, novel design options and expectations and experience for necessities in routine testing. For example, ISO 13232-3 specifies skin extensions for the Hybrid III head to improve helmet fit. Helmet fit remains a priority for a PTW riding dummy, but more recent dummy head designs already include a fuller head representation and may offer other benefits, such as improved biofidelity for multi-directional impacts. The PTW dummy anthropometry is based on the RAMSIS Motorbike Posture Models Allrounder and Scooter. These posture models were developed from volunteer riding posture studies involving 47 women and men on two allrounder motorcycles and three scooter models [4].

Test set-up for first experiment

It is understood that the priority modes of collision for PTWs vary around the world [5]. In a first step, a typical European crash mode was sought and recreated in the laboratory. This was to crash the front of a PTW, moving at 50 km/h, into the side of a car, moving at 20 km/h.

III. INITIAL FINDINGS

A dummy has been developed physically and in finite element modelling. In both domains a crash test has been performed. The PTW dummy (version 1.0, shown in Figures 1 and 2) is specified as a standing Hybrid III 50^{th} percentile male with the following substitutions: a WorldSID 50M head and neck assembly, specific neck buffers and a bespoke lower neck to top of thorax bracket (with flexion/extension adjustment), a modified bib and neck spacer (to fit with the new neck bracket), and above and below the straight lumbar spine there are new brackets (an upper lumbar spine bracket and a sacrum block, both are rigid parts). It was found that the Allrounder and Scooter postures could be captured with one single upper-lower torso arrangement, but only with the addition of the brackets above and below the flexible lumbar element (Figure 3).

Jolyon Carroll is a Biomechanics Specialist at Autoliv Research in Sweden (jolyon.carroll@autoliv.com; +46 723 611476). Bernard Been is Engineering Manager Europe based in the Netherlands and Mark Burleigh is a Design Engineer in the UK, both for Humanetics. Håkan Sundmark is an Expert System Engineer and Bei Li a Senior System Engineer at Autoliv Sweden and China Technical Centre respectively.

The riding posture of the PTW dummy can be adapted to individual powered two-wheelers by rotating the pelvis and by adjusting the lower neck bracket to get the head in position. A set of flexion-extension buffers in the top neck segment is used to lift the head position to the desired vision angle.

Fig. 1. The PTW Dummy (Version 1.0).

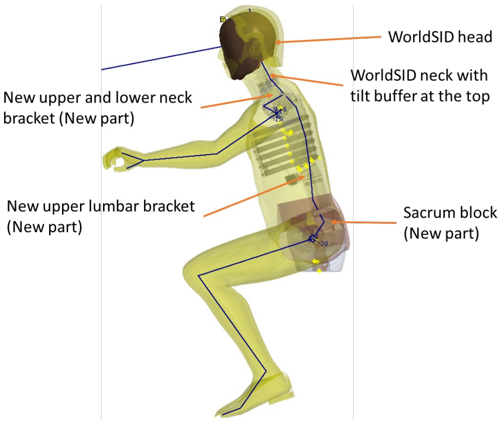

Fig. 2. Design image of PTW Dummy (Version 1.0).

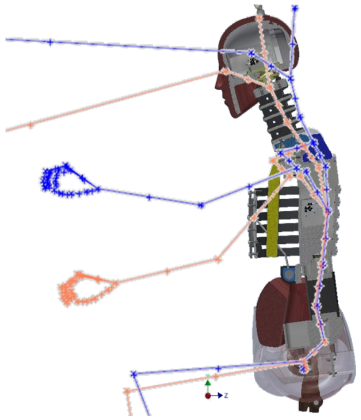

Fig. 3. RAMSIS stickmen Scooter (pink) and rotated Allrounder (blue).

First experiment

Peak head acceleration from the crash test occurred when the helmeted head of the PTW Dummy hit the roof rail of the car (Figure 3). The Head Injury Criterion (HIC_{15}) value from this test is 2079. Equivalent simulations have been conducted and showed similar body part interactions with the motorcycle and car. Correlation activities have identified some differences in detailed interactions, such as the pelvis to fuel tank, but also the need for improved vehicle-to-vehicle equivalency. Future correlation activities will also use a helmet model validated at the component level.

Fig. 3. Image from video of physical PTW to car crash test using the PTW Dummy.

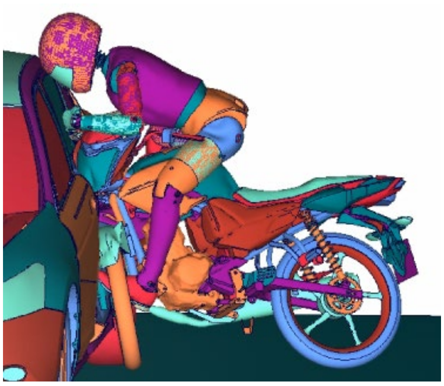

Fig. 4. Image from simulation of equivalent PTW to car crash using the PTW Dummy.

IV. DISCUSSION

A new PTW riding dummy is proposed. There are no specific biofidelity requirements for a motorcycle rider; therefore, no claims are made about *performance*. Without such targets, effort has been focused on using common well-established components and a minimal set of bespoke modifications.

Efforts have been taken to begin validating the finite element model by comparing it with the experiment. However, from full-scale crash test data there are other features of the environment that need validation. As such, future attention will be given to both full-scale and component-level validation of dummy behaviour. This should assist in confirming physical to simulation equivalence and also component response in respect to other known certification or biofidelity requirements.

V. REFERENCES

[1] Newman J. et al., IRCOBI, 1991.
[2] St. Laurent A. et al., ESV, 1989
[3] Van Driesssche H., ESV, 1994
[4] Preiss A. and Wirsching H.-J. RAMSIS User Conference RUC2020@home, 2020
[5] Puthan et al., AA&P, 2021