

UK - Rear Impact Dummy Research

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to

GR Head Restraints Informal Working Group

25th January 2006

Rear Impact Dummy Research

- In 1999, no dummy existed that had been shown to be suitable for use in a regulatory rear impact test to assess rear impact spinal injury risk;
- At that time two dummies were in very early stages of development in Sweden and the Netherlands, but neither was available for evaluation;
- Within the European regulatory framework two crash test dummies existed:
 - the Hybrid-III, which was designed and being used for high energy frontal impact, and
 - the Euro SID dummy designed for use in high energy side impacts;
- UK DfT (at that time DTLR) commissioned a project with TRL as the contractor;
- The aim of the project was to see if the Hybrid III dummy could be used or easily adapted for rear impact evaluations (*addressing the issues raised in previous accident studies carried out for the Department*).

Rear Impact Accident Research (1)

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- In-depth UK clinically based accident studies revealed that injuries to the cervical (neck) and lumbar (lower) spine, for restrained occupants, were more prominent and more significant than previous analyses had indicated;
- UK clinical accident data, that specifically studied whiplash associated disorder injury, suggested that any evaluation test procedure, to address low severity rear accidents with a view to reducing whiplash associated disorder type injury, should cover the whole spine and not only focus on the neck as an isolated entity;
- This was because many of the cases studied presenting a whiplash injury also displayed other spinal injuries.

Rear Impact Accident Research (2)

Department for
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- **Minton R, et al. (1998).** *Lower back and neck strain injuries: The relative roles of seat adjustment and vehicle/seat design.* 16th ESV Conference. 1998. Windsor, Canada.
- **Minton R, et al. (1998).** *Whiplash injuries, causative studies - final report.* TRL Limited.

Dummy Development to Evaluate Spine Injuries (S083D/VF) (1)

- The project consisted of a number of key work tasks:
 - A comprehensive literature review;
 - A series of volunteer, rear impact, sled tests to obtain suitable data for specifying the performance of whiplash dummies;
 - Rear impact sled tests with three different anthropomorphic test dummies and two dummy variants with alternative necks;
 - The dummy results were compared with the volunteer performance corridors.

Dummy Development to Evaluate Spine Injuries (S083D/VF) (2)

- The deficiencies of the Hybrid-III dummy especially its neck and spine were found to be well understood and reported in the literature;
- The original H-III was designed in the 70's and much of the injury knowledge at the time has since been discredited, e.g. hyperextension as the sole cause of whiplash injury;
- The H-III was reported as being far too stiff for **low** severity impacts, which is not surprising since it was designed for high energy frontal impact conditions;
- The rest of the Hybrid III spine was determined to be clearly lacking in human biofidelity for rearward flexure. Within the dummy it is a rigid structure on which to support a rib cage compliant with frontal deflection.
- It was proposed that measurements of head acceleration using the Hybrid III may yield misleading results because the head sits on top of a rigid spine and stiff neck, whose dynamic behaviour does not match that of a human spine.

Dummy Development to Evaluate Spine Injuries (S083D/VF) (3)

- Baseline rear impact tests were carried out using the H-III at 4, 8, 16 and 32 km/h to establish mechanical and kinematic performance data.
- The nominal sled acceleration in each test was 2 g, 3 g, 6 g and 10 g respectively in the 4, 8, 16 and 32 km/h tests.
- The data was used to obtain ethical approval for the subsequent volunteer tests.

Dummy Development to Evaluate Spine Injuries (S083D/VF) (3)

- Volunteer tests were completed and a series of performance corridors derived. These corridors can be used to specify the low severity response of whiplash dummies;
- Tests repeated using H-III with TRID neck, THOR, THOR with Euro SID neck (likely to exhibit better omni-directional characteristics).

Dummy Development to Evaluate Spine Injuries (S083D/VF) (4)

- Dummy results were compared with the volunteer performance corridors and showed that **no** version of the Hybrid III dummy tested gave a satisfactory performance, despite it meeting some of the proposed performance criteria.
- Fundamentally this was due to the dummy having a rigid thoracic spine.

Dummy Development to Evaluate Spine Injuries (S083D/VF) (5)

- Although the THOR contained flexible joints in both its lumbar and thoracic spine, it was considered (in both versions tested) unsuitable for use as a whiplash dummy since it did not demonstrate the required biofidelic flexibility of the spine and torso;
- The Bio RID displayed potential for use as a whiplash dummy. However, the torso together with the spine was shown to require greater flexibility and further tuning of the individual spine sections' stiffness was needed;
- **Roberts AK, et al. (2002)**. Biomechanics and Injury Mechanisms of the Human Spine in Rear Impacts. I Mech E Vehicle Safety 2002.

Dummy Development to Evaluate Spine Injuries (S083D/VF) (6)

- The project demonstrated that it seemed possible to compensate for a non-biofidelic rigid thorax by adjusting the neck stiffness. However, this method only produced reliable results in the impact situation for which the neck was adjusted;
- As a prerequisite, it was agreed that a test device should produce sensible results over a range of impact conditions;
- It was strongly recommended that future regulatory dummies for rear impact should have a fully biofidelic spine;
- The project only examined two-dimensional dummy behaviour. In real world impacts, occupants are loaded from a number of different directions;
- Future research to examine oblique behaviour was recommended to ensure that the injury predicting devices (i.e. the dummies) worked in impacts other than pure rear.

Biomechanics and Evaluation of Whiplash Associated Disorder Injury (S0010/VF) (1)

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- The EC 5th Framework project Whiplash II extended work that had already been performed within the 4th Framework Whiplash I project (in which the UK had not been a partner);
- As a contribution to the Whiplash II project, DfT funded a project to:
 - Make current the knowledge base through an update to the previously completed literature review;
 - Replicate the low-speed oblique-rear volunteer tests, but modify it to investigate an oblique-rear impact scenario;
 - Evaluate the new RID3D prototype dummy, developed in the EC Whiplash II Project, using the TRL volunteer test data generated from both pure and oblique test conditions.

Biomechanics and Evaluation of Whiplash Associated Disorder Injury (S0010/VF) (2)

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- The corridors generated from the oblique rear volunteer responses provide a useful basis for the evaluation of rear impact dummies;
- An analysis of the seat back forces suggested that the volunteers' spines were being loaded torsionally and laterally by the impact;
- The oblique rear results showed differences between the left and right side head accelerations not present in the pure rear results;
- The oblique rear impacts produced greater vertical displacement at T1 level, and showed lateral head displacement and head rotation about the z-axis ;
- Rear impact dummies should be evaluated against both sets of corridors if there is any possibility that they could be subjected to asymmetric loading due to non-symmetric seat yield.

Biomechanics and Evaluation of Whiplash Associated Disorder Injury (S0010/VF) (3)

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- It was concluded that the RID3D should undergo further development to investigate the effects of lumbar and thoracic spine element properties on dummy response.
- When the RID3D response was compared to those of other dummies under pure rear impact loading conditions it was seen that there were many similarities to the Bio RID response.
- Neither dummy had particularly human-like vertical response. However, the Bio RID had more human-like head and neck motion in terms of the characteristics of the response, even if the timing was not always correct.
- Aspects of both the Bio RID and RID3D were shown to be promising and the research concluded that these should be developed into a single rear impact dummy, as neither has a completely human-like response in its current form.

Biomechanics and Evaluation of Whiplash Associated Disorder Injury (S0010/VF) (3)

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- **Willis C, et al.** (2004). Kinematics of the Human Spine in Rear Oblique Impact – A Volunteer Study. I Mech E Vehicle Safety 2004.
- **Willis C, et al.** (2005). An Evaluation of a Current Rear Impact Dummy Against Human Response Corridors in both Pure and Oblique Rear Impact. ESV 19.
- DfT website: <http://www.dft.gov.uk>

Current research activities

- Active within both relevant EEVC Working Groups:
 - WG 12 (Biomechanics), and
 - WG 20 (Rear Impact);
- EEVC WG12 currently completing a rear impact dummy evaluation programme to make objective scientifically based recommendations in November 2006 (see additional presentation).

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