Reconstruction of Accidents within the Frame of Joint Biomechanical Research Project

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Introduction

On September 1977, several European institutions joined together to establish the Joint Biomechanical Research Project (KOB) to study certain problems in the fields of passive safety, in particular the biomechanical processes important in this context.

The objectives and the research programmes, the organization, the members and the funds were described at the IIId. International Conference on Impact Trauma, 1977 [1].
The research work has been finished in May 1981 and the final report will be available in the next months. The whole test programme included 18 reconstructions with 87 dummy- and 46 cadaver tests. Therefore it is quite clear, that this large research project has created a considerable amount of data and detailed results.

In the following paper it is only possible to present a small view of the whole work and only some special results. This short version was prepared on the basis of a draft of the final report written by various authors [2].

1. Frontal Reconstructions

The difficulties in reproducing impacts between two cars nearly frontal and under small angle are substantial. Small variations in angle, offset and speed can cause significant differences in both the interior deformation of the passenger compartment and the input pulses transmitted through the restraint system to the occupant. With regard to this and with respect that only two accidents with minor injuries of belted occupants were reconstructed, the following observations can be reported here:

a) In the case of the driving position there is the additional problem of a head contact with the steering wheel. The results show more forward movement of both live occupants and cadavers than with the dummy. This is because of different chest and neck characteristics, the dummy being more rigid than the human. There is a need demonstrated by these results for an improvement in the dynamic response of the neck and thorax of the Hybrid II-dummy for the restrained condition.

b) For the chest, the results are of valid interest. The cadavers all demonstrated higher level of injury than did the live occupants. All of the cadavers showed rib fractures whereas none of the live occupants showed anything for the chest higher than AIS 1. There was an obvious age effect demonstrated with the cadavers in comparison to the live occupants and these may well be a separate influence of bone strength as well. There were no major inthrathoracic injuries in either cadavers or living subjects and it is clear that rib fracture is the appropriate type of injury for the

basis of a thoracic protection criteria for a belted occupant.

c) Apart from kinematic differences, the method of measurement of head accelerations and hence HIC values for cadavers was not very different from the procedure with dummies. In the dummy the accelerometer was at the centre of the head. In the cadaver the accelerometers were mounted at a small distance from the centre of gravity and therefore direct comparisons between the detailed results for the two surrogates should be made with caution. Without head impact the cadavers did not show any head injuries and HIC values on cadavers and dummies were low. The use of the HIC for assessing facial injury is not appropriate.

In general it was difficult to find in frontal collisions moderate or severe injured belted occupants in the data file of four different European teams of in depth investigations.

2. Lateral Reconstructions

This section of the KOB project has been most successful in demonstrating the validity of accident reconstruction. Car to car, front-to-side collisions can be reproduced with considerable accuracy. Vehicle position, alignment, vehicle decelerations and intrusion are the main parameters which influence the exposure of the occupants to injury producing loads.

Five lateral impacts were reconstructed. An example for the comparison between injuries of a real accident victim and of the cadavers are shown in table 1. A scatter of the observed thorax injuries is apparent.

In general from the results of the cadaver tests is appears that the presence of the arm and shoulder between the side of the car and the thorax is a significant factor in load distribution and absorption. Thus it is important that any dummy used to simulate the lateral loading of the thorax ought to have an arm and shoulder linkage.

The results using the Hybrid II-dummy give a clear conclusion that it is unsuitable for lateral impacts. Therefore no realistic protection criteria for the head and thorax can be defined. The absence of appropriate thoracic deflection, together with unrealistic neck and shoulder response result in kinematics quite different from either cadavers or living people. Consequently the output results for the head and thorax with the Hybrid II-dummy are quite unrealistic.

With the head particularly it is of interest that in some instances there was no head contact at all because of the rigidity of the neck and shoulder linkage. In the case of cadavers the head follows a lateral path with little rotation initially, indicating only a small constraint being applied through the neck, although at a later part of the lateral displacement significant rotation of the head may occur.

A small number of tests were conducted with an advanced lateral impact dummy (APROD 80). The results indicate that it is clearly possible to develop a dummy which has the correct compliance for the thorax in comparison to cadaver results. Also the APROD 80 appears to offer a better reproduction of head motion and further developments of the neck and shoulder result in a test device which can be used for realistic reproduction of head motion, head acceleration and thoracic deflection.

Table 1

INJURIES DESCRIPTION / RECONSTRUCTIONS PEUGEOT 304/ RENAULT 15

Body Segment	Real Accident Victim	Cadaver test 1	Cadaver test 2	Cadaver test 3
HEAD	left parietal wound AIS = 1	--	--	--
THORAX	13 rib fractures with flail chest AIS = 4	fracture of the clavicle 20 rib fractures with a flail chest AIS = 4	10 rib fractures AIS = 3	fractures of the clavicle 5 rib fractures AIS = 3
PELVIS	--	--	--	--

The most interesting conclusions are as follows:

a) The kinematics of cadavers and living people show good correspondence. Thus comparisons of outputs between cadaver response and living people are valid.

b) For the head, HIC values well above 1000, measured on cadavers, showed an absence of intracranial injury. The results suggest that a tolerance level more than 1500 for the HIC may well be appropriate. But it will be necessary to consider also angular accelerations as well.

c) For the thorax, a deflection of 30% correlates with multiple rib fractures in cadavers. However in discussions it was pointed out that the exact time of rib fractures is not known. Therefore the correlation between deflection and rib fractures must be studied in further investigations. Work outside this project suggests that cadavers may display more injuries then do living people for the same deflection even when allowance is made for age and other factors. Hence the work here suggests that a deflection criterion of 30% would be a conservative one.

d) For the pelvis, the indications from the dummy and cadaver results are that a value above 100 g (within 3 ms) would be an appropriate criterion, but the number of results makes this conclusion tentative.
It is an unsolved question whether acceleration is the right parameter. It could be that the space between door and belt lock remaining after a side collision is more important in producing pelvis injuries. Therefore measuring compression forces could be appropriate.

The reconstruction programme demonstrated substantial benefits in the class of lateral collisions investigated here from the use of seat belts. This applies to both seating positions, on the struck and the none-struck sides. For the none-struck position it is clear that the pelvic restraint prevents lateral motion and contacts, and hence the transmission of forces into the occupant on the struck side. Thus a seat belt benefits both the person using it and the person in the adjacent seat. Secondly, for the occupant on the struck side without a belt, substantial travel of the head out through the side window was observed. That motion can result in contact on the bullet car or in significant rotation with the potential for injury. The use of a seat belt diminished the chances of those phenomena occuring.

3. Pedestrian Reconstructions

Nine pedestrian accidents were reproduced. In the following table a comparison between dummy and cadaver tests for acceleration values of the head, thorax and pelvis are given.

	Dummy tests			Cadaver tests		
	Head	Thorax	Pelvis	Head	Thorax	Pelvis
primary impact	113	41	66	146	65	188
	92	49	61	130	78	118
	187	39	56	100	85	70
secondary impact	63	23	27	120	24	224
	48	48	19	59	58	46
	35	67	24	35	59	19

Table 2: Resultant acceleration/ 3 ms

This figure gives the results of one of the reconstructed cases; also here the variations of the 3 ms value is apparent.

In order to demonstrate the kinematics of cadavers and dummies the following film is shown.

The reasons for the different kinematics between the living person or the cadavers on the one hand and the Hybrid II-dummy on the other are as follows:

a) Differences in dynamic response of the pelvic region

b) Differences in the rotational response about a vertical axis in the lumbar region; Hybrid II being much stiffer

c) Differences in the neck and shoulder compliance, the dummy has a much stiffer shoulder in comparison to the human, this can have a major influence on the head velocity at contact

d) Differences in the thoracic compliance, the Hybrid II is known to have a thorax which is too stiff. This influences the nature of the head and chest contacts.

The general conclusions of the pedestrian reconstructions are:

a) A Hybrid II-dummy used in the pedestrian mode gives surprisingly repeatable results when one dummy test is compared to another. This conclusion should be qualified by saying that the nature of the head contact zone greatly influences the outputs from the dummy, so that even very small variations in the head trajectory may influence the output responses greatly. However, the kinematics of dummies appear to be very repeatable.

b) An incompatability normally exists in attempting to reproduce all the accident characteristics. If an impact speed was calculated from the accident data, based on an established point of impact, skid marks and points of rest of the car and pedestrian, then reproduction with a Hybrid II-dummy consistently gave different contact zones on the car. This occurs even when allowances are made for differences in stature. The dummy consistently gives a head contact zone closer to the front of the car for a given impact speed in comparison to both cadavers and the living person for cars with a significant

forward edge to the bonnet.

c) The nature of the bonnet forward edge contact is critical in effect on the head and chest trajectories and velocities. Depending design of the car, this can be of greater or lesser importance; some such as the VW Beetle do not have a significant bonnet leading edge.

The protection of pedestrian via change of the car exterior needs further research, specially the development of an appropriate pelvis and lumbar spine of the dummy.

4. Concluding Remarks

Clearly a research programme of the magnitude demonstrated in this report contains many specific results and conclusions. The KOB Steering Committee hopes that the material presented here will be reviewed in detail by all interested organizations and individuals, and the data will be used to further our knowledge on human tolerance limits and the means of specifying appropriate protection criteria. However the results indicate very clear the necessity to built more realistic dummies, specially for side- and pedestrian reconstructions. The use of improved dummies is helpful to define appropriate protection criteria.

References

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