DETERMINATION OF INJURY THRESHOLD LEVELS BY REKONSTRUCTION OF REAL ROAD ACCIDENTS

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Abstract

All methods used to determine the biomechanical tolerance levels of humans exposed to shock loads are hampered by the fact that it is not possible to simulate human reactions. The only possibility of investigating the real load of car occupants in the injury threshold range consists in the reconstruction of suitable road accidents.

This method, which has been reported by other authors, is also applied at Battelle-Institut e.V., Frankfurt (Main). After assessing the damage to parts in the interior of the vehicle and the injuries to the occupants, the damage is simulated in the laboratory. Subsequently, the loads which have caused the injuries are measured in dynamic and static experiments. After definition of the threshold levels, injuries (e.g. to head, shoulder, knees) and loads are then correlated.

The first results have shown that this method yields statistically significant tolerance levels, provided that a sufficient number of cases is investigated. In addition, it is possible to check data determined by other methods.

Problem

To determine the injury threshold levels for humans different approaches have been adopted in biomechanical research, but the informative value of the methods applied is limited (Fig. 1):

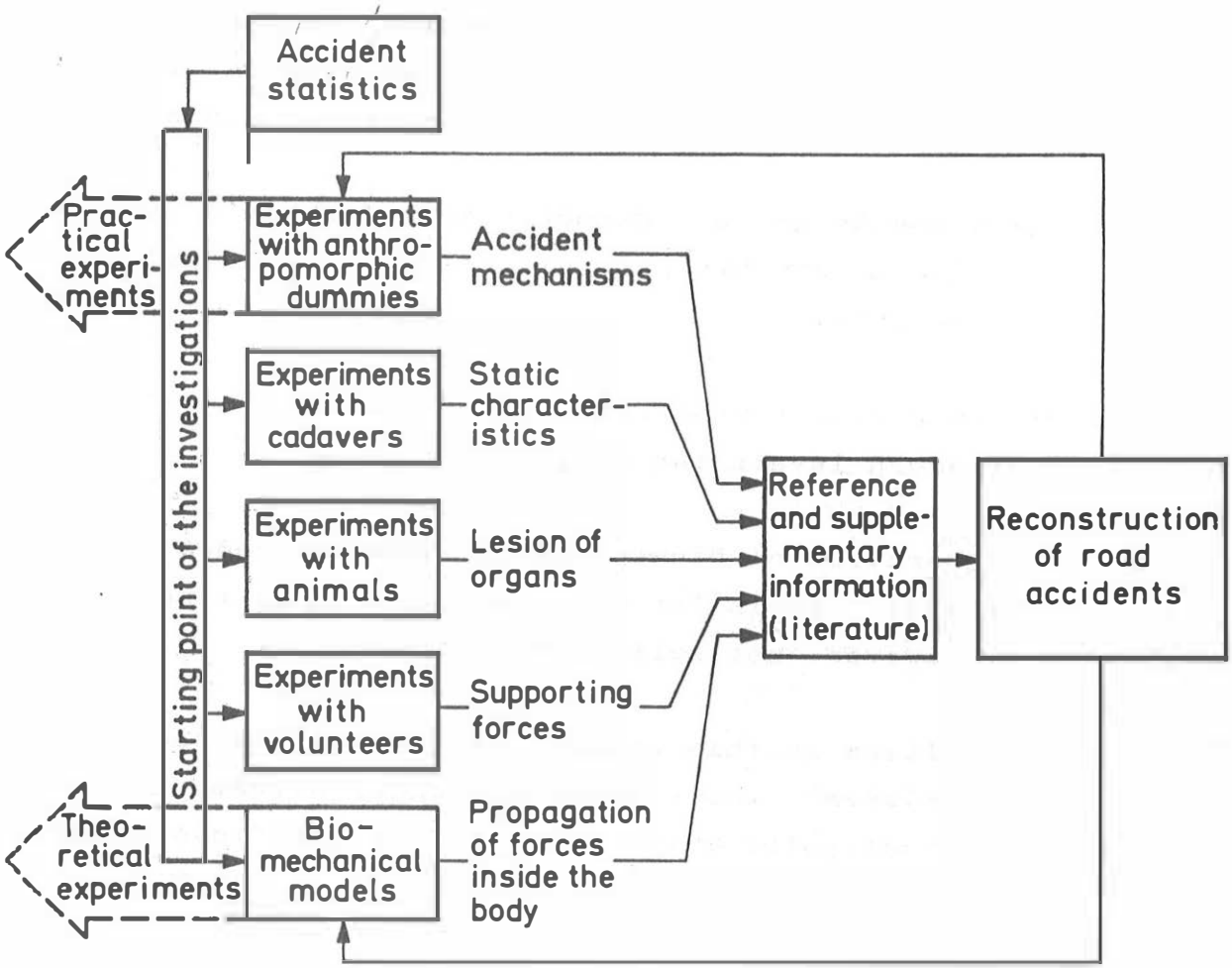

Fig. 1: Methods of determining biomechanical threshold levels

- The accident statistics only provide information about frequency, types and causes of injuries, but not about the loads involved; they suggest the lines along which investigations should be conducted.

- Experiments with anthropomorphic dummies do not show any injuries, because, for example, fracture loads for individual parts of the skeleton and the injury threshold levels for the human body are still largely unknown.

- Experiments with cadavers are not readily compatible with ethical principles, the supply of cadavers is problematic, and in particular they lack the (dynamic) muscular tonus.

- Animal experiments are not directly transferable to humans because of the anthropomorphic differences or the different mass distributions.

- In experiments with volunteers only loads far below the injury threshold levels can be applied.

- For the elaboration of biomechanical computer codes, the injury threshold levels for man are required as input data; these are, however, not sufficiently known.

Special difficulties in this respect are due to the very complex "human system", whose behaviour under extreme shock loads can be investigated only by evaluating the "involuntary experiment road accident".

Methods

In the reconstruction of road accidents the relationship between interior structural damage to the vehicle and injuries of

occupants is utilised to draw conclusions on the loads acting on man. To this end the technical details of the accident including the damage to the car are taken down at the site of the accident, and the injuries of the car occupants are subsequently determined by medical examination.

By simulating the impact of occupants against the interior of the vehicle, the interior structural damage to the vehicle is reproduced and the loads are measured which correspond to the forces that acted on the occupants during internal impact. It is thus possible to obtain the relationship between load and injury, and the definition of the tolerance of specific loads then leads to the threshold level (Fig. 2).

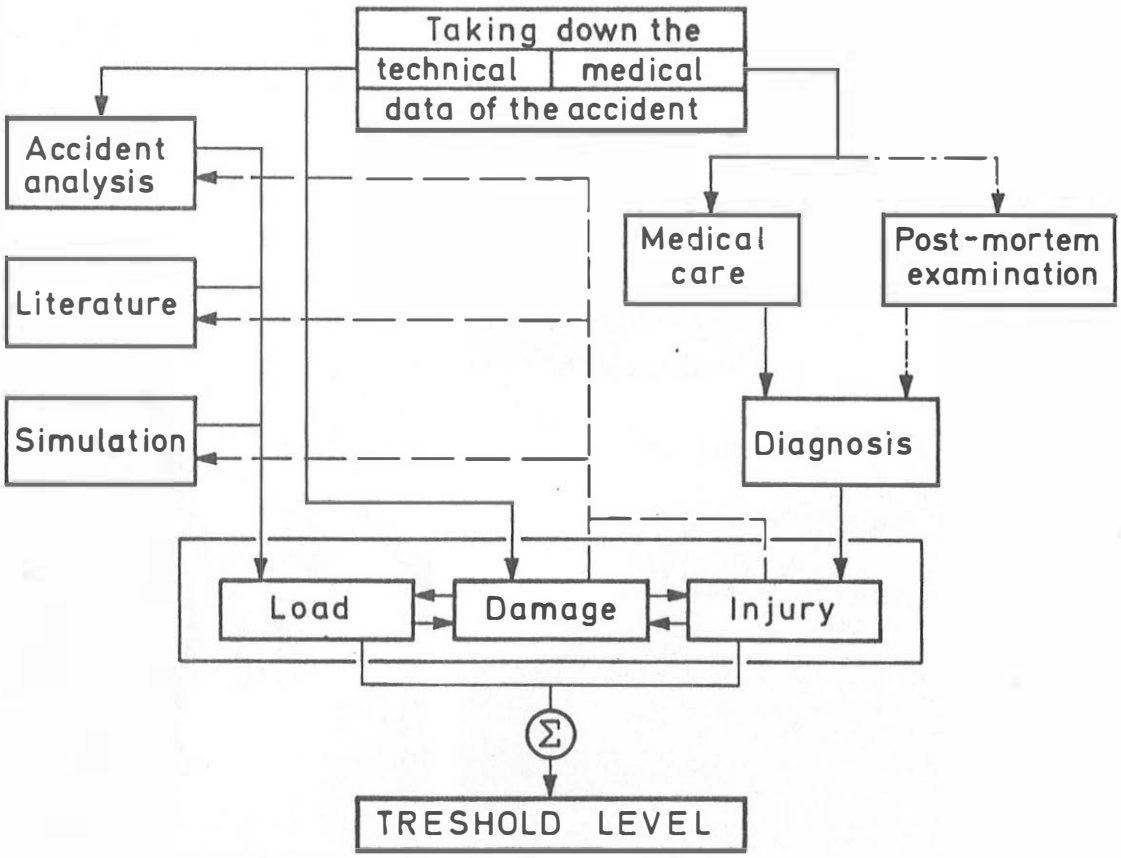

Fig. 2: Information flow in the reconstruction of a road accident

A similar method was applied for the first time in investigations conducted at the Transport and Road Research Laboratory, Crowthorne /1/. These showed threshold levels or at least their range for injuries of thorax and lower extrmities.

Investigations carried out at the Battelle-laboratories concerned in particular with injuries of the shoulder girdle, i.e. of the shoulder joints, because literature studies /2/ had shown that injury threshold levels for lateral impact of the body are little known, while data for the shoulder joints are completely lacking.

An example of interior structural damage produced in a road accident and in the laboratory is shown in Fig. 3; the car occupant is represented in the impact experiment by a suitably shaped equivalent mass.

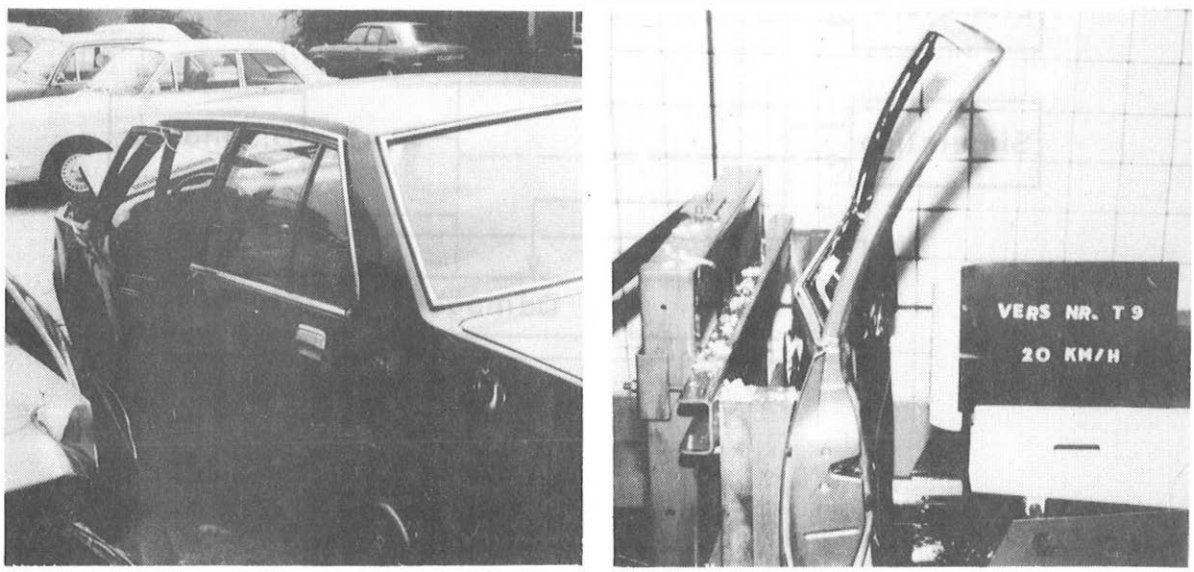

Fig. 3: Damage resulting from accident and simulation

First Results

To try out the reconstruction method, the interior structural damage corresponding to that resulting from real accidents was produced in 15 impact experiments, and the loads - this case the deceleration and the impact load acting on the equivalent shoulder mass - were measured. These loads were then correlated with the injuries caused by accidents (Fig. 4).

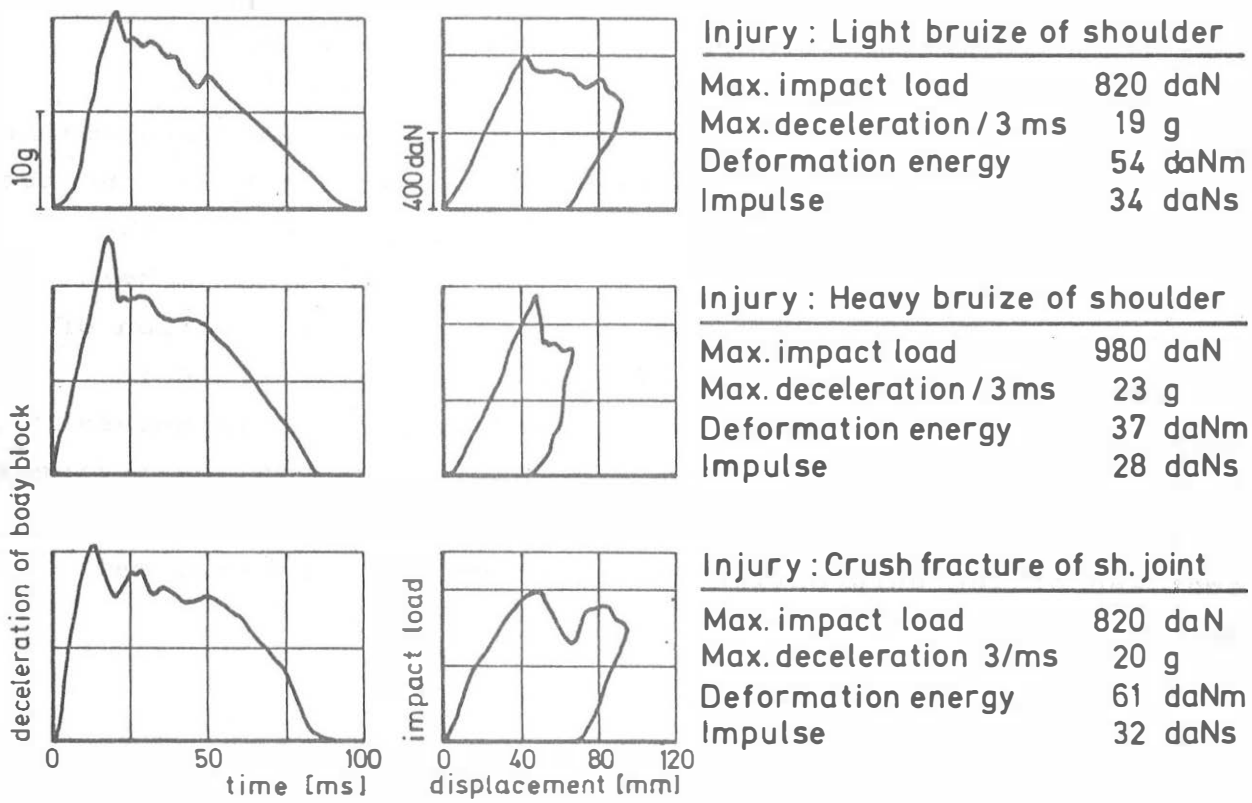

Fig. 4: Results of selected impact experiments "shoulder/door"

As a description of the constitution of the injured persons is not available, the experimental results shown in Fig. 4 do not permit an exact injury threshold level for shoulder impact to be determined, because maximum impact load, deformation energy and impulse cannot be correlated reliably with the severity of the injury. Thus, it can only be concluded from the results of the three experiments that a maximum impact load in the range between 800 and 1000 daN may, but must not necessarily lead to crush fracture of the shoulder joint.

Additional quasistatic deformation experiments have shown that the deformation velocity is of significant importance. At a deformation velocity of 10 cm/min, for example, the maximum forces and the energy absorption by the door are smaller by about 25 percent and about 10 percent, respectively, and the elastic deformation is about 50 percent higher than in the dynamic experiment with an impact velocity of 15 to 30 km/h. In addition, it has been found that an exact reproduction of the impact situation and the part of the body involved is necessary. In the case of doors, for example, it is necessary to use the same windows in the same position as in the accident, as otherwise deviations of impact loads of up to about 10 percent and of the deformation energy of up to 30 percent may occur.

Conclusions

The above-described method is suited to determine statistically significant injury threshold levels or to check tolerance levels obtained by other methods, provided that a sufficient number of cases is investigated and sufficient data are available about the accidents under consideration. It is possible to investigate any conceivable impact situation of car occupants (examples of Fig. 5).

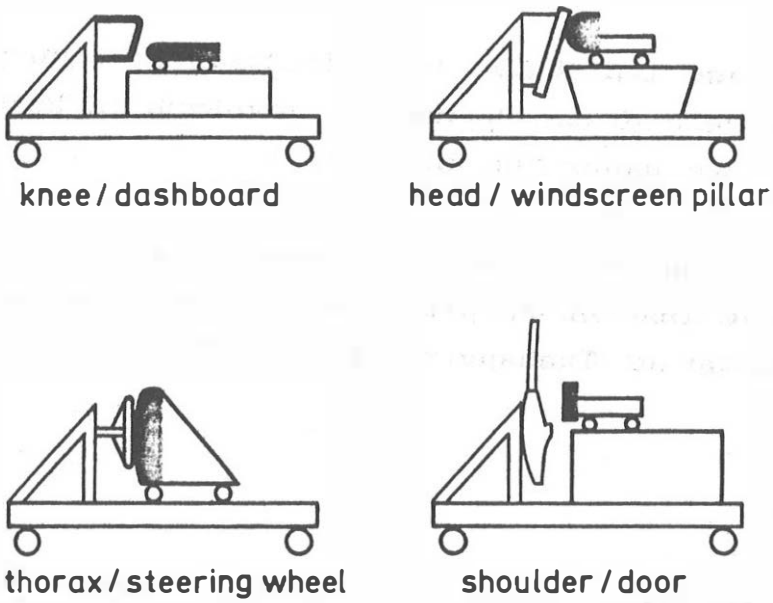

Fig. 5: Simulation of internal impacts

The most important investigations that should be conducted for further refining the reconstruction method are an exact description of the constitution of the car occupants and use of electronic data processing (EDP). The constitution has to be determined when taking down the details of the accident and compared with the injury threshold level as constitution factor. Additional factors to be included are age, sex, mass, stature, previous injuries, illnesses, and muscular and nutritional state. The constitution should be indicated by percentiles related, e.g., to that of dummies.

The use of EDP in the reconstruction of accidents is not only aimed at reducing the amount of work involved, but also at simulating complete impact situations and the propagation of forces inside the body in digital form and thus permits a more rapid and less expensive variation of the impact parameters compared with the impact experiment.

Literature

/1/ R.D. Lister and I.G. Wall: Determination of Injury Threshold Levels of Car Occupants Involved in Road Accidents. SAE paper 700 402 (1970)

/2/ Battelle-Institut e.V.: Beanspruchungsgrenzen des Menschen beim inneren Aufprall. Report for the West German Minister of Transport, April 1975

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