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汽车被动安全和损伤生物力学*

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摘　要:主要描述了交通伤害保护,包括伤害流行病学,碰撞生物力学,提出了用于交通安全研究的(人体)模型以及目前正在研究的伤害保护措施.

关键词:被动安全;伤害流行病学;碰撞生物力学

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Automobile Passive Safety and Injury Biomechanics

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Abstract: The topics in traffic injury prevention are briefly described, which cover injury epidemiology, impact biomechanics. The models used in traffic safety study and current focus on research of countermesures are also presented.

Key words: passive safety; injury epidemiuology; impact biomechanics

1　Introduction

During the 1930's injury prevention as a research topic started to gain interest. However, it was not until the middle of the 1950's, with studies of crashes and their consequences, that the research really got underway. Engineers and physicians started to collaborate in order to gain insight into the primary causes of injuries and fatalities, which as time went on proved to be a far more complex task than originally anticipated. During a collision, the velocity of car occupants will rapidly change, which means that the occupants will be exposed to retardation. In order to minimise injuries, the amount and duration of the velocity change needs to be controlled. The aim is therefore that the vehicle should, through deformation of its structure, absorb as much of the energy as possible and thus transmit as little energy as possible to the restrained occupants in a

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stiff compartment.

The energy absorption at the most usual impact speeds (50—60 km/h) may have, for these circumstances, a relatively long duration and will last during a relatively long deformation distance (50—85 cm).

Therefore the deformation zone, in a first sequence, will reduce the energy transmitted to the occupants as the vehicle starts to decelerate, which must take as long as possible. Occupants will then impact the restraint system and/or the interior of the vehicle. This second sequence has a much shorter duration than the first sequence and a long stopping distance since it is limited to deformations of impact areas within the compartment, and in some part to deformations of human tissue. The duration in typical frontal collisions is reduced from the first to the second sequence from 100 ms to 10 ms and the deformation from typically 50—85 cm to some cm. The last sequence of the collision will result in an impact into surrounding bone structures by the organs due to inertial forces.

The research aims of our group are to develop principles for injury prevention by limiting the crash violence, e. g. by enhancing the effectiveness of protective systems so that they better suit all the variations of the population and types of collisions. To achieve these aims there is a need to develop knowledge about injury mechanisms, and the mechanical reactions of various tissues, as well as to develop basic understanding of impact tolerances. There is also a need to develop better injury prevention tools such as crash dummies and mathematical models for risk evaluation of a specific injury. In addition, there is a need for accident investigations and reconstructions to improve the knowledge.

Our research covers the areas from accident investigations and reconstructions via model developments to principles for countermeasures, i. e. from basic medical research to applied engineering. The research is thus multidisciplinary and is mapped in fig. 1.

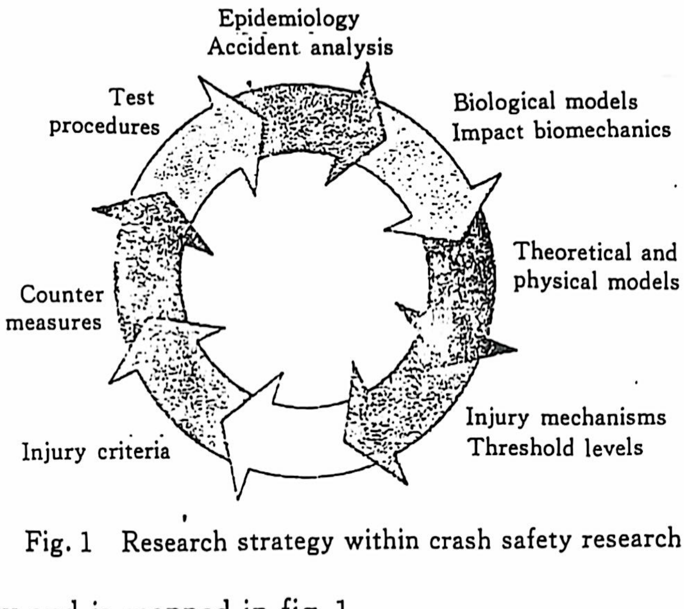

Fig. 1　Research strategy within crash safety research

2　Accident investigations and reconstructions

As in other research areas, there is a need to gather empirical evidence on which to base the basic and applied research. This is performed by epidemiological studies, among others. These mainly statistical studies give an overview of injuries and injury distribution in terms of frequency and severity. However, accident investigations and reconstructions must complement these studies, which is done by crash tests and mathematical modelling. Analyses of vehicle deformations (interior and exterior) related to certain accident parameters can give information about injury mechanisms and are useful to evaluate protective system effects. By reconstructions it is possible to estimate acceleration levels and time sequences during the crash. It is important to have access to a wide register of mathematical models and other tools to achieve high reliability. Some of our ongoing research deals with accident investigations and reconstructions of accidents resulting in severe brain injuries.

3 Models (substitutes of the human)

To acquire knowledge about injury mechanisms in a certain type of accident, various types of models/tools have to be developed. The biofidelity of the models must be as high as possible. It is very beneficial and often of the utmost importance to be able to use several complementary models, i. e. mechanical, mathematical and biological models in parallel when developing principles for an optimal protective system. Our research includes this range of models, which has resulted in a leading edge position for our group.

The properties of the mechanical and mathematical models must also be based on clinical and accident data. Furthermore they have to be based on research with various biological models exposed to relevant crash injuries. The models are mainly used to study kinematics and loading during crashes (for examples of ongoing neck injury re-

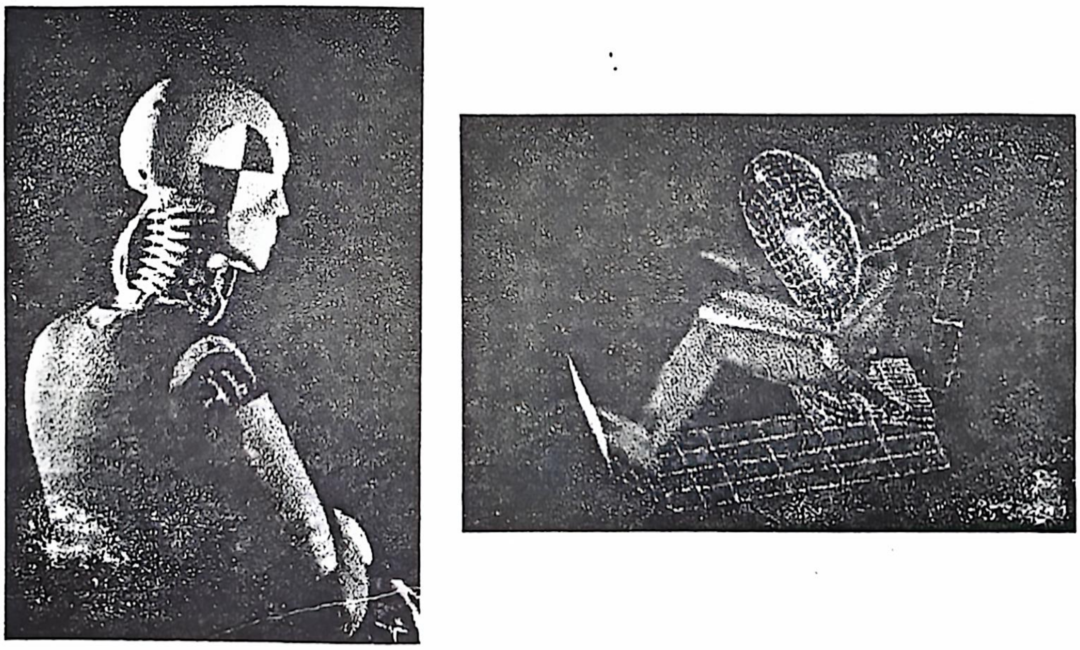

Fig. 2 Examples of a mechanical (BioRID) and a mathematical model for whiplash studies.

search, see fig. 2).

The biological models allow studies of anatomical, physiological and neurophysiological measures under certain types of violence. These models are used as input to mechanical and mathematical models. Various types of biological models can be used as human substitutes, but there is no ideal solution, as none has all the properties needed to be a good representation of the human being (for an example of ongoing research, see fig. 3).

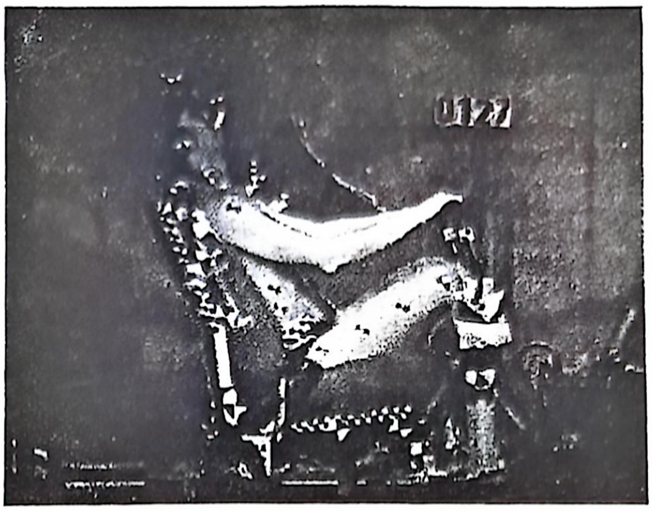

Fig. 3 Example of a biological model (volunteer) for whiplash studies

4 Injury mechanisms and tolerances

The mechanical properties of the human body can be specified as for other physical structures. Physical parameters can be determined such as acceleration, pressure, and deformation at certain types and levels of violence to the body. In reality there are, however, a number of problems, such as, a range of different injuries at various severities might occur within a certain body part or organ depending on the type of loading. When estimating the injury risk for a certain type of injury within a body part, we have to consider various loading situations, several injury mechanisms and also that the dynamical properties for a human tissue is velocity dependent (visco elastic). The properties vary largely between different humans (biological variation), e. g. depending on gender and age.

Many contributing factors complicate a clear definition of tolerances to certain types of violence. Examples are direction, deformation level, duration and level of the applied violence, and not least a number of biological factors. Important tools to determine injury mechanisms are the above mentioned models. Our basic research today mainly deals with neck injuries (whiplash) and severe brain injuries.

5 Countermeasures

A thorough understanding of the mechanisms which cause injuries and disabilities must be the basis for the development of new effective protective systems. Furthermore an access to valid models and injury criteria is essential. Relevant test methods and connections to accident investigations are other needed prerequisites. The applied research in our group today has a focus on countermeasures for neck injuries and injuries to the lower extremities and on pedestrian protection. New research challenges are to develop intelligent restraint systems that take into account occupant position and size/weight, crash severity and direction among other things. This will require a new focus on the development of algorithms and sensor techniques.

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