INTERNATIONAL HARMONIZED RESEARCH ACTIVITIES (IHRA) STATUS REPORT OF THE BIOMECHANICS WORKING GROUP

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ABSTRACT

A summary of the efforts of the Biomechanics Working Group to complete the task given to it by the International Harmonized Research Activities Steering Committee to determine specifications for a Universal Side Impact Anthropomorphic Test Devices is presented. Topics discussed are the nature of the world side impact problem, the anthropometric characterization of the world population at risk, dummy impact response specifications, and necessary and appropriate injury criteria and performance levels.

INTRODUCTION

This report summarizes the activities and accomplishments of the International Harmonized Research Activities (IHRA) Working Group on Biomechanics Research (BWG) for the period from its last report, given in Windsor, Canada on the occasion of the 16th International Technical Conference on the Enhanced Safety of Vehicles, to the present. At that June 1998 meeting, the International Harmonized Research Activities Steering Committee specifically directed the Biomechanics Working Group to form a Government only, ad hoc group to determine specifications for a universal side impact Anthropomorphic Test Device (ATD) by undertaking the following tasks:

- Analyze the safety problem in side crashes worldwide and quantify the type and severity of injuries contributing to the side impact problem.
- Analyze the human injury data and identify all meaningful injury functions that address the above identified safety problems.
- Review all available biofidelity test results according to their real world relevance and establish desired dummy response corridors.
- Examine all available side impact ATD's with regard to their biofidelity and injury risk assessment capabilities.
- Make recommendations of the most suitable dummy, if any, and suggest areas that require refinement. Establish estimates of a realistic time frame in which such devices may become available.
- Provide an interim report to the BWG's activities by November 1998 and a final report no later than November 1999

Because the BWG did not have any specific financial resources to devote directly toward addressing and resolving any issues associated with the above tasks, it has relied on the available time and talent that each of the group's individual members could contribute to the above effort and beyond their normal professional duties. Likewise, funding limitations have also limited the scope of the effort to information that was available either in the current literature or at the individual participating research institutions. Therefore, the report being assembled for presentation to the Steering Committee will represent both a thorough compilation of available data and information known to be related to the above assigned tasks as well as a series of specific conclusions and recommendations resulting from an analysis of the data by the BWG members.

DISCUSSION

The efforts of the BWG's activities to date have been documented in a Draft Final Report titled: Considerations and Specifications for a Universal Side Impact Dummy. This draft report was submitted to the Steering Committee at its recent meeting in Geneva. The report concentrates on the four major components of the tasks assigned: Magnitude and nature of the global side impact problem, anthropometry necessary to represent world population at risk, impact response specifications necessary for defining performance of a side impact dummy, and injury criteria and performance limits necessary to detect and effect a safe environment. Brief descriptions of these activities and their initial results will now be presented.

Global Side Impact Problem

A number of major crash data bases from around the world were examined and provided the bases of the BWG's initial effort to characterize and generalize the world side impact problem as it would influence biomechanical considerations. Included in the analysis were three data sources from Australia: the Fatality File maintained by the Federal Office of Road Safety, (FORS) of Australia, the Crashed Vehicle File (CVF) a sample of in-depth collision investigations conducted between 1989 and 1992, and the Australian Harm database assembled by the Monash University Accident Research Center.

Canadian data sources used included the Traffic Accident Information Database maintained by Transport Canada, the Passenger Car Study run between 1984 and 1992, and Transport Canada's Directed Study of Side Collisions. European sources were primarily two recent reports, one prepared by the Transport Research Laboratory (TRL) and a second report by Germany's Bundesanstalt fuer Strassenbewesen (BASt), which examined and summarized crash data from France, Sweden, Germany, and the UK in support of the SID 2000 project. This data, combined with data from national data bases in Japan and the United States (NASS and FARS), were analyzed to understand the physical characteristics of the side crash as well as the types, severity, and source of prevalent injuries sustained by side impact crash victims.

It was found that in most jurisdictions, approximately one-third of all passenger vehicle deaths and serious injuries were attributable to side collisions. Additionally, the review found that a general uniformity existed among what body regions were injured in side impact. That is, for all jurisdictions examined, the chest and head represented the two most frequently injured body regions in near side impacts with abdominal injuries also being quite frequent. While a majority of these injuries were produced in vehicle-to-vehicle crashes, 25% were associated with crashes involving poles and other narrow, vertical objects. Two-thirds of the injuries were to occupants seated on the impact side while the remaining third were far-side occupants.
A spread in both age and stature of the victims was also evident.

Summarizing these results from the perspective of dummy design, testing, and evaluation, the field data suggests that dummies of several sizes (and weights) may be necessary to provide adequate representation for the diverse population exposed to side impacts. Likewise, the diversity of side impact conditions will most probably require crash test designers to institute multiple crash scenarios for safety evaluation needs, thus concomitantly requiring the multiple-sized dummy family to possess both appropriate mechanical response characteristics and injury evaluation techniques to match these diverse impact characteristics.

Anthropometric Characterization of Crash Victims

Several anthropometric studies were used to investigate the potential diversity of size among the various crash populations of the world. One study, "International Data on Anthropometry," by Jurgens, Aune, Pieper (1990) provided standardized, world encompassing anthropometric data. The data was analyzed five different ways using either an un-weighted worldwide mean, worldwide mean weighted by population in each region, unweighted mean of regions containing OECD countries, mean weighted by population for each OECD region, or mean weighted by fatality rate for each OECD country in that region.

The first two approaches yielded dimensions significantly smaller than current crash dummies. The third and fourth methods provided larger dimensions while the fifth method matched the 50^{th} percentile dimensions but with larger 5^{th} and 95^{th} sizes.

Since additional parameters are necessary to properly specify a dummy, i.e., description of seated posture, joint locations, geometry of exterior surfaces, segment definitions, segment mass, inertia and CG locations, both the RAMSIS and UMTRI anthropometric data bases (DOT HS 806 715) were investigated. Conclusions were that base dimensions are very similar across sources, some differences exist in definition of spinal lordotic and abdominal bulge but considered of minor consequence, and that the UMTRI data was most useful because it was developed specifically for dummy design issues. Because the anthropometry of the world's population at risk appears to converge to the UMTRI study and the UMTRI study provides almost all of the necessary parameters (those missing or not quite clear can be supplemented by the RAMSIS study), it is the current recommendation of the BWG that the UMTRI data set become the basis for the 50^{th} percentile male dummy as well as the 5^{th} and 95^{th} sizes if it is determined that they should also be developed.

Biofidelic Impact Response Specifications

The BWG took the ISO Task Report 9790 as the basis of its impact response specification recommendations. These recommendations span the entire body starting with the head and on to the neck, shoulder, thorax, abdomen, pelvis, and the legs. The original work has augmented and/or replaced these specifications when it found additional or more comprehensive data available. The most notable addition was data generated by NHTSA research efforts at Medical College of Wisconsin and Ohio State University. These efforts provided over 40 additional repeated tests of highly instrumented cadavers being impacted by a multi-segmented load sensing side impacting wall under typical side impact crash conditions. The observed responses were then generalized for each test condition by developing a mean time-history response from each set of similar tests as well as confidence bands documenting the repeatability of the desired specifications. Test conditions include high and low speed as well as rigid and padded wall treatments. Additional efforts are underway to provide response specifications for a frontal oblique impact direction as well as responses from tests where certain segments of the load wall are offset to simulate an arm rest or another intruding structure impacting the subject first.

Injury Criteria and Associated Performance Limits

The BWG's previously discussed analysis of the side impact safety problem has demonstrated that a variety of body areas are at certain impact risk and if they are to be protected, they must have an appropriate criteria and an effective performance criteria to limit injury severity. A brief summary of the BWG's findings for individual body areas follows.

Head: The majority of head criteria are kinematically based and provide protection by either limiting peak resultant translational acceleration of the head or some kinematic function, such as HIC, that operates on the resultant translational accelerations to produce a severity rating. Rotational kinematics have been demonstrated to produce certain forms of serious brain injury and it would be desirable to include dummy instrumentation capable of capturing these variables and a criteria that would appropriately limit this form of hazardous head motion.

Neck: The majority of current neck criteria are kinetically based criteria and provide their protection by limiting either the individual or combination of observed forces and moments in the dummy's neck. An example of a combined criteria is the Nij that NHTSA adopted in its recent frontal rulemaking activity.

Thorax: Criteria proposed for thoracic injury evaluation and control can be classified as using either relative measurements, such as rib cage deformation, deformation rate, and/or combination thereof, kinematic criteria that use primarily individual or multiple inertial accelerations, such as TTI, of those that use both relative and kinematic responses, such as CTI.

Pelvis: Existing pelvic criteria either limit peak resultant acceleration of the pelvis, the peak force it experiences at either the rami, the iliac wing, or the acetabulum when load cells are present or its relative deformation.

Lower Extremities: While considerable research has been devoted toward developing lower extremity criteria for frontal impact injury criteria, there has been less effort devoted to lateral loading conditions. It is, however, expected that limiting either forces and moments, either individually or in combination, will be the form of the criteria eventually developed.

Because the injury criteria development is such a fluid and active area of research, it is felt by the BWG that it would be a better strategy to develop the side impact dummy family's capability to mimic and capture all currently used injury predictive measurable engineering parameters by specifying their necessary impact response characteristics as a dummy design requirement and deferring the choice of a specific criterion to the institutions that must actually promulgate and justify the actual injury criteria and their performance limits.

SUMMARY

To accomplish its task of developing and providing necessary and sufficient specifications to develop a universal side impact anthropometric test device(s), the BWG has reviewed crash data, anthropometric data, biomechanical response and injury data. The consensus among the BWG's participants is that the world side impact problem possesses sufficient significant similarities to allow a definition of a single family of dummy test devices to be made. This single family should be able to appropriately represent the diversity of the world's nationalities as well as be able to monitor and control all significant injury and crash modes they experience. The BWG also believes that sufficient information exists for it to accomplish this task and that they can be accomplished in the near future.