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A methodology to estimate the kinematics of pediatric occupants in frontal impacts

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Abstract-

Objective: The goal of this article is to propose a new methodology to estimate the sagittal plane displacement of the head, spine, and pelvis of a 6-year-old (6YO) occupant during a high-speed frontal impact. Research has shown major discrepancies between the spinal kinematics of current pediatric anthropomorphic test devices and humans during frontal impacts. This article provides an estimation of the kinematics of a pediatric subject that may assist in the development of physical and computational models of a 6YO occupant in high-speed frontal impacts.

Methods: This article presents data on 4 different experimental data sets corresponding to noninjurious low-speed (nominally 9 km/h) frontal impacts involving pediatric and adult volunteers and to low-speed (9 km/h) and high-speed (40 km/h) frontal impacts with postmortem human subjects (PMHS). Kinematic data from each subject were first normalized to the size of a 50th percentile within its age group. Two already published and commonly used scaling methods (mass scaling and the Society of Automotive Engineers [SAE] scaling methods) were assessed using volunteer data. A new scaling method based on energy considerations was developed.

Results: Both the mass scaling and the SAE scaling methods failed to predict the actual pediatric displacement at 9 km/h. The newly proposed method substantially improved the prediction of the pediatric kinematics at low speed and it was applied to the high-speed PMHS data to provide an approximation of the displacements of the head, thoracic spine, and pelvis of a 6YO occupant in a 40 km/h frontal impact.

Conclusions: A new scaling method based on energy conservation improved the prediction of the displacement of the pediatric head, thoracic spine, and pelvis at 9 km/h. This method was then applied to the response of the PMHS in a high-speed impact to provide an approximation of the 6YO kinematics in a 40 km/h frontal impact. The article also discusses the limitations of the method, which failed to completely describe the kinematics of pediatric occupants.

Index Terms- Children, Biofidelity, Front impact, Occupant kinematics

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