C5 The Misuse of Daily Activities in Understanding Occupant Response in Motor Vehicle Collisions

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The goal of this presentation is to educate attendees regarding motor vehicle injury biomechanics.

This presentation will impact the forensic science community by providing understanding of injury parameters in motor vehicle collisions.

Over the last 20 years, there have been numerous papers published that report acceleration values on occupants and Anthropometric Test Devices (ATDs) in full-scale vehicle impacts, sled tests, amusement park rides, activities of daily living, and other events. These experiments often involve measurements at just a few locations, or even a single point, on the test subject or device. It has become common for investigators to take the values from these experiments and compare the forces on the vehicle's occupants to the accelerations on the vehicle or to the forces in other biomechanically dissimilar events, such as daily activities.

The U.S. National Highway Traffic Safety Administration (NHTSA) conducts numerous full-scale staged crash tests on a variety of vehicles and ATDs. While the NHTSA tests are typically conducted at higher speeds than observed in volunteer tests and the resultant kinetics are different, the kinematics can be compared biomechanically.

The data from these tests reveals that the measured maximum accelerations, loads, and moments for the head, upper neck, lower neck, chest, pelvis, left femur, and right femur are not the same. Additionally, the values vary in time and involve both minimums and maximums. Figure 1 is adapted from an NHTSA rear impact test on a 2000 BMW 328. The data is similar for hundreds of other rear impact tests. As the data demonstrates, the peak values for the upper neck, the lower neck, and the chest occur at different times. The data demonstrates that even if the acceleration values on the vehicle are known, the acceleration values on the occupant cannot be determined with accuracy and that one value on the vehicle does not describe the event in terms of the occupant.

Even if the change in velocity of a vehicle is known, Freeman has analyzed peak acceleration values of human subjects' heads as reported in 24 different studies.[1] Freeman showed that measured peak head acceleration values can vary by 600 percent for the same change in velocity under controlled experimentation.

The current literature has been reviewed and demonstrates that the use of a single acceleration value, or a dissimilar set of forces, does not provide the same resultant acting on a vehicle's occupant during a collision. Furthermore, this approach is not biomechanically relevant to understanding injury potential in a motor vehicle collision. The kinematic response of an occupant in a motor vehicle collision typically does not replicate the motion in a daily activity such as sitting in a chair or jumping off a stool.

In 1994, McConnell et al. demonstrated the fallacy of using a single value in their 1993 paper on volunteer rear-impact testing.[2] Their paper showed a constellation of resultant accelerations at the top of the neck. This demonstrated that a rear impact was not similar to a daily activity. McConnell described the motion in a rear impact as a "unique kinematic pattern."

In 1994, Szabo et al. conducted volunteer impact tests involving rear impacts.[3] Szabo demonstrated that the motions of the head, shoulder, wrist, and knee were all different. This study established that the angular displacement between the head and torso experienced by the volunteers was not repeatable and showed significant variation. This study showed that the peak lumbar accelerations were different than the peak cervical accelerations which were different than the head resultant accelerations. Additionally, the maximum and minimum values were not repeatable.

In 1998, Kroonenberg, et al., conducted 43 sled tests using nineteen subjects.[4] Significant variation was demonstrated in head center of gravity displacement, T1 displacement, head angle relative to T1, head lag, resultant head acceleration, head angular acceleration, T1 resultant accelerations, upper neck shear forces, upper neck axial forces, upper neck torque, and head restraint impact forces.

Numerous other studies have demonstrated both the lack of repeatability of acceleration values among subjects and variation in values applied at different locations on the body. The data and relevant physics demonstrate that the accelerations involved in activities of daily living cannot be compared to the accelerations involved in a vehicle crash.

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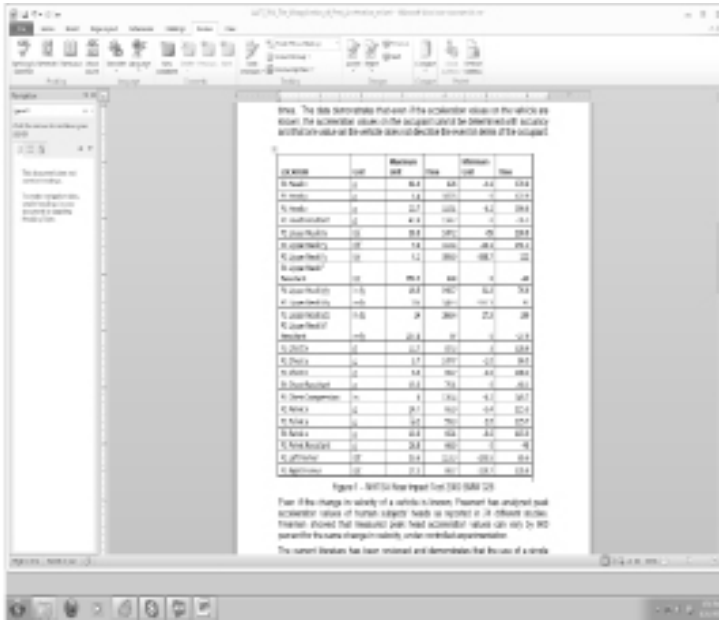

Figure 1. – NHTSA Rear Impact Test 2000 BMW 328

References:

1. Freeman M, graph provided in email September 6, 2008
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3. Szabo TJ, Welcher JB, Anderson RD, Rice MM, Ward JA, Paulo LR et al. “Human occupant Response to Low Speed Rear-End Impacts,” SAE Paper 940532, Warrendale, PA, 1994
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