D9 Biomechanics of Short Falls in Children

John D. Lloyd, PhD, 32824 Michigan Avenue, San Antonio, FL 33576*

After attending this presentation, attendees will comprehend the risk of traumatic head and brain injuries in a pediatric population associated with short household falls.

This presentation will impact the forensic science community by informing attendees of the mechanisms of head and brain injuries in pediatric populations and the risks associated with short falls.

Introduction: This study involved systematic assessments of falls from heights ranging from two to six feet onto varying flooring surfaces including concrete, linoleum, apartment-grade carpeting with underlay, Berber carpet with underlay, commercial carpeting without pad, and wood laminate.

Methods: A Child Restraint and Airbag Interaction (CRABI) -12 biofidelic mannequin (29.5in/22lb) and a Hybrid III three-year-old (37.2in/35.65lb) biofidelic mannequin were used during this systematic evaluation of short falls. A tri-axial piezo electric accelerometer, calibrated and certified by PCB® Piezotronics, was installed at the center of mass of the CRABI headform, in accordance with convention described in the **Society of Automotive Engineers** (SAE) J211 along with an InvenSense® tri-axial digital gyroscope. Still photography and high-speed video were used to record the fall sequences.

A height-adjustable platform was used to represent the fall surface. The platform has trap doors, which are held in place by electromagnets. Interruption of power to the electromagnets causes the sprung trapdoors to open instantaneously, thereby initiating the fall sequence. To investigate biomechanical mechanisms of injury associated with short falls in children, 175 trials were completed.

Data from the tri-axial piezo-electric accelerometer, mounted in the head of the biofidelic mannequin, were acquired at a rate of 10,000 samples per second using LabVIEW® software. Data from the Microelectromechanical System (MEMS) tri-axial gyroscope were acquired at 3,800Hz per channel. Raw data were displayed on-screen for visual verification. These data were analyzed using MATLAB®, including Fast Fourier Transform analysis to visualize the frequency spectrum of the data, followed by phase-less filtering using a 4th-order low-pass Butterworth filter with a cut-off frequency of 1650Hz. The peak magnitude value of head linear and angular acceleration components were derived and Head Injury Criterion (HIC) computed.

Results: Both the CRABI-12 infant representative and Hybrid III toddler representative exceeded injury threshold values from a fall height of only two feet (61cm), based on peak magnitude linear acceleration and HIC, which indicates that such short falls can cause substantial head/brain injuries in young children.

Conclusions: Results clearly show that household short falls events do exceed established thresholds of injury based on linear and angular accelerations. Furthermore, kinematic measures associated with household short falls are comparable to high-risk adult sporting activities, such as a typical boxing punch or a concussive tackle in college football. Based upon these evaluations and associated results presented herein, it is the expressed conclusion that household short falls present a very real and significant risk of head and brain injury among infants and toddlers.

Biomechanics, Pediatrics, Falls