D15 Biomechanical Evaluation of Shaking Impact Syndrome

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After attending this presentation, attendees will understand the risk of traumatic head and brain injuries in a pediatric population associated with shaking impact syndrome, a method often alleged in cases of abusive head trauma in young children.

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

Introduction: A biomechanical evaluation of shaken impact syndrome was performed to evaluate the risk of injury to an infant. Injury risk was measured as a function of linear and angular head kinematics of a biofidelic infant surrogate during a biomechanical recreation.

Methods: Two adult males performed the shaken impact and impact activities. A Child Restraint and Airbag Interaction (CRABI) -12 biofidelic mannequin, height 0.75m and mass 10.0kg, was utilized as the infant surrogate. A 500G piezo-electric tri-axial accelerometer was installed at the Center of Mass (CoM) of the CRABI headform, in accordance with the Society of Automotive Engineers (SAE) J211 along with a tri-axial digital gyroscope.

A number of conditions were explored using a height-adjustable test apparatus. These included: non-contact shaking; shaken impact (which implies a brief shaking episode, followed immediately by impact); and, impact only. For the shaken impact and impact-only scenarios, participants were instructed to impart gentle, moderate, and vigorous impacts on the infant surrogate. In addition, the act of dropping the mannequin onto the surfaces was explored for the impact-only technique. Surfaces impacted included a standard infant crib mattress, a standard changing table pad with cover, and a hard wooden tabletop. Mattress height was set at a standard bed height of 23 inches, whereas the changing mattress and tabletop were both studied at 35 inches, as measured from the floor. Both participants performed five repeated trials for each condition, for a total of 230 trials.

Data from the analog linear accelerometer was acquired at 10,000Hz, per channel, using LabVIEW™ and filtered in MATLAB® using a phaseless 4th-order Butterworth filter with a 1650Hz cutoff frequency, per SAE J211. Data from the gyroscope was recorded at 5,585Hz, per channel, with no filtering necessary for this digital sensor. Head linear acceleration and angular velocities were recorded, angular acceleration was derived, peak magnitude values were calculated, and Head Injury Criterion (HIC15) computed.

Results: Findings indicate that angular accelerations associated with intentional impact and shaken impact are typically below infant brain injury thresholds of 8,000-10,000rad/s2. The exception is vigorous impact against the changing pad or wood tabletop. It was also noted that dropping the infant surrogate onto the test surface produced injury risk similar to the moderate impact condition.

Conclusions: Across all events where sufficient rotational brain motion was recorded to produce significant brain injury, sufficient linear acceleration to cause skull fracture in an infant was also documented. Thus, considering the shaking impact or impact-only mechanisms, findings suggest that for there to be an underlying brain injury, a skull fracture is also likely.

Biomechanics, Pediatrics, Shaking Impact