D13 Biomechanical Evaluation of Head Kinematics During Infant Shaking vs. Pediatric Activities of Daily Living

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After attending this presentation, attendees will understand the mechanisms associated with traumatic brain injury in a pediatric population. Thresholds for injury will be discussed and compared against alleged forms of physical harm.

This presentation will impact the forensic science community by informing attendees that abusive shaking of infants has been asserted as a primary cause of subdural bleeding, cerebral edema, and retinal hemorrhages. This presentation seeks to compare linear and angular accelerations between infant shaking and pediatric activities of daily living.

Background: A biomechanical evaluation was performed to quantify kinematic variables associated with various infant shaking techniques, with comparison to a series of pediatric activities of daily living, as abusive shaking of infants has been asserted as a primary cause of subdural bleeding, cerebral edema, and retinal hemorrhages; however, manual shaking of various biofidelic mannequins has failed to generate the head kinematics believed necessary to cause these intracranial symptoms in the human infant. This study sought to compare linear and angular accelerations between infant shaking and pediatric activities of daily living. Additionally, injury risk as a function of known biomechanical thresholds of injury was determined.

Methods: Using InterSense^{Ô} sensors attached to the heads and torsos of two infant surrogates, investigators collected linear and angular motion data during resuscitative, aggressive, and gravity-assisted shaking as well as during various non-abusive activities normally experienced by infants, such as burping, rough play, etc. Tasks were performed by nine subjects, ranging in age from 20 years through 77 years and included two females and seven males. The researchers also collected data from a 7-month-old infant spontaneously at play in a commercial jumping toy. Raw data including orientation, angular velocity, and linear acceleration were acquired wirelessly. Using MATLAB®, data was filtered by a 4th-order Butterworth low-pass filter. Angular accelerations were subsequently derived, root mean square values calculated and Head Injury Criterion (HIC15) computed. Results were compared between the experimental conditions, against other biomechanical studies of shaking, and in contrast to accepted biomechanical thresholds of injury.

Results: In these experiments, the peak rotational acceleration generated, averaged across nine adult subjects, during aggressive shaking of the Child Restraint and Airbag Interaction (CRABI) -12 biofidelic mannequin (1,068rad/s2) were both consistent with the reports of prior biomechanical studies and, most interestingly, statistically undifferentiated from angular accelerations spontaneously generated and well tolerated by a normal 7-month-old infant at play in a commercially available jumping toy (954rad/s2). Furthermore, measures of head angular acceleration are substantially below scientifically accepted biomechanical thresholds of injury. Thus, shaking produces head kinematics that are clearly benign and well tolerated by normal infants, even if repetitive. If intracranial injury (SDH, EDH, SAH, DAI, concussion) is clinically presented, this data would indicate that shaking would not be part of its etiology.

Conclusions: This is the first scientific study of the effects of shaking-related shear forces on a human infant brain and, of course, there were no ill effects experienced by the infant.

Non-contact shaking appears to result in head kinematics that are well tolerated by normal infants, even if these rotational accelerations are repetitive, as experienced by the infant at play. This data would indicate that intracranial injury in an infant is unlikely to be the direct result of the linear and/or angular accelerations generated during non-contact shaking.

Biomechanics, Pediatrics, Shaken Baby