Head Injury Risk Associated With Falls From Standing in Children and the Influence of Joint Stiffness

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ABSTRACT

Child abuse is the leading cause of fatalities due to trauma in children less than four years of age. Objective information is needed to aid clinicians in distinguishing between inflicted and non-inflicted injuries.

The purpose of this project was to determine the risk of head injury associated with falls from standing for a 12-month-old child and to determine the effect of joint stiffness on injury risk. Falls with stiff joints are typically referred to as "matchstick falls," and are often presented by defense experts in child abuse legal cases as a worst-case scenario in which severe injuries can occur.

Falls were experimentally simulated using an instrumented ATD representing a 12-month-old child, suspended so that it was initially standing on a platform 9" above the ground. Falls were performed both with the ATD joints adjusted to manufacturer specifications and tightened to allow no movement. Five impact surfaces were tested: linoleum over wood, linoleum over concrete, carpet, playground foam, and wood. Ten drops were completed for each fall scenario. HIC values and angular accelerations (α) were calculated. A one-way ANOVA was conducted to determine the effect of joint stiffness on injury risk.

The maximum HIC was 261 which is well below the threshold of 390. The mean peak anterior-posterior and medial-lateral α were 7,346 rad/s^2 (95% CI: 7,041–7,651) and 2,002 rad/s^2 (95% CI: 1,668–2,335), respectively. All α values fell below reported thresholds for diffuse axonal injury and subdural hematoma.

Our findings suggest that head injury risk may be greater for falls with tightened joints (HIC $p=0.279$ but 4% increase for tightened joints; anterior-posterior α $p<0.001$). However, medial-lateral α was greater for normal joint stiffness ($p=0.029$), likely due to more out of plane motion in these falls. Results indicate that the risk of head injury is low for all tested scenarios.