

Concussive brain injury criterion development

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ABSTRACT

OBJECTIVE: Utilize measurable head impact parameters in athletic activities to quantify concussion risk for athletes

PROBLEM: Approximately 3.2 million athletes suffer traumatic concussive brain injuries, costing a total of \$51 billion/year. An injury criterion is needed to help protect at-risk athletes, especially football players and boxers, from potentially long-lasting neurological injury due to concussion.

METHODOLOGY: Head acceleration, angular acceleration, angular velocity, neck forces and neck moments were measured for a HybridIII ATD during 151 heavyweight boxer and calibrated pendulum impacts. Characteristic impact profiles were determined for various punches. Pendulum impacts were conducted with and without padding.

RESULTS: The hook had the lowest impact duration (0.0136s) and highest impact force (4289N), head acceleration (72.0g), and HIC (103.2). The oblique hook had the highest angular velocity (31.1 rad/s) and neck force (1652N). The cross had the highest neck moment (99.8N-m). Other results included maximum head jerk (2.48e5m/s³), angular acceleration (4379rad/s²), angular jerk (1.46e6rad/s³), energy transfer (43.1J), power developed (8458W), delta-V (3.65m/s), impulse (18.5kg-m/s), angular impulse (0.542kgm²/s), RMDM (2.33), CSDM (0.87) and DDM (1.0e-4). Padding the pendulum and head reduced peak acceleration by up to 72%, but peak angular acceleration remained unchanged, peak angular velocity increased by up to 40% and contact duration increased by up to 22%.

CONCLUSIONS: HybridIII head acceleration, angular acceleration, angular velocity, RMDM and CSDM levels measured in this study might produce concussive brain injury in athletes. Padding the head or pendulum did not appreciably reduce some peak head kinetic or kinematic measures such as angular acceleration and may increase concussion exposure by increasing contact duration. Football and boxing carry high risk of concussive brain injury, neurological deficits and death. Concussion in these sports may be related to combinations of impact magnitude, direction and duration.