The Effect of Overall Head Mass on Concussion Risk in Youth Football Players

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Abstract

There are between 1.6-3.8 million diagnosed sports related concussions in the United States each year, a majority of which come from American football. Of all age groups that play football, youth (ages 7-17) are at the greatest risk of suffering a concussion during play. Advancements in helmet design have introduced new padding schemes which have greatly reduced head injuries in the past 40 years; however, a majority of these advancements were aimed to protect athletes at the professional and collegiate levels. Increased technology employed in football helmets has more than doubled their weight in the last 20 years; yet the effect of this added weight on head stability in youth players is still unknown. This study sought to correlate the effect of increased head mass with concussion risk in youth football players. The study utilized a laboratory setting to investigate how varying the overall mass of a helmeted anthropomorphic test device (ATD) headform affects injury criteria values related to concussion risk.

The study utilized a pneumatic ram to impact a helmeted ATD headform at various speeds and locations. A 10-year old Hybrid III ATD headform was utilized along with three different youth helmets of varying weight and padding design. More weight was then added to further increase the overall head mass from a bare-head scenario. This was accomplished by placing a tungsten plate weighing .67 kg at the headform CG. The mass simulates approximately a 40% increase in helmet weight. The ATD headform was attached to a Large Omni-Directional Child (LODC) neck. The LODC neck was rigidly attached to a mass on roller bearings which simulated the mass of a 10 year old child. The helmeted headform was impacted at 3 different speeds: 2.5, 3.75 and 5 m/s; and, 5 separate locations: front, front-oblique, side, rear-oblique, and rear. These impact speeds and locations were designed to be representative of on-field collisions experienced in youth football. From each test, CG linear acceleration and angular velocity were *measured directly within the headform. Angular accelerations were then calculated using numerical differentiation.*

Results highlighted for side impacts show that increases in weight cause an average decrease of 5.6%, 5.1 %, and 2.6% for peak linear acceleration, peak angular acceleration, and peak angular velocity, respectively. In terms of concussion risk, Head Injury Criteria (HIC) is a common criteria used. With the additional mass added to the headform, HIC values decreased an average of 14%. Brain Injury Criteria (BrIC) is a more recently developed criteria focusing specifically on traumatic brain injury. The additional mass caused a 1.5% average increase in BrIC values; however, BrIC values were highly dependent on which helmet was used with certain helmets having increases as high as 20% when additional mass was added. Results display that for commonly used concussion prediction criteria such as HIC and peak rotational/linear acceleration, increases in overall head mass caused a decrease in concussion risk; however, for the newly developed BrIC criteria, increases in head mass predict an increase in concussion risk.