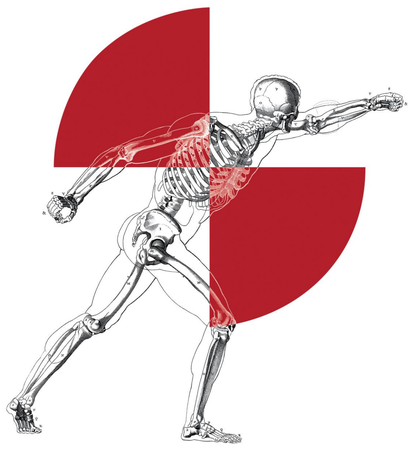

The Effect of Overall Head Mass on Concussion Risk in Youth Football Players

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INTRODUCTION

- There are between 1.6-3.8 million sports related concussions each year in The United States, many come from American football.[1]
- Of American football players, youth participants (ages 8-12) are nearly twice as likely to sustain a concussion than high school players and nearly 3 times as likely when compared to professional NFL players.[1]
- Increased technology employed in football helmets has more than doubled their weight in the last 30 years; yet the effect of this added weight on concussion risk in youth players is still unknown.[2]
- This study sought to correlate the effect of increased head mass with concussion risk in youth football players.
- A laboratory setting was used to investigate how varying the overall mass of a helmeted anthropomorphic test device (ATD) headform affects injury criteria values related to concussion risk, namely the Head Injury Criteria (HIC) and Brain Injury Criteria (BrIC).

MATERIALS & METHODS

- A pneumatic ram weighing 23.9 kg was used to impact a helmeted ATD headform at 3 speeds (2.5, 3.75, 5 m/s) and 5 locations (front, front-oblique, side, rear-oblique, rear).

Figure 1: Test setup for a rear-oblique impact of the Riddell helmet

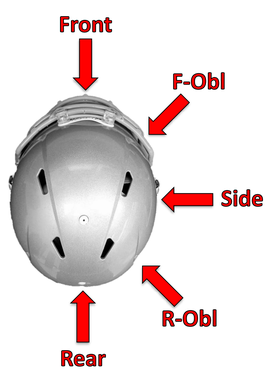

Figure 2: Impact locations, directed through the CG in the transverse plane

- A 10-year old Hybrid III ATD wore three different youth helmets of varying weight and padding design (see table 1). A human hair wig was placed on the ATD to simulate a realistic head helmet interface. The ATD headform was attached to a Large Omni-Directional Child (LODC) neck, a biofidelic neckform which allows for 90° of free rotation in the transverse plane. [3]

Table 1: Description of the 3 helmets used during testing

Helmet	Manufacturer	Model	Padding Type	Weight (kg)
	Schutt	Youth Air Standard III	Foam	1.49
	Riddell	Revolution Speed Youth	Foam + Air Bladders	1.73
	Xenith	X2E Youth	"Bonnet System" + Collapsible Air Bladders	1.87

- Additional weight was added to further increase the overall head mass from a bare-head scenario. 1-2 Tungsten plates weighing 0.33 kg each were placed at the headform CG.

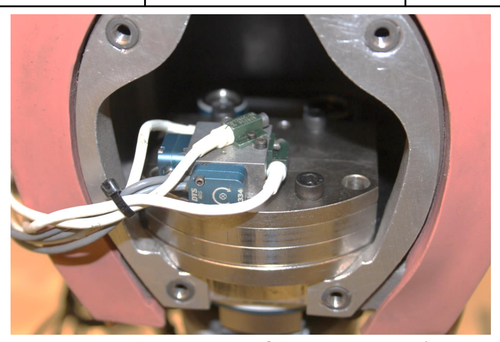

Figure 3: Depiction of 2 Tungsten plates within the headform, 0.66kg added

- From each test, CG linear acceleration and angular velocity were measured directly within the headform, this data was used to calculate HIC-15 and BrIC values, respectively.

RESULTS & DISCUSSION

- Averaging across all helmets, impact speeds and impact directions, a 0.66 kg increase in head mass caused a **3.5% decrease** in HIC values and a **2.3% decrease** in BrIC values.

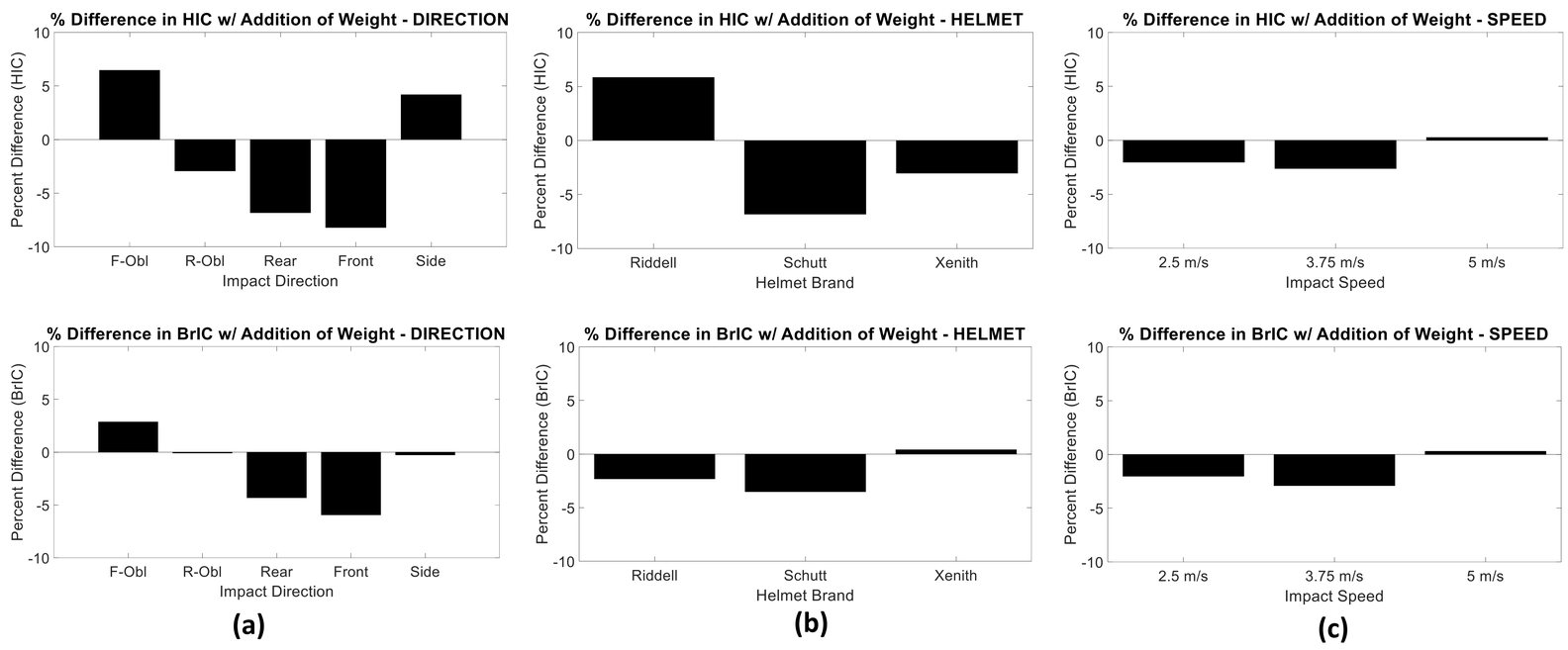

Figure 4: Percent differences of HIC and BrIC values caused by the addition of 0.66 kg to the ATD headform CG, Percent differences are averaged over (a) impact direction, (b) helmet brand, (c) and impact speed

- Increases in weight caused **increases in injury criteria values** for the F-Oblique impact direction. Increases in weight caused **decreases in injury criteria values** for Rear, and Frontal impact directions.
- Increases in weight caused **decreases in injury criteria values** for the Schutt helmet and lower speeds (2.5, 3.75 m/s), **slight increases in injury criteria values** were observed at higher speeds.

Table 2: Summary of statistically significant results, found using Lenth's Method for single observation experiments ($p \leq .05$)

Statistically Significant Treatment Effects								
HIC	Direction	Helmet	Speed	Speed * Direction	Helmet * Direction	**Weight** * Direction	**Weight** * Helmet	Helmet * Speed * Direction
BrIC	Direction	Helmet	Speed	Speed * Direction	Helmet * Direction	**Weight** * Helmet	Helmet * **Weight** * Direction	Speed * **Weight** * Direction

Note: Significant effects involving weight are highlighted for emphasis

- **Weight did not have a significant main effect**; however, it was involved in several significant interaction effects.

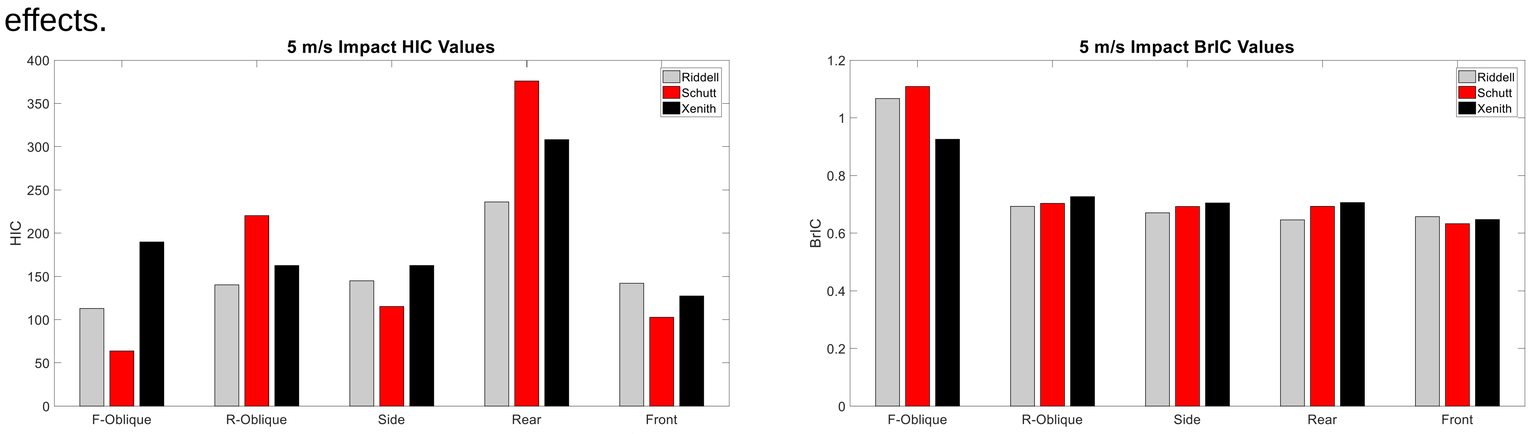

Figure 5: HIC & BrIC values for 5 m/s impacts categorized by impact direction and helmet brand

Table 3: Comparison of injury criteria values averaged over impact direction

	Helmet			
	Riddell	Schutt	Xenith	Max % Difference
BrIC	0.550	0.594	0.553	**8%**
HIC	86.2	89.7	98.4	**14%**

Table 4: Comparison of injury criteria values averaged over helmet brand

	Direction					
	F-Obl	R-Obl	Side	Rear	Front	Max % Difference
BrIC	0.799	0.522	0.538	0.481	0.489	**66%**
HIC	63.9	93.9	84.4	153.9	60.9	**153%**

- The Schutt helmet had the highest HIC value for rear impacts but the lowest HIC value for F-Oblique, Side, and Frontal impacts.
- On average, the Riddell helmet performed the best over all speeds and impact directions.

CONCLUSIONS

- Overall, increases in head mass did not significantly effect concussion risk based on HIC & BrIC injury criteria.
  - However, in Front-Oblique impacts, increases in weight correlated with increases in concussion risk for both HIC and BrIC criteria.
- Front-Oblique and Rear impact locations had significantly higher BrIC & HIC values for all helmets, respectively.
- Helmet-to-helmet comparison was highly dependent on the impact location being tested.
- Future work includes repeat testing of vulnerable locations (Front-Oblique & Rear), eccentric impacts, and the addition of weight not centered at the headform CG.

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