REDESIGNING FOOTBALL HELMETS TO REDUCE CONCUSSION RISK: RETURN TO THE LEATHERHEADS?

Austin Nakatsuka, Loren G. Yamamoto, MD, MPH, MBA, FAAP, FACEP
Department of Pediatrics, University of Hawaii John A. Burns School of Medicine, Kapiolani Medical Center For Women And Children

Background

In American football, players at all levels of competition have sustained significant head injuries.

CURRENT FOOTBALL HELMET DESIGN-The current design has a hard, rigid exterior with a padded interior.

HELMET HITS-Intending for a harder hit, players may use their helmets as a striking force to hurt other players. This may injure both players involved. Consequently, recent penalties have been enforced against this practice.

LEATHER HELMETS-In former days, football helmets were made of leather. Penalties were not necessary for "helmet hits," presumably because these helmets did not have the same hard strike potential as the current design. Players may have had less incentive to use their helmets as a striking force.

NEW DESIGN- New helmet designs have focused on reducing the injury potential of the helmet, but most of the efforts have focused on modifying/improving the interior of the helmet.[1] Helmet designers focusing on impact reduction are currently in need of more data to create safer helmets.[2] While internal helmet design can reduce the potential for injury, the hardness of the outer portion of the helmet continues to promote its use as a striking force. Softening the contact surface reduces the incentive to use the helmet for this purpose.

Significance

The National Football League (NFL) has been conducting studies aiming to reduce concussions. Riddell, the official football helmet manufacturer of the NFL, is gathering statistics to assess how helmet design can be modified to reduce head injury. This study provides data on helmet design modification to reduce potential for head injury.

Hypotheses

Our hypothesis is that adding a soft cushion layer to the exterior of the helmet will reduce the impact potential of the helmet.

<u>This potentially has two benefits:</u>

1) Additional head protection

2) Eliminating the external hardness of the helmet removing the incentive to use the helmet to inflict a hard hit on opposing players

Methods

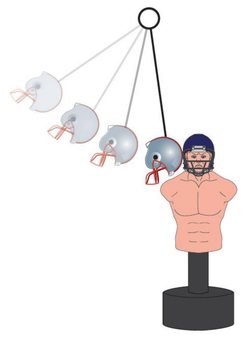
The study was an experimental design with no human subjects.

HITS Helmet

A product made by football helmet manufacturer Riddell (Elyria, OH) measures complex impact characteristics via accelerometer-based sensors built into the helmet. The helmet is equipped with Riddell's patented Head Impact Telemetry System (HITS) technology that records the location, magnitude, duration and direction of up to 250 impacts per session. Data downloads wirelessly to a desktop or laptop computer programmed with Riddell's Red Zone Software.

Mannequin-Helmet

The HITS helmet was placed upon a heavy duty head and torso mannequin used for boxing practice (Century BOB, Century MMA) to mimic the degree of neck movement that would normally occur with a helmet strike.

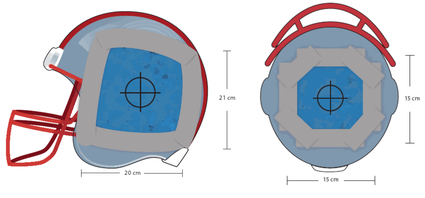


Pendulum Helmet

The helmet was struck with a reproducible force by swinging a standard helmet (Size Medium, Riddell) with internal weights (two 3-lb. barbells) from a nylon rope attached to a fixed height. This "pendulum" model simulates a standard impact from the helmet of an opposing player to the HITS helmet.

External Foam Layer

Pieces of 1.3 cm polyolefin foam were applied to the exterior surfaces of the helmets using fixed amounts of duct tape.



HITS Helmet (on mannequin) Normal Helmet (on pendulum)

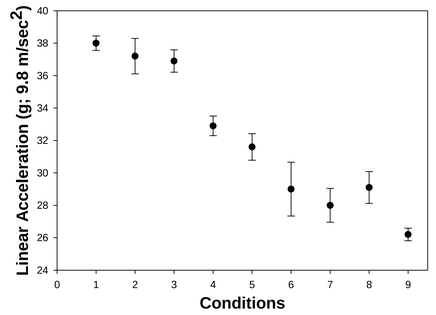
Results

All impact severity measures were significantly reduced with the application of the external foam. The graphing points are means +/- one standard error.

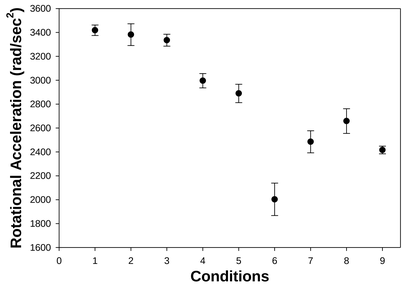
Conditions:
1)0 layer HITS, 0 layer pendulum
2)0 layer HITS, 1 layer pendulum
3)1 layer HITS, 0 layer pendulum
4)0 layer HITS, 2 layer pendulum
5)1 layer HITS, 1 layer pendulum
6)2 layer HITS, 0 layer pendulum
7)1 layer HITS, 2 layer pendulum
8)2 layer HITS, 1 layer pendulum
9)2 layer HITS, 2 layer pendulum

HITS=HITS helmet on mannequin
Pendulum=normal helmet on pendulum rope
Layer=Piece of 1.3 cm foam
(Up to 2 layers of foam were added to each helmet)

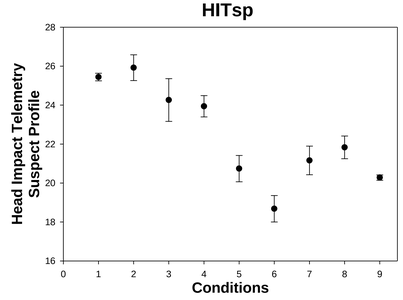
Linear Acceleration



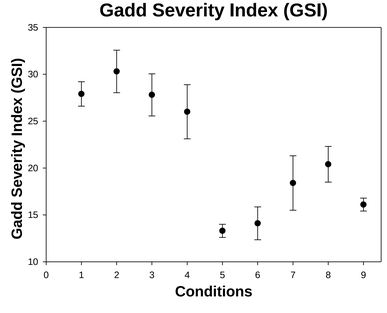
Rotational Acceleration



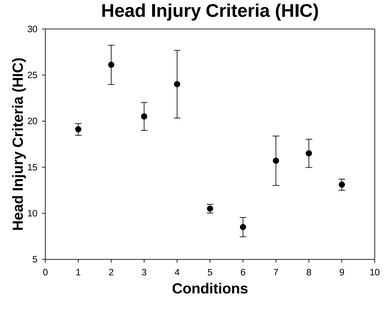
HITsp



Gadd Severity Index (GSI)



Head Injury Criteria (HIC)



<u>Impact Metrics</u>
Linear Acceleration: Peak linear acceleration of the head center of gravity. Measured in g units.
Rotational Acceleration: Peak rotational acceleration of the head center of gravity. Measured in rad/s^2
Gadd Severity Index (GSI): Head impact severity metric that relates injury to head acceleration over time. Measurement is unit-less
Head Injury Criteria (HIC): Head impact severity metric that relates injury to head acceleration over time for a discrete time frame (15 ms). Measurement is unit-less.
HIT Suspect Profile (HITsp): A weighted combination of inputs (peak linear acceleration, GSI, HIC, impact location) used as a single impact metric to predict concussion. Measurement is unit-less.

Limitations

- **Inability to cover entire helmet with foam covering.** This may have limited dispersion and dampening of striking forces over a larger area.
- **Low impact potentials.** The pendulum model was not sufficient to produce an impact potential large enough to reach concussion threshold levels (98g).[3]
- **Few angles of impact.** Data was taken solely from strikes to the left side of the HITS helmet.
- **No human subjects.** Although the mannequin was representative of a human subject in size and form, the material composition does not match that of a human body.

Conclusions

- Our results support the hypothesis that adding an exterior foam layer to a football helmet reduces the injury potential for concussion.
- Increasing the number of exterior foam layers to a football helmet may decrease impact magnitude and further reduce injury potential for concussion.
- Striking helmets that both have exterior foam covers results in lower impact magnitudes than striking helmets where only one helmet has an exterior foam cover.

Future Studies

- **More Angles of Impact.** The HITS helmet will be struck in more areas, including the back and right side.
- **Increasing Force of Impact.** Modifications to the pendulum model or a new model will be developed to increase force of impact to concussion threshold levels (98 g).
- **Heavy Hand Impacts.** Current or former football players will strike the HITS helmet with their hand, measuring impact from a celebratory "head slap" that often occurs during games.
- **Different Types of Material.** Other dampening material such as cloth, leather, or rubber will be used as exterior covering.
- **Complete Covering of Helmet**. A fitted exterior wrapping will be made to cover the entire helmet.
- **Intent of Impact.** Surveys will be taken of football players to find out if they intentionally try to strike opponents with their helmets.

Acknowledgements

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