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.

HEAD 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. This potentially has two benefits:
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 HITS helmet was struck with a reproducible force by 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.

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

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 (38 g).3
- Few angles of impact. Data was taken solely from strikes to the top 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.
- Stirling helmets that both have exterior foam covers results in lower impact magnitudes than stirring 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 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 (38 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 damping materials such as cloth, leather, or rubber will be used as foams.
- 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
This work was supported by a grant from the Hawai‘i Pediatric Association Research and Education Foundation and the University of Hawai‘i Department of Native Hawaiian Health. We thank Dr. Bruce Shintani for his assistance in technical support and Ms. Kaylee Arai for her assistance in graphic design.

References
4) http://meetinthelobby.com/new
7) http://www.nfl.com/player/helmet.html

Impact Metrics
- 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/s²
- 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.