High-tech football helmets: lifesavers, or just a Hail Mary?

By Jason Dearen | May 22, 2012, 3:00 AM PDT

Special Feature: The Safety Issue

Vin Ferrara felt woozy. He was wearing a football helmet and his limbs were splayed on the field's turf, this much he knew. He had just taken a jarringly hard hit to his chin that sent his world spinning. The collision, which happened during a kick return, was much different than the other bone-crunching assaults that he'd endured so many times before as a quarterback. As Ferrara staggered over to the bench and to talk to his coach, he discovered that his mouth no longer worked.

He remembers the blinking lights and colors of the ambulance that came for him. The ride, not so much. At the hospital, he was diagnosed with a concussion. He was in the seventh grade.

After that day in 1985, Ferrara four more times in his youth football career had what he now refers to as "concussive episodes" — impacts that made his head foggy. Like any kid involved in a tough-guy sport, he played through it. It's the credo of football that millions of young men have lived by: get your "bell rung," then "walk it off."

It didn't end there. Ferrara continued to take his licks on the field as starting quarterback for the Crimson at Harvard University in the 1990s. The unsurprising result: more injuries, more surgeries. For this brainy jock, a lifetime of head injuries posed a puzzle that needed solving — and a chance to use his mind to improve the sport he loved. Upon graduation, Ferrara enrolled in medical school at Columbia University with plan to become an orthopedic surgeon.

Then, an epiphany: while in the bathroom, he spied a squirt bottle sitting in his medicine cabinet. Ferrara took it off the shelf and gave it a squeeze. The resilient, load-reducing nature of the bottle's walls gave him an idea: what if there's a better way to cushion a football player's head before impact? Ferrara used the inspiration to develop what he calls "the shock bonnet," a system of black, air-filled, marshmallow-like pads with a small hole in the top that fit inside a football helmet.

"Really, what we've created is a helmet that has a collection of air cell shock absorbers, like mini air bags in your helmet," said Ferrara, who is now the founder CEO of Xenith, LLC, now one of the fastest-growing helmet makers thanks to its successful design innovations. "It minimizes how the head moves. It's like how an air bag brings a driver's head to a more gradual halt after a collision, our helmets help reduce the head's sudden movement."

A recent study by researchers at Virginia Tech found that pee-wee players, aged 7 to 8, experience surprisingly high levels of impacts on the field, especially during practice. Concussions in the NFL, collegiate and high school levels have been well-studied, and new helmets like Xenith's are making athletes at all levels safer than ever. Xenith's X1 helmets are now worn by high-profile National Football League players like Ray Rice and Dallas Clark, and have been used by more than 100,000 athletes, from youth to the pro levels.

While helmets are being designed larger and more protective, concussions still occur regularly. It's unlikely that they will ever be eliminated completely. Indeed, helmet technology has come a long way since the leather caps worn by old-time footballers. But helmet makers like Ferrara believe their products can only do so much to keep players safe in a culture that glorifies the big hit.

"We must end the gladiator mentality that permeates football," Ferrara wrote in a 2010 paper entitled, "Building the Enlightened Warrior." "In ancient Rome, a gladiator was defined as a professional combatant or a captive who entertained the public by engaging in mortal combat. While this sounds about right in describing football these days, at least at the highest levels, this must come to an end."

Scientists who study concussions in an effort to drive new helmet technologies say modern helmets like Xenith's utilize the latest data available, but that far more is not known than is known about how the head and brain react during certain collisions.

The science of big hits

Data are being collected now on an increasing basis using the "HITS" system, short for the "Head Impact Telemetry System." Developed by helmet maker Riddell and in use at Virginia Tech and other football programs at the high school and pee-wee levels, HITS measures the frequency and severity of collisions by placing sensors inside players' helmets. These sensors send data to computers, which create charts and reports that can help guide both helmet design and on-the-field behavior.

But understanding the biomechanics of concussions is still a work in progress.

"There are two kinds of forces that are at play in concussions: linear acceleration — or straight-line acceleration — which is like what happens when a fighter lands a jab on another fighter," said Mike Oliver, executive director of the National Operating Committee on Sports Athletic Equipment (NOCSAE). "Then there's rotational acceleration, when the brain twists not back and forth in a linear way, but more like when a fighter lands a roundhouse hook and the head is rotating."

Oliver's organization is responsible for developing testing standards for sports helmets and it provides grants to researchers to help better understand head and neck injuries. For decades, the research funded by NOCSAE has led to more rigorous helmet standards and has improved quality dramatically.

Oliver said modern helmets like Xenith's and Riddell's are excellent at protecting against linear acceleration, because its effect on the head and brain is better understood. But science has not unlocked a similar threshold for rotational acceleration, leaving a big blank spot in the data that, if solved, will drive future helmet design.

"We've seen players with a slow rotational acceleration still get a concussion and others with a high acceleration get no concussion," Oliver said. "That makes it complicated from a helmet standpoint because most concussions and head hits in football are some combination of linear and rotational acceleration. It's never purely one or the other."

When football was fatal

Ferrara's Xenith helmets are, in a way, just the latest reaction to what happened in 1968.

That year, 32 football players died in the United States during organized games from head injuries, mostly broken or crushed skulls, according to NOCSAE. At the time, interest in football was growing quickly, fueled by television and increased media attention, which brought more athletes to the field and made the game tougher and faster than ever.

In response to the increase in fatalities on the field, sporting officials turned to science and data. With limited research funds, NOCSAE, the organization today led by Oliver, developed the first safety standards using data from drop tests, in which a helmet is placed on a synthetic head and dropped on different areas from 60 inches. In its first round of tests on helmets in 1975, 84 percent of the helmets failed to qualify under its standard.

The result set off a shockwave in the sports equipment industry and the first significant wave of helmet safety innovation, spurred by NOCSAE's standards. In 1978, the NCAA mandated helmets used by players be certified, and two years later the National Federation of State High School Associations required them.

It wasn't until 1990 that zero deaths were recorded. This statistic has been tracked since 1931.

Data is king

While Xenith's shock bonnet has offered a different take on modern helmet technology, Riddell's HITS data-gathering system is changing the way football coaches and players think about head injuries.

Helmet makers agree that they can only do so much with design innovation. If rule changes do not reduce the number of head-to-head hits on the football field, no helmet will ever be 100 percent effective.

But analysis of how hard and how often big hits cause concussions is already greatly influencing Riddell's new helmet design, said Thad Ide, senior vice president for research and product development.

"The new Riddell 360's designs are based in large parts on HITS data," Ide said. "We've been identifying more of the concussion-causing impacts on the front portion of the helmets, and we like to make design choices based on firm data."

Virginia Tech recently created a star rating system for football helmets based on the biomechanic HITS data, giving a five-star rating to the best helmets. Four-star helmets are "very good" under the system. The ratings are based on comparative impacts tests using data from HITS and other biomechanical equations.

"We utilized over 1 million measured head impacts to quantify the impact exposure and concussion risk for the development of the STAR equation," Steve Rowson, assistant professor at Virginia Tech in the School of Biomedical Engineering and Sciences, said in a statement after the results.

Riddell's Revolution Speed helmet, which features something that the company calls "concussion-reduction

technology," retails for about $250. It also features air-filled padding and a polycarbonate shell. Some safety experts have criticized the company's claims that the Revolution reduces concussions more than its previous helmets — especially given the lack of understanding about the effects of rotational acceleration.

Xenith's helmets address rotational forces in a unique way, which is why its products have caught the attention of scientists like Oliver who study concussions. The helmet's "shock bonnet" is detached from the shell, unlike traditional padding, allowing it to "shear in a scalp-like fashion, thereby minimizing the rotation of the skull," Ferrara said.

Data may be driving helmet design, but it's also beginning to drive on-field behavior, which many agree will be as crucial to eliminating severe head injury as head gear, if not more.

"The data has changed the way teams behave," Ide said. "In the Ivy League, Dartmouth University and Brown are HITS users and have changed the way practice is scheduled. They realized players were exposed to unnecessary head impacts during practices, so they eliminated full-contact practices during the regular season."

And this ongoing research will improve safety across all sports. The data gathered through HITS is being collected in a National Impact Database that will eventually cover many sports.

Yet with a dearth of knowledge about the precise link between rotational head acceleration and concussions, more innovation and design is still possible.

"There's a lot of research left to be done in biomechanics of concussions," Ide said. "The HITS system does measure rotational acceleration, but it's just scratching the surface."

Xenith's Ferrara — whose work has been guided by his passion for reducing head injuries in the game he loves — now has an even more personal stake in making football a safer sport.

"My son plays football now, and I tell him not to use his head to hit people," he said. "Some say helmets aren't the problem — car accidents are not caused by cars but by people's behavior.

"Imagine years from now: with changes to the game implemented and better equipment, football can be safer. It doesn't have to be the blood sport it's become over last few decades."

Photo based on the original by John McStravick.

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