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Small tech tackles concussion syndrome with MEMS helmets

By Garry Kranz
Small Times Correspondent

Jan. 13, 2004 – By the time the 2004 football season rolls around, scientists at Virginia Tech expect small technologies to help them better understand how gravitational force triggers concussions and other head trauma.

Researchers say the key to unlocking those secrets lies in data gathered from specially designed helmets equipped with MEMS accelerometers. Selected Virginia Tech football players wore the special headgear during the 2003 season.

The MEMS-equipped helmets measure the force of gravity at which a player's head accelerates after receiving a blow. The aim is to determine the level of force that precipitates severe head injuries, especially concussions. Six MEMS sensors are spring-loaded inside the helmet to record the severity and frequency of individual head impacts in real time, thus creating an "impact history" for each wearer.

The helmets are part of Head Impact Telemetry System, or HIT System, produced by Simbex of Lebanon, N.H. The company specializes in biomechanical feedback systems.

Virginia Tech used Simbex's telemetry-based system to gather data on more than 3,300 head impacts sustained by players during both practices and actual games. A preliminary analysis of the data collected thus far has surprised researchers. It shows that players on average sustain blows to the head up to 50 times a game, with the average force of a blow about 40 times the force of gravity (40g).

Some blows per game are more than three times as high, up to about 120 G's – roughly equivalent to that of severe auto crashes. About one or two such high-impact hits occur in every game, said Stefan Duma, director of the Center for Injury Biomechanics at Virginia Tech.

"We were surprised to learn that the threshold (for impacts) that we thought was good was probably too low," said Duma. "The impacts were greater in number and in magnitude that we had thought."

Each head impact is recorded by the sensors and sent via a microprocessor, developed by Shelbourne, Vt.-based Microprocessor Designs, to a wireless radio-frequency transceiver, which in turn communicates with a sideline receiver hooked up to a laptop computer. The laptop has a user interface that gives medical staff and researchers a three-dimensional view of the location and magnitude of each impact. The laptop runs special software that uses algorithms for processing the data and storing it in a local database for transfer to a central database later.

The key to the system is the MEMS sensors, which are embedded neatly inside the shell of the football helmet. Produced by Analog Devices Inc. of Norwood, Mass., the accelerometers provide instant feedback that help sideline staff determine if a player may have suffered a hit severe enough that he ought to be removed from the game for examination, said Jeff Chu, research engineer for the HIT System.

"The major goal is to pinpoint causes of concussion. The current state of the art for understanding concussion is very limited because of the inability to collect a lot of data on different players on the field, which is really the key point," Chu said.

Football, by contrast, provides an environment that is "ripe for getting a lot of impacts and understanding how these impacts are distributed," Chu said.

About 50,000 people die from traumatic brain injury (TBI) in the United States each year, according to the National Center for Injury Prevention and Control. Another 80,000 to 90,000 are permanently disabled as a result of TBI. Costs associated with such injuries total $37 billion.

The National Football League initiated studies several years ago into the nature and causes of concussion following the early retirements of quarterbacks Troy Aikman of the Dallas Cowboys and Steve Young of the San Francisco 49ers. Both men called it quits after sustaining numerous concussions.

Virginia Tech was the first school to use the HIT System, and its interest stems from its own research into biomechanics and bodily injury. Duma said Virginia Tech wants to expand its use of the technology to include more players in 2004, along with better plans for evaluating the data clinically. "We can look at that data and see how it could be used, such as how equipment could be modified," said Duma.

Chu said several other major universities have expressed interest in the HIT System, although he declined to name the schools. Simbex focused first on colleges and university gridiron players, but eventually the company's business plan calls for making inroads into the youth sports market. "Our goal is to get to the youth market, so to do that we need to substantially decrease our development and manufacturing costs," Chu said.

Simbex sells the HIT System for about $2,000 per unit, including the helmet, hardware and software. Protective equipment makers present one potential market. Other applications include medical diagnostics and sports-governing bodies.

After completing trials with football teams, Simbex plans to push its technology to other helmeted sports such as hockey and lacrosse. The company's other products include rehabilitative prosthetic devices and an in-bed exerciser for sufferers of sarcopenia, a disease which wastes muscle mass.

Simbex received about $850,000 in grant funding from the National Institutes of Health to develop the HIT System. Right now, however, the system is limited to monitoring impacts based on preset thresholds. "The system isn't predictive right now, but that's our eventual goal," said Chu.