



▲ A child prepares to participate in football practice while wearing a youth helmet—a scaled-down adult helmet—chinstrap in place and mouthguard dangling.

Much attention has been paid recently to the long-term effects of concussions suffered by former National Football League players. But it's not just adult players who face the risks of playing football—particularly head, neck and spinal injuries. In 2011, 21 high school and youth football athletes suffered brain and cervical spine injuries with long-lasting damage—the highest number of brain injuries on record. This translates to an injury rate of 0.51 per 100,000, which may seem low, but is up nearly 50% from 2010.* Considering the 4.1 million U.S. high school and youth players at risk, it's a serious matter.

GRIDIRON PROTECTION:

Unique research team works to improve football safety

Efforts are being made, for players of all ages, to raise awareness about the risks of concussions and cervical spine injuries, and to change rules for improved safety during practices and games. But little is known about what measures are needed to protect young players. There are significant disparities between adult and youth players, such as neck strength, impact energy and head anthropometry, which have not been adequately accounted for, particularly in the development of youth helmets.

A research team at Cleveland Clinic, which received an OREF Prospective Clinical Research Grant in Spine Care, made possible with support from Medtronic Sofamor Danek, USA, plans to quantify these disparities. The team, which includes investigators from several Cleveland Clinic Health System centers, hopes its research will lead to new helmet design strategies and other forms of protection for youth athletes, and contribute to youth protective equipment-testing standards and sideline assessment tools to mitigate trauma. The team is one of several research collaboratives contributing to the work of the Clinic's new Concussion Center, directed by **Jay L. Alberts, PhD**, who holds the Edward F. and Barbara A. Bell Family Endowed Chair at the Lerner Research Institute.

YOUNG PLAYERS REQUIRE DIFFERENT PROTECTION

Edward C. Benzel, MD, principal investigator for the project and chair of the Cleveland Clinic Department of Neurological Surgery, said youth helmets are adult helmets that have been scaled down to fit a child's head. These helmets, which replicate protective features based on adult skull fracture risk, likely do not address potential risks to the developing skull, brain, neck and spine of youth players.

* According to the National Center for Catastrophic Sports Injury Research at the University of North Carolina



▲ A high school ice hockey player takes a break from practice while chewing on his Intelligent Mouthguard. The high-definition camera attached to the player's helmet captures key impacts to correlate with data collected on the Intelligent Mouthguard.

Adam J. Bartsch, PhD, PE, a traumatic neuromechanics engineer and director of the Clinic's Head, Neck and Spine Research Laboratory, gave the example of a 50-pound child wearing a 4-pound helmet.

"If you watch collegiate or professional football, you might see a 300-pound athlete wearing a nearly identical 4-pound helmet," Dr. Bartsch said. "We want to understand how current adult helmets have been designed, and how that design should be modified for a child player. We need to pay particular attention to helmet weight, center of gravity, moment of inertia and rotational impact protection."

Dr. Benzel added that younger players may not generate enough momentum to cause catastrophic injury, but need more protection against midrange injuries. A helmet that is lighter and optimized ergonomically would place less stress on the head and cervical spine.

The team will compile data—both on the football field and in the lab—using actual players as well as crash test dummies and robots. They will select football players who are 13 to 22 years old and who play any number of positions, from running back to linebacker.

First, the researchers will test the necks of youth and adult players for strength, stiffness and range of motion. On the field, they will use a relatively new device, called an Intelligent Mouthguard, that the team developed in a prior study.

"The Intelligent Mouthguard is a data-acquisition tool we developed to document the range of acceleration, rotation, kinetic energy and

OREF AWARDS \$1.2 MILLION IN CLINICAL SPINE RESEARCH GRANTS

In July, OREF awarded five Prospective Clinical Research Grants in Spine Care totaling \$1.2 million, made possible with support from Medtronic Sofamor Danek, USA. Grant recipients were selected from a field of more than 75 through OREF's competitive peer-review process, which is modeled on that used by the National Institutes of Health. Selection criteria included the potential to change clinical practice and provide better patient care.

In addition to the grant given to Dr. Benzel as principal investigator of the study on reducing the risk of injury for football players, four spine research grants were awarded to:

Charles Fisher, MD

The Epidemiology, Process and Outcomes of Spine Oncology (EPOS): A Prospective Database to Answer Three Key Clinical Questions

Stefan Parent, MD, PhD

Prospective Multicenter Analysis on 3D Factors Involved in the Decision to Perform a Selective vs. Nonselective Fusion in AIS

David W. Polly Jr., MD

Minimize Implants Maximize Outcomes (MIMO) Clinical Trial

John K. Ratliff, MD

Developing a Patient-centered Clinical Tool for Assessment of Risk of Perioperative Complications in Spine Surgery Procedures

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▶ A high school ice hockey player is fitted for an Intelligent Mouthguard. The dots on his face assist in registering Intelligent Mouthguard sensor locations to anatomical reference points for increased head impact calculation accuracy.

▶▶ A laboratory assistant measures head anthropometry of a youth football player. These measurements will be correlated to neck strength in order to develop helmet design considerations for youth players.



momentum affecting the player's brain, neck and spine," explained Dr. Bartsch. "It can be worn by players of all ages and represents one way we are working to advance the state of the science at all levels—from the 7-year-old to the professional athlete."

Players will wear the mouthguard during practices and games. The device will capture data from every collision that exceeds a significant head impact threshold—from 10 to 20 g-forces. In the lab, the researchers will use the data to attempt to replicate the on-field collisions, employing a variety of collision techniques with crash test dummies and robots. Twenty-one helmet styles currently used by youth and adult players will be tested to determine static and dynamic physical properties, such as mass and force-deflection response.

SOLUTIONS REQUIRE MANY DIFFERENT PERSPECTIVES

Athletes who experience head, neck or spinal injuries receive a wide range of diagnoses, including concussion, skull fracture, spinal cord trauma, depression and neurocognitive impairment, and diseases such as Alzheimer's and Parkinson's. Depending on the diagnosis, a host of clinicians—sports medicine physicians, orthopaedic surgeons, neurosurgeons, neurologists, athletic trainers and others—may be called upon to treat the athletes. Dr. Benzel said his and other Cleveland Clinic teams that are dedicated to collaborative principles are uniquely positioned to engage in the care of these patients, and to conduct research that is designed to mitigate injury via advances in protective technologies.

Elaborating on the team concept as it has pertained to spine care, Dr. Benzel recalled that when he arrived at Cleveland Clinic in 1999, orthopaedic spine surgeons and neurosurgeons worked collegially but not as a formal team. Eventually, a small interdisciplinary team was formed that included neurosurgeons, orthopaedic surgeons and medical spine specialists. That team has evolved to encompass even more specialists, including clinical psychologists. Dr. Benzel said this model includes a shared philosophical and operational commitment that extends to working under the same budgetary umbrella—an approach difficult to achieve in most academic environments. Such multidisciplinary teams are a rarity today, he said, but they are common at Cleveland Clinic and contribute to better care, and facilitate innovative thinking, resulting in an enhanced ability to address complex problems like concussion and sports-related spine trauma.

"We have the same pocketbook, the same administrator, the same research laboratory," said Dr. Benzel. "We all work together; we sink or swim together. This defines the essence of a true team."

Dr. Alberts agreed. "At its best, true teamwork makes an exponential contribution to patient care. The collaboration that underlies the work that Drs. Benzel and Bartsch are doing under the OREF grant will be magnified as their findings and those of other Cleveland Clinic teams stream into the Concussion Center knowledge base."

The Concussion Center's team members apply fundamental principles and newly acquired information to clinical care algorithms and research strategies that are designed to protect and improve the care of athletes involved in



◀ The Intelligent Mouthguard is tested on a crash test dummy headform via a robotic testing arm in the Cleveland Clinic Head, Neck and Spine Research Laboratory.

contact sports, and to move research and innovation forward along meaningful and productive pathways.

In that spirit, Dr. Benzel said he hopes that the OREF-supported research will not only lead to immediate benefits—helmets that are better suited for young players—but also that it will lay a foundation for new strategies for diagnosis and treatment of on-field injuries. If so, the team’s efforts would benefit the spectrum of clinicians who treat patients with sports-related head, neck and spine trauma.

“The facilitation of diagnosis and treatment via better tools and more sophisticated algorithms combined with enhanced protectivity is our ultimate goal,” Dr. Benzel said.

While he credits OREF for providing essential funding to launch this study, Dr. Benzel said his team also seeks funding from concerned citizens, grants and other philanthropic sources. His team also tries to share its research with the general public as often as possible.

“We’re anxious to spread the word about what we’ve found, and solicit input from players, coaches, parents and administrators,” he said. “I see huge potential with this research to develop technologies that provide information for other physicians, and to improve safety for all athletes, but particularly for the most vulnerable of all— young athletes in their formative years.” ■

All photos, pages 4-7, courtesy of Cleveland Clinic.

NFL AND ITS PLAYERS

RESPOND TO CRITICISM BY DEDICATING \$100 MILLION TO RESEARCH

Former football players nationwide—from the Pittsburgh Steelers to the Oakland Raiders—are criticizing the National Football League for failing to protect them from the long-term risks of concussions. Their efforts may not only change the game, but also enhance research opportunities for those investigating head, neck and spinal injuries.

As of this writing, more than 2,000 former players are plaintiffs in lawsuits against the NFL, accusing the organization of deliberately concealing information about the effects of repeated head injuries. Media coverage of the accusations has been frequent, particularly after former Chicago Bears defensive back Dave Duerson committed suicide, leaving a note asking that his brain be studied. Other plaintiffs complain of experiencing depression, early-onset dementia and Alzheimer’s disease.

The NFL said the accusations have no merit, and contends it has worked to advance understanding and treatment of concussions. Now, as part of its most recent collective bargaining agreement, the NFL and its players committed \$100 million over the next 10 years to medical research. The majority of the funding will go toward brain injury research. An NFL spokesman said they plan to announce allocation plans later this year.

In September, the NFL announced a grant of \$30 million over three years to the National Institutes of Health. The NIH grant is intended to investigate chronic traumatic encephalopathy, concussion management and treatment, and the relationship between traumatic brain injury and late-life neurodegenerative disorders, particularly Alzheimer’s disease. Asked if this grant was part of the previous pledge, the same NFL spokesman said the players association hadn’t yet allocated any portion of the \$100 million commitment.

The prospect of long-term support excites researchers such as **Edward C. Benzel, MD**, chair of the Department of Neurological Surgery at Cleveland Clinic.

“For every ounce of data we have, we’ve got a pound more of ideas, but we need more researchers, and more dollars to pay those researchers,” Dr. Benzel said. “This field really needs more resources to help it move forward. Not just with us, but with institutions around the country.”