

REPORT

Spring 2004

National Operating Committee on Standards for Athletic Equipment, a Non-Profit Corporation

New and Ongoing NOCSAE Research Studies

 t the Winter 2004 NOCSAE Meeting, the Board voted to fund the following proposal:

“Acute effects and recovery after concussion in high school athletes: A clinical and functional magnetic resonance imaging (fMRI) study.”

Michael McCrea, Ph.D., ABPP, of Waukesha Memorial Hospital, Waukesha, WI is the Principal investigator and his co-investigators are Thomas Hammeke, Ph.D., Kevin Guskiewicz, Ph.D., ATC, University of North Carolina at Chapel Hill, Stephen Rao, Ph.D., ABPP, Medical College of Wisconsin, William Barr, Ph.D., ABPP, New York University Medical Center, Robert Cantu, MD, Emerson Hospital, and Thomas Gennarelli, MD, Medical College of Wisconsin.

The investigators intend to build on their research findings by expanding the sample, incorporating an intermediate recovery assessment point not present in earlier studies, and increase the sensitivity to abnormalities of functional activation by shifting their imaging platform from a 1.5T to a 3.0T MRI

scanner. The scientific aim of this study is to utilize innovative fMRI techniques and standardized testing (e.g., neuropsychological, postural stability, and symptom assessment) to gain a better understanding of the acute effects and recovery from sports-related concussion, both clinically and neurophysiologically. Their findings are expected to support empirically-based recommendations for tracking recovery, instituting a symptom-free recovery period, and making clinical decisions about an athlete’s return-to-play after sport-related concussion.

Ongoing NOCSAE Research Studies

Continuation of the United States commotio cordis registry. The principal investigator is Barry Maron, MD of the Minneapolis Heart Institute Foundation. Dr. Maron and his collaborators have been very successful with the Commotio Cordis Registry in furthering our understanding of this important condition as evidenced by

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CEREBRAL CONCUSSION

by Robert C. Cantu, M.D., F.A.C.S., F.A.C.S.M.

Concussion is derived from the Latin work *concussus* which means to shake violently. Initially, it was thought to produce only a temporary disturbance of brain function due to neuronal, chemical, or neuroelectrical changes without gross structural change. We now know that structural damage with loss of brain cells does occur with some concussions. In the last several years, the neurobiology of cerebral concussion has been advanced and it has become clear that, in the minutes to days after concussive brain injury, brain cells that are not irreversibly destroyed remain alive but in a vulnerable state. This vulnerability appears to be due to an uncoupling of the demand for glucose, which is increased after injury, with a relative reduction in cerebral blood flow. Precisely how long this period of metabolic dysfunction lasts is not presently fully understood. Unfortunately, there are today no neuroanatomic or physiologic measurements that can be used to precisely determine the extent of injury in concussion or the severity of metabolic dysfunction or precisely when it has cleared. This is what makes return to play decisions after a concussion so difficult.

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Research News

Highlights of Important Recent Research on Concussions

This past year there have been some noteworthy research advances in the area of concussions. Two studies that were published by the NFL and Virginia Tech had eight players instrumented with a Head Impact Telemetry system from Simbex. Below are highlights of both exciting studies.

The NFL's committee on mild traumatic brain injuries recently published its results assessing the impact type and injury biomechanics of concussions in professional football. A combination of video surveillance and laboratory reconstruction allowed the committee to quantify the direction and magnitude of the collisions.

Between 1996 and 2001, 182 helmeted impacts were videotaped and evaluated for the direction and location of impact. In 31 cases, the speed of impact was attainable by the analysis of multiple videos. This data was subsequently used to recreate the cases and quantify the relevant dynamics. A helmeted head/neck assembly was aligned in the proper orientation and guided in free fall to reach the predetermined speeds and allow for data acquisition.

Peak accelerations obtained in the 25 concussive impacts ($98 \pm 28g$) were statistically greater than those found in the six non-concussive cases ($60 \pm 24g$). The impacts occurred within a 15-millisecond half-sine wave duration. The video showed 71%

of the impacts occurred on the side or back of the helmet, primarily in the upper portions. Side impacts were primarily the result of contact with a striking player's helmet, arm, or shoulder pad, while rear impacts were often a result of ground impact.

Concussive impacts to the facemask yielded the lowest average accelerations ($78 \pm 18g$) in comparison to other locations (107 to $117g$). These impacts were primarily from the striking player's helmet and occurred mostly below the cg (center of gravity) of the head. Striking players maintained equal impact speeds but yielded lower resultant accelerations and no concussions. The committee claims that the variance of concussive impact data by location could form the basis for future performance standards.

Concussions were primarily related to translational acceleration and consistently detectable by conventional measures of head injury risk. Nominal tolerance levels for HIC and GSI were found to be 250 and 300, respectively. A strong correlation existed between rotational and translational acceleration leading the committee to conclude that translational values remain sufficient for detection and standards.

Pellman EJ, Viano DC, Tucker AM, Casson IR, Waeckerle JF: Concussion in professional football: Reconstruction of game impacts and injuries. *Neurosurgery* 53: 799-814, 2003.

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Recently Completed NOCSAE Research

Swartz EE, Norkus SA, Cappaert TA, Decoster LC. (2004) Various types of football helmets, face masks, and face mask loop straps, and their effects on the efficiency of face mask removal. *J Athl Train*; 39(Suppl).

Dr. Swartz and his colleagues examined the ability to effectively remove the face mask from a football helmet in a suspected spine injury

situation. The investigators found that the ability to safely remove the face mask in such a situation is negatively affected by the equipment components; the helmet, face mask, or loop strap. In some trials during the study, specific combinations of equipment resulted in the complete inability to remove the mask. Further, investigators found that in nearly all cases, a cordless screwdriver

was easier, took less time, and created less movement compared to two popular face mask removal tools. Sports medicine professionals responsible for management of the spine injured athlete must be knowledgeable in the type of equipment utilized by their institution and aware of the best option available for accessing the airway. ■



NOCSAE Standards

All NOCSAE standards and proposed standards are available on the Web site (<http://www.nocsae.org>) in PDF format and can be easily downloaded. The three levels of NOCSAE standards are Draft (a working document), Proposed Status (a formalized document for obtaining written comments from manufacturers, governing bodies and other interested parties. Minimum one-year period), and Final Status (elevated from Proposed and becomes effective one year after vote for elevation).

At the Winter 2004 NOCSAE Meeting, the Board Members voted on the following:

These Standards (some new and some are revisions) were elevated from proposed status to a final status effective January 1, 2005:

- Basic Methods and Equipment for Testing Helmets (ND001-04)
- Hockey Helmets (ND030-04: newly manufactured helmets)
- Lacrosse Face Protectors (ND045-04)
- Lacrosse Helmets (ND041-04: newly manufactured helmets ND043-04: recertified helmets)
- Polo Helmets (ND050-03)
- Youth Baseballs (ND027-00)

These documents are in proposed status for consideration to final status no sooner than January 1, 2005. While in proposed status, NOCSAE invites and encourages written comments from all interested parties regarding the scientific or technical aspects of the proposed standard. Questions about NOCSAE standards can be directed to the Technical Advisor.

- Polo Eye Protection (ND055-03)
- Re-certification Batters and Catchers Helmets (ND026-04)
- Baseball and Softball Face Protectors (ND072-04)
- Hockey Face Protector (ND035-04)
- Soccer Shin Guards (ND090-03)

- Hockey Helmets (ND032-04: recertified helmets)

Things you need to know about the NOCSAE standard setting timetables and how you can provide input.

NOCSAE standards are living documents that are updated on a regular basis and reviewed periodically. The standards change with some regularity, as needed, to keep up with emerging technology and the latest scientific data available. If you see areas where language could be improved or a test parameter should be reviewed, please feel free to talk with the Technical Director and/or send you comments to the Executive Director. All comments will be reviewed. To make a formal request of the committee, comments must be in writing to the Executive Director.

Each NOCSAE standard is identified with a number system that identifies the standard number, the year of last revision and the year of last modification, if more than one revision or modification takes place in a given year an alphabetic code is added. For example ND001-04m04 tells us that document number 001 was last revised in 2004 and was last modified in 2004, if there was an a, b, c and so on after either the year of modification or the year of revision you would know there was a change during the year, 001-04m04 would be superseded by 001-04m04a, for example.

Revisions and modifications are changes in NOCSAE standards. Revisions are changes that effect certain key areas identified in ND 001 and require board action to implement. Anytime a revision is made the document is published and the effective date is one year later. That means that the new standard can be used by those making products but cannot be required by a governing body until one year later. Modifications are changes that clarify, or correct things that are not likely to effect the outcome of a test and

are not listed as causes for revision. Modifications take place as they are made and the documents published.

While it is true that NOCSAE standards change frequently, within the confines of the procedures for setting standards, revisions and new standards are first in proposed status for at least one year. During the first six months of this time public comment is solicited and considered by the board. While the documents can be revised and modified at any time, the second six months are reserved for the committee to undertake the task of evaluating and implementing, where needed, the comments that have been made to improve the proposed standard.

Once a standard reaches final status it can be used by manufactures on product that meet the standard and who have entered into a license agreement with NOCSAE. One year later the standard will be moved to current status at which time governing and sanctioning bodies can require products meeting the standard be used in play.

Is NOCSAE on the verge of introducing new standards that may obsolete certain products now in the field?

No. However NOCSAE is always looking for ways to improve athlete safety and routinely reviews its standards and technology with emerging data on injuries, possible interventions and preventions that may be implemented through standards development. While NOCSAE is working diligently with the scientific community on new test methods and standards, reports of wide sweeping changes in the near future are incorrect. As the technology to measure, address and set threshold values for less serious head injury evolve NOCSAE expects to be among the leaders in implementation, but as of this writing much remains to be done before new methods and performance requirements can be incorporated with any assurance that the result will be reduced injuries. ■

Cerebral Concussion

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Team physicians, athletic trainers, and other medical personnel responsible for the medical care of athletes face no more challenging a problem than the recognition and management of concussion. Indeed, such injuries have captured many headlines in recent years and have spurred studies within both the National Football League and the National Hockey League.

When discussing concussion one must realize that there is no universal agreement on the definition or grading of concussion. While post traumatic amnesia and loss of consciousness remain hallmark symptoms of grading scales, all signs and symptoms are important and include; a feeling of being stunned or seeing bright lights, light headedness, vertigo, loss of balance, headaches, cognitive and memory dysfunction, tinnitis, blurred vision, difficulty concentrating, lethargy, fatigue, personality changes, inability to perform daily activities, and sleep disturbances. Table 1 is the most recent grading system that uses symptom, type and duration as the basis for concussion severity.

Table 1. Data Driven Cantu Revised Concussion Grading Guidelines

Grade 1 (Mild)	No LOC* PTA‡/PCSS‡‡ < 30 min
Grade 2 (Moderate)	LOC <1 min or PTA > 30 min <24hrs, other PCSS >30 min <7days
Grade 3 (Severe)	LOC > 1 min or PTA > 24 hrs, PCSS > 7 days

*Loss of consciousness

‡Post-traumatic amnesia (antegrade/retrograde)

‡‡Post-concussion sign/symptoms

Cantu RC Post-traumatic (retrograde and anterograde) amnesia: pathophysiology and implications in grading and safe return to play. J of Athletic Training 36(3)244-248,2001

RETURN TO COMPETITION AFTER CONCUSSION

A sobering realization is that the ability to process information may be reduced after a concussion, and the severity and duration of impairment may be greater with repeated concussions. Studies currently suggest that the damaging effects of the shearing injury of nerve fibers and neurons are proportional to the degree to which the head is accelerated and that changes may be cumulative. Once a player has incurred an initial cerebral concussion, his or her chances of incurring a second one are three to six times greater than for an athlete who has never sustained a concussion. Table 2 presents guidelines for return to play after a concussion, including termination of a season. Before an athlete returns to play, he or she must be free of all post concussion symptoms at rest and exertion. All guidelines agree on this salient point. ■

TABLE 2. First Concussion Second Concussion Third Concussion

Grade	First Concussion	Second Concussion	Third Concussion
Grade 1 (mild)	May return to play if asymptomatic for 1 week	Return to play in 2 weeks if asymptomatic at that time for 1 week	Terminate season; may return to play next season if asymptomatic
Grade 2 (moderate)	Return to play after asymptomatic for 1 week	Minimum of 1-month may return to play then if asymptomatic terminating the season	Terminate season; may return to play next season if asymptomatic
Grade 3 (severe)	Minimum of 1 month; may then return to play if asymptomatic for	Terminate season; may return to play next season if asymptomatic 1 week	

Asymptomatic means no headache, dizziness, or impaired orientation, concentration, or memory during rest of exertion

Cantu RC Post-traumatic (retrograde and anterograde) amnesia: pathophysiology and implications in grading and safe return to play. J of Athletic Training 36(3)244-248,2001

Recertification/Reconditioning

NOCSAE standards for several types of headgear include test methods, performance criteria and procedural guides for use by reconditioners who recertify headgear. The National Athletic Equipment Reconditioners Association (NAERA) has a long and close relationship with NOCSAE that fosters ongoing compliance with NOCSAE standards as equipment is subjected to the rigors of use season after season. The reconditioners follow a version of the NOCSAE test that is similar to the manufacturer's protocol, but a shortened version. They maintain a database of information indicating how helmets have been maintained as outlined in the NOCSAE manual, available by contacting the Executive Director.

NAERA members have been beta testing new software and hardware used for data acquisition called HITS (Helmet Impact Test System). These custom-made computer based setups have shown themselves to be reliable and repeatable. While some beta sites have experienced some hardware issues and one site found a major software bug, all reported problems have been addressed and the system is ready for wider distribution. To learn more about NAERA visit their Web site at <http://www.NAERA.net>. If you have technical questions regarding NOCSAE recertification contact the Technical Director. ■

Future NOCSAE Board Meetings

- **The Summer 2004 NOCSAE Meeting will be held June 4-5, 2004 in Knoxville, TN.**
- **The Winter 2005 NOCSAE Meeting will be held January 21-22, 2005. The location remains to be determined.**

New and Ongoing Research

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their recent major publication in JAMA (Maron BJ, et al. 2002;287:1308-1320). Many important issues remain unresolved with regard to commotio cordis, questions which can only be answered through the detailed analysis and assembly of data from greater numbers of victims. This process of data gathering and analysis will help develop a better understanding of the precise circumstances and broad clinical spectrum of commotio cordis. Investigators hope to gain insight into the mechanisms of cardiac death and survival, the prevalence of survival and the role and importance of protective gear. A relatively small number of cases in which protective gear failed to prevent ventricular fibrillation have been reported to date. These cases are the focus of the continuing efforts.

Catastrophic football injuries – 1987-2001. The principal investigator is Fred Mueller, Ph.D. of the University of North Carolina at Chapel Hill. While the risks of catastrophic injuries in football are extremely low, such injuries are tragic events. For the purpose of this research project, catastrophic injuries are defined as quadriplegia, paraplegia, and permanent brain damage. The National Center for Catastrophic Sports Injury Research (<http://www.unc.edu/depts/nccsi/>) has collected catastrophic spinal cord injury data since 1977 and catastrophic brain injury data since 1984. The purpose of this research project is to advance the understanding of catastrophic injury causation in football by conducting a retrospective review of catastrophic spine and brain injuries in high school and college football from 1987-2001. This research design has proved effective in collecting retrospective catastrophic injury data from 32 pole vaulting injuries that occurred from 1982-1998. ■

Further details on these and other research studies supported by NOCSAE can be found at <http://www.nocsae.org>.

Highlights of Important Research

(continued from page 2)

Pellman EJ, Viano DC, Tucker AM, Casson IR: Concussion in professional football: Location and direction of helmet impacts – Part 2. **Neurosurgery** 53: 1328 -1341, 2003.

The head impact accelerations of 38 different players were studied this past season - while they were playing football! A Virginia Tech and Edward Via Virginia College of Osteopathic Medicine team, led by Stefan Duma, PhD, Director of the Center of Injury Biomechanics and Gunnar Broolinson, DO, Head Team Physician, is the first to measure head accelerations in actual games and practices. "What is exciting about this project is the biomechanical data and insight we will gain concerning head impacts that occur on every play as a natural part of this game," said Dr. Duma. "For the first time, we are able to measure player impacts during practices and game situations and compare impacts by player position and other variables." The study uses new wireless technology incorporated into the HIT System™ that monitors and records the severity and incidence of impacts taken by an athlete during contact sports, such as football and hockey. The miniature impact monitor is worn inside protective equipment (padding, helmets, etc.), where accelerometers and state-of-the-art telemetry can provide vital, real-time, hit-by-hit data. The HIT System™ was developed with funding from the National Center for Medical Rehabilitation Research at National Institutes of Health by led by researchers Rick Greenwald, Ph.D. and Jeff Chu, MS of Simbex (<http://www.simbex.com>), a Lebanon, New Hampshire research and product development company, and Trey Crisco, Ph.D. of Brown Medical School/Rhode Island Hospital.

Simbex and its collaborators are enlarging the football study to include up to 500 players at five colleges for the 2004 season and hopes to expand the study to include the NFL and high schools as soon as possible. There are also plans to study men's and women's collegiate hockey teams. ■

Research Funds Available

Preliminary Grant Applications Due May 7, 2005

In its effort to commission research, NOCSAE solicits grant proposals from any and all qualified investigators. The scope of the grants considered for funding include basic and/or applied research bearing a relationship towards increasing our understanding of sports injury mechanisms and injury prevention through the use of protective sports equipment. Priority is given to proposals focusing on recurring injury where the injury is either "catastrophic," "serious," and/or "costly." Awards are based upon scientific merit as ranked by a national panel of experts and upon the priorities of the NOCSAE Board of Directors.

Applying for Funding. Due to the diversity and complexity of potential research proposals, NOCSAE has

instituted a two-phase application procedure. Those interested in seeking funding are required to first submit a Preliminary Grant Application. This brief, one page proposal is reviewed by the NOCSAE Board of Directors. From these preliminary proposals, the Board votes to invite full proposals based upon the funds available and upon the Board's goals for that funding cycle. An external scientific study section reviews the invited full proposals. The final decision for funding is made by the NOCSAE Board of Directors based upon these reviews and the Boards goals. ■

Further details on the grant application process can be found at <http://www.nocsae.org>.



REPORT

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Our mission: Commissioning research and establishing standards for athletic equipment, where feasible, and encouraging dissemination of research findings on athletic equipment and sports injuries.

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