



2018

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Recommended Citation

Crook, Carrie (2018) "Making an ImPACT: How Immediate Post Concussion Assessment and Cognitive Testing Became a Standard in Sport," *Momentum*: Vol. 5 : Iss. 1 , Article 5.
Available at: <https://repository.upenn.edu/momentum/vol5/iss1/5>

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This paper evaluates how the Immediate Post Concussion Assessment and Cognitive Testing (ImPACT) system became a standard in the NCAA from its release in 2001 to today. ImPACT is a computerized neurocognitive testing system that physicians use in assessing and managing concussions. Sociological study often discusses the creation of standards in a broad sense. This paper focuses expressly on the creation of a particular standard in a particular context: ImPACT in the NCAA. The effort, tinkering, reformulation, and doubt that surrounds the creation of a standard is often forgotten once that standard is accepted. This paper unearths the process necessary to establish ImPACT as a standard. It evaluates primary evidence from international conferences on concussion in sport, national medical organization position statements on concussion, and the NCAA's guidelines to concussion management. Support from powerful institutions, technological expertise, and monetary and practical impetus promoted ImPACT as the standard for concussion assessment in the NCAA.

I. WHAT IS IMPACT, AND WHY DO WE CARE?

MANY UNIVERSITY OF PENNSYLVANIA ATHLETES HAVE HAD A CONCUSSION themselves or have had a teammate who was had to go through the concussion protocol mandated by Penn Sports Medicine. First, some sort of blow to the head occurs, in my case, it was a collision between my defender's cleat and my head during our season opening soccer game against the University of Maryland in the fifteenth minute. Next, the athlete is brought to the athletic trainer. Generally, after the sideline evaluation by a certified athletic trainer, an athlete can expect a prescription for complete brain rest: no exercising, no drinking, no schoolwork, no socialization, no light, and most importantly, no electronic screens. Then the counterintuitive nature of concussion management begins. A short time from the initial head injury, the athlete can expect to walk to a nearby clinic; to sit in a small, very bright room in front of a computer screen; and to take a challenging computerized neurocognitive testing battery. In the case of Penn athletes and most other NCAA athletes, this testing battery is Immediate Post-Concussion Assessment and Cognitive Testing, colloquially known as ImPACT.

The ImPACT test is the gold standard of computerized concussion management tools.¹ ImPACT proudly advertises that over 7.5 million people have taken its test for some form of concussion management.² According to its website, it is "the most widely used and most scientifically validated computerized concussion management tool available" with "more than 250 peer-reviewed and 145 independent studies" supporting it.³ It is a 25 minute online test that is administered by physicians, nurses, athletic trainers, and other medical personnel first as a baseline test prior to any competition in sport and if necessary as a post-injury test.⁴ In the event of injury, a medical provider can use the comparison between the scores on the baseline test and the post-injury test in association with other neurocognitive assessments to assess and manage the injury.⁵ It should be noted that the ImPACT system does not require baseline testing.⁶ Medical professionals can use ImPACT's database of age-specific test scores to compare with an athlete's post injury test.⁷ Not only is ImPACT the most widely used test of this form, with its implementation in approximately one thousand colleges and universities, in two hundred professional sports programs, and in nine hundred clinical centers,⁸ it is also the first test of this kind to be certified by the Food and Drug Administration as a tool for doctors to use to assess head injuries.⁹

But why is ImPACT considered the "standard," when there are other available testing methods to help assess head and brain injuries?¹⁰ It is unclear if this test is actually the best tool to use in the management of concussions for athletes. There are several other neurocognitive testing batteries including some whose tests do not require the potentially concussed athlete to stare at a computer screen. For example, the Sport Concussion Assessment Tools 2 and 3 (SCAT2 and SCAT3) are pencil and paper concussion tests designed to measure post-concussion cognitive abilities on the sideline for free.¹¹ ImPACT charges anywhere from \$10 to \$20 per examination.¹²

This paper will analyze how ImPACT gained the approval and trust of the NCAA, and which factors were involved with its rise to becoming a standard. ImPACT is a tool to objectify concussion symptoms and severity in an athlete. It is a useful tool for standardized research on concussions. The practice of evidence-based medicine in the clinical setting created ideal conditions for the development of NCAA protocols for concussion management. Systems with specific cognitive assessment capabilities, like

¹ Bill Bradley, "Researchers Question Reliability of ImPACT Testing for Concussions," NFL.com. September 17, 2013. Accessed December 03, 2016. <http://www.nfl.com/news/story/0ap1000000245812/article/researchers-question-reliability-of-im-pact-testing-for-concussions>

² "ImPACT Test." Ing & Computerized Neurocognitive Assessment Tools. Accessed September 29, 2016. <https://www.impacttest.com/>.

³ *Ibid.*

⁴ *Ibid.*

⁵ *Ibid.*

⁶ *Ibid.*

⁷ *Ibid.*

⁸ *Ibid.*

⁹ U.S. Food and Drug Administration. "FDA Allows Marketing of First-of-kind Computerized Cognitive Tests to Help Assess Cognitive Skills after a Head Injury." News release, August 22, 2016. FDA.gov. Accessed October 20, 2016. <http://www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/ucm517526.htm>.

¹⁰ "ImPACT Test"

¹¹ Christie Aschwanden. "Fancy Concussion Tests Won't Protect Our Student Athletes." Slate Magazine. January 20, 2012. Accessed October 25, 2016. http://www.slate.com/articles/health_and_science/medical_examiner/2012/01/impact_and_other_concussion_tests_for_athletes_may_not_work.html

¹² *Ibid.*

¹³ Stefan Timmermans, and Steven Epstein. "A world of standards but not a standard world: toward a sociology of standards and standardization." *Annual review of Sociology* 36 (2010): 69.

¹⁴ Ibid., 72.

¹⁵ Ibid., 72.

¹⁶ Ibid., 83.

¹⁷ Ibid., 72.

¹⁸ Ibid., 73.

¹⁹ Ibid., 79.

²⁰ Ibid.

²¹ Ibid.

²² Stefan Timmermans, and Rene Almeling. "Objectification, standardization, and commodification in health care: a conceptual readjustment." *Social Science & Medicine* 69, no. 1 (2009): 25.

²³ David L. Sackett, "Evidence-based medicine." In *Seminars in perinatology*, vol. 21, no. 1, pp. 3 WB Saunders, 1997.

ImPACT, are included in these NCAA protocols. Support from powerful institutions, technological expertise, and monetary and practical impetus promoted Immediate Post Concussion Assessment and Cognitive Testing as the standard for concussion assessment in the NCAA.

II. THE SOCIOLOGY OF STANDARDS

STANDARDS

STANDARDS ARE UNIVERSAL AND PERVASIVE. THEY REPRESENT THOSE TOOLS that are recognized and used in the same context across heterogeneous cultures. As Timmermans and Epstein explain in their 2010 review article about standards, they "aim to render the world equivalent across cultures, time, and geography."¹³ Standards can range from mundane tools, like a No. 2 pencil, to the complex protocols that govern modern biomedicine. Because of their pervasiveness within our society, the study of standards has gained much popularity within the field of sociological study.¹⁴ However, while sociologists typically study standards more generally, the study of particular standards is far less common.¹⁵ Sociologists Timmermans and Epstein claim that much of the work put into establishing a standard and the uncertainty that may have originally surrounded a new tool or concept "is [rendered] invisible" once the standard is accepted.¹⁶ That is, the lobbying, tinkering, campaigning, and reformulating that go into the creation of standard and some doubts surrounding the creation of a standard tend to become either irrelevant or disappear once the standard is applied across heterogeneous contexts. Timmermans and Epstein reveal that there is much discourse on the broader terms on standards such as gold standards, standards-of-living, and double standards, but there is less study on particular standards.¹⁷ This paper focuses on the study of a particular standard: The ImPACT test.

Expertise plays a large role in developing and implementing standards.¹⁸ For example, those authorities most trusted in developing a standard for trade regulation will be those persons or entities considered experts in trade. The same is true for those standard-setting with regard to branches of medicine. Experts in cognitive function and neurology will be the expected and accepted authorities to create the standards within concussion management. However, experts may not be the only stakeholders involved in the creation of the standards.

A standard can also be backed by a particular institution to promote its use. This institution will incentivize other stakeholders to adopt the standard.¹⁹ For example, governments may require trade organizations to adhere to regulatory standards in exchange for permission to transport goods over that nation's borders.²⁰ Third parties can act to incentivize standards through monetary gain for those who adopt the standard; other times standards can be adopted because of "crowd effect," in which it is a loss not to adopt the standard.²¹

Within medicine, the standard of "evidence-based medicine" has been widely accepted and utilized in clinical practice. According to Timmermans and Almeling, "[evidence-based medicine] generally denotes the use of standardized clinical practice guidelines based on the best available scientific evidence to inform medical decision making and encourage a more effective care."²² "Evidence-based medicine" began gaining popularity in the mid-1800s in Paris.²³ It encourages physicians to integrate

their own personal knowledge with “the best available external clinical research.”²⁴ To gain acceptance, evidence-based medicine practices and guidelines were supported by several professional medical organizations.²⁵ First, the implementation of a protocol or guideline begins with a specific clinical problem an existing institution wants to address.²⁶ These organizations, like national medical associations, will provide many resources and financial incentives to attempt to motivate clinicians to adhere to their new standard.²⁷ However, it is important to note that in the case of evidence-based medicine— and in the case of many other standards— its support from professional organizations and the strong incentive measures put in place did not ensure total adherence to the guidelines by clinicians in daily practice.²⁸ The adoption of evidence-based medicine has put two dueling medical epistemologies into struggle: the qualitative knowledge possessed by clinicians themselves gained by experience and the quantitative knowledge resulting from randomized controlled trials and the production of statistical knowledge in medicine.²⁹ To resolve this struggle, medical practice today requires the ability to turn qualitative experiences like symptoms into objective facts via grading scales and measurement tools. A significant portion of decision-making in medicine requires objectification and standardization.

Standardization “[constructs] uniformities across time and space,” and is often supported by outside entities.³⁰ Standards are the tangible product or guidelines accepted across space and communities; standardization is the result of the application of the standard. Third parties may promote standardization by offering financial incentives linked to performance measures that reward providing service according to the standard.³¹ The acceptance of evidence-based medicine in the clinical setting standardizes the care patients receive. As such, clinical practice guidelines will determine what care a patient receives based on that patient’s affliction.³² Therefore, if a patient is an athlete diagnosed with sports-related concussion, the physician will be enticed to follow the clinical guidelines set forth by some outside entity to manage and treat that diagnosis.

OBJECTIFICATION

Since the 1800s, medicine has moved away from subjective reporting of symptoms to the more objective, mechanistic model of biomedicine today.³³ This required a change in how symptoms were reported and measured, resulting in the use of grading scales that often use numerical values. Objectification of patient symptoms can provide “a... way of getting things done in medicine.”³⁴ It can provide an avenue to connect a patient’s illness with an appropriate decision and practice guidelines.

Some critiques of medical objectification include its capacity to take uniquely human experience and transform them into something that can be manipulated by medicine, and that it signals a loss of patient agency in the clinical encounter.³⁵ Physicians have faced the challenge of transforming the patient’s experience of illness or disease into something they can assess with medical knowledge.³⁶ For example, the common 0-10 grading scale that is commonly used to assess pain developed out of the need to study pain in a clinical setting.³⁷ Pain is a qualitative symptom that manifests differently in different people. To account for this variation in the experience of pain enough to study it, researchers developed a pain scale from 0-10 to make the individualistic nature of pain into something that can be understood by the observers: clinicians and researchers.³⁸ Many other standards in medicine follow this model.

24 Ibid.

25 Timmermans and Almeling
“Objectification, standardization and commodification in health care,” 25.

26 Ibid.

27 Ibid.

28 Ibid.

29 Carl May, Tim Rapley, Tiago Moreira, Tracy Finch, and Ben Heaven.
“Technogovernance: Evidence, subjectivity, and the clinical encounter in primary care medicine.” *Social science & medicine* 62, no. 4 (2006): 1022.

30 Stefan Timmermans, “A World of Standards, but not a Standard World,” 71.

31 Stefan Timmermans, “Objectification, standardization, and commodification in health care,” 25.

32 Ibid.

33 Carl May, “Technogovernance,” 1023.

34 Stefan Timmermans “Objectification, standardization, and commodification in health care,” 23.

35 Timmermans and Almeling “Objectification, standardization, and commodification in health care,” 22.

36 Carl May, “Technogovernance,” 1023.

37 Elana Gordon, “Reassessing the assessment of pain: how the numeric scale became so popular in health care.” The Pulse. Podcast audio, September, 2016. <http://www.newsworks.org/index.php/thepulse/item/96922-reassessing-the-assessment-of-pain-how-the-numeric-scale-became-so-popular-in-health-care>

38 Ibid.

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39 Ibid., 54.

40 Ibid.

41 Ibid., 58.

42 Ibid.

43 Ibid., 61.

44 Ibid.

45 Ibid., 62.

46 Michael W. Collins, Mark R. Lovell, and Douglas B. McKeag. "Current issues in managing sports-related concussion." *JAMA* 282, no. 24 (1999): 2283.

47 Ibid., 2283-84.

48 Ibid.

49 Ibid., 2284.

50 Ibid.

51 Mark Lovell is the creator of the ImPACT Test. This article was published in *JAMA* prior to the release of ImPACT. However, ImPACT was released within two years of 1999 and it is probable that the authors of this article were recommending a concussion management system in which the newly released ImPACT test would have a place.

52 Collins, "Current Issues in Managing Sports-Related Concussion," 2285.

53 Ibid.

54 Resch, Jacob E., Michael A. McCrea, and C. Munro Cullum. "Computerized neurocognitive testing in the management of sport-related concussion: an update." *Neuropsychology review* 23, no. 4 (2013): 336.

55 This information is not readily available on impacttest.com. I placed a call with

III. THE DIFFICULTY IN MANAGING CONCUSSIONS FROM 1991 TO 2001

PRIOR TO THE ESTABLISHMENT AND ACCEPTANCE OF COMPUTERIZED neurocognitive testing batteries, like ImPACT, concussion management guidelines were still standardized across state and national lines. For example, in 1991 the Colorado Medical Society created and submitted Guidelines for the Management of Concussions in Sports to several national professional organizations, including the American Academy of Pediatrics, the American Academy of Sports Physicians, and the American College of Surgeons Committee on Trauma.³⁹ According to physicians Kelly and Rosenberg, once accepted, this set of guidelines was one of the first standard procedures for concussion management and care.⁴⁰ Even in this first nationally accepted guideline, a short, verbal sideline evaluation was given to assess cognitive and mental function.⁴¹ The American Academy of Neurology recommended a standardized test, Standardized Assessment of Concussion, to detect any mental deficits and lack of cognitive functioning present to allow the physician to manage the injury effectively.⁴² To manage concussion in the early 1990s, athletic trainers and physicians used grading scales with grades 1 through 3.⁴³ Under the grading system, the severity of the concussion was determined by loss of consciousness and length of time the abnormalities from the sideline evaluation last.⁴⁴ The return-to-play decisions made by physicians were determined by the concussion grade assigned to the athlete after the sideline assessment by the medical personnel on the scene.⁴⁵ The Standardized Assessment of Concussion objectified the severity of concussions to allow for management and care. *The Guidelines for the Management of Concussions in Sports* was the first set of concussion management protocols to standardize management on a larger scale for physicians. This testing system and this set of guidelines were precursors to the current model of care for concussions today.

In 1999, concussion management followed similar practices to those set forth by the Colorado Medical Society. However, concussion management did face several challenges. As described by the *JAMA* 1999 article by concussion researchers Collins, Lovell, and McKeag, there was no general consensus among experts on the definition of a concussion.⁴⁶ Secondly, medical professionals assessing sports-related concussion could use one of fourteen different concussion grading scales, and all of them required some sort of subjective judgment as to the severity of the concussion.⁴⁷ Thus, the diagnosis and management could change from athletic trainer to physician to medical system, leading to variable care for the athlete. Lastly, each of the recommended concussion grading scales had different return-to-play guidelines.⁴⁸ For example, if an athlete is diagnosed with a grade 2 concussion, a physician using the Colorado Guidelines will not permit return to play for one week.⁴⁹ However, if the physician uses the Cantu scale, he or she may not return to play for two weeks.⁵⁰ Sports-related concussion experts Collins, Lovell⁵¹, and McKeag, reported, "because current guidelines are not evidenced-based, concussion is difficult to categorize. Further, response to injury is highly individualized."⁵² These experts recommended that more cognitive testing besides a simple sideline evaluation take place in order to "delineate the subtle cognitive changes associated with concussion."⁵³

Prior to the release of ImPACT, there were concussion management guidelines present, but there was no consensus on the appropriate measures to diagnose a concussion. Since 1996, there was a push from some experts for physicians and athletic trainers to perform baseline testing of cognitive function for athletes who could be at risk of sports-related concussion in their athletic endeavors.⁵⁴ However, there was no

standard concussion testing system or national set of guidelines. The ImPACT test was uniquely positioned the fit within the vacancies of concussion management in the 1990s. In 2001, ImPACT was released by ImPACT Applications™ in an initial desktop version.⁵⁵ Seven years later in 2008, the online platform of ImPACT testing was released.⁵⁶ This is the recognizable form of ImPACT today.

IV. FROM RESEARCH TOOL TO STANDARD OF CARE: IMPACT FROM 2001 TO TODAY

INTERNATIONAL SUPPORT: THE CONFERENCES ON CONCUSSION IN SPORT 2001-2012

THE 2001 CONFERENCE ON CONCUSSION IN SPORT (CONCUSSION IN SPORT GROUP) in held in Vienna invited experts involved research of sports-related concussion, the International Ice Hockey Federation (IIHF), the Federation Internationale de Football Association Medical Assessment and Research Centre (FIFA, F-MARC), and the International Olympic Committee Medical Commission (IOC) to define concussion and to establish a protocol for concussion management in sport.⁵⁷ The Concussion in Sport Group (CISG) formally defined concussion as:

Concussion is defined as a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces. Several common features that incorporate clinical, pathological, and biomechanical injury constructs that may be used in defining the nature of a concussive head injury include:

- (1) Concussion may be caused by a direct blow to the head, face, neck, or elsewhere on the body with an “impulsive” force transmitted to the head.
- (2) Concussion typically results in the rapid onset of short-lived impairment of neurological function that resolves spontaneously.
- (3) Concussion may result in neuro-pathological changes but the acute clinical symptoms largely reflect a functional disturbance rather than structural injury.
- (4) Concussion results in a graded set of clinical syndromes that may or may not involve loss of consciousness. Resolution of the clinical and cognitive symptoms typically follows a sequential course.
- (5) Concussion is typically associated with grossly normal structural neuroimaging studies.⁵⁸

This conference, held shortly after the release of ImPACT, released a globally accepted concussion protocol system, including discussion on the recommended methods to evaluate concussion.⁵⁹ The CISG claimed that sideline evaluation of the injured athlete is necessary for proper concussion management.⁶⁰ Additionally, the CISG showed strong support for neuropsychological assessment following the diagnosis of concussion to determine appropriate management and return to play.⁶¹ In fact, the CISG named the newly released ImPACT specifically as an acceptable mean of neuropsychological assessment.⁶² “The Summary and Agreement Statement of the 1st International Symposium on Concussion in Sport” published in the *Clinical Journal of Sports Medicine* stated: “the consensus of the CISG was that neuropsychological testing is one of the cornerstones of concussion evaluation and contributes significantly to both understanding of the injury and management of the individual.”⁶³

ImPACT Applications Inc. and inquired. The sales representative gave precise dates for ImPACTs release.

⁵⁶ Ibid.

⁵⁷ M Aubry, Cantu R, Dvorak J, et al. "Summary and agreement statement of the 1st international symposium on concussion in sport," Vienna 2001. *Clin J Sport Med* 2002;12: 6.

⁵⁸ Ibid, 6.

⁵⁹ Ibid, 6-11.

⁶⁰ Aubry, "Summary and agreement statement of the 1st international symposium on concussion in sport," 7.

⁶¹ Ibid, 8.

⁶² Ibid, 8.

⁶³ Ibid.

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⁶⁴ Although three other computerized neurocognitive testing systems were named in the report from the "Summary and agreement statement of the first International Conference on Concussion in Sport, Vienna 2001," Mark Lovell, creator of ImPACT, was the only founder of these testing systems involved with this conference. This could potentially mean that the governing sports bodies in attendance (IIHF, FIFA, and the IOC), had more exposure to ImPACT than the other computerized neurocognitive testing.

⁶⁵ Paul McCrory, Karen Johnston, Willem Meeuwisse, Mark Aubry, Robert Cantu, Jiri Dvorak, Toni Graf-Baumann, James Kelly, Mark Lovell, and Patrick Schamasch. "Summary and agreement statement of the 2nd International Conference on Concussion in Sport, Prague 2004." *British Journal of Sports Medicine* 39, no. 4 (2005): 196.

⁶⁶ *Ibid.*, 197.

⁶⁷ *Ibid.*, 197.

⁶⁸ *Ibid.*, 201.

⁶⁹ *Ibid.*, 201.

⁷⁰ *Ibid.*, 201.

⁷¹ *Ibid.*, 201.

⁷² *Ibid.*, 201.

⁷³ This conference group of experts included the Chief Medical Officer of the International Ice Hockey Federation, the Chairman of the Fife Medical Research and Assessment Center and various professors of neurosurgery and exercise science.

⁷⁴ Timmermans and Epstein. "A world of standards but not a standard world" 69.

⁷⁵ Paul McCrory, Willem Meeuwisse, Karen Johnston, Jiri Dvorak, Mark Aubry, Mick Molloy, and Robert Cantu. "Consensus statement on concussion in sport: the 3rd International Conference on Concussion in

The 1st International Conference on Concussion in Sport gathered major stakeholders in sports-related concussions and institutions with power to enforce any concussion decisions (FIFA, IIHF, and the IOC) to develop a standard protocol for managing sports-related concussion. By recognizing neurocognitive testing as an integral part in concussion management, and ImPACT as an accurate and useful tool to assess concussion in this manner, ImPACT was supported by several large institutions that control many levels of professional and collegiate sport.⁶⁴

The 2nd International Conference on Concussion in Sport in 2004 assembled the same core group of experts; FIFA, IIHF, and the IOC, along with experts in trauma and sports psychology.⁶⁵ These experts, a group again containing ImPACT founder Mark Lovell, recommended the abolition of concussion grading scales.⁶⁶ Instead, the experts recommended a system that can determine the severity of a concussion.⁶⁷ The CISG continued their support for neuropsychological assessment in managing concussions.⁶⁸ They posited that computerized testing may allow for easier administration than traditional pencil and paper testing.⁶⁹ According to the Concussion in Sports Group in their 2004 published statement, "inherent problems with most [pencil and paper] neuropsychological tests include the normal ranges, sensitivity and specificity of tests, and practice or learning effect, as well as the observation that players may return to baseline while still symptomatic."⁷⁰ The experts in the CISG reported that the "infinitely variable test paradigms" of computerized cognitive testing could overcome some of these concerns.⁷¹ Furthermore, computerized testing systems were more practical because team physicians could administer the test without a neuropsychologist present.⁷² While ImPACT is not specifically named in this conference report, this conference began the process of creating a standard of practice in sport-related concussion management by heavily supporting computerized neurocognitive testing measures. Moreover, the conference members represent the experts⁷³ and expertise necessary for the establishment of a standard as explained by Timmermans and Epstein.⁷⁴

Unlike the two conferences in 2001 and 2004, Mark Lovell, founder of ImPACT, was not present at the 3rd International Conference on Concussion in Sport in Zurich in 2008.⁷⁵ Unlike the previous concussion conferences, the main emphasis was placed on the pencil and paper SCAT2 sideline concussion assessment.⁷⁶ Some of the research produced about the ImPACT test was referenced in the bibliography as relevant evidence to the concussion management protocols established.⁷⁷ For example, the Concussion in Sport Group consulted a research study produced by Mark Lovell that focused on the successful use of ImPACT in the NFL and speculated about how its use can be extended to college football.⁷⁸ Another one of the studies referenced, again produced by Lovell, used ImPACT to determine the correlation between concussion and neurocognitive performance in collegiate football players.⁷⁹ The consensus statement issued by the Concussion in Sport Group cited eight different studies produced by Mark Lovell that used ImPACT.⁸⁰ Experts were using medical knowledge, produced specifically about the ImPACT to form medical guidelines for sports medicine practices globally.

In 2012 the 4th International Conference on Concussion in Sport assembly of institutions and experts did not include Mark Lovell.⁸¹ The group of experts and sporting body institutions supported SCAT3 for the initial neuropsychological assessment tool.⁸² However, the consensus statement also recommends that "all athletes should have a clinical neurological assessment... as part of their overall

management. This will normally be performed by the treating physician often in conjunction with computerized neuropsychological screening tools.⁸³ In other words, the governing international conglomerate of experts on concussion in sport recommended that computerized testing batteries be used to manage concussions.⁸⁴ Although the statement does not mention ImPACT by name, nor does it mention any other computerized testing battery, it does include a section on the viability of computerized testing assessment to diagnose and manage concussion:

“Concussion management programmes that use neuropsychological assessment to assist in clinical decision-making have been instituted in professional sports, colleges and high schools. Brief computerised cognitive evaluation tools are the mainstay of these assessments worldwide, given the logistical limitation in accessing trained neuropsychologists.”⁸⁵

That is, the conference recognized that many concussion management protocols at every level of sport use computerized cognitive testing tools as they allow access to neuropsychological assessment without the presence of a neuropsychologist. However, the conference did not recommend baseline testing, for lack of sufficient evidence that this practice was necessary.^{87,88}

Overall, the four conferences on concussion in sport created an environment backed by powerful sporting institutions and concussion management expertise that supported neurocognitive testing programs like ImPACT. Although ImPACT was only mentioned in the earlier conferences when the founder was included in the group of experts coming to consensus about concussion management, all of conferences utilized medical knowledge produced about the ImPACT test via randomized controlled trials and statistical studies. The conferences illustrate the trend of evidence-based medicine in the practice of concussion management because they utilize acceptable medical knowledge⁸⁹ to determine the best practice guidelines for sports medicine physicians and neuropsychologists assessing sport-related concussions. In these standard-setting conferences, ImPACT is given a special nod as an important tool for concussion management, as it creates the biomedical facts necessary for use in evidence-based medicine. These conferences consolidated technological expertise on sports-related concussion and institutions invested in the management of sports-related concussion. Both relevant expertise and institutional support are instrumental components creating and enforcing standards.

NATIONAL SUPPORT: POSITION STATEMENTS OF SPORTS MEDICINE PERSONNEL 2004-2014

The international conferences on concussion in sport had far-reaching influence. Their determinations played a vital role in the protocol established for management of concussion in the United States. In 2004, the same year as the 2nd International Conference on Concussion in Sports, the National Athletic Trainers' Association (NATA) released a statement of the protocols that American trainers should follow when treating sport-related concussion.⁹⁰ First, this statement adopted the definition of concussion as posed by the 1st International Conference on Concussion in Sport.⁹¹ This position statement offered three approaches to the treatment and management of sport-related concussion, including using a grading scale at the time of injury, using a grading scale after symptoms have resolved, or “not using a grading scale but rather focusing attention on the athlete’s recovery via symptoms, neurocognitive testing,

Sport held in Zurich, November 2008.” *British journal of sports medicine* 43, no. Suppl 1 (2009): 76-84.

76 McCrory, “Consensus statement on concussion in sport: the 3rd International Conference on Concussion in Sport held in Zurich, November 2008,” 76.

77 Ibid, 182.

78 Mark R. Lovell, and Michael W. Collins. “Neuropsychological assessment of the college football player.” *The Journal of head trauma rehabilitation* 13, no. 2 (1998): 9-26.

79 M. Collins, S Grindel, M Lovell, et al. Relationship between concussion and neuropsychological performance in college football players. *JAMA* 1999;282:964–70.

80 McCrory et al, “Consensus statement on concussion in sport: the 3rd International Conference on Concussion in Sport,” 184.

81 Paul McCrory, Willem H. Meeuwisse, Mark Aubry, Bob Cantu, Jiří Dvořák, Ruben J. Echemendia, Lars Engebretsen et al. “Consensus statement on concussion in sport: the 4th International Conference on Concussion in Sport held in Zurich, November 2012.” *British journal of sports medicine* 47, no. 5 (2013): 250-258.

82 Ibid, 251.

83 Ibid, 252.

84 Ibid.

85 Ibid, 256.

86 Ibid, 253.

87 Ibid.

88 As referenced on the ImPACT test website (www.impacttest.com), ImPACT does not require baseline cognitive testing and contains a database with scoring metrics to compare to the injured athletes.

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89 Kelly and Rosenberg define acceptable evidence for concussion management in the earliest concussion protocol in the 1990s as "evidence provided by one or more well-designed randomized controlled clinical trials." This definition is still applicable in later published data protocols for concussion management.

90 Kevin Guskiewicz, Scott L. Bruce, Robert C. Cantu, and Michael S. Ferrara. "National Athletic Trainers' Association position statement: management of sport-related concussion." *Journal of athletic training* 39, no. 3 (2004): 280-297.

91 *Ibid.*, 283.

92 *Ibid.*, 281.

93 *Ibid.*, 282.

94 *Ibid.*, 285.

95 *Ibid.*, 285.

96 *Ibid.*, 288-9.

97 Practice in testing refers to the downfall of pencil and paper tests mentioned early. Because pencil and paper tests only offer one paradigm, athletes can get better results simply because of testing and retesting. Computerized tests have several paradigms to prevent this effect.

98 The AMSSM's statement was endorsed by NATA and the American College of Sports Medicine.

99 Kimberly G. Harmon, Jonathan A. Drezner, Matthew Gammons, Kevin M. Guskiewicz, Mark Halstead, Stanley A. Herring, Jeffrey S. Kutcher, Andrea Pana, Margot Putukian, and William O. Roberts. "American Medical Society for Sports Medicine position statement: concussion in sport." *British journal of sports medicine* 47, no. 1 (2013): 15-26

100 *Ibid.*

and postural-stability testing."⁹² In considering the third approach, which NATA gives the most time and care to describing appropriate measures, the association recommends the use of neurocognitive testing measures with "population-specific normative data, test-retest reliability, clinical validity, and sufficient sensitivity and specificity established in the peer-reviewed literature," thereby illustrating the importance of statistically relevant, scientifically produced medical knowledge in the evidence-based medicine practices of athletic trainers.⁹³ NATA does admit that there is a lack of consensus among which of the grading scales to use in the management of sports-related concussion.⁹⁴ Furthermore, the position statement addressed that using loss of consciousness and amnesia— a metric proven via scientific evidence to occur infrequently in concussion— to determine concussion severity may not be accurate.⁹⁵ Finally, the NATA position statement supported the use of computerized neurocognitive tests, including ImPACT, for their "ease of administration," "ability to baseline test a large number of athletes in a short period of time, and multiple forms used within the testing paradigm to reduce" effect of practice in testing.^{96,97}

Later in 2012, the American Medical Society for Sports Medicine (AMSSM)⁹⁸ released a similar position statement on the management of concussion in sport.⁹⁹ This statement did not use the exact language employed by the international conferences on concussion in sport.¹⁰⁰ Even still, the AMSSM more strongly supported computerized neuropsychological testing the more time-consuming, expensive traditional pencil and paper testing.¹⁰¹ The AMSSM, like the prior conferences on concussion, recommended computerized neuropsychological testing to aid physicians in managing a concussion, not in diagnosing a concussion alone.¹⁰²

Within the next two years, NATA released an update on their position on concussion in sport. NATA remained supportive of the definition of concussion proposed by the CISG, and of neurocognitive testing in the management of concussions.¹⁰³ Again, it calls for programs that have demonstrated sensitivity to detect changes in cognitive function and test-retest reliability.¹⁰⁴

The three position statements issued by two of the most important institutions for sports medicine in the United States represents the path of ImPACT (and computerized neurocognitive testing in general) moving from a new technology to the gold standard in concussion management and evaluation. By issuing a formal statement and guidelines to managing concussion, NATA and the AMSSM attempted to standardize the practice of concussion management among national boundaries. ImPACT was included as a tool for standardization. NATA and AMSSM represent national medical organizations that offered institutional backing to computerized neurocognitive testing systems.

IMPACT AND THE NCAA TODAY

In 2014, following the publication of the notes from the four conference on concussion in sport and the position statements issued by the NATA and AMSSM, the National Collegiate Athletics Association issued "Inter-Association Guidelines" to be followed by the universities and athletic teams participating in NCAA sport.¹⁰⁵ Drawing from the determinations of the Fourth Conference on Concussion in Sport, and the most recent statements issued by the NATA and AMSSM, the NCAA established legislation to ensure that all concussion policies would be treated with the same policies in colleges and universities across the nation.¹⁰⁶ Although the NCAA does remain skeptical in

the use of neuropsychological assessment as a diagnostic tool on its own, it argues that they can be useful in appropriately managing a concussion.¹⁰⁷ Moreover, the NCAA supports a system in which all athletes are baseline tested prior to competing in NCAA athletic competitions and practices via cognitive assessment.¹⁰⁸ It should be noted that this stipulation would require colleges and universities to test large numbers of individuals at the same time with limited staff present: a problem that both NATA and the AMSSM said is easily solved by administration of computerized cognitive testing.^{109,110}

In the event of a concussion, the NCAA supports the use of “brief concussion evaluation tools,” like the SCAT3 and the SAC.¹¹¹ These tools are useful for evaluation because they “provide standardized methods and can be compared to a baseline evaluation.”¹¹² Though ImPACT is not specifically mentioned, the NCAA calls for the use of neurocognitive testing methods that can be administered in large quantities over short periods of time. The NCAA also promotes the use of tests that can be compared to a baseline score taken earlier. The NCAA standardizes concussion management across state boundaries. It calls for a specific method of managing concussions that few testing systems can support. For example, the concussion policy for the NCAA member University of Miami uses ImPACT specifically in its concussion because “per NCAA guidelines, institutions should record a baseline assessment for ALL student-athletes prior to the first practice.”¹¹³

All NCAA universities may not use ImPACT, but because of guidelines mandated by the NCAA to achieve standardization and the need to objectify concussion severity into a metric that can be interpreted by physicians and trainers, ImPACT soon rose to be heavily utilized in collegiate athletics. Additionally, because ImPACT was able to offer several peer-reviewed studies representing its efficacy, national organizations and universities were more persuaded to use this system.^{114,115,116}

In addition to the concussion protocols that the NCAA set forth for its member colleges and universities, the NCAA is a part of an ongoing research project called the CARE Consortium with the Department of Defense.¹¹⁷ This study is currently being conducted across thirty different NCAA universities with over 16,000 college athletes currently enrolled.¹¹⁸ Moreover, the NCAA and the institutions involved in conducting this concussion research are funded by a \$30 million dollar grant from the Department of Defense to “help change the culture of concussion reporting management.”¹¹⁹ At some sites in the CARE Consortium, ImPACT is the tool used assess baseline neurocognitive function and post-injury neurocognitive function.¹²⁰ Within the NCAA since 2014, ImPACT has been a tool to study sports-related concussion and to create future concussion management protocols.

V. WHY IMPACT?

EVEN WITH ALL OF THE CONCUSSION ASSESSMENT OPTIONS AVAILABLE TO NCAA sports teams, ImPACT is the most widely used system among NCAA universities.¹²¹ While the NCAA guidelines, the international concussion conferences, and the national position statements of sports medicine professionals all advocate for the use of a system like ImPACT, these entities never mandate the use of this system. So, how has ImPACT grown to become the leading computerized cognitive testing system in

101 Ibid, 20.

102 Ibid.

103 Steven Broglio, Robert C. Cantu, Gerard A. Gioia, Kevin M. Guskiewicz, Jeffrey Kutcher, Michael Palm, and Tamara C. Valovich McLeod. "National Athletic Trainers' Association position statement: management of sport concussion." *Journal of athletic training* 49, no. 2 (2014): 245-252.

104 Ibid, 252.

105 "Sport-Related Concussion." In *2014-2015 Sports Medicine Handbook Guideline* 21, compiled by John T. Parsons, 56-64. 25th ed. Indianapolis, Indiana: National Collegiate Athletic Association, 2014: 56-64.

106 Ibid, 56-7.

107 Ibid, 56.

108 Ibid, 58.

109 Steven Broglio, "National Athletic Trainers' Association position statement: management of sport concussion." 245-252.

110 Kimberly G. Harmon, "American Medical Society for Sports Medicine position statement: concussion in sport." 15-26

111 "Sport-Related Concussion," 59.

112 Ibid.

113 "ImPACT Test."

114 Derk A. Van Kampen, Mark R. Lovell, Jamie E. Pardini, Michael W. Collins, and Freddie H. Fu. "The "value added" of neurocognitive testing after sports-related concussion." *The American journal of sports medicine* 34, no. 10 (2006): 1630-1635.

115 Tracey Covassin, Robert J. Elbin III, Jennifer L. Stiller-Ostrowski, and Anthony P. Kontos. "Immediate post-concussion assessment and cognitive testing (ImPACT)

practices of sports medicine professionals." *Journal of athletic training* 44, no. 6 (2009): 639-644.

116 Anthony P. De Marco, , and Donna K. Broshek. "Computerized cognitive testing in the management of youth sports-related concussion." *Journal of child neurology* 31, no. 1 (2016): 68-75. Concussion policy for University of Miami

117 "Concussion." NCAA.org - The Official Site of the NCAA. Accessed December 06, 2016. <http://www.ncaa.org/health-and-safety/medical-conditions/concussion>.

118 Ibid.

119 NCAA. "Concussion and College Sports." Digital image. Ncaa.org. December 15, 2015. Accessed December 6, 2016.

120 After reaching out to the Deputy Director of Administrative Operations Core of the CARE Consortium via e-mail, she provided the information that sites involved with this study do, indeed, use ImPACT. However, the use of ImPACT was not mandated by the Consortium, only the use of a neurocognitive assessment tool in general.

121 NCAA. "Concussion and College Sports." Digital image. Ncaa.org. December 15, 2015. Accessed December 6, 2016.

122 Timmermans and Epstein, "A World of Standards but not a Standard World," 73.

123 Objectification, Standardization, and Commodification in Health Care," 25.

124 Ibid.

125 Ibid.

126 Kelly, and Rosenberg. "The development of guidelines for the management of concussion in sports." 53-65.

127 "Sport-Related Concussion," 56-64.

the industry?

To establish a standard, some key components are necessary: support from scientific expertise¹²², support from a well-established institution,¹²³ and incentives for the adoption of the standard.¹²⁴ Timmermans and Almeling assert that the evidence-based medicine system promotes the use of standard protocol guidelines for practice.¹²⁵ This has been especially true with regard to medical practice regarding concussion in sport, as evidenced by the early concussion protocols¹²⁶ and *Guideline 2I* released by the NCAA.¹²⁷ The new concussion management guidelines set forth by the NCAA¹²⁸ created an environment in which collegiate athletic programs had to use a form of neurocognitive assessment in their sports-related concussion management protocols.¹²⁹ Moreover, these programs had to use a system that was easily accessible and could be administered to thousands of athletes for the mandatory baseline testing.¹³⁰ The development of these guidelines was indicative of the scientific consensus of experts in concussion on how to manage sports-related concussions for college athletes. Support from scientific expertise also came in the form of the published scientific studies evaluating the efficacy, and statistical sensitivity and specificity of ImPACT.¹³¹ ¹³² Another study asserted that ImPACT was a culturally competent form to measure concussion testing.¹³³ According to ImPACT's website, hundreds of peer-reviewed scientific studies cite ImPACT.¹³⁴ This amalgamation of scientific research and expertise in support of Immediate Post Concussion Assessment and Cognitive Testing created conditions that were favorable for ImPACT to prevail as the standard of care in assessing sports-related concussion. However, these conditions alone were not sufficient for ImPACT's ascension.

ImPACT also had the support of several institutions supporting its use including: the NCAA, the National Athletic Trainers Association, the American Medical Society for Sports Medicine, the IOC, IIHF, FIFA, and the Department of Defense. Popular media attributes ImPACT's success to partnerships with Wells Fargo Bank, Dick's Sporting Goods, and high profile professional athletes.¹³⁵ Another article published by ESPN postulates that the widespread acceptance of ImPACT stems from founder Mark Lovell's personal relationships as a consultant for the NFL and NHL and Riddell Helmets.¹³⁶ ImPACT had reputable national organizations acknowledging its efficacy and role in the management of concussions. Moreover, some institutions like Wells Fargo and Dick's Sporting Goods actively promoted its use as the standard for neurocognitive testing.¹³⁷

The vast array of sport and medical institutions supporting the use of ImPACT, created incentive to use this system. One such incentive may be "crowd effect," which was previously introduced.¹³⁸ "Crowd effect" occurs when a standard is so pervasive, that it is a loss not to have it.¹³⁹ In sports-related concussion testing, when a majority of powerful institutions support a system, like ImPACT, it is a loss to any other institutions that does not support ImPACT. ImPACT is a proprietary, for-profit system, and there is also monetary incentive to using ImPACT. For many schools, ImPACT is a more cost-effective and time-saving technique to administer neuropsychological assessment to its athletes. Secondly, with \$30 million grant from the Department of Defense study, universities have large monetary incentive to participate.¹⁴⁰ If a university joins this Department of Defense study for monetary incentives, they may adopt the ImPACT testing system to record data, as many other study participants do.¹⁴¹

Lastly, ImPACT became a standard partially because of convenience. Ongoing studies, like the Department of Defense study, and other independent and smaller studies on concussions used the ImPACT test as a metric. ImPACT was already being used to assess sports related concussion for research purposes. Much like how the pain scale became a standard-of-care in modern medicine, the ImPACT test too became a standard because it was already present.¹⁴² ImPACT is a technology that was present in the literature from its release in 2001 to the currently ongoing Department of Defense study. It was a familiar technology supported by expertise, powerful institutions, and promoted by incentive. Together, these favorable circumstances elevated the Immediate Post Concussion Assessment and Cognitive Testing system to a standard for concussion testing in the NCAA.

VI. CONCLUSION: FUTURE DIRECTIONS

IMPACT ADDRESSES THE SPECIFIC NEED TO QUANTIFY COGNITIVE FUNCTION before and after concussion for physicians. There appears to be a unique focus on how to measure and treat concussion effectively. However, there also appears to be an exclusion of a discourse on concussion prevention. None of the international conferences on concussion in sport nor the national position statements of NATA and AMSSM address policies concerning concussion prevention in sport. The Department of Defense and NCAA study focuses what happens to athletes after concussion and return-to-play, but does not study reliable preventative measures.¹⁴³ Perhaps ImPACT benefitted from an environment unwilling to alter the nature of sport. That is, institutions like the NCAA, NFL, IIHF, and FIFA could have been more receptive of tools that could provide “damage control” once a concussion happened rather than a policy that would prevent tackling in football or prevent heading in soccer. College athletes in the last five years have suffered from approximately 10,500 concussions with the largest rates in wrestling, football, hockey, and women’s soccer.¹⁴⁴ Future concussion management protocols must extend to the preventative phase to protect high school, NCAA, and professional athletes. While ImPACT Applications™ may provide accessible, commonly used concussion management software, the company does not provide a solution to rates of concussion in sport.

136 Peter Keating. "Concussion Test May Not Be Panacea." *ESPN*. August 26, 2012.

Accessed October 20, 2016. http://www.espn.com/espn/otl/story/_/id/8297794/neuropsychological-testing-concussions-not-panacea.

137 "Fancy Concussion Tests Won't Protect Our Student Athletes."

138 Stefan Timmermans, and Steven Epstein. "A world of standards but not a standard world: toward a sociology of standards and standardization." 79.

139 Ibid.

140 NCAA. "Concussion and College Sports."

141 The Deputy Director of Administrative Operations Core of the CARE Consortium explained that many participant sites in the study use ImPACT as a testing system via e-mail.

142 Gordon "Reassessing the assessment of pain."

143 "Concussion."

144 NCAA, "Concussion and College Sports."

128 NCAA guidelines were influenced by the International Conferences on Concussion in Sport and the Position statements of Sports Medicine professionals.

129 "Sport-Related Concussion," 56-64.

130 Ibid.

131 "The 'value added' of neurocognitive testing after sports-related concussion."

132 Philip Schatz, Jamie E. Pardini, Mark R. Lovell, Michael W. Collins, and Kenneth Podell. "Sensitivity and specificity of the ImPACT Test

Battery for concussion in athletes." *Archives of Clinical Neuropsychology* 21, no. 1 (2006): 91-99.

133 Anthony P. Kontos, Robert J. Elbin, Tracey Covassin, and Elizabeth Larson. "Exploring differences in computerized neurocognitive concussion testing between African American and White athletes." *Archives of clinical neuropsychology* (2010): acq068.

134 "The ImPACT Test."

135 "Fancy Concussion Tests Won't Protect Our Student Athletes."