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Concussion Assessment Management in High School and Collegiate Athletics

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Concussion Assessment Management in High School and Collegiate Athletics
A Synthesis of the Research Literature

A Synthesis Project
Presented to the
Department of Kinesiology, Sport Studies, and Physical Education
The College at Brockport
State University of New York

In Partial Fulfillment
of the Requirements for the Degree
Master of Science in Education
(Physical Education)

by
Erin McNeely
12/11/19

THE COLLEGE AT BROCKPORT
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BROCKPORT, NEW YORK

Department of Kinesiology, Sport Studies, and Physical Education

Title of Synthesis Project: Concussion Assessment Management in High School and Collegiate
Athletics

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Accepted by the Department of Kinesiology, Sport Studies, and Physical Education, The College at Brockport, State University of New York, in partial fulfillment of the requirements for the degree Master of Science in Education (Physical Education).

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Date

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Abstract

Research indicates that protocol regarding concussion assessment management at the high school and collegiate level is advancing, however, there are holes in consistency that need to be filled in order to ensure accuracy. The purpose of this synthesis was to review the literature on concussion assessment management in high school and collegiate athletics. The results indicate that the lack of consistency comes as a direct result of key factors including a school's lack of funding and lack of resources, the emphasis placed on the self-efficacy of athletic trainers, and the willingness of athletic trainers to follow guidelines provided for the testing methods.

Keywords: Concussions, Sports-related Concussions, Concussion Assessment, ImPACT Testing, Athletic trainer, Concussion management, High School Athletes, Collegiate Athletes

Chapter 1

Introduction

Sports have remained a part of history dating back hundreds of thousands of years in a number of different forms. The origin of sports dates back roughly 3,000 years to the introduction of the Olympic games in Ancient Greece in 776 BC (Bellis, 2019). What started as a leisurely activity to pass the time, or a way for a country to demonstrate their dominance, sports and the world of athletics have developed into a key aspect of American society. Not only have sports become the basis for physical fitness and entertainment but have also become a way for children and young adults to learn valuable life skills and lessons. “Sport is a human institution, a universal phenomenon which serves to instill a sense of belonging or meaning to many individuals lives.” (Macri, 2012, pg. 1).

The development of the “student-athlete” is much of what defines the world of sports today. “Hundreds of millions of Americans have participated in organized sports programs, and the educational setting has been the primary source of most experiences” (Whitehead & Blackburn, 2013, pg. 3). Athletics and education have found ways to mesh together which allows for student-athletes to grow physically, mentally and emotionally. Athletics have acted as an “agent of change for a nation” and have become essential in providing students with fundamental life skills (Whitehead & Blackburn, 2013). As sports have become a larger commodity and have developed along with the changing landscape of society, the level of play has advanced as well. However, with this growth also comes the inherent possibility for injury and other health related issues. “Recent research suggests that as many as four in 10 emergency room visits for children between five and 14 years old are for sports-related injuries” (Gordon, 2019). The biggest risk that comes along with starting children at such a young age is many of them begin their athletic

career during a time in their life when they aren't fully developed physically. Dr. Michael Kelly, chairmen of the department of orthopedic surgery at Hackensack University Medical Center, along with Dr. Cynthia LaBella, medical director of the Institute for Sports Medicine at Children's Memorial Hospital in Chicago, state that because children are participating in sports while still developing through their growth states, they are more susceptible to repetitive injuries. "According to the U.S. National Institutes of Health, growth-plate injuries are fractures, and they account for 15 percent of all childhood fractures" (Gordon, 2019). With the continuing trend in increasing participation rates also comes the increase in emphasis on fitness and skill, opening the door for increased rates of injury.

Sports and athletics over the last decade have progressed into more of an endgame towards college and pro sports careers rather than for recreational or educational purposes. According to Dr. LaBella (Gordon, 2019), "Sports are much more competitive at an earlier age, and many children are playing one sport year-round now. They're not getting enough time off for their bodies to recover" (p. 5). As these trends continue and athletes are pushed to their limits, so does the number of sports-related injuries.

There are a number of different injuries that can occur in sports, however the two most common forms are acute injuries, which are a direct result of a single impact macrotrauma, and overuse injuries, which occur from repeated training which results in microtrauma (Micheli & Klein, 1991, pg. 6). An example of an acute injury, or macrotrauma, includes fractures, ligament sprains and soft tissue contusions, whereas an overuse injury would include stress fractures, tendinitis, bursitis and joint disorders. Although these physical and often visible injuries are extremely serious, one of the biggest injuries that has come to face within the last decade is the severity of concussions. Even though overuse and acute injuries are serious matters and should

be handled as such, concussions have proven to be some of the most serious injuries that athletes are sustaining due to the “silent” nature of them. Concussions are often hard to detect and do not necessarily reveal symptoms which in turn makes diagnosing and managing them that much more difficult.

With increased rates of injury, and children becoming more susceptible to them, the need for athletic trainers has become more prevalent as well, especially at the high school and collegiate levels where competition occurs at a higher level. “The Centers for Disease Control estimates that 1.6 to 3.8 million concussions occur in sports and recreational activities annually” (Daneshvar, et. al., 2011). A concussion by definition is the “an injury to the brain that results in temporary loss of normal brain function” (American Association of Neurological Surgeons, 2019). No one sport is the main target for possibility of concussion as a blow to the head can occur in many different situations. The biggest issue that athletic trainers and medical professionals often face is that in many cases, there is no visible or physical signs that a concussion has occurred. In very mild cases of concussion, individuals either are not aware of the concussion or do not seek medical advice, therefore making it even harder to accurately depict the number of traumatic brain injuries that are occurring (Daneshvar, et. al., 2011). “An estimated 300,000 sport-related traumatic brain injuries, predominantly concussions, occur annually in the United States. Sports are second only to motor vehicle crashes as the leading cause of traumatic brain injury among people aged 15 to 24 years” (Gessel, et. al., 2007, p. 495). That being said, concussion management protocol and return to play guidelines have become essential in the athletics realm and will only continue to develop as more is learned about the injury.

Statement of the Problem

Concussion rates are continually increasing as a direct result of the competitive nature of sports and athletic competition. “An estimated 1.6-3.8 million sports and recreation related concussions occur in the United States each year” (Brain Injury Research Institute, 2019, para. 4). Concussion management protocol has become a major focus for athletic trainers and medical training staff as it can be one of the trickiest to treat because of the nature of the injury. Research suggests that there is a strong need for the use of concussion assessments and an emphasis needs to be placed on the efficiency and accuracy of the methods and processes used by athletic trainers.

Research Questions

1. What are the different methods of concussion assessment?
2. What is the level of training provided to athletic trainers in high schools regarding concussions?
3. What factors play a role in concussion assessment at the high school and collegiate level?
4. What qualifications are necessary to be able to properly assess concussions and complete concussion protocol?
5. What governing entities are responsible for monitoring or assessing the best practices in concussion protocol?
6. What are the varying methods of concussion assessment at the high school and collegiate levels?

Purpose of the Study

The purpose of this synthesis project is to review the literature on concussion assessment management in high school and college athletics.

Operational Definitions

1. Concussion- an injury to the brain that results in temporary loss of normal brain function.
2. Athletic Trainer- a certified and licensed health care professional who practices in the field of sports medicine.
3. Concussion Assessment- tests that are used to assess brain function after a head injury.

Delimitations

The following are the variables that have been delimited in this synthesis review:

1. Athletes participating at the high school and collegiate levels.
2. Peer reviewed articles including athletic trainers' perceptions of concussion management.
3. Articles published within the last decade.
4. Athletic injuries pertaining specifically to concussions.

Chapter 2 – Methods

The purpose of this chapter is to review the methods used to review the literature on concussion assessment management in high school and college athletics.

The studies collected for this synthesis were located using the EBSCO database from The College at Brockport's Drake Memorial Library. Within the EBSCO database the following databases were searched: SPORTDiscus, Google Scholar and Academic OneFile.

Within these databases a total number of 12 articles met the criteria for inclusion as part of the critical mass within this literature review. In order for an article to meet the criteria for selection in this synthesis it must have been published between 2009-present, this will provide the synthesis with the most up to date and current information available. Other criteria for selection included scholarly and peer reviewed articles that were full-text. Having scholarly and peer reviewed articles provides more validity within the articles and better overall quality. Other articles or sources selected as part of this literature review provided context about the topic, background information and supplemental information to complete the review. All articles and sources are appropriately cited in the reference section of this paper.

In order to gather valuable articles for this synthesis certain keywords and phrases were used when searching the data-base. The first keyword searched was concussion assessment in high schools that resulted in 1,317 hits. From there, the search needed to be narrowed so the phrase was reconstructed to concussion testing and athletic trainers in high schools and resulted in 23 hits. In an effort to hone in on the specifics of the statement of purpose, the word testing was substituted with management. Looking at concussion management and athletic trainers and high schools resulted in 20 total hits. The final search aimed at looking for numerical data to back up the statement of purpose, which included concussion rates and resulted in 6,946 hits.

Since the information about concussion at the high school and collegiate level available is so vast, little changes in word phrasing was necessary in order to find articles that were most closely tailored to the statement at hand. In the four different searches, 26 articles were selected and then that list was narrowed down to 12 based off of the necessary criteria for inclusion in the critical mass.

Full text articles that were selected for use in this synthesis were scholarly and peer reviewed articles. Also, when selecting articles for use in this synthesis it was important that each article selected had valuable information that focused specifically on the use of concussion assessment methods at the high school and collegiate level. Each of the articles had to focus solely on the assessment methods themselves, and the variety that are being used, as well as the use of these methods by athletic trainers and the correlation between them. The articles varied anywhere from the accuracy of said methods and the evaluation of implementation to the self-efficacy of athletic trainer in assessing and managing sports related concussions.

Specific criteria were used in order to be a part of the literature review. All of the articles selected were based on the use of concussion assessment methods by high school and collegiate athletic trainers, most specifically regarding the kinds of assessment methods, how they are managed, trainers perceptions on said methods, and the trends that have continued to arise as concussions and concussion assessment have become a more prevalent topic. Participants in the studies reviewed were high school and college athletes, athletic trainers or clinicians who work closely with sports related injury.

For this synthesis, a total number of 12 articles were used to compile data on the topic of concussion management in high school and collegiate athletics. Articles came from a variety of journals including the *Journal of Athletic Training*, the *American Journal of Sports Medicine*, the

Journal of Sports Sciences, the Journal of School Nursing, Research in Sports Medicine and the Journal of Clinical and Experimental Neuropsychology.

The critical mass for this synthesis is comprised of 8,460 participants. Within the 12 articles used for the literature review seven of the 12 articles specified sex, including 4,524 males and 2,367 females. The remainder of the articles categorized participants in a variety of different ways, including high school vs. college, certified athletic trainers at different divisions, athletic trainers who were members of the National Athletic Training Association, and athletes competing at the high school and collegiate levels in contact and collision sports. Multiple studies, including McGuine et.al. (2018), included a specification in where the school were located, including but not limited to Wisconsin, Massachusetts and Michigan.

Data was analyzed using the following methodologies for the studies under review: cohort studies, descriptive epidemiology studies, descriptive observational studies, cross sectional studies, web-based surveys and questionnaires, control and practice groups, focus groups and qualitative studies.

Chapter 3

Review of Literature

The purpose of this chapter is to present the review of literature related to concussion assessment management in high school and collegiate athletics. There are three specific areas of concussion assessment associated with the literature review and they are:

management/implementation, reliability/accuracy and influence/self-efficacy. Specifically, the following areas will also address the variation between high school vs. collegiate athletes in regards to concussion management and the role they play in each respective group.

Management/Implementation

Before you can understand the importance that concussion assessment plays in the realm of high school and collegiate athletics, it is first important to understand the methods, techniques, procedures and policies that are being used. Concussions are continually becoming more and more common at the high school and collegiate levels, with athletes recording roughly 1.6 to 3.8 million concussion annually (Chin, Nelson, Barr, McCrory & McCrea, 2016). Therefore, the need for accurate assessment is becoming more and more relevant. With the interest level in assessment and management of concussions peaking, there have been several international conferences that have met to try and categorize consensus statements and update guidelines to assess clinicians in their assessment of sports-related concussions (Meehan, Hemecourt, Collins & Comstock, 2011).

The management of sports-related concussions is tough to assess because they can occur by a number of different people in a variety of different settings. In an investigative study conducted by Meehan et.al (2011), all concussions that were recorded by the High School

Reporting Information Online (HS RIO) injury surveillance system from 2009-2010 analyzed who and how sports-related concussions were being conducted. The purpose of the study was “to describe the medical providers and medical studies used when assessing sports-related concussions and to determine the effects that medical provider type on timing of return to play, frequency of imaging, and frequency of neuropsychological testing” (Meehan et. al., 2011, p. 2,304).

The researchers went on to also examine how the effects of medical providers on certain aspects including return to play, frequency of imaging and frequency of neurological testing (Meehan et. al., 2011). The study included data from 192 US high schools and 20 different sports who used the HS RIO. The research involved the presence of information from athletic trainers affiliated with the National Athletic Trainers Association who were compensated to record their injury incidents and athletic exposure weekly into the HS RIO (Meehan et al., 2011). In each report, each athletic trainer was asked to “complete a detailed injury report from providing information on the injured athlete, the injury itself, and the injury event” (Meehan et. al., 2011, p. 2,305).

To narrow down results, Meehan et al. (2011), specified that injury was said to be defined as those resulting from participation in high school athletic practice or competition, with this study focusing specifically on concussions. The results indicated that of the 7,257 sport-related injuries recorded, 1,056 were concussions with the highest reports being recorded in football, boy’s hockey and boy’s lacrosse (Meehan et al., 2011). The study did not focus solely on the number and types of injuries but who was responsible for assessing and managing the concussions. According to Meehan et al. (2011), a medical professional was on site for concussions 92.7% of the time and athletic trainers were on site for at least 70 % of the

concussions. The consensus from the HS RIO revealed that in many cases concussions are being assessed by primary care physicians, which is of concern because they may not have the proper resources or knowledge of current concussion protocol in order to do so. “The National Athletic Trainer’s Association reports that only 42% of high schools in the United States use the services of an AT” (Meehan et. al., 2011, p. 2,308). In addition, the research indicated that at least 2.5% of decisions to return to play were being made by nonmedical personnel, putting athletes at a high risk of second-impact syndrome (Meehan, et. al., 2011). This research is an example of why the presence of a trained medical professional, or athletic trainer, is necessary in relation to sports-related concussion assessment.

“Youths who sustain concussions and prematurely return to activity can be at risk for intensified symptoms, prolonged recovery, additional injuries, and even permanent disability” (Davies, Coxe, Harvey, Singichetti, Guo & Yang, 2018, p. 873). Another study conducted by Davies et. al. (2018), on the evaluation of strategies commonly used to implement concussion laws at the school and district levels, continues to discuss the steps that need to further be taken in regards to concussion management. The purpose of this study was “to evaluate the strategies commonly used to implement concussion laws at the school and district levels, as reported by certified athletic trainers” (Davies et. al., 2018, p. 873). A continuous effort to enact laws has shown face over the years in an effort to enhance concussions protocol, however not much is known on the extent to which these laws and policies are being implemented by schools.

Much like the previous study, the one conducted by Davies, et. al. (2018) was a qualitative study that focused on the use of the HS RIO system in an effort to get a read on the strategies used to implement concussion protocols. In the 2014-2015 and 2015-2016 school years, 71 participants, including 64 athletic trainers and seven athletic directors from 26 different

states participated in a 30-40 minute phone interview, where they were questioned on the implementation procedures and practices of the participating high schools, most specifically removal from play, return to play and concussion education (Davies et. al., 2018). The transcripts were first compared and then used to develop themes about the general practices amongst the 64 interviews that were analyzed. The results were broken down into the following categories: demographic characteristics of schools and participants, strategies to implement the removal from play tenet, strategies to implement the return to play tenet and strategies to implement the concussion-education tenet. From each category it was determined that all participating schools had written concussion policies and 78.1% of the AT's were involved in developing those policies (Davies et. al., 2018). The overall results of the study identified that each of the tenets listed above are important however should not be the only strategies being used. The athletic trainers questioned "emphasized the importance of involving multiple stakeholders and using various existing resources for the successful implementation of their state concussion laws and policies at the school level" (Davies et. al., 2018, p. 878).

In addition to the importance of who is conducting assessment, the techniques used and frequency of assessment is crucial as well. A study conducted by Lynall, Laudner, Mihalik & Stanek (2013) looks closer at the concussion-assessment techniques used by athletic trainers in an effort to clarify where concussion education is lacking. The study focused on the current clinical concussion diagnostics and return-to-participations practices set in place.

The first convenience sample collected was of 3,222 email addresses of athletic trainers who were members of the National Athletic Trainers Association. Then from that list, an email was distributed with a link to a web-based survey that they were asked to complete. A total of 1,053 surveys were submitted and analyzed to determine descriptive statistics (Lynall et. al.,

2013). In terms of demographic information, the athletic trainers experience levels ranged anywhere from two to 20 years, with the majority of them being at the high school level. The AT's reported having observed 11,2476 total concussions per year.

When asked about their assessment methods, the majority responded that clinical examination was their most common reporting method, however when using other methods, 90% reported using the Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT) computer-based test (Lynall et. al., 2013). When comparing the usage by high school and college programs, college AT's were more likely to use the Balance Error Scoring System (BESS) than high schools and high schools were more like to use noncomputerized neuropsychological testing. Alternatively, college AT's were more likely to use computerized neuropsychological testing than both high school AT's and clinical AT's. (Lynall et. al., 2013). Overall, the results revealed that AT's are relying more on balance and neuropsychological testing than the use of clinical examinations and continue to prove that there needs to be some sort of standardization in the management of post-concussion protocol. While they are making headway towards more effective and efficient methods, this study provides insight into the idea that AT's should continue to focus on the use of multiple tools for assessment in an effort to maintain accuracy (Lynall et. al., 2013).

It is continuously noted that computerized neurocognitive testing is becoming more and more popular in regards to assessing sports-related concussions. "Because of the difficulty in detecting the signs and symptoms that often accompany concussions, baseline neurocognitive testing has resulted in increased detection of post-concussion neurocognitive impairments" (Covassin, Elbin, Stiller-Ostrowski & Kontos, 2009, p. 639). Similarly, the study conducted by Lynall, Covassin et. al., (2009), aimed to look specifically at the implementation and practice

trends, using baseline neurocognitive testing at the high school and collegiate levels. Being that concussion management is a growing topic in the sports medicine and training world, the use of effective tools is growing, however can only be effective if the necessary training and protocols are put in place. ImPACT is a neurocognitive test that aims to use six modules to evaluate things such as attentional processes, verbal recognition memory, visual working memory, visual processing speed, reaction time, numerical sequencing ability and learning (Covassin et. al., 2009). Covassin et. al., (2009) research consisted of contacting 1,209 institutions (404 high school and 805 universities) to participate in an online survey regarding their use of ImPACT. Of the 1209, 399 athletic trainers responded with experience ranging anywhere from five to 21 years and reported using ImPACT for anywhere from 1-5 years. Even though roughly 95% of the athletic trainers specified that they administer baseline testing, only half of them reported taking the time to examine whether the tests were accurate or not. Not only did results show that athletic trainers are not reviewing the initial testing, but fewer than half had attended an ImPACT training workshop (Covassin et. al., 2009). Programs are taking steps in the right direction by using systems like ImPACT to control their concussion assessment, however they may be defeating the purpose if not using the programs correctly or even to their fullest potential. According to Covassin et. al. (2009), ImPACT even provides a manual with suggestions for ensuring validity but many who invest in the product are ignoring the instructions. In addition, the results revealed that the ImPACT is also being used inconsistently with only half of the athletic trainers reporting having given the first post-concussion test within 1 to 2 days post injury. With this combination of misuses, it is very likely that athletic trainers are also not interpreting data correctly as a result.

Reliability/Accuracy

Over the years there have been a number of different assessment methods that athletic trainers and sports medicine professionals have used, including the transition from pen and paper assessment to computerized neurocognitive testing. These methods include, but are not limited to the SCAT3 tandem gait test and the Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT) method. In order to use these assessment methods, it is essential that those administering the tests are aware of how to properly use them as well as all of the factors that play a part in the assessment.

Register-Mihalik, Kontos, Guskiewicz, Mihalik, Conder & Shields (2012) aimed to assess age and practice effects on computerized and paper and pencil neurocognitive testing batteries in collegiate and high school athletes. In order to compare assessment methods, 20 NCAA Division I collegiate athletes and 20 high school athletes were given multiple tests including the Hopkins Verbal Learning test, Brief Visual-Spatial Memory test, Trail Making test, Symbol Digit Modalities test, Stroop test, and the ImPACT test. Once each of the student-athletes completed the test, mixed-model analyses were compiled to determine variance (Register-Mihalik et. al., 2012).

Ultimately from the study, Register-Mihalik et. al. (2012), looked to examine the role that age difference plays on neurocognitive performance and then compared the reliability of response and practice effects between the two age groups. The athletes were tested on both computer-based programs and paper and pencil methods through three test sessions. Even though no statistical data was observed on the paper and pencil method, age did show an effect on ImPACT processing speed scores showing that college students generally performed better than high school students across all three of the testing sessions. The results compiled from the study highlight the need to understand the variability in performance on measures included in both

forms of testing and try to control for as many factors as possible to get more stable results (Register-Mihalik et. al., 2012). It also provided athletic trainers and clinicians with knowledge that the differences reflected in this study show that there is enough of a differentiation in brain development between these two age groups that it may reflect “underlying neuromaturational processes” (Register-Mihalik et. al., 2012, p. 302). It is important for athletic trainers and clinicians to be aware of the reliability of different types of testing methods depending on the age groups that they are assessing.

With the growing frequency of concussions and the introduction of it as a public health crisis, Schatz and Sandel (2012) also broke down the utility of post-concussion neurocognitive testing versus symptom data as well. When comparing the two, researchers have demonstrated that computer-based neurocognitive testing is a more effective tool than pencil and paper because it can be administered to large groups simultaneously, it has increased timing accuracy and shows the least frequency of practice effects (Schatz and Sandel, 2012). In this study, Schatz and Sandel (2012), data was collected from ImPACT Applications INC. on large samples of baseline and post-concussion testing of athletes from high school and colleges across the United States in the 2011-2012 school year, looking specifically at data in three categories including symptomatic concussed athletes, asymptomatic concussed athletes, and nonconcussed athletes. After reviewing the data, Schatz and Sandel (2012) found that the ImPACT test scores demonstrated a sensitivity of 91% and a specificity of 69% and that when an athlete tries to “fix” their results by downplaying the presence of their symptoms, they in turn “display more variable behavior and paradoxically distinguish themselves from matched controls” (para. 14). Therefore, demonstrating that ImPACT is a reliable source in diagnosing concussion, however much like

many other forms, should still be analyzed according to the inherent variability of the student-athletes.

One of the key elements of concussion testing is the effective use of test-retest when using an athlete's baseline performance. When it comes to the use of ImPACT testing and its reliability of test-retest, studies have resulted in mixed results. Brett and Solomon (2017) conducted a study in an effort to "examine the test-retest reliability of repeated ImPACT baseline assessment in high school athletes across various validity criteria reported in previous studies" (p. 286). For this study, the scores of 1,146 high school athletes age 13-18 who were enrolled in 30 high schools in the southern region of the United States who completed baseline cognitive testing using ImPACT at two time periods of approximately two-year intervals. In addition, there were five forms of validity criteria used in previous test-retest studies that were examined to compare differences in reliability (Brett and Solomon, 2017). When broken down further, the data collected revealed minimal variation in test scores. The results were in line with those of previous studies conducted, proving that the reliability was at its lowest when looking at verbal memory and at its highest when looking at visual motor speed and reaction time (Brett and Solomon, 2017). What the research did provide was the suggestion that "applying extended, or more stringent criteria does not increase test-retest reliability, and that the ImPACT manual's criteria for test validity should be utilized (Brett and Solomon, 2017, p. 292).

Aside from ImPACT, one of the other most frequently used tools is the Sports Concussion Assessment Tool-3 (SCAT3), which is utilized for sideline assessment of an athlete's symptoms, cognition and balance (Chin et. al., 2016). Because there is yet to be little published about how clinically relevant SCAT3 is yet, Chin et. al. (2016) evaluated the main components of SCAT3 listed above and developed "clinical decision criteria" for the benefit of

clinicians to use in situations both with and without baseline data. Much like the data presented by Brett and Solomon (2017), this study relied heavily on the use of using preinjury baseline data to assess concussions. The participants included 2148 athletes from nine high schools and four colleges in southeastern Wisconsin, who were observed from August 2012 until October, 2014. When broken down, Chin et. al. (2016) was able to provide evidence that sex and the level of competition both play a part in SCAT3 performance and that female, high school athletes who have a prior history of psychological disorders show more severe results of concussion during the baseline assessment. The study conducted by Chin et. al. (2016), correlates very similarly with others in that it demonstrates the need for meticulous work when going about concussion assessment. Each of these assessment methods provides their own benefit to being able to detect and monitor concussions, however if athletic trainers and physicians are not aware of and/or, taking into account the other factors that play a part in the results, then these tools are not being used to their fullest potential or correctly for that matter.

Influence/Self-Efficacy

Being that there are a number of external factors that can play a part in the kind of results concussion assessment tools provide, it is also important to look at athletic trainers and clinicians and the role that they play in the management process as well. Currently, all 50 states have passed concussion management legislation and have enacted some form of system by which these guidelines are enforced (Buckley, Burdette & Kelly, 2015). Most specifically, at the college level, the NCAA created an initiative to provide institutions with set requirements in addition to best-practice recommendations (Buckley, Burdette & Kelly, 2015).

When the importance of concussion assessment first came to light, early studies showed that in most cases, athletic trainers simply relied heavily on the evaluation by physicians in terms

of return to play. According to Buckley, Burdette & Kelly (2015), roughly a decade later more than half of DI athletic trainers reported using “multifaceted assessments” at each stage of the concussion management process. Many researchers have found it difficult to accurately assess the different levels of competition from a practice setting so a lot of previous data has relied on athletic trainers and their assessment in the employment settings (Buckley, Burdette & Kelly, 2015). In addition, little observation has been completed at the DII and DIII levels so the purpose of this study was to assess concussion management practice patterns among DII and DIII athletic trainers. The purpose of this study was “to descriptively define the concussion-management practice patterns of NCAA Division II and III athletic trainers” (Buckley & Kelly, 2015, pp. 879). For the study, Buckley, Burdette & Kelly (2015) sent 1,976 athletic trainers, who identified themselves as full-time certified or licensed athletic trainers and who aided institutions in May of 2013. Each of these athletic trainers was then sent a link to a list of 65 questions, previously used to assess DI athletic trainers, and focused primarily on their concussion management patterns. The results provided by the 1,880 finalized participants demonstrated patterns outlining that most athletic trainers questioned did not use a multifaceted concussion assessment at baseline, the most commonly used computerized neuropsychological testing (CNT) was ImPACT, and “the primary reason that CNTs was not used by respondents were lack of staffing or funding to perform the test” (Buckley, Burdette & Kelly, 2015, pp. 881-882). One of their main findings was that at both levels there was definitely a lack of baseline assessment being conducted, however there were a higher level of responses when using assessment for acute injuries and return to play scenarios. A lot of the issues that DII and DIII institutions are demonstrating stem from their smaller budgets and resources than those of DI programs and therefore their level and ability of elevated assessment is lacking (Buckley, Burdette & Kelly, 2015). The lack of

resources and the frequency of lack of reporting is continuously an issue that institutions are facing. This study aims to highlight the need for the use of both clinical assessment and the use of programs like ImPACT testing in order to be able to most accurately assess and report symptoms (Buckley, Burdette & Kelly, 2015).

In addition to the importance of the role athletic trainers play in administering and controlling assessment, another key factor that often plays into test results is the athletic trainers understanding of beliefs and self-efficacy towards concussion management. Continuous organizations have worked to try and create “multifaceted approaches” to evaluating concussions but the biggest issue is that there is little intervention in actually making sure athletic trainers are adhering by these guidelines (Rigby, Vela & Housman, 2013).

Using a theory of planned (TPB) behavior, Rigby, Vela & Housman (2013) conducted a study that aimed at identifying what athletic trainers’ beliefs are regarding the recommended guidelines. During the study, a total of 1,000 members (221 of which actually responded) of the National Athletic Trainers Association were emailed a 66-question survey on thoughts regarding the current concussion guidelines. The assessment was broken down into three TPB constructs, including attitude towards the behavior, subjective norms, perceived behavioral control, and behavioral intention (Rigby, Vela & Housman, 2013). From the responses, Rigby, Vela & Housman (2013) were able to outline two core themes, including those with positive attitudes about the recommendations being provided were more likely to use them and those who do not implement them, do so because they do not believe they have the power to do so. While the number of athletics trainers using multistep approaches to assessing concussion, there are still a significant number of the population who are not using the recommended tools. Through the study, recommendations further suggested that by identifying where the lack in interest in

compliance is occurring, organizations should be putting intervention programs in place to help improve motivation and willingness of athletic trainers to incorporate these recommendations.

There are a number of different factors that can play into this lack of support for recommendations including the increasing presence of burn out in athletic trainers and the perception of lack of support, lack of funds, and a lack of time.

With that being said, an athletic trainers' presence in reporting and managing concussions is still unknown. Their role as a facilitator in the process is essential but it is important to recognize how the frequency and reliability of an athletic trainer's presence has an effect on reporting, maintaining and assessing sports related concussions. It has been proven that having a sport medical professional present for the aid of sports related concussions has been "integral to the prompt identification and evaluation of the injury, necessary to provide appropriate evidence-based managed care, and important to ensuring that the athlete is not allowed to return to play prematurely" (McGuine, Pfaller, Post, Hetzel, Brooks & Broglio, 2018, pp. 1017-1018). A recent study conducted by McGuine et. al. (2018) assessed 2,459 student athletes from 31 Wisconsin high schools in an effort to determine how the presence of an athletic trainer affects the reporting and management of sports related concussions. The participants were put into three categories; having low availability, mid availability and high availability of athletic trainers and then recorded whether post-concussion management differed depending on the availability of an athletic trainer (McGuine et. al., 2018). Throughout the study, athletic trainers electronically recorded the number of athlete exposure, any suspected incidence of sports related concussions and any additional information regarding the atmosphere, type of competition, etc. When broken down further, McGuine et. al., (2018) began to notice patterns. The availability of athletic trainers in secondary schools had a direct correlation with the rates of reported sports related

concussions. From the data, researchers were able to uncover that the incidence of reported sports related concussions in the low availability athletic trainer schools was lower than the studies previously conducted on the subject. This raised significant concerns because the research suggests that the prevalence of unrecognized sports related concussions could approach 50% if the trend continues (McGuine et. al., 2018). Being that there is a direct correlation between the presence of athletic trainers in institutions and the frequency and accuracy of reported sports related concussions, it is essential that schools continue to increase athletic trainer availability to be able to identify, assess and manage all athletes.

It's easy to look at the physical impact that athletic trainers have on the concussion assessment process, but little has been studied in regards to the self-efficacy of athletic trainers in assessing and managing sports related concussions. When looking at the factors that play into an individual's self-efficacy, they include past performance accomplishments, vicarious experiences, verbal persuasion and physiological states (Savage & Covassin, 2018). Prior to completing the study, both authors hypothesized that collegiate athletic trainers have higher self-efficacy than high school athletic trainers because of their financial resources, time available and accessibility to certain concussions tools. The participants in the study included 94 athletic trainers at the high school and collegiate level who were asked to complete a self-administered online survey that highlighted three main categories; demographics, self-efficacy in assessment, and self-efficacy in management of sports related concussions. Of the 94 athletic trainers who responded, most reported moderate self-efficacy for their use of SRC assessment and management tools and a pattern in difference between high school and collegiate athletic trainers arose as well. Most athletic trainers demonstrated that when there is an increase in their self-efficacy in assessment it is most directly related to an increase in their self-efficacy of

management (Savage & Covassin, 2018). Savage & Covassin (2018), were able to use the data collected to provide direction for programs in suggesting that athletic trainers need to understand their own self-efficacy and continue to use effective techniques to enhance their clinical ability.

Summary

Studies have revealed that there are a number of different factors that play into the evaluation, assessment, and validity of concussion management. When looking directly at the sources, athletic directors are essential in all aspects of assessment. Concussions and concussion assessment are becoming more and more prevalent and it is important that programs and athletic trainers are evolving with the trends. Some key takeaways include making sure to use manuals provided by neurocognitive testing tools in order to maximize efficiency and accuracy. The need for continuous education and legislation to ensure concussion protocols are being enforced, making sure that athletic directors understand and are aware of the role that they play in concussion assessment, as well as a number of other external factors including sex, age, level of competition, etc.

Chapter 4

Results, Discussion and Recommendations for Future Research

The purpose of this chapter is to present the review of literature on concussion assessment management in high school and collegiate athletics, and how these results align with the purported research questions which guided this synthesis project. In addition, recommendations for future research as it relates to concussion assessment management in high school and collegiate athletics are presented. The results of this review of literature revealed the following. Overall, concussion protocol is continuously being adjusted and implemented into institutions at both levels, however the research suggests that a heavier emphasis needs to be placed on all of the contributing factors related to concussion assessment. The research revealed that in regards to computerized neurocognitive testing, athletic trainers are not following the provided resources for proper use, therefore having a direct impact on the accuracy of results as well as the frequency by which the testing tools are being used. In addition, demographic factors such as gender, age and mental medical history played a much larger role in the athlete's ability to effectively complete testing than most athletic trainers account for when distributing the tests. With this knowledge, athletic trainers and institutions need to put a stronger emphasis on the guidelines and restrictions provided as well as pay closer attention to the extrinsic factors that play a part in concussion assessment.

Discussion

Interpretations/Implications

As part of this literature review, several research questions were posed. In line with the first research question regarding the different assessment methods used by athletic trainers, the research revealed that a majority of schools are a push for the use of computerized

neurocognitive assessment tools, most specifically the Immediate Post Concussion Assessment and Cognitive Testing (ImPACT) tool because of its ability to provide the most accurate results in the most efficient manner when regarding large sums of athletes. Other tools that were mentioned throughout the research included the Balance Error Scoring System (BESS), the Sports Concussion Assessment Tool 2 and 3 (SCAT2/SCAT3). When looking specifically at how athletic trainers are reporting the frequency of concussions, the tool most often used is the High School Reporting Information Online injury surveillance system.

The second research question investigated the level of training that high school athletic trainers receive regarding concussion assessment, and contrary to popular belief, very little training is conducted by the schools themselves. Athletics trainers at these institutions are required to be active members of the National Athletic Training Association (NATA), have background in the particular subject matter at the educational level and are given sets of laws and policies to use as a guideline, however “little is known about how such laws and policies have been implemented at the school level, including what strategies are commonly being used in the successful implementation of such laws and state policies” (Davies et. al., 2018, p. 873).

Research questions three through five all address the guidelines and governing entities that are responsible for overseeing concussion protocol. A study conducted by Lynall et. al. (2013), identified that with the crossover use of both objective concussion tools and clinical examination, athletic trainers are more likely to be able to better identify, assess and manage concussion from start to finish. Whereas, there is a continuing trend in the push towards using computerized testing many of the athletic trainers studied admitted that they relied more heavily on the personalized examination of symptoms rather than online testing scores (Covassin et. al., 2009). In regards to the research question focusing on qualifications, in addition to being

members of NATA and having some sort of degree or certification, it was identified that it is also essential for athletic trainers to be knowledgeable about how to properly operate concussion assessment tools and fully understand the factors that play into the results. When broken down, there was very little variability in the training or governing entities between high school and collegiate athletics, however a study conducted by Chin et. al. (2016), aimed to identify the difference in variables regarding the kinds of athletes at the high school and collegiate levels and how that plays a role in the results. Chin et.al. (2016) revealed that an athlete's sex, level of competition, learning disabilities, ADHD, and verbal intellectual ability all have different effects on the baseline scores of athletes.

Another difference between assessment at the high school and collegiate level looked at the difference in the tools being used. Athletic trainers across the country identified that the reason for the limited use of online neurocognitive testing often is affected by budgets and lack of resources (Buckley et. al., 2015). Although there are currently rules and guidelines set nationwide, very little is still known about how effectively these methods are being implemented at each respective institution. A study by Rigby et. al. (2013), examined that one way to get higher results of compliance and self-efficacy about concussion assessment from athletic trainers is first by understanding their beliefs towards the multi-faceted approaches set in place. From the research examined, a trend appeared that as the need for online computerized testing becomes apparent, and as the technology gets smarter, the implementation and education of athletic trainers about the tools is essential in making sure that schools are getting the strongest and most effective results in an effort to minimize the risks for high school and collegiate athletes.

Recommendations for Future Research

In reviewing the data base on concussion assessment management in high school and collegiate athletics, the following limitations were noted regarding the studies under review including selection bias, the low level of responses in many cases, the possibility of false or untruthful responses, measurement error, large standard deviations and the lack of time for study. Many of these limitations were a direct result of the fact that these studies were being conducted through online surveys.

Based on these limitations, and other insights related to the literature, the following recommendations for future research should be considered:

1. To evaluate in person discussion groups/observations to get a stronger response rate and allow for more insightful responses.
2. To examine the effect that the level of involvement of athletic directors and other administrators plays in the concussion assessment process.
3. To continue to look into the guidelines and recommendations put in place by governing bodies.
4. To continue to identify the demographic and psychological factors that have a direct effect on the accuracy of concussion assessment results.
5. To identify ways that tools such as ImPACT testing can be made more readily available to schools with lower funding.
6. To review manuals and guidelines for concussion testing and to determine how to get athletic trainers to use and read them more frequently.

Summary

The purpose of this literature review was to determine what concussion assessment management looks like at the high school and collegiate levels. Delimiting variables were used to do an exhaustive data-based search which yielded 13 articles. These articles were then systematically used to determine what concussion assessment management looks like at the high school and collegiate levels. When looking directly at this set of studies regarding concussion assessment management, there were a number of holes in the research that stood out. The emphasis being placed on the importance of using ImPACT testing, and using it correctly, is not being translated well enough. From the research, there was a common theme that kept reoccurring; that until institutions make the push to doing things 100% according to the books, athletic trainers' abilities to accurately and effectively assess concussions is going to falter. Research revealed that where the implementation of laws and guidelines for institutions is headed in the right direction, a heavier emphasis needs to be placed on the education of athletic trainers on how to properly use the assessment tools and how to properly interpret the data that is being presented to them.

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Appendix A**Article Grid**

Author	Title	Source	Purpose	Methods & Procedures	Analysis	Findings	Discussion/ Recommendations Research Notes – Commonalities/Differences
Register-Mihalik, J.K., Kontos, D.L., Guskiewicz, K.M., Mihalik, J.P., Conder, R., & Shields, E.W., (2012).	Age-related differences and reliability on computerized and paper-and-pencil neurocognitive assessment batteries	<i>Journal of Athletic Training</i>	To assess age and practice effects on computerized and paper-and-pencil neurocognitive testing batteries in collegiate and high school athletes.	<p>Forty healthy and active volunteers participated in this study. Participants consisted of 20 National Collegiate Athletic Association Division I student-athletes (age = 20.00 ± 0.79 years) and 20 student-athletes (age = 16.00 ± 0.86 years) from 2 high schools. Each age group contained 10 males and 10 females.</p> <p>Hopkins Verbal Learning Test scores. Brief Visual-Spatial Memory Test scores. Trail Making Test B total time. Symbol Digit Modalities Test score, Stroop Test total score, and 5 composite scores from the Immediate Post-Concussion</p>	One 2 X 3 mixed-model analysis of variance (age X time) was calculated for each of the 14 outcome measures. For each outcome measure, analysis of variance was conducted to examine the main effects for group (age) and test time (practice effects) to determine differences between collegiate and high school athletes for the ImpACT and paper-and-pencil neurocognitive test scores. Interaction effects were analyzed to examine the joint effects of age and test time (practice) for each outcome measure.	<p>Collegiate student-athletes performed better than</p> <p>high school student-athletes on ImpACT processing speed composite score ($F_{1,38} = 5.03, P = .031$) at all time points. No other age effects were observed. The Trail Making Test B total time ($F_{2,66} = 73.432, P < .001$), Stroop Test total score ($F_{2,76} = 96.85, P < .001$) and ImpACT processing speed composite score ($F_{2,76} = 5.81, P = .005$) improved in test sessions 2 and 3 compared with test session 1. Intraclass correlation coefficient calculations</p>	<p>These results highlight the need to understand this variability and to control for as many factors as possible to produce more stable results across serial testing sessions.</p> <p>A small window of time was allowed between test sessions; often the period of time to the initial postinjury session from baseline is longer. In addition, we only used a few of the paper-and-pencil tests available and 1 computerized test battery, which may limit our findings to these particular batteries. Lastly, the study had a relatively small sample size. However, given the effect sizes observed in the study, the lack of differences observed was most likely not clinically meaningful.</p>

				Assessment and Cognitive Testing (ImPACT) variance were used to examine each measure.		demonstrated values ranging from 0.12 to 0.72. An athlete's neurocognitive performance may vary across sessions. It is important for clinicians to know the reliability and precision of these tests in order to properly interpret test scores.	
Meehan, W.P., d'Hemecourt, P., & Collins, C.L., Comstock, R.D. (2011).	Assessment and Management of Sport-Related Concussions in United States High Schools	<i>The American Journal of Sports Medicine</i>	To describe the medical providers and medical studies used when assessing sport-related concussions. To determine the effects of medical provider type on timing of return to play, frequency of imaging, and frequency of neuropsychological testing.	All concussions recorded by the High School Reporting Information Online (HS RIO) injury surveillance system during the 2009 to 2010 academic year were included.	Over the course of the 2009 to 2010 academic year, HS RIO recorded 7257 sport-related injuries, of which 1056 (14.6%) were concussions. Concussion accounted for 90.0% of the 1173 injuries recorded to the head and face, followed distantly by lacerations (3.8%) and contusions (2.8%). Male athletes sustained 75.7% of all recorded concussions. Most concussions	A medical professional was on site at the time of injury for 92.7% of concussions. Athletic trainers were on site for at least 70.0% of concussions. Physicians were on site at the time of 7.7% of concussions. A medical professional was more likely to be on site if a concussion occurred during football as opposed to other sports (96.1% vs	Concussions account for nearly 15% of all sport-related injuries in high school athletes. The timing of return to play after a sport-related concussion is similar regardless of whether the decision to return the athlete to play is made by a physician or an AT. When a medical doctor is involved, most concussions are assessed by primary care physicians as opposed to subspecialists. Computed tomography is obtained during the assessment of 1 of every 5 concussions occurring in high school athletes.

					<p>(88.6%) were new injuries, while 11.4% were recurrent. Of recurrent concussions, 37.0% recurred within the 2009 to 2010 academic year, while for 61.3%, the index concussion occurred before the 2009 to 2010 academic year. Data regarding the timing of prior concussions were unavailable for 1.7% of recurrent injuries.</p>	<p>89.6%, $P \leq .001$). Medical professionals were more often on site at the time of concussions that occurred during competition or performance as opposed to during practice or training sessions (94.7% vs 89.1%, $P = .001$). When sports played by both boys and girls were analyzed, there was no difference in the likelihood of a medical professional being on site at the time of injury between boys' sports and girls' sports. There were no significant associations between having a medical professional on site at the time of injury and duration of symptoms or timing of return to play.</p>	
Lynall, R.C., Laudner, K.G.,	Concussion- assessment and -management	<i>Journal Of Athletic Training</i>	To assess current clinical concussion diagnostic and	Web Based Survey.	Participants reported observing 10.7 6 11.0	Our study demonstrated a growth in the	<ul style="list-style-type: none"> • Athletic trainers are making progress in

Mihalik, J.P., & Stanek, J.M.	techniques used by athletic trainers		return-to-participation practices among ATs.	<p>A link to the survey was sent randomly to a convenience sample of 3222 members of the National Athletic Trainers' Association. A total of 1053 (32.7%) certified ATs (experience as an AT 1/4 11.2 6 9.1 years) responded to the survey.</p> <p>Prospective participants received electronic correspondence informing them of the purpose of the study and providing a link to the Web-based survey instrument. A reminder e-mail was sent approximately 6 weeks later, and the survey remained online for a total of 8 weeks.</p>	<p>concussions per year. Clinical examination (n 1/4 743, 70.6%) was the most commonly reported means for evaluating and diagnosing concussion. Less than half of our respondents employed the Standardized Assessment of Concussion (n 1/4 467, 44.3%), any variation of the Romberg test (n 1/4 461, 43.8%), and computerized neuropsychological testing (n 1/4 459, 43.6%). Clinical examination (n 1/4 773, 73.4%), return-to-participation guidelines (n 1/4 713, 67.7%), physician recommendation (n 1/4 660, 62.7%), or player self-report (n 1/4 447, 42.5%) contributed to the return-to-participation decisions of ATs. Only 20.8% (n 1/4 219) of ATs reported using all 3 recommended</p>	<p>number of ATs incorporating objective clinical measures of concussion as a part of their concussion management. Conversely, fewer ATs reported using a standard clinical examination in their concussion assessment. These findings suggest ATs must continue to increase their use of both objective concussion assessment tools and the standard clinical examination.</p>	<p>assessing concussions and formulating safe return-to-participation decisions after these injuries.</p> <ul style="list-style-type: none"> • Athletic trainers are using more objective tools available to them but have greatly decreased their use of clinical examinations and symptom evaluations when assessing and managing concussions. • More athletic trainers appear to be using all 3 components of the concussion-assessment battery than in the past, but the overall percentage who use all 3 components remains low. • Athletic trainers need to remember that the most effective concussion management involves using both objective clinical assessment tools
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					domains of the concussion battery.		and a standard clinical examination.
Buckley, T.A., Burdette, G., & Kelly, K. (2015).	Concussion-Management Practice Patterns of National Collegiate Athletic Association Division II and III Athletic Trainers: How the Other Half Lives	<i>Journal Of Athletic Training</i>	To descriptively define the concussion-management practice patterns of NCAA Division II and III athletic trainers.	<p>Web based questionnaire.</p> <p>A total of 755 respondents (response rate 1/4 40.2%) from NCAA Division II and Division III institutions.</p> <p>The primary outcome mea- sures were the rate of multifaceted concussion-assessment techniques, defined as 3 or more assessments; the specific practice patterns of each assessment battery; and tests used during a clinical examination.</p>	<p>Most respondents indicated using a multifaceted assessment during acute assessment (Division II 1/4 76.9%, n 1/4 473; Division III 1/4 76.0%, n 1/4 467) and determination of recovery (Division II 1/4 65.0%, n 1/4 194; Division III 1/4 63.1%, n 1/4 288) but not at baseline (Division II 1/4 43.1%, n 1/4 122; Division III 1/4 41.0%, n 1/4 176). Typically, when a post-concussion assessment was initiated, testing occurred daily until baseline values were achieved, and most respondents (80.6% [244/ 278]) reported using a graded exercise protocol before return to participation.</p>	<p>We found limited use of the multifaceted assessment battery at baseline but higher rates at both acute assessment and return-to-participation time points. A primary reason cited for not using test-battery components was a lack of staffing or funding for the assessments. We observed limited use of neuropsychologists to interpret neuropsychological testing. Otherwise, most respondents reported concussion-management protocols consistent with recommendations, including a high level of use of objective measures and incorporation of a progressive return-to-</p>	<ul style="list-style-type: none"> • Use of a baseline multifaceted concussion protocol by National Collegiate Athletic Association Divisions II and III athletic trainers (ATs) was limited. • Overall, concussion-management practice patterns of these ATs were largely consistent with recommendations, including the use of a multifaceted assessment battery at acute assessment and a return-to-participation protocol. • Use of objective assessments was less among Division II and III ATs than among Division I ATs, possibly reflecting staffing and funding differences.

						participation protocol.	<ul style="list-style-type: none"> • Interpretation of neuropsychological testing by neuropsychologists was limited.
Davies, S., Coxe, K., Harvey, H.H., Singichetti, B., Guo, J., & Yang, J. (2018).	Qualitative Evaluation of High School Implementation Strategies for Youth Sports Concussion Laws	<i>Journal of Athletic Training</i>	To evaluate the strategies commonly used to implement concussion laws at the school and district levels, as reported by certified athletic trainers (ATs).	<p>We interviewed 64 ATs from high schools (1 per school) participating in High School Reporting Information Online.</p> <p>Interviews were conducted with participants between April and October 2015 regarding implementation of the 3 core tenets of concussion laws. Research team members independently evaluated the interview transcripts and field notes to identify common themes in implementation strategies.</p>	Of the 64 schools represented, 90.6% were public schools, 89.1% sponsored more than 15 sports, and all schools employed at least 1 AT and had a written concussion policy. Four commonly used strategies to implement removal from play were reliance on coaches, immediate response, referral and guidance after injury, and notification of key individuals. Use of assessment or baseline tests, communication among parties involved, reliance on AT assessments, and return-to-learn policies were 4 frequent strategies to implement return to play. Finally, 3 major	Although concussion laws were passed at different times and varied in content across states, common themes in implementation strategies emerged across jurisdictions. The identification of strategic approaches to implementation will help ensure proper concussion management and education, reducing negative health outcomes among youths with concussions.	<ul style="list-style-type: none"> • Implementation of concussion laws in schools relies on common tenets: removal from play, return to play, and concussion education. • High school athletic trainers indicated that removal from play was facilitated by coaches, an immediate response, postinjury referrals, and notification of key individuals. • Return to play was facilitated by the use of baseline tests, communication across parties, athletic trainers' assessments, and return-to-learn policies. • Concussion education was facilitated by educational tools, timing of

					implementation strategies to effectuate concussion education were use of existing educational tools, timing of education, and concussion training for school professionals.		education, and training school professionals.
Chin, E.Y., Nelson, L.D., Barr, W.B., McCrory, P. & McCrea, M.A. (2016).	Reliability and Validity of the Sport Concussion Assessment Tool-3 (SCAT3) in High School and Collegiate Athletes	<i>The American Journal of Sports Medicine</i>	The purpose of this study was to advance knowledge on the clinical utility of the SCAT3 by providing a comprehensive summary of the test's properties and performance in a novel sample of male and female high school and collegiate athletes.	High school and collegiate athletes (N = 2018) completed preseason baseline evaluations including the SCAT3. Re-evaluations of 166 injured athletes and 164 noninjured controls were performed within 24 hours of injury and at 8, 15, and 45 days after injury. Analyses focused on predictors of baseline performance, test-retest reliability, and sensitivity and specificity of the SCAT3 using either single postinjury cutoffs or reliable change index (RCI) criteria derived from this sample.	Athlete sex, level of competition, attention-deficit/hyperactivity disorder (ADHD), learning disability (LD), and estimated verbal intellectual ability (but not concussion history) were associated with baseline scores on ≥ 1 SCAT3 components (small to moderate effect sizes). Female sex, high school level of competition (vs college), and ADHD were associated with higher baseline symptom ratings ($d = 0.25-0.32$). Male sex, ADHD, and LD were associated with lower baseline Standardized Assessment of	Individual predictors should be taken into account when interpreting the SCAT3. The normative conversion tables and RCIs presented can be used to help interpret concussed athletes' performance both with and without baseline data, given the comparability of the 2 interpretative approaches.	Future work will be important to document the performance of the SCAT3 in novel samples and to understand how applying differing decision rules influences clinical decision accuracy and the recovery of concussed athletes. Supplementary analyses explored whether reliable change cutoffs should be stratified by sex and level of competition and supported the derivation of a single set of reliable change criteria. Specifically, we measured the differences in test-retest reliability coefficients (using Fisher z transformations) and variance (using Levene tests) for each SCAT3 measure (symptom severity score, SAC total score, and fBESS total score) and for every pairwise comparison using the 4 groups by which normative tables were stratified (female high

					<p>Concussion (SAC) scores ($d = 0.28-0.68$). Male sex, high school level of competition, ADHD, and LD were associated with poorer baseline Balance Error Scoring System (BESS) performance ($d = 0.14-0.26$). After injury, the symptom checklist manifested the largest effect size at the 24-hour assessment ($d = 1.52$), with group differences diminished but statistically significant at day 8 ($d = 0.39$) and nonsignificant at day 15. Effect sizes for the SAC and BESS were small to moderate at 24 hours (SAC: $d = -0.36$; modified BESS: $d = 0.46$; full BESS: $d = 0.51$) and became nonsignificant at day 8 (SAC) and day 15 (BESS). Receiver operating characteristic curve</p>	<p>school, female college, male high school, and male college). Reliability coefficients (in the control sample only) were nearly all statistically equivalent (Fisher z test, P values $>.05$), with the exception that the college female control sample demonstrated lower reliability than the other groups on SAC total scores (the sample size for this group was only 12). The groups all demonstrated equivalent variance (Levene test, P values $>.05$) on all 3 SCAT3 measures.</p>
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					analyses demonstrated a stronger discrimination for symptoms (area under the curve [AUC] = 0.86) than cognitive and balance measures (AUCs = 0.58 and 0.62, respectively), with comparable discrimination of each SCAT3 component using postinjury scores alone versus baseline-adjusted scores ($P = .71-.90$). Normative conversion tables and RCI criteria were created to facilitate the use of the SCAT3 both with and without baseline test results.		
Schatz, P. & Sandel, N. (2013).	Sensitivity and Specificity of the Online Version of ImPACT in High School and Collegiate Athletes	<i>The American Journal of Sports Medicine</i>	To document the sensitivity of the online ImPACT version in samples of (1) symptomatic concussed (high school and collegiate) athletes, and (2) asymptomatic concussed (high school and	A total of 81 athletes observed to sustain a concussion by a certified athletic trainer or team physician, a finding that was confirmed with reported post-concussion symptoms, completed the ImPACT test within 3 days of injury.	Data from the ImPACT online version yielded 91.4% sensitivity and 69.1% specificity. For asymptomatic athletes suspected of hiding their concussion, data from ImPACT yielded 94.6%	The online version of the ImPACT tool is a valid measure of neurocognitive performance at the acute stages of concussion, with high levels of sensitivity and specificity, even when athletes appear to be	Overall, our results show that ImPACT provides postinjury cognitive data that can assist in diagnosis of concussion. Using the neurocognitive data provided by ImPACT, 91% of cases were correctly classified as concussed. When athletes were suspected of hiding concussion-related symptoms and displayed

			collegiate) athletes suspected of hiding their concussions.	Data were compared with an independent sample of 81 athletes who completed preseason baseline cognitive assessments using ImPACT and who were matched (with concussed athletes) on the basis of sex, age, sport, concussion history, and absence of attention deficit hyperactivity disorder and learning disability. An independent group of 37 athletes who were also observed to sustain a concussion completed ImPACT within 3 days of injury. These athletes reported no post-concussion symptoms but were noted for suspected invalid response patterns on ImPACT (Impulse Control index .30 and Verbal Memory index 69%). The subscale data from the assessments (excluding those contributing to the	sensitivity and 97.3% specificity.	denying post-concussion symptoms.	suspicious test-taking behavioral patterns, nearly 95% of cases were correctly classified as concussed. When used appropriately by a trained sports medicine professional, in conjunction with a thorough clinical interview, ImPACT can serve as an effective tool in the concussion management process. The results of this study must be interpreted within the context of its limitations. Although concussed and nonconcussed athletes were carefully matched (eg, on age, sex, sport, history of concussion, absence of ADHD/ADD/LD), this remains a retrospective analysis of data and not a prospective cohort-controlled study. Also, although qualitative observations were made by documented sports medicine professionals, as a means of validating that athletes did, indeed, sustain a concussion, there may have been variability in diagnostic criteria and concussion severity within the sample of concussed athletes. Further, these data represent psychometric properties of the ImPACT
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				<p>aforementioned indices) were compared with a matched sample of 37 athletes who completed preseason baseline cognitive assessments in ImPACT (using the same criteria described above).</p>			<p>test, online version, for only high school and collegiate athletes. As such, these results should not be extended to semi-professional, professional, or youth athletes. Finally, these results demonstrate the clinical utility of the online ImPACT test for diagnosing acute phases of concussion. Future research may allow for its utility to be extended to later stages of recovery.</p>
<p>McGuine, T.A., Pfaller, A.Y., Post, E.G., Hetzel, S.J., Brooks, A. & Broglio, S.P. (2018).</p>	<p>The Influence of Athletic Trainers on the Incidence and Management of Concussions in High School Athletes</p>	<p><i>Journal Of Athletic Training</i></p>	<p>To determine how the presence of an AT affects the reporting and management of SRCs.</p>	<p>A total of 2459 (female 1/4 37.5%, age 1/4 16.1 6 1.2 years) athletes from 31 Wisconsin high schools were categorized as having low availability (LoAT), mid availability (MidAT), or high availability (HiAT) of ATs. Athletic trainers recorded the incidence, days lost from sport, and postconcussion management through return to sport. The incidence of SRC reporting among categories was examined using a multivariate Cox proportional hazards</p>	<p>The level of AT availability positively influenced the reported incidence of SRCs as well as post-concussion management activities in this sample of high schools.</p>	<p>The incidence of reported SRCs was lower for the LoAT schools (2.4%) compared with the MidAT (5.6%, hazard ratio 1/4 2.59, P 1/4 .043) and HiAT (7.0%, hazard ratio 1/4 3.33, P 1/4 .002) schools. The median time before the first AT interaction was longer for LoAT schools (24.0 hours) than for MidAT (0.5 hours, post hoc P 1/4 .012) and HiAT (0.2 hours, post hoc P 1/4 .023) schools. The</p>	<ul style="list-style-type: none"> • Athletes enrolled in high schools with high athletic trainer (AT) availability were more likely to be determined to have sustained a sport-related concussion (SRC) compared with athletes at schools with low AT availability. • Fifty percent of high school athletes who sustained SRCs at schools with low AT availability underwent a return-to-play protocol versus 100% at schools with high AT availability.

				model. Fisher exact tests were used to determine if postconcussion management differed based on AT availability.		number of post-SRC interactions was different in all groups (LoAT 1/4 2 interactions, MidAT 1/4 3, and HiAT 1/4 4; all post hoc P values, .05). Days lost were greater for MidAT and HiAT (both 14 days lost) schools compared with LoAT schools (11.5 days lost, post hoc P 1/4 .231 and P 1/4 .029, respectively). Athletes at LoAT schools were less likely to undergo a return-to-play protocol (9/18 SRCs, 50.0%) than athletes at MidAT (44/47 SRCs, 93.6%; post hoc P 1/4 .001) or HiAT (64/64 SRCs, 100%; post hoc P, .001) schools.	<ul style="list-style-type: none"> Athletes with SRCs at schools with high AT availability were kept out of sport for longer than those at schools with low AT availability.
Brett, B.L. & Soloman, G.S. (2017).	The influence of validity criteria on Immediate Post-Concussion Assessment and Cognitive Testing	<i>Journal Of Clinical And Experimental Neuropsychology</i>	To examine test-retest reliability of repeated ImPACT baseline assessments in high school athletes across various validity criteria reported in previous studies.	A total of 1146 high school athletes completed baseline cognitive testing using the online ImPACT test battery at two time periods of approximately two-year intervals.	Intraclass correlation coefficients (ICCs) ranged in composite scores from .47 (95% confidence interval, CI [.38, .54]) to .83 (95% CI [.81, .85]) and	The application of more stringent validity criteria does not alter test-retest reliability, nor does it account for some of the variation observed across previously	Ultimately, the lack of variation in stability across the different validity criteria sets suggests that applying extended, or more stringent, criteria does not increase test-retest reliability, and that the ImPACT manual's

	(ImPACT) test-retest reliability among high school athletes			No participant sustained a concussion between assessments. Five forms of validity criteria used in previous test–retest studies were applied to the data, and differences in reliability were compared.	showed little change across a two-year interval for all five sets of validity criteria. Regression based methods (RBMs) examining the test–retest stability demonstrated a lack of significant change in composite scores across the two-year interval for all forms of validity criteria, with no cases falling outside the expected range of 90% confidence intervals.	performed studies. As such, use of the ImPACT manual validity criteria should be utilized in the determination of test validity and in the individualized approach to concussion management. Potential future efforts to improve test–retest reliability are discussed.	criteria for test validity should be utilized. Findings from the current study demonstrate that the application of more stringent validity criteria attempting to control for factors associated with validity does not improve test–retest reliability or account for some of the variation observed across previously performed studies. These findings, while providing further insight into the instrument’s reliability, should not be used to alter clinical practice, as invalid scores on individualized baseline assessments can obstruct the serial assessment method in testing.
Savage, J.L. & Covassin, T. (2018).	The Self-Efficacy of Certified Athletic Trainers in Assessing and Managing Sport-Related Concussions	<i>Journal Of Athletic Training</i>	To examine the self-efficacy of ATs in assessing and managing athletes with SRCs, with a secondary purpose of examining job setting (high school and college).	Web-based questionnaire. A total of 94 ATs (high school setting 1/4 54.3%, n 1/4 51; collegiate setting 1/4 45.7%, n 1/4 43) completed an online survey, for a response rate of 9.2%. The survey contained 3 primary	The self-efficacy of all 94 participants in their assessment of SRCs was 60.34 6 14.5 and in their management of SRCs was 55.30 6 14.1. Collegiate ATs reported higher self-efficacy in the assessment of SRCs using balance (P, .001) and the King-Devick test (P 1/4 .04), and their responses	Athletic trainers had moderate self-efficacy regarding their assessment and management of SRCs. Collegiate ATs had higher self-efficacy in newer SRC assessment and management tools than high school ATs.	<ul style="list-style-type: none"> • Athletic trainers reported moderate self-efficacy ratings in the assessment and management of athletes with sport-related concussions. • Collegiate athletic trainers had higher self-efficacy in the assessment tools of balance measures, vestibular-ocular motor screening,

				<p>subsections: demographics, self-efficacy in assessing SRCs, and self-efficacy in managing SRCs. Possible self-efficacy ratings for SRC assessment and management in the survey ranged from 0 to 100. Multivariate analyses of variance were performed to identify differences in the self-efficacy of high school and collegiate ATs in assessing and managing athletes with SRCs.</p>	<p>approached significance for vestibular-ocular motor screening (P 1/4 .05). Additionally, their self-efficacy in the management of SRCs was greater using balance (P , .001) and vestibular- ocular therapy (P 1/4 .01) compared with high school ATs.</p>		<p>and the King-Devick test and reported higher self-efficacy ratings in the management tools of balance measures and vestibular-ocular therapy than high school athletic trainers.</p> <ul style="list-style-type: none"> • Clinicians should continue to improve their self-efficacy in assessing and managing sport-related concussions to promote the safe participation of athletes.
<p>Rigby, J., Vela, L. & Housman, J. (2013).</p>	<p>Understanding athletic trainers' beliefs toward a multifaceted sport-related concussion approach: application of the theory of planned behavior</p>	<p><i>Journal Of Athletic Training</i></p>	<p>To examine the influence of ATs' beliefs toward the current recommended concussion guidelines on concussion-management practice through an application of the TPB.</p>	<p>A Web link with a survey was e-mailed to 1000 randomly selected members of the National Athletic Trainers' Association (NATA).</p> <p>A total of 221 certified ATs working in secondary school/clinic, high school, and college/ university settings.</p>	<p>Descriptive statistics and frequencies were computed to understand the practice patterns of ATs with regard to baseline testing, diagnosing concussions, and making RTP decisions after concussion.</p> <p>We recoded the frequency data to show the number of ATs who</p>	<p>In this sample, the TPB constructs predicted BI and behavior of ATs' compliance with recommended concussion-management guidelines. The BA and PBC were the most influential constructs, indicating that those with positive attitudes toward concussion-management recommendations</p>	<ul style="list-style-type: none"> • Using the theory of planned behavior constructs to investigate the application of recommended concussion-management guidelines by athletic trainers, we found that attitudes toward the behavior and perceived behavioral control were most influential.

				<p>A 66-item survey reflecting the current recommended concussion guidelines of the NATA and International Conference on Concussion in Sport was created to measure beliefs using the TPB constructs attitude toward the behavior (BA), subjective norms (SN), perceived behavioral control (PBC), and behavioral intention (BI) of ATs. We used a linear multiple regression to determine if the TPB constructs BA, SN, and PBC predicted BI and if PBC and BI predicted behavior according to the TPB model.</p>	<p>concurrently used 5 tests to diagnose a concussion: (1) clinical examination, (2) symptom checklist, (3) postural-control assessment, (4) sideline neurocognitive testing, and (5) neuropsychological testing.</p> <p>Our results indicate increasing use of concussion-management tools by ATs (Tables 2 through 4). Compared with the latest study,⁹ for diagnosis and RTP decision making, use of computerized neuropsychological testing and the BESS increased 10.1% and 12.9% and 9.2% and 12.0%, respectively.</p> <p>Also encouraging is that a majority of ATs used a multifaceted approach to diagnose and make RTP decisions after</p>	<p>are more likely to implement them, and ATs are less likely to implement them when they do not believe they have the power to do so. We theorize that interventions targeting ATs' attitudes and control perceptions will lead to improved compliance</p>	<ul style="list-style-type: none"> Interventions that take into account athletic trainers' attitudes and perceived control may help to increase compliance with concussion-management guidelines.
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					concussion. However, only a small percentage used all the recommended tools.		
Covassin, T., Elbin, R.J., Stiller-Ostrowski, J.L. & Kontos, A.P. (2009).	Immediate post-concussion assessment and cognitive testing (ImPACT) practices of sports medicine professionals	<i>Journal of Athletic Training</i>	To examine implementation and practice trends of sports medicine professionals using baseline neurocognitive testing at the high school and collegiate levels.	<p>Online survey.</p> <p>Certified athletic trainers (ATs) from approximately 1209 US institutions listed on the ImPACT Web site were recruited. A total of 399 ATs completed the survey, for a response return rate of 32.7%.</p> <p>Survey questions addressed educational level, years of certification, employment setting, percentage of athletes baseline tested, and accuracy of baseline tests. Other items addressed post-concussive neurocognitive testing protocols and scenarios for return-to-play decisions based on neurocognitive testing.</p>	<p>Nearly all ATs (94.7%) administered baseline computerized neurocognitive testing to their athletes. However, only 51.9% examined these baseline tests for validity. The majority of ATs indicated that they administer baseline neurocognitive tests most frequently to football players (88.4%), followed by women's soccer players (78.8%) and men's soccer players (71.2%). Nearly all respondents (95.5%) stated that they would not return a symptomatic athlete to play if the athlete's neurocognitive scores were back to baseline. However, when asked if they</p>	<p>The use of baseline testing, baseline testing re-administration, and post-concussion protocols among ATs is increasing. However, the ATs in this study reported that they relied more on symptoms than on neurocognitive test scores when making return-to-play decisions.</p>	<p>Most athletic trainers administered baseline computerized neurocognitive testing to their athletes, but only half examined these tests for validity.</p> <p>Although virtually no athletic trainers would return a symptomatic athlete to play despite baseline neurocognitive test scores, some would return a symptom-free athlete despite below-baseline neurocognitive test scores.</p>

					would return an athlete who is symptom free but who scores below his or her baseline, 86.5% responded no, 9.8% responded yes, and 3.8% indicated that it depended on the importance of the competition.		
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