Multidisciplinary Management of Collegiate Sports-Related Concussions

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ABSTRACT

Purpose Collegiate varsity athletes are at risk for sustaining a sports-related concussion, which can negatively impact performance during academic, social, work, and athletic endeavors. Because of the complex nature of concussions and high rates of underreporting by athletes, concussion education, identification, and postinjury care require a collaborative, multidisciplinary approach. Therefore, the purpose of this paper is to describe the specific responsibilities of the team members along with the established pre- and postconcussion procedures of one of the oldest university-based multidisciplinary concussion management programs that is coordinated by speech-language pathology.

Method The authors provide a theoretical review of current best practices for the multidisciplinary team along with a discussion of baseline and postconcussion neurocognitive assessment and management procedures directly involving speech-language pathology. Included is a case example illustrating the postinjury procedures utilized by the team.

Conclusion Management of the complex sequelae of sports-related concussion for the varsity collegiate athlete necessitates implementation of a multidisciplinary, collaborative approach. Speech-language pathologists' training in the assessment and treatment of brain injury provides the team with an objective perspective in the evaluation and postinjury management of the injured student athlete. While our understanding of concussions has improved greatly over the past two decades, researchers and clinicians on the front lines of care recognize that continued voids exist in our knowledge, with the need to continually explore new methods to identify and manage

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the complex immediate and potentially long-term ramifications of concussion.

KEYWORDS: concussion, cognition, symptoms, multidisciplinary

Learning Outcomes: As a result of this activity, the reader will be able to (1) list the members of the multidisciplinary team and discuss their roles in the management of sports-related concussions; (2) summarize the neurocognitive baseline and postinjury assessment methods utilized by speech-language pathologist; (3) list the somatic, emotional, and neurocognitive symptoms associated with concussion; (4) discuss factors that may influence an athlete's willingness to report a suspected concussion to the management team.

Collegiate varsity athletes sustain an estimated 10,560 sports-related concussions annually.¹ Historically, athletes underreport their concussions; therefore, the true incidence is estimated to be even higher.² All collegiate athletes are at risk for sustaining a concussion because of the competitive nature of both high- and low-impact sports and the inherent risk of a direct blow to the face, head, neck, or body from an opponent, object, or the ground. The hits sustained induce rapid acceleration, deceleration, and rotational forces onto the brain, which disrupt neuronal function³ resulting in short- or long-term physiological/somatic, cognitive, or emotional changes^{4,5}; these changes negatively affect performance during tasks previously performed with ease. Therefore, there is a need to educate athletes about the postconcussion symptoms that may occur, along with the benefits of prompt injury reporting.^{6,7} In addition, because of the complexity and potential seriousness of all concussions along with the need to provide swift postinjury care, a team approach utilizing professionals from multiple disciplines specializing in concussion management is warranted. Therefore, the purpose of this paper is to present the procedures utilized by a university-based multidisciplinary team for the management of sports-related concussions through theoretical and clinical foundations and a case example. The review will include the specific responsibilities of the team members with a focus on the role of the speechlanguage pathologist (SLP).

PATHOPHYSIOLOGY AND SYMPTOMATOLOGY

Concussion is a brain injury produced by biomechanical forces which can stretch and distort neuronal cell bodies, axons, dendrites, glial cells, and blood vessels, causing a disruption of axonal and membrane function⁸, leading to hypermetabolism along with reduced cerebral blood flow.⁹ Returning to physical activity while the brain is experiencing these chemical changes makes the system vulnerable to recurrent injury and can increase the athlete's risk for prolonged recovery following concussion.¹⁰⁻¹² Hence, immediate recognition of the symptoms of concussion by the athlete or athletic or medical personnel on the sideline is warranted to make immediate and appropriate removal from play and for injury management decisions.

Symptomatology. The neurologic changes and symptoms experienced by the collegiate athlete following concussion can vary in severity, length, and degree. Specifically, athletes may experience physiologic/somatic symptoms such as headache, sensitivity to noise and light, slurred speech, general sleep disturbances, reduced coordination/balance, and decreased oculoperformance.13-17 control and motor Exacerbation of some of these symptoms can occur with computer use or during academic activities requiring prolonged visual focus or cognitive demand. Emotional symptoms such as depression, irritability, emotional instability, or lability are less recognized signs of concussion but still greatly impact performance.^{17,18}

Athletes may also experience changes in neurocognitive functioning. Most common

declines occur in working verbal and visual memory, speed of information processing, impulse control, orientation, sustained and selective attention, and executive function (e.g., reasoning, problem solving, initiation), with the most common persistent deficits occurring in verbal memory, speed of processing (i.e., reaction time), and attention.^{5,19,20} As a result, athletes postinjury may experience varying degrees of difficulty completing tasks previously performed with ease for several days, weeks, or even months postinjury.^{12,21,22}

Underreporting concussion symptoms. Many of the symptoms associated with concussion are not outwardly observable (e.g., noise sensitivity, headache); therefore, in many cases medical professionals on the sidelines are dependent on the athlete to self-report any sequelae that may suggest a new injury. However, when surveyed, 45% of athletes relayed not reporting potential concussion symptoms to personnel or teammates secondary to both internal and external factors.² These influences include but are not limited to a personal desire to play the game through the injury or feeling the need to meet expectations established by coaches, teammates, and parents.^{23,24} In addition, lack of knowledge or underestimating the seriousness of the injury can also influence underreporting.^{7,24,25} Specifically, 64% of athletes who failed to report their suspected injury did so because they did not believe their symptoms were severe enough to signify a concussion.² Results from a recent survey study revealed a lack of postconcussion symptom knowledge among collegiate varsity athletes and nonathletes, with no significant difference in knowledge between groups even though varsity athletes receive annual mandated concussion education.⁷ These factors suggest that athletes are not consistently reliable in accurately reporting concussion-like symptoms, possibly putting them at risk for repeated and more significant injury.^{2,24} Therefore, a multidisciplinary approach to concussion identification and management is warranted.

CONCUSSION MANAGEMENT GUIDELINES

The National Collegiate Athletic Association (NCAA) requires all college athletic departments

to have a detailed concussion management policy in place, which includes education, preparticipation assessment (e.g., brain injury history, symptom rating, baseline cognitive assessment, balance evaluation), methods to recognize and diagnose a concussion, and postconcussion management plans (e.g., step-wise progression for return to play and academics, targeted treatment).²⁶ While the NCAA requires the inclusion of specific guidelines within the concussion management protocol, each university program has the flexibility to utilize different approaches to provide care for the student athlete.

MULTIDISCIPLINARY CONCUSSION TEAM

The collaboration between the Department of Speech Pathology and Audiology and the Intercollegiate Athletics program at Miami University (MU) developed through years of open communication and willingness to understand each discipline's role and responsibility in the management of concussion. The program began in 1999 with the goal to provide a multidisciplinary team approach to the identification, education, assessment, diagnosis, management, and prevention of the neurocognitive and physical sequelae resulting from sports-related concussions. The management team recognizes that every concussion is serious and each athlete should receive an individualized approach to concussion management both on and off the field. Still today, primary members of the team include the team physician, the team/athletic trainer (AT), the SLP, and the student athlete, with additional members of the team recruited as needed, including neuropsychology for behavioral/emotional and intelligence testing and physical therapy for vestibular dysfunction and cervical spine instability.²⁷ See Table 1 for team members and roles.

Team physician. The team physician must have an unrestricted medical license with proficiency in the education, prevention, emergency management (e.g., neurologic, cardiac, spinal injuries), and care of musculoskeletal and other sports-related injuries.²⁸ Facilitation of effective concussion management requires that the physician integrate expertise from a variety of health care professionals (e.g., AT, SLP,

Team roles	Team members involved
Pre and postinjury education	TP, AT, SLP, A
Preparticipation physical	TP, AT, A
evaluation	
Baseline neurocognitive and	SLP, A
symptom evaluation	
Game and practice	TP, AT, AS, T, A
monitoring	
On-the-field postinjury	TP, AT, A
assessment	
Postconcussion neurocognitive	SLP, A
and symptom assessment	
Academic accommodations,	SLP, A
recommendations,	
and strategies	
Rehabilitation	SLP, AT, PT, NP, A

Table 1	ΙМ	ultidisc	plinary	7 Team	Roles
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Abbreviations: A, athletes; AS, athletic staff; AT, athletic trainer; NP, neuropsychology; PT, physical therapy; SLP, speech-language pathologist; T, teammates; TP, team physician.

physical therapist) based on the unique medical needs of the athlete. The physician also provides referrals for neuroimaging and recommends medications to alleviate the physical symptoms of concussion such as headache and muscle pain. Based on the information obtained during preparticipation physical examinations, physicians are aware of each athlete's unique medical history and presence of comorbidities which may prolong recovery (e.g., history of migraines/headaches, learning disabilities, depression, concussion history).²⁹ The physician integrates this knowledge with pre- and postassessment data obtained from team members to make final decisions on clearance to participate in physical activity following concussion. This is especially important for cases where the recovery patterns are atypical following concussion. More specifically, the physician may help the management team determine if prolonged recovery is secondary to physical (i.e., cervicogenic headache), neurologic (i.e., concussion), or psychologic (i.e., depression) factors.

Athletic trainer (AT). The AT is the member of the concussion team with the most contact with the athlete. This interaction begins during preparticipation physical testing and continues throughout the season. Because

the AT often has daily contact with the athlete, they have a strong knowledge of past injuries and performance levels, in addition to the athletes' personality and internal drive, making them ideal to recognize the subtle changes in behaviors exhibited postconcussion. The AT is also present during all NCAA varsity practices and games and is typically the first medically trained professional to identify and provide care to the athlete following a suspected concussion. During the initial evaluation, the AT assesses for loss of consciousness, breathing, and vital signs.³⁰ Most often, athletes will not show visible signs of a concussion during this level of assessment. If severe medical conditions are ruled out, continued clinical assessment based on NCAA guidelines²⁶ occurs on the sidelines and can include the evaluation of alertness, pain, orientation, recall of events immediately before and after the injury, speech patterns, coordination, sensation, pupil size, reactivity to light, and posture. In addition, the AT completes the Balance Error Scoring System Screen (BESS),³¹ King-Devick Concussion Screening Test,³² and the Standardized Concussion Assessment Tool 3TM (SCAT3TM).³³ Any student athlete assessed to have a suspected concussion will not return to participation for the remainder of the day until the completion of formal neurocognitive testing by SLP.

Speech-language Pathologist (SLP). The SLP on the team has extensive training in the assessment and management of cognitive-linguistic disorders and behavioral changes resulting from brain injury and coordinates all neurocognitive baseline and postconcussion testing procedures. The SLP interprets all assessment data, educates the athletes posttesting regarding testing outcomes, and makes recommendation following the injury to help the athlete best manage the symptoms and neurocognitive changes associated with the concussion by providing individualized academic supports and strategies.

PRECONCUSSION MANAGEMENT PROTOCOL

Education. Based on NCAA guidelines,²⁶ all athletes, medical, and athletic staff must participate in preseason education programs reviewing

the symptoms and potential neurocognitive sequelae of concussion. Following the training, all participants sign a form acknowledging an understanding of the information and an agreement to report any observed or self-perceived concussion-like symptoms to athletic or medical personnel.

Neurocognitive baseline testing: SLP. Prior to the start of the athletic season and with the assistance of the AT, the SLP coordinates neurocognitive baseline testing for all incoming varsity athletes who are at risk for concussions. While it is possible to compare postconcussion neurocognitive results to age- and gender-based norms, the effectiveness of such tests is enhanced with preinjury baseline data due to the athlete's unique preinjury cognitive status. Collection of baseline neurocognitive and symptom data provides one method to estimate preinjury cognitive and neurobehavioral function, which can be used as an initial step to determine concussion recovery and potential readiness to return-to-play.^{34–37}

The MU baseline testing protocol includes ImPACT, Grooved Pegboard Test (GPT),³⁸ Postconcussion Rating Scale (PCRS),³⁹ the Controlled Oral Word Association Test (COWAT),⁴⁰ King-Devick Screen,³² and the BESS.³¹ See Table 2 for domains assessed and time required for test completion. Administration occurs individually, in a quiet distractionfree environment. While many institutions complete computer-based baseline testing in a group environment to save time and costs, research supports that baseline and postinjury testing results are most reliable when completed individually⁴¹ by a professional and in an environment not associated with athletics.⁴² At MU, trained graduate students in SLP complete baseline testing under the supervision of the certified SLP. These students monitor the athlete throughout testing and document any signs of test confusion or behaviors that suggest the athlete is purposefully sandbagging results. The SLP also educates each athlete individually on the signs and possible symptoms of concussion prior to the completion of preparticipation neurocognitive baseline testing.

POSTCONCUSSION NEUROCOGNITIVE TESTING RATIONALE

Biomarkers such as EEG findings,⁴³ blood sampling,^{44,45} and more advanced structural and functional MRI methods³⁴ to objectively diagnose concussion are under evaluation.

Assessment Domains assessed Average completion time Medical history 5 min Controlled Oral Word Verbal fluency /executive functioning 3–5 min Association Test (COWAT) Grooved Pegboard (GP) Motor speed/eye-hand coordination 3-5 min King-Devick (KD)^a 3–5 min Attention Rapid number naming Balance Error Scoring Standing balance and vestibular function 5 min System (BESS)^a ImPACT Verbal recognition memory 35-45 min Visual working memory Cognitive speed Impulse control Verbal working memory Visual-motor speed Spatial recognition memory Symptom reporting Postconcussion Subjective reporting of symptoms 2 min Rating Scale (PCRS)

Table 2 Miami University Baseline and Postconcussion Assessment Protocol

^aAdministered by SLP at baseline and AT postinjury.

However, secondary to concerns regarding the sensitivity, cost, and functionality of these methods, implementation has not carried over to clinical practice.³ In contrast, with the collection of baseline data prior to injury, neurocognitive assessments are 82% effective in identifying performance consistent with concussion 72 hours postinjury and 89% accurate in identifying control participants without injury.³⁷ Because of high rates of reliability and ease of administration, neurocognitive testing protocols are widely utilized clinically to determine the subtle changes in cognition often experienced by athletes following concussion.^{22,34}

Depending on the level of care and population of focus, various forms and combinations of paper or computer-based neurocognitive test batteries are currently used clinically.^{22,46-48} However, when working with collegiate student athletes, there are many advantages to using computer-based neurocognitive tests (e.g., ImPACT, CANTAB) as a portion of the established baseline and postconcussion assessment protocol. Since collegiate athletic programs complete over 100 baseline neurocognitive tests annually in addition to numerous postconcussion assessments,²² the ease of test administration, availability of numerous alternative test forms, and high rates of reliability,³⁵ sensitivity,⁴⁹ and validity^{50,51} make computer-based assessments a feasible testing option for this population. However, computer-based neurocognitive assessments do not diagnose concussion, but instead highlight individualized cognitive changes in performance following a suspected injury. Therefore, these tests should not be used as a stand-alone measure following concussion for clinical return-to-play or clinical management decision.³⁵ Additional traditional neurocognitive measures along with structured clinical interviews, self-rating of subjective symptoms of concussion, balance and vestibular function, and eye coordination should be implemented.

POSTCONCUSSION MANAGEMENT PROTOCOL

Within 24 to 48 hours following the initial evaluation of a suspected concussion by the AT, the SLP receives a referral for neurocognitive testing, as discussed previously. The AT includes in the referral details regarding the injury (e.g., location, initial symptoms, and screening results). The SLP incorporates this information during the postconcussion clinical interview to identify potential inconsistencies in the injured athlete's report and recollection of the events associated with the injury.

The testing protocol utilizes the same diagnostic assessments administered during the baseline, minus the King-Devick³² and BESS.³¹ The session begins by asking the athlete specific questions about the suspected injury, symptoms via the PCRS³⁹ (e.g., immediately postinjury, 24 hours postinjury, and current), and detailed questions relating to academic performance. The athlete then completes the Grooved Pegboard Test,³⁸ COWAT,⁴⁰ and ImPACT. Finally, the athlete self-rates perceived symptoms again to determine if symptoms increased during computer testing. The SLP team closely monitors the athlete's responses throughout the assessment to document and clarify any inconsistencies in reported symptoms, and observe behavior associated with mental and emotional fatigue, anxiety, frustration, disorientation, confusion, or failure to comply with testing procedures.

The certified SLP analyzes and reviews the results with the athlete and AT on the day of testing. Postconcussion performance is compared with the athlete's individualized baseline performance levels. If scores on any section of the neurocognitive test battery deviate at least 1 standard deviation (SD) from the preestablished baseline or if there is report of any concussionlike symptoms, athletes are encouraged to refrain from strenuous physical and cognitively activity until the physician provides additional or alternative recommendations. In some cases, heightened physical and cognitive activity following a concussive event can impact symptoms and delay neurocognitive recovery in athletes.^{34,52} Factors influencing recommendations can include severity of symptoms reported, degree of deviation from baseline neurocognitive scores, and number of previous concussions.

Postconcussion management. Neurobehavioral and neurocognitive symptoms experienced following concussion can negatively impact academic performance to varying degrees based on the severity of the injury and prior concussion history.^{12,21} Following written approval by the athlete, academic instructors receive notification that the athlete requires classroom accommodations. Academic accommodations include but are not limited to: (1) postponement of exams; (2) extended time to complete exams and assignments; (3) use of quiet, distraction-free environment for exams; (4) preferential classroom seating; and (5) modifications to classroom environment due to noise and light sensitivity. In addition, the SLP provides athletes with strategies to help manage postconcussion symptoms and academic requirements, which can include: (1) journaling to determine factors which lessen or heighten symptoms; (2) pacing academic and computer activities and rest breaks; (3) recording lectures or obtaining peer notes; (4) refraining from activities in loud or distracting environments; and (5) refraining from excessive electronic device use.

A continuation of initial recommendations provided by the SLP occurs until reassessment, about 5 to 7 days following the concussive event. In the interim, the AT monitors the athlete daily and notifies the SLP and physician of any change in level of function or report of symptoms which may warrant earlier or delayed reevaluation. Upon reassessment, if the athlete reports no postconcussion symptoms and if neurocognitive test results are consistent with baseline measures, the AT supervises the gradual increase physical activity by the athlete while monitoring for return of postconcussion symptoms. If the athlete experiences an increase in symptoms when physical activity resumes, they are referred for the reassessment of neurocognitive functioning. The athlete returns to full physical activity only after physician approval.

CASE STUDY

The following case illustrates the management procedures implemented by the team for a collegiate athlete following a concussion. The Miami University Institutional Review Board reviewed and approved all methods and procedures.

This is a case of a 20-year-old female softball player (E.P.) with a history of two previous sports-related concussions in high school. The athlete sustained the current concussion during practice when she hit her forehead on a teammate's chin following a collision and then fell backward, hitting the posterior portion of her head on the gym floor. The initial assessment, completed by the AT, revealed normal cranial nerve and pupillary reactions but the athlete's scores on the King-Devick deviated greater than 1 SD from her baseline. E. P. was immediately removed from practice. The athlete reported the following symptoms immediately following the event: severe headache, sensitivity to light, dizziness, and moderate nausea without vomiting.

Postconcussion neurocognitive testing. One day following the incident, the SLP completed postconcussion team testing. History of the incidence verbalized by the athlete mirrored information provided by the AT. E.P. self-reported somatic (e.g., moderate headache, sensitivity to light and noise, mild nausea, dizziness, and fatigue, with sleeping more than usual), emotional (e.g., mild irritability), and cognitive symptoms (e.g., mild mental fogginess and difficulty remembering) with a total symptom score of 20/132. The athlete completed all neurocognitive tests previously discussed. Results revealed a greater than 1 SD decline in verbal memory, visual motor speed, reaction time, and verbal fluency when compared with baseline scores. Following testing, E.P. self-reported an increase in symptom severity and type (e.g., drowsiness, sadness, and difficulty concentrating) with a total symptom score of 33/132.

The SLP provided the physician and AT with the results the day of testing, along with recommendations that the athlete refrain from physically and cognitively strenuous activity. The SLP also implemented special academic accommodation with her academic instructors, following the approval by E.P. (e.g., postponement of exams, extended time given to complete assignments). The SLP reviewed testing results and recommendations at length with the athlete, providing ample time for questions with encouragement to refrain from participating in noisy social activities. Strategies reviewed included rotating short periods of time spent working on academic work with additional rest breaks and journaling to document activities which increased/decreased the symptoms experienced. Following approval by the AT and physician, E.P.

participated in supervised low-impact physical activity (e.g., walking, stationary bike riding) as long as symptoms did not escalate.

Eight days following the injury, the athlete completed repeated neurocognitive testing. E. P. exhibited improvements; however, verbal memory, visual motor speed, and verbal fluency continued to deviate more than 1 SD from her baseline. Her overall symptom score declined (i.e., 4/132) with complaints of a persistent mild headache, fatigue, and difficulty remembering. Because of continued report of postconcussion symptoms and a deviation in neurocognitive performance, previous recommendations were maintained.

Fourteen days following the original injury, neurocognitive performance returned to baseline and the athlete reported no postconcussion symptoms. The physician recommended that the athlete gradually increase physical activity under close supervision. Her concussion symptoms did not reoccur and the athlete returned to all athletic and academic activities.

Case application. The majority of athletes return to baseline cognitive and symptom reporting levels within 5 to 7 days postinjury following a sports-related concussion.^{5,34,52-54} E.P., however, required 14 days to return to previous baseline levels. Multiple factors, either in isolation or combined, may have contributed to this delay. Specifically, previous studies suggest that male collegiate athletes often return to baseline levels of neurocognitive functioning before female athletes.¹ In addition, females often report more symptoms and were twice as likely to experience declines in cognitive function following a concussion compared with males.55,56 Finally, this athlete also had a history of two prior concussions and sustained two hits to the head during this reported incident. These findings provide support to the growing body of research suggesting that athletes with a history of head injuries often have additional and more severe symptoms as well as take a longer time to recover than those without a history of concussion.55,57,58 This case further illustrates the need to consider an athlete's complete medical and concussion history along with the unique nature of the injury when considering management and outcomes.

FUTURE DIRECTION AND CONCLUSION

Over the past two decades, athletes, medical professionals, and the general public have gained a greater awareness of the potential seriousness of concussion. Because of mandates imposed by the NCAA, more athletes are receiving pre- and postconcussion care than ever before. However, current identification, assessment, and treatment methods are still in the development stages, with a continued need for research to determine the most effective and efficient ways to manage the complex sequelae associated with concussion. We still have much to learn with a continued need to redesign preinjury educational programs, so every athlete feels comfortable reporting a suspected injury immediately after onset. Finally, more research is needed examining the benefits of postinjury rehabilitative care provided by SLPs, especially for those individuals with chronic postconcussion syndrome.

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