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Concussion in Student Athletes: Prevention, Assessment, and Recovery

Miriam A. Carroll-Alfano
Western Michigan University, alfano@sxu.edu

CONCUSSION IN STUDENT ATHLETES: PREVENTION, ASSESSMENT, AND RECOVERY

by

Miriam A. Carroll-Alfano

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Doctoral Committee:

Linda Shuster, Ph.D., Chair
Nickola Wolf Nelson, Ph.D.
Roberta DePompei, Ph.D.

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Miriam A. Carroll-Alfano

CONCUSSION IN STUDENT ATHLETES: PREVENTION, ASSESSMENT, AND RECOVERY

Miriam A. Carroll-Alfano, Ph.D.

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The research presented in this study examines concussion among athletes from the perspectives of prevention, assessment, and recovery. The first study examines concussion education for high school athletes by surveying 157 collegiate athletes, who primarily attended high school in Illinois and Indiana, about their previous concussion education, including whether they received mandated education, the methods and providers of education, and their ability to name a variety of concussion symptoms. This study finds that despite legislative mandates in these states, 20% of student-athletes continue to report not receiving concussion education in high school, with females more likely to report not receiving education than males. A casual conversation is the most commonly reported method of education, and an athletic trainer the most common provider. Athletes who report receiving education show no improvement in ability to name a diversity of concussion signs and symptoms, compared to those who report receiving no education. These results indicate that continued efforts need to be made to ensure that all athletes report receiving education, and that there are still deficiencies in athletes' knowledge of the signs and symptoms of concussion, particularly cognitive and behavioral ones.

Early identification of concussion-induced cognitive deficits is imperative for student athletes, and functional cognitive deficits following concussion can be difficult to assess. The second study examines whether story retell is a useful tool for identifying concussion-induced

cognitive communication changes in collegiate athletes following concussion. This cross-sectional study finds that athletes with recent (<30 month) concussions perform worse on the immediate story retell than on the Montreal Cognitive Assessment (MoCA). Little or no correlation was seen between the MoCA and either the immediate or delayed story retell tests, or between self-reported academic difficulties of athletes with concussion with the immediate or delay story retell tasks. Immediate story retell appears to be a more sensitive measure of cognitive and language differences that presented in participants who sustained a recent concussion.

The final study consists of descriptive case studies examining the experiences of two collegiate athletes who had sustained concussions and experienced post-concussion syndrome (PCS), detailing their recovery process and reintegration into their educational and athletic activities. Both students experienced disruptions to their academic studies and participation in sporting activities because of their concussions, as well as social difficulties and feelings of isolation. For both students, despite the attempted utilization of best-practice protocols, there was a breakdown in the return-to-learn and return-to-play processes.

Concussion in athletes is a complex problem. These studies highlight concerns regarding concussion education, assessment, and recovery in collegiate athletes that are best served by an interdisciplinary team including a variety of health-care and educational professionals.

TABLE OF CONTENTS

Table of Contents—Continued

CHAPTER

Table of Contents—Continued

CHAPTER

Table of Contents—Continued

CHAPTER

APPENDICES

Table of Contents—Continued

APPENDICES

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

Traumatic brain injury is one of the most frequently occurring injuries in childhood and adolescence. The Centers for Disease Control and Prevention (CDC, 2017) reported that in 2013, about 2.8 million traumatic brain injuries occurred in the United States, leading to emergency department visits, hospitalizations, and deaths. Traumatic brain injury (TBI) can range from mild to severe, with most being classified as mild (mTBI), also referred to as concussion (CDC, 2017). Causes of TBI include falls, motor vehicle accidents, being struck by or striking an object, and recreational and sporting activities. The rate of emergency department visits for sports and recreation-related injuries with a diagnosis of concussion or TBI more than doubled among children age 19 or younger in recent years (CDC, 2016; Coronodo et al., 2015; Zhang et al., 2016). Concussion in sports has received increased attention over the last 10 years, from professional sports to youth sports.

The consensus statement on concussion in sport from the 4th International Conference on Concussion in Sport (McCrory, Meeuwisse, Aubry, Cantu, et al., 2013) defined concussion as a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces. Concussion results in rapid onset of short-lived impairment of neurologic function, with acute clinical symptoms emerging as a functional disturbance of the brain, rather than a structural injury; therefore, no abnormality is seen on standard structural neuroimaging studies (McCrory et al., 2013). The CDC (2015) estimated that between 1.6-3.8 million concussions occur annually because of participation in sporting and recreational activities. It is difficult to pinpoint the exact number of concussions annually due to the various locations of treatment. Concussions that are treated via the emergency room of a hospital or result in hospital admissions are tracked through the CDC (CDC, 2015). Concussions that are treated by other healthcare providers outside of hospitals, including physicians and athletic trainers, are not easily counted.

Concussion in children and adolescent athletes is of concern due to the high prevalence of concussions among this population, coupled with increasing recognition of the potential serious long-term health sequelae of concussions and TBIs (Institute of Medicine (IOM) and National Research Council (NRC), 2013). This high prevalence and potentially serious long-term sequelae have led to both state and federal legislation designed to address the issue of concussion in children and adolescent athletes. Beginning in 2008 through 2014, all 50 states in the United States passed legislation regarding concussion education, with some including specific return to play (RTP) and return to learn (RTL) protocols for youth sports (The Network for Public Health Law, 2014). The Traumatic Brain Injury Act of 2008 authorized research and public health activities, such as education, related to traumatic brain injury (TBI) (CDC-Report to Congress, 2014), and in 2016, the CDC announced a proposal to create a National Concussion Surveillance System to improve prevention, care, and recovery efforts (CDC, 2017).

Concussions in children and adolescents are an important consideration due to differences in physiology that leave them more vulnerable to the serious effects of concussions when compared to a similar injury in adults (Collins, Lovell, Iverson, Cantu, Maroon, Field et al., 2002; Guskiewicz, McCrea, Marshall, et al., 2003; Moser, Schatz, & Jordan, 2005; Scorza, Raleigh, & O'Connor, 2012). About 21 percent of all TBIs among adolescents result from participation in sports and recreational activities, with 6 of the top 8 activities being sports commonly offered by high schools and colleges (American Academy of Neurosurgery (AANS), 2014). Studies have shown that adolescents may have longer recovery times than adults following concussions (McCrory et al., 2013; Scorza, 2012). Young athletes have less developed cervical-spine musculature, differences in neurobiology, and less training in the use of proper sports technique, leaving them more vulnerable to concussions (Cantu, n.d.). Concussion induced cognitive deficits are particularly serious for students because their academic performance can be impacted (Halstead, et al., 2014).

Addressing concussions in student athletes necessitates a multi-faceted approach involving prevention, assessment, and treatment. Prevention, via concussion education, is needed to provide this population with facts and decision-making structures to take steps to minimize their exposure to concussion, to know the signs and symptoms of concussion, and to seek treatment after experiencing concussion symptoms. Assessment tools are needed to identify the effects of concussion, particularly those subtle cognitive symptoms that can have a serious detrimental impact on student-athletes. Finally, the recovery of athletes following concussion, including return-to-learn protocols (RTL), must be understood by identifying the mechanisms, processes, and supports that lead to successful recovery. This dissertation examines concussion in student athletes through research studies investigating concussion education, assessment of cognitive sequelae of concussion through story retell, and the recovery process following concussion, as reported by student athletes who have experienced it.

Study 1. Concussion Education for Student Athletes: Who Is Getting It? What Kind? Does It Matter?

The first study, described in chapter 2, presents a research study with an emphasis on concussion education. Since 2009, all 50 states have passed legislation designed to address the issue of concussion in student athletes, with most of these laws requiring mandatory education for student athletes in high school. Despite the passage of these laws, studies examining the effectiveness of this legislation in delivering education to student-athletes and of receiving concussion education being associated with better outcomes in terms of knowledge of concussion symptoms and self-reporting after experiencing a concussion show mixed results. It is also an open question as to which methods of training are best associated with improved outcomes. This study addressed the following research questions:

1. Is there an association between implementation of concussion legislation and collegiate athletes reporting having received concussion education in high school, and has this changed over time?
2. Is there an association between collegiate athletes reporting having received concussion education in high school by sport played and gender?
3. What methods do student-athletes report as being used to deliver concussion education, and who do they report is providing the education?
4. Is there an association between reporting having received specific types of concussion education and being able to name the diverse symptoms of concussions?

Study 2. Assessment of Concussion in Collegiate Athletes Using Story Retell

The second study, described in chapter 3, presents an investigation examining the use of story retell as an assessment tool for identifying deficits in student athletes who have sustained concussions. This study aimed to determine if story retell is a sensitive tool for identifying concussion-induced cognitive and language deficits in collegiate athletes who have sustained a concussion. Prior research has suggested that assessment of discourse skills in persons who have had TBI can identify cognitive communication deficits, even following mild TBI (Galetto, Andreetta, Zettin, & Marini, 2013; Hartley & Jensen, 1991; Le, Mozeiko, & Coelho, 2011; Stout, Yorkston, & Pimentel, 2000). Story retell is one type of discourse skill that can be assessed (Hartley & Jensen, 1991, Stout, Yorkston, & Pimentel, 2000).

During story retelling, a person listens to a story and then repeats it as closely as possible. In most protocols, retelling is requested both immediately after hearing the story, and after a period of delay. This task assesses several key functional cognitive and language skills including: auditory comprehension, attention, memory, and verbal output, all of which are skills that have been shown to be impaired after TBI (Helm-Estabrooks, 2001; Chapman et al., 2006; Hotz, Plante, Helm-Estabrooks, & Nelson, 2014). Story retelling has advantages over other commonly used cognitive screening tests, such as the Montreal Cognitive Assessment (MoCA) (Nasreddine, 2005), because story retell is functionally related to specific cognitive skills that students must use every day in the classroom. Thus, it may be more relevant for identifying those types of mild cognitive deficits that would be most detrimental to a student-athlete in the classroom. Full standardized assessment batteries contain story retells tasks, but also contain many other subtests that add to the length and complexity of administering the test. By focusing on the portion of these full standardized test batteries that most closely mimics skills that are important to a student-athlete in the classroom, story retell has the potential to be a sensitive tool to identify functional cognitive communication deficits without the length and complexity of a full standardized test battery, particularly in clinical settings where time is limited.

The cross-sectional study reported in chapter three involved comparison of story retelling by three groups: collegiate athletes who have had a concussion, collegiate athletes who have not had a concussion, and non-athlete college students who have not had a concussion. The research questions for this study included:

1. Do collegiate athletes who have reported sustaining a concussion demonstrate significantly lower scores on immediate and delayed story retell than collegiate athletes and non-athlete college students who report never having sustained a concussion?

2. Is there a difference between post-concussive cognitive and language deficits identified by immediate and delayed story retell vs. the MoCA?
3. Is there a correlation between immediate and delayed story retell scores and MoCA scores, for each of the three groups?
4. Is there a correlation between self-reported academic difficulties and scores on story retell and the MoCA?

Study 3. Concussion Recovery in Student Athletes: Case Studies

The final study, presented in chapter 4, is a descriptive case study examining the experiences of two student athletes who sustained concussions. In recent years, there has been a consensus on the need for a formal process of recovery, including returning to play and returning to school, for student athletes who have sustained concussions. The return-to learn process for a student athlete recommends an individualized plan that includes a balance between cognitive and physical rest, and activity (Baker et al., 2014; Blackwell, Robinson, Proctor, & Taylor, 2017; DeMatteo, 2014; DeMatteo, et al., 2015; Halstead, et al., 2013; Master, Gioia, Leddy, & Grady, 2012; McGrath, 2010; Sady, Vaughan, & Gioia, 2011). This research study investigated the pathways that collegiate athletes followed in returning to learning, returning to play, and other daily activities following a concussion. The purpose of this study was to gain an in-depth understanding of the experiences of collegiate athletes who sustained concussion with subsequent post-concussion syndrome, including the recovery process, how learning, sports, and daily activities were affected, and their perspective on the how the concussion and PCS affected their learning and return to play.

Summary

The research presented in this dissertation was conducted to gain insights into aspects of concussion among collegiate student athletes from a variety of perspectives. The work is designed to be clinically relevant to an important problem facing collegiate athletes. This research has the potential to have a positive impact on clinical practice by providing information and tools to help in the prevention, assessment, and management for student athletes who have sustained concussions.

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CHAPTER 2

CONCUSSION EDUCATION FOR STUDENT ATHLETES: WHO IS GETTING IT? WHAT KIND? DOES IT MATTER?

Concussions, also termed mild traumatic brain injuries, are the most common form of traumatic brain injuries (TBIs) (National Institute for Neurological Disorders and Stroke, 2017). Sports-related concussions have become a major public health issue in the United States, and there is increasing discussion about this topic among health professionals, as well as in the popular media (Cantu & Hyman, 2012; CDC, 2016; Giza, et al., 2013). The Centers for Disease Control and Prevention (CDC) estimated that up to 3.8 million traumatic brain injuries (TBIs) are sustained annually as a result of participation in sporting and recreational activities (Langlois, et al., 2006). The number of reported sports related concussions in adolescents has increased over the last 10 years (Coronado, et al. 2015; Zhang, et al., 2016).

Concussions result in a variety of signs and symptoms that may be grouped into physical, cognitive, and behavioral categories (Stoler & Hill, 2013). Common physical symptoms of concussion include headaches, visual disturbances, and fatigue (Cantu & Hyman, 2012; Lovell & Collins, 1998). Common cognitive symptoms include memory loss and attention difficulties (Cantu & Hyman, 2012; Lovell & Collins, 1998). Behavioral symptoms are much less commonly recognized and include symptoms such as depression and changes in mood (Cantu & Hyman, 2012; Lovell & Collins, 1998). Serious long-term health effects have been found in professional athletes with a history of concussions including long-term cognitive deficits, dementia, depression, and chronic traumatic encephalopathy (Institute of Medicine and National Research Council, 2013; Willer & Leddy, 2006).

Children and adolescents are more vulnerable to the serious effects of concussions (Guskiewicz et al., 2003; Scorza, et al., 2012), and may have longer recovery times than adults

(McCrory, et al., 2005). Concussion-induced cognitive deficits are particularly serious for this population because of potential impact on their academic performance (Halstead, et al., 2013). Repeated concussions have been shown to have a cumulative effect on high school and collegiate athletes (Guskiewicz et al., 2003).

The vulnerability of youth to the effects of concussion give rise to the need for concussion education and awareness among student athletes. Despite increased efforts in this area, studies have demonstrated deficits in student-athletes' knowledge of concussion symptoms (Carroll-Alfano, 2017; Chrisman, et al., 2013; Cournoyer & Tripp, 2014; Fedor & Gunstad, 2014). Of particular concern is the poor recognition and knowledge of the behavioral symptoms of concussion (Carroll-Alfano, 2017; Chrisman, et al., 2013; Cournoyer & Tripp, 2014; Fedor & Gunstad, 2014).

State governments have turned to legislation to address this problem. In the United States, all 50 states and the District of Columbia have passed concussion legislation (The Network for Public Health Law, 2016). Nearly all of these laws include mandatory concussion education programs for high school athletes; however, there is variability regarding the details of the educational mandates (The Network for Public Health Law, 2016). Relevant to this study, which drew a sample of student athletes who came almost exclusively from the states of Illinois and Indiana, these states enacted concussion legislation in July, 2011, requiring all high school athletes to receive concussion education (State of Illinois, 2011; State of Indiana, 2011). Therefore, beginning with the graduating class of 2012, all high school athletes in Illinois and Indiana should have received concussion education; however, these laws did not specify how this education should be delivered, or its content.

In assessing the effectiveness of concussion legislation, there are two issues to consider. First, is legislation mandating education sufficiently enforced as to ensure that all student athletes are actually receiving this education? Second, is receiving concussion education associated with better outcomes in terms of knowledge of concussion symptoms and self-reporting after experiencing a concussion?

Research investigating the question whether students in states with legislation report receiving education is limited (Carroll-Alfano, 2017; Chrisman, et al., 2014). These studies report that a sizeable portion of student-athletes report minimal or no education, even in the presence of legislation, and these researchers suggest that it cannot be assumed that legislatively mandated concussion education will result in education being provided or remembered (Carroll-Alfano, 2017; Chrisman, et al., 2014).

Research investigating the question whether concussion education is associated with better outcomes in terms of symptoms knowledge and self-reporting after a concussion has shown mixed results. Some investigations have shown a statistically significant improvement of athletes' knowledge of symptoms for those who have received education (Bagley al., 2012; Parker et al., 2015), with other studies showing little or no association between education and concussion knowledge (Cournoyer & Tripp, 2014; Kurowski al., 2014; Willer & Leddy, 2006).

Studies investigating the association of concussion education with student athletes' self-reporting of concussions and health care utilization following concussions have shown that more is needed than just education alone. A considerable body of evidence indicates that concussion education has minimal or no association with self-reporting, and that other factors such as the athletes' attitudes toward concussion, age, gender, and pressure from coaches, parents, teammates, and fans may play a larger role in student athletes' decision to self-report (Gibson et al., 2014; Kerr et al., 2014; Kroshus et al., 2014; Kroshus et al., 2015). Other studies have shown increased health care utilization for concussion after legislatively mandated education (Gibson et al., 2014; Trojian et al., 2015).

An important consideration in evaluating the effect of concussion education is to look more specifically at the nature and methods used in delivering the education. Education can be provided in a variety of ways, including formalized in-person training, videos, handouts, and casual conversations. Some general principles have been suggested for concussion education programs, with knowledge transfer, learning styles, and identifying who is receiving the training as important considerations for training programs (Provvidenza et al., 2013; Sady et al., 2011; Vassilyadiet et al., 2009). It remains an open question as to what key components of an education program lead to improved outcomes in symptom knowledge and self-reporting. To address these issues, this study proposed the following four research questions:

1. Is there an association between implementation of concussion legislation and collegiate athletes reporting having received concussion education in high school, and has this changed over time?
2. Is there an association between collegiate athletes reporting having received concussion education in high school by sport played and gender?
3. What methods do student-athletes report as being used to deliver concussion education, and who do they report is providing the education?
4. Is there an association between reporting having received specific types of concussion education and being able to name the diverse symptoms of concussions?

Methodology

Research Design and Participants

The research design was a cross sectional associational survey study. Collegiate student-athletes participated in an anonymous survey that asked participants a variety of questions about their knowledge of concussion symptoms, and about their participation in, and the nature of, any previous concussion education.

Procedures

Students were invited to complete a data-collection survey that was administered prior to concussion education seminars that student-athletes were required to attend. Although attendance at the education session was mandated, completion of the survey was not required of participants in the education program. Participants were informed of the details of the study both verbally and in writing, and of the fact that their participation was not mandatory, and they would not be penalized if they elected not to participate (under a protocol approved by two Human Subjects Institutional Review Boards). The surveys were administered during 6 separate concussion training sessions conducted between March 2015 and March 2017.

Participants

Participants were 157 collegiate student-athletes. Approximately 90% of the athletes in this study attended high school in Illinois, with 5% attending high schools in Indiana, and 5% in other states. Almost all (98.1%) participants had graduated from high school during a period when mandated high school concussion education should have been offered in their state to them because of legislation.

Data-Collection Instrument

The data-collection instrument consisted of a nine-question survey developed for this study based on prior literature (see Appendix 1). Demographic information was collected, which included academic year (freshman, sophomore, junior, senior), gender (male/female), sport or sports played (open ended), high school graduation year (open ended), and high school graduation state (open ended). Participants were asked whether they had previous concussion training (yes/no).

If the athlete reported participating in training, additional questions were asked about the training, including when they had participated (*middle school/Jr. high, high school, college, or other*), what types of education were provided (*formal group training, casual conversation, watched a video/slides, handouts, signed a form*), and who provided the training (*coach, athletic trainer, athletic director, doctor, nurse, other*). Concussion knowledge questions included an open-ended question asking the participant to name symptoms of a concussion, and whether a concussion was a brain injury (*yes/no*). Participants were also asked about previous concussion history (*yes/no*), and whether they had sought treatment (*yes/no*).

A variety of signs and symptoms can occur following a concussion. Signs and symptoms of concussions that were named by students in response to the open-ended question were classified into one of three categories, physical, cognitive, and behavioral, based on the literature (Stoler & Hill, 2013).

Data Analysis

A Pearson Chi-Squared test was used to assess the statistical significance of the association of reports of receiving concussion education with gender, the association of reporting receiving education with the ability to name a cognitive sign or symptom, and the association of reporting receiving education with high school graduation year. For statistically significant results, the odds ratios were calculated. For analysis of the association of sport played and gender on receiving training, and the association of training method and the ability to name a cognitive sign or symptom, binary logistic regression analyses were performed. An alpha level of $p<0.05$ was considered statistically significant for all analyses. Statistical investigations were conducted using IBM SPSS Statistics Version 23.

The data collection instrument in this study had several questions that were identical with those used by the author in a previous research study on the same population, including those that asked if the participant had received concussion education (Carroll-Alfano, 2017). This commonality between the two data collection instruments and their target population made it possible to combine the new data with the existing data, which was part of the prior study, (Carroll-Alfano, 2017) from these identical questions. This single combined dataset was used to investigate how the reported rates of concussion education varied over nine graduation years, and these combined data were analyzed using descriptive statistics and using a Pearson Chi-Squared test to test the association between reports of receiving concussion education with graduating pre- and post-legislation.

Results

Demographics

As summarized in Table 1, the 157 survey participants included male (63.1%) and female (36.9%) athletes and represented eight different sports. Participants attended high school in Illinois (89.8%), Indiana (4.5%), and Michigan (1.9%), as well as six other states each with less than 1%. Seventy six percent of participants were freshman, and the remaining 24% were students who transferred to the university as sophomores, juniors, or seniors. Of the 157 participants, 44 (28.0%) reported experiencing a concussion, and of these, 40 (90.9%) reported seeking medical treatment for the concussion.

Table 1. Demographic Information of Participants

Sport		**Percent**	**n**
	Football	34.4	54
	Soccer	15.9	25
	Baseball	10.8	17
	Volleyball	9.6	15
	Softball	9.6	15
	Basketball	8.3	13
	Cross country/track	8.3	13
	Cheerleading	1.9	3
	Golf	1.3	2
Gender			
	Male	63.1	99
	Female	36.9	58
State			
	IL	89.8	141
	IN	4.7	7
	Other	5.5	9

Proportion of Athletes Reporting Education

Of the 157 participants, 124 (79.0%) reported having received concussion education, with the remaining 33 (21.0%) reporting not receiving any education. A graph of high school graduation year vs. percent reporting education is shown in Figure 1. For graduation years 2013, 2014, 2015, and 2016, the percent reporting receiving education fell in a range between 75% and 87%, with no statistically significant difference observed across these graduation years ($X^2(3)=1.590$, $p=0.662$, Pearson chi-square).

In total, 124 of the 157 participants reported having received education. Of these, 8 (6.5%) reported receiving the education in middle school, 108 (87.1%) in high school, 41 (33.1%) in college, and 6 (4.8%) in some other setting (park district, club sport, fire department). The totals add to more than 100% as participants may have reported receiving education at multiple times.

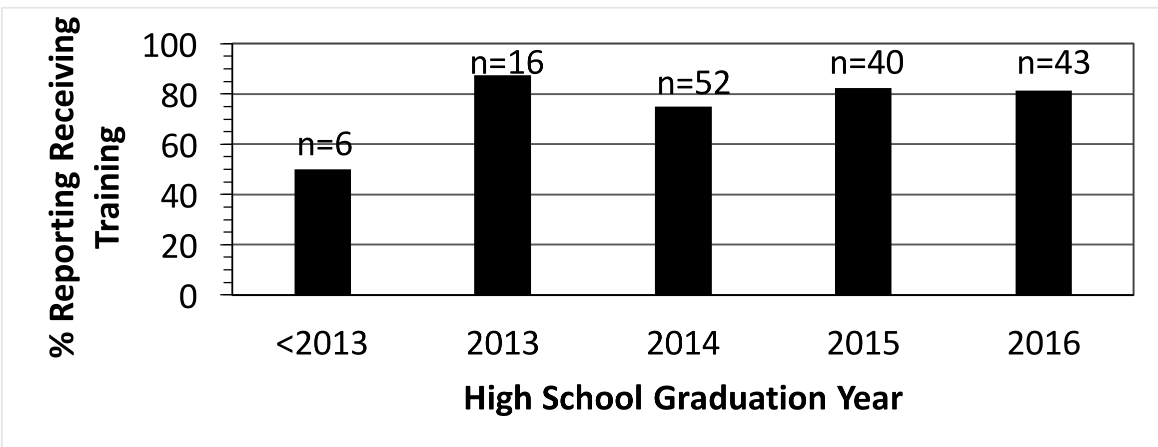

Figure 1. Percentage of Athletes Reporting Receiving Concussion Education by High School Graduation Year (N=157).

When combining the new data from this study with existing data from the previous study (Carroll-Alfano, 2017) to form a single longitudinal dataset, it is possible to examine the rate of reported concussion education over nine graduation years. This combined dataset is shown in Figure 2 and presents the percentage of student-athletes reporting receiving concussion education for high school graduation years between 2008 and 2016. In this longitudinal dataset, over 95% of the participants attended high school in either Illinois or Indiana, thus participants were separated into two groups: athletes who graduated before legislation went into effect (graduation year < 2012) and athletes who graduated after legislation went into effect (graduation year >= 2012). Pre-legislation, 59.5% of athletes reported receiving training, and 78.2% of athletes who graduated post-legislation reported receiving training. This difference was statistically significant, Pearson chi-square).

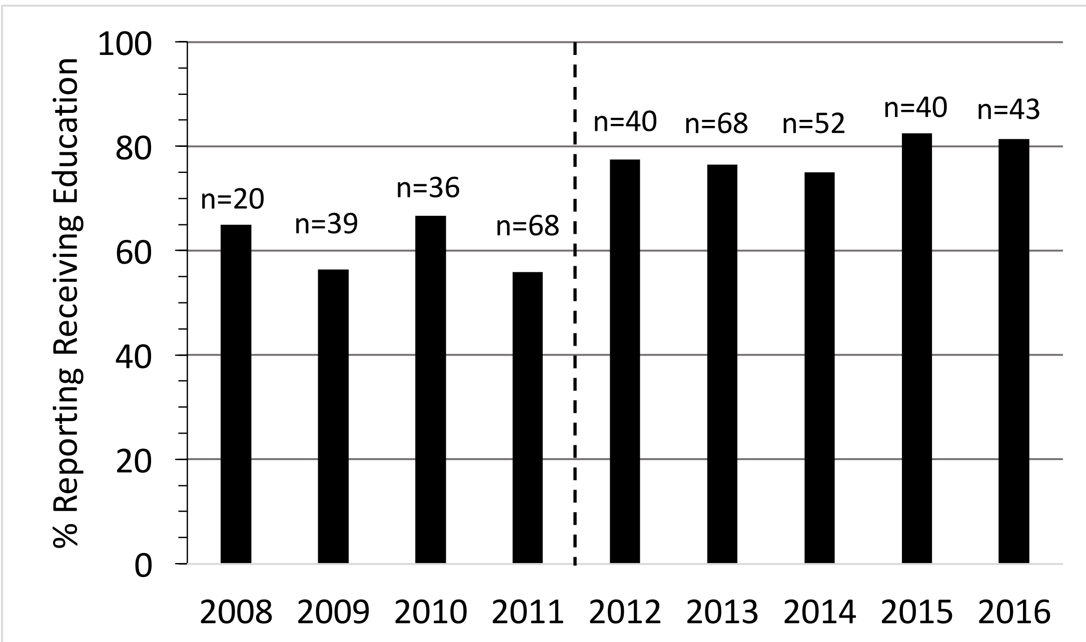

Figure 2. Combined Longitudinal Dataset Showing the Percentage of Athletes Reporting Receiving Concussion Education by High School Graduation Year (N=406). The vertical dashed line shows when concussion legislation went into effect in Illinois and Indiana.

Proportion of Athletes Reporting Education by Gender and Sport

When analyzing education by gender, males reported receiving education at a rate of 84.8% and females at a rate of 69.0%. This difference was statistically significant ($X^2(1)=5.56$, $p=0.018$, odds ratio=2.52, Pearson chi-square).

Figure 3 shows the percentage of participants who reported receiving training by sport and gender. Overall, volleyball players had the highest percentage reporting receiving education, and cross country/track athletes had the lowest. To determine if these differences were statistically significant, logistic regression was performed using the combination of sport and gender as the independent variable (e.g. women's basketball, men's basketball), with reported concussion education as the dependent variable. No statistically significant difference was found among the various gender-sport combinations ($X^2(13)=19.71$ $p=0.103$ binary logistic regression). It should be noted that some of the gender-sport combinations had very small cell sizes (<5). Consequently, this analysis had low statistical power, and these results should be viewed as exploratory.

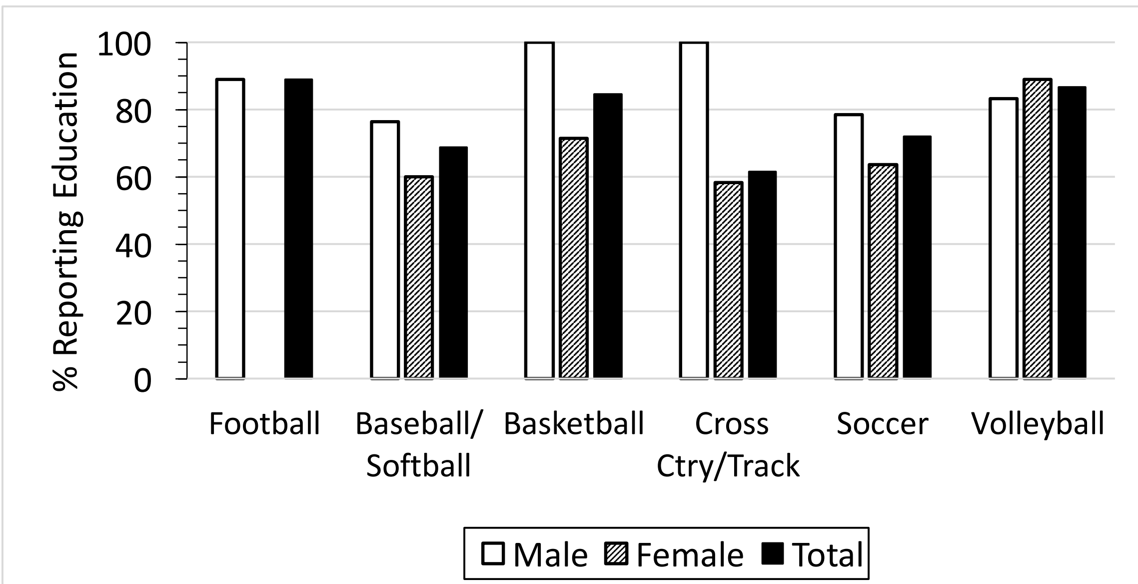

Figure 3. Percentage of Athletes Who Reported Receiving Concussion Education, by Sport and Gender.

Football players were more likely to report receiving education than athletes playing a different sport than football (88.9% vs. 73.8%), and this difference was found to be statistically significant ($X^2(1)=4.87$, $p=0.027$, odds ratio=2.84, Pearson chi-square). As all football players were men, this difference may reflect the previously reported gender difference in education rates. To test this, a Pearson chi-square test was run to examine the likelihood of receiving education comparing football players to males in all other sports. The percentage of male football players reporting education was 88.9% and the percentage of male non-football players reporting education was 80.0%. This difference was not statistically significant ($X^2(1)=1.51$, $p=0.219$, Pearson chi-square).

Methods Used for Education and Who Provided Education

Athletes were asked to characterize the method of the concussion education that they had previously received, using a checklist. The most common method of concussion education selected was casual conversation. This option was selected by 54.8% of participants. Watching a video or slide show was next, reported by 31.8% of participants, followed by formal group training (30.6%), receiving handouts (22.3%), signing a form (19.1%), and other types of training (4.5%). Note that these percentages total more than 100% since participants could select more than one training method.

Nearly a quarter (23.3%) of athletes reported receiving no methods of training (i.e. they reported that they did not receive training). A little more than a quarter reported receiving a single method (28.0%), and another quarter (26.1%) reporting two methods. Smaller percentages reported 3 methods (17.2%) and four or more methods (7.6%).

Athletes who reported receiving concussion education were asked to identify the role of the person who provided the education. The most common persons providing education were athletic trainers (65.6%) and coaches (42.0%), followed by athletic directors (15.3%), doctors (9.6%), nurses (7.0%), and other providers (2.5%). Totals add to more than 100% because training could be provided by more than one person and may have occurred more than once.

Participants who reported experiencing a concussion were more likely to report receiving training from a doctor (11 out of 44, 25.0%) compared to those who reported not having a previous concussion (4 out of 107, 3.7%). This difference was statistically significant ($p<0.001$, odds ratio=6.69, Fisher's exact test).

Association Between Type of Education and Naming Symptoms

Participants were asked the question "Is concussion a brain injury." Nearly all participants (95.5%) correctly answered this question with an answer of yes.

Athletes were tested on their knowledge of concussion signs and symptoms by asking them to name some signs and symptoms of a concussion. Nearly all participants (97.4%) correctly named at least one valid sign or symptom. Participants named a total of 462 signs and symptoms (an average of 2.94 symptoms named per participant), of which 447 (96.8%) were generally recognized as being indicative of concussion, and 15 of which were not symptoms of concussion. A symptom was considered as valid if it was contained in the generally recognized list of symptoms of concussion (Cantu & Hyman, 2012; Stoler & Hill, 2013). The incorrect signs and symptoms named by participants were generally symptoms of a more serious traumatic brain injury, such as dilated pupils, and were excluded from further analysis.

Table 2 shows the signs and symptoms that were named by the participants by category and frequency. The top three (headache, dizziness, and nausea/vomiting) accounted nearly 60% of the total symptoms named, and the top nine symptoms accounted for over 90% of the total. Memory impairment was the most reported cognitive sign or symptoms at 10.3%, and emotional lability was the most reported behavioral sign or symptom at less than 1% of the total signs and symptoms named.

Figure 4 shows the percentage of athletes naming at least one sign or symptom for each of the three categories, stratified by whether the athlete reported receiving education. Athletes both who reported being with and without training named at least one physical sign or symptom of a concussion at a high rate (98.4% with training, 84.8% without training). This difference was found to be statistically significant (p=0.005, Fisher's exact test); however, the expected cell sizes for athletes who did not name a physical symptom were very small (≤5), and thus these results should be viewed with caution. For cognitive signs and symptoms, 30.3% of athletes with education correctly named at least one cognitive sign or symptom, compared to 41.9% of athletes without education. This difference was not statistically significant ($X^2(1)=1.48$, $p=0.224$, Pearson chi-square). For behavioral signs and symptoms, none of the participants without training named a behavioral sign or symptom, and only 1.3% of those with training named at least one correct behavioral sign or symptom.

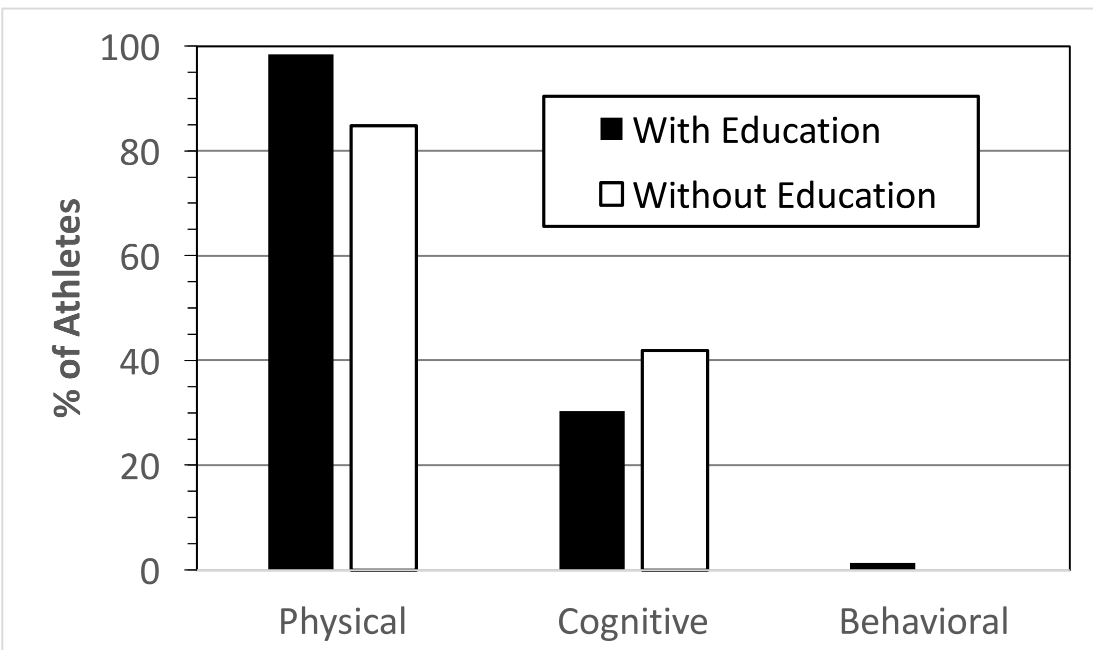

Figure 4. Percentage of Athletes Naming at Least One Concussion Symptom in the Specified Category.

Logistic regression was used to determine the association between the method of concussion training reported with the ability of athletes to name signs and symptoms and the results are summarized in Table 3. For this analysis, only cognitive symptoms were considered, because physical and behavioral symptoms both had extremely small (≤5) expected sizes for some cells (for physical, those who did not name a symptom, and for behavioral, those who did name a symptom). There was no association between the method of training reported and whether an athlete named a cognitive sign or symptom ($X^2(6) = 11.90$, $p = 0.064$).

Logistic regression showed no association between reporting having received concussion education from a specific type of provider and being able to name a cognitive sign and symptom of concussion ($X^2(6) = 4.08$ $p = 0.666$). A summary of the logistic regression results is shown in Table 4.

Table 2. Valid Concussion Symptoms Named by Participants

Signs & Symptoms	Category	Times named	% of total
Headache	Physical	106	23.7%
Dizziness	Physical	90	20.1%
Nausea	Physical	66	14.8%
Memory impairment	Cognitive	46	10.3%
Fatigue/Lethargic	Physical	22	4.9%
Blurred/Double Vision	Physical	22	4.9%
Hypersensitivity to light	Physical	22	4.9%
Disorientation	Physical	17	3.8%
Light Headedness	Cognitive	15	3.4%
Impaired Coordination	Physical	14	3.1%
Loss of consciousness	Physical	11	2.5%
Sleep disturbances	Physical	7	1.6%
Decreased attention	Cognitive	6	1.3%
Emotional Liability	Behavioral	2	0.5%

Table 2. Continued			
Perceptual disturbances	Cognitive	1	0.2%
Total valid symptoms		**447**	**100%**
Total invalid symptoms		**15**	

Table 3. Logistic Regression Results for Named Cognitive Symptom Versus Educational Method

Method	Odds Ratio	95% Confidence Interval
Formal Group Training	0.74	[0.36, 1.55]
Casual Conversation	0.50	[0.25, 1.03]
Video or Slide Training	1.08	[0.52, 2.26]
Handouts, no Presentation	4.03	[1.45, 11.19]
Signed a Form	0.69	[0.26, 1.84]
Other Training	0.35	[0.07, 1.76]

Model $X^2(6)=11.90$, $p=0.064$. $R^2=0.073$ (Cox & Snell), 0.99 (Nagelkerke).

Table 4. Logistic Regression Results for Named Cognitive Symptom Versus Education Provider

Provider	Odds Ratio	95% Confidence Interval
Coach	0.94	[0.46, 1.93]
Athletic Trainer	1.42	[0.69, 2.92]
Athletic Director	2.00	[0.80, 5.01]
Doctor	1.13	[0.33, 3.85]
Nurse	0.49	[0.28, 4.49]
Other	0.47	[0.05, 5.02]

Model $X^2(6)=4.08$, $p=0.666$. $R^2=0.026$ (Cox & Snell), 0.035 (Nagelkerke).

Discussion

Proportion of Athletes Reporting Education

Results from this study indicate that continued efforts are needed to ensure that all student athletes report receiving concussion education. Twenty-two percent of athletes participating in this study reported not receiving concussion education, despite attending high school when legislation was in effect mandating education for student athletes. Similar results were seen in a previous research study performed by the author (Carroll-Alfano, 2017). All students in the combined longitudinal dataset (Figure 2) who graduated in 2012 or later should have reported receiving this legislatively-mandated concussion education. Whereas a statistically significant increase was observed upon implementation of legislatively-mandated concussion education (Carroll-Alfano, 2017), following this increase, the percent reporting education has plateaued at around 80% in the years after legislation implementation, with no statistically significant improvements observed. Approximately 20% of athletes continue to report not receiving education up to five years after it became mandatory. This may indicate that these athletes did not receive education, or that they received the education, but they did not recall participating. The lack of a steady increase of students reporting education over time suggests that implementation of the legislation has stalled, and the desired effect of the legislation is not impacting one student out of five.

Proportion of Athletes Reporting Education by Gender and Sport

When the data from the current study were analyzed by gender, a statistically significant difference was seen between males and females, with males reporting education at a higher rate. One possible explanation for the males reporting receiving this education in higher levels than females may be that this education has been especially targeted at football players and all football players are male. In the popular media, one of the driving forces on the need for concussion legislation has been the widely-publicized prevalence of chronic traumatic encephalopathy (CTE) in former professional football players (Cantu & Hyman, 2012). Thus, there has been an emphasis on the need for football players at all levels of play to receive concussion education.

This study showed that there was a statistically significant difference between the rate of reporting receiving education between football players and non-football-playing athletes of both genders; however, when football players were compared to male non-football-playing athletes, no statistically significant difference was observed. These results suggest that the difference in reported rates between male and female athletes cannot be explained by higher education rates for football players, as football players do not exhibit significantly higher training rates than non-football-playing males. This difference in the percentage of athletes reporting education between males and females was not seen in the previous research (Carroll-Alfano, 2017) and is an area that merits further study.

No statistically significant difference was found in reported rates of education when stratified by both sport and gender; however, some gender-sport combinations had very small sample sizes. These low sample sizes resulted in low statistical power which can lead to Type II errors, and these results should be viewed as exploratory only. Additional studies with larger sample sizes are needed to more effectively probe for an association between sports-gender combinations and reported rates of receiving training.

Methods of Education and Who Provided Education

The most commonly reported providers of education were athletic trainers and coaches, with only about 10% of participants reported receiving training from a doctor. Participants who reported experiencing a concussion were nearly seven times more likely to report training from a doctor than those who did not experience a concussion. This could be explained by the finding that nearly all (>90%) of the participants who experienced a concussion sought medical treatment. During this treatment, they were more likely to have personal interactions with a doctor, which provided them the opportunity for the doctor to provide them with educational counseling and information.

Association Between Type of Education and Naming Symptoms

Deficiencies were observed in student athletes' knowledge of cognitive and behavioral signs and symptoms of concussion, even for those students reporting having received education about concussion. Athletes reporting receiving concussion education failed to exhibit a statistically significant improvement in being able to name a cognitive sign or symptom relative to those without education.

The results of this study showed no statistically significant association between an athlete naming a cognitive sign and symptom and the method of training reported. One might expect that formal classroom training on concussions might be more effective in enabling athletes to name cognitive signs and symptoms that other methods such as a casual conversation, watching a video, or simply signing a form, but this was not seen in this study. This lack of knowledge of cognitive and behavioral symptoms relative to physical symptoms has been seen elsewhere (Chrisman, et al., 2013; Cournoyer & Tripp, 2014; Fedor & Gunstad, 2014) and highlights the need for the development of evidenced-based concussion education programs that have been proven effective in increasing awareness in athletes of the diverse symptoms of concussion.

Almost all student athletes recognized that concussion is a traumatic brain injury. Although this is a positive sign, it is not known whether this recognition is due to better concussion education or increased media attention to the topic.

Limitations

This study has several limitations. First, this was a retrospective study which relied on participants' ability to recall specific details about concussion education they may have had in the past, and details about the education. An athlete's ability or lack of ability to recall participating in concussion education may reflect the quality or type of education that was provided. Second, some sample sizes were small when stratified by sport and gender, leading to low statistical power and possible type II errors for some of the statistical analysis. Finally, all participants in this study attended a small private NAIA university in the Midwest. Future research needs to continue to look at these questions in a variety of universities, including public vs. private, Division I vs. Division III, and various geographic regions, to probe the generalizability and external validity of these findings.

Conclusions

In summary, this study highlights several aspects of concussion education that need improvement. First, continued efforts are needed to ensure that all student athletes are receiving mandated concussion education, and that the education being provided is sufficiently meaningful as to be remembered by the athletes. Second, even with education, there are still deficiencies in student athletes' knowledge, particularly in identification of cognitive and behavioral signs and symptoms, which may lead them to ignore these symptoms if they experience them after a concussion, either immediately or sometime later. Finally, the findings of this study are consistent with those of previous literature indicating a continuing need for evidence-based education that will improve the student athletes' knowledge of all the signs and symptoms of concussion, particularly cognitive or behavioral ones that are poorly identified. Additional research is needed to determine the best techniques, methods, and providers that should be used to provide concussion education.

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CHAPTER 3

ASSESSMENT OF CONCUSSION IN COLLEGIATE ATHLETES USING STORY RETELL

A traumatic brain injury (TBI) is an injury from an external force that affects functioning of the brain (National Institute of Health, 2017). TBIs are classified along a continuum, from mild to severe. According to the Centers for Disease Control and Prevention (CDC), mild TBIs, also referred to as concussions, or mTBIs, account for most of the brain injuries that occur annually (CDC, 2016). Diagnosing a concussion can be challenging because there are typically no signs on neuroimaging; rather, diagnosis is made based on clinical assessment and symptoms reported (Choe & Giza, 2015; MacFarlane & Glenn, 2015).

In recent years, concussion in student athletes has become a topic of interest due to the high prevalence of concussions among this population, coupled with the increasing recognition of the potential serious long-term health sequelae of concussions (Institute of Medicine and National Research Council, 2013). Among these sequelae are cognitive problems, including difficulty with attention, memory, language, information processing, and executive function. Although most people recover from a concussion within several weeks, approximately 10-30% of persons with concussions experience prolonged recovery times (Makdissi, et al., 2013; McCrory et al., 2013) in a condition termed post-concussive syndrome (PCS). This work presented here is a study of the less obvious but potentially significant cognitive-linguistic sequelae in the production of narrative discourse that may be a symptom of PCS.

Assessment of Cognition in Concussion

Assessment of sports-related concussion can occur at a variety of times in relation to the concussion event. These times range from baseline testing before an injury occurs, to the sideline immediately following a concussion, to medical settings in emergency rooms or outpatient care within hours, days, or weeks following a concussion. It is the latter period that was of primary interest in the current study, but it is helpful to consider other points in the assessment process first.

Baseline testing involves an athlete completing a neurocognitive assessment to assess attention, memory, problem solving, and other skills prior to the start of the season. Results from baseline testing serve as a benchmark of the athlete's cognitive abilities for comparison following a suspected concussion and help to identify the effects of the concussion on the athlete (CDC, 2015). By comparing the results for the same athlete pre- and post-injury, diagnostic accuracy may be higher due to controlling for any other confounding variables (Echemendia, Iverson, McCrea, et al., 2013; Echemendia & Julian, 2001).

Screening tools are used to assess for concussion immediately or shortly after a suspected incident. Sideline assessments are simple tests used to quickly assess an athlete for signs and symptoms of concussion, physical abilities such as balance and vision, and cognitive skills including orientation and memory. Sideline assessments have become increasingly important in concussion management due to the need to determine if the athlete has sustained a concussion, or if the athlete can return to play, particularly when many state concussion laws have return-to-play requirements (Children's Safety Network, 2016).

Cognitive-specific screening tools, such as the Mini Mental State Exam (MMSE) (Folstein, Folstein, & McHugh, 1975) and the Montreal Cognitive Assessment Test (MoCA) (Nasreddine et al., 2005), are used in medical settings when it has been suspected that an athlete has sustained a concussion. These tests can be used to assess for deficits when athletes report cognitive symptoms, and are popular because they are readily available, short, and easy to administer. They provide information regarding visual-spatial, memory, language, and attention skills (Folstein, Folstein, & McHugh, 1975; Nasreddine et al., 2005). Although these tests can be useful, they have been shown to have limited sensitivity in identifying individuals with mild but sustained cognitive deficits in traumatic brain injury, due to the structured and brief nature of the tests (both can be administered in 10 minutes or less) (Arciniegas, et al., 2005; DeGuise et al., 2014).

For persons who experience PCS, more detailed cognitive and communication assessment may be performed, typically by a psychologist or speech-language pathologist. Speech-language pathologists assess and treat cognitive-linguistic deficits in the context of cognitive communication disorders, as cognition and language are interrelated, so an impairment in cognition will disrupt language, and an impairment in language will disrupt cognition (ASHA, 2005).

Cognitive communication disorders can be assessed using standardized assessment measures. These standardized tests tend to be domain specific, assessing various cognitive domain such as memory, attention, or language. Administration of full-battery standardized tests can take anywhere from 30 minutes to several hours. This can pose challenges for persons who have sustained a concussion and have physical symptoms that may co-occur, such as headaches, dizziness, visual disturbances, and fatigue, which may limit the person's ability to participate in testing for extended durations. Common full-battery standardized tests used following concussion include the Woodcock Johnson Tests of Cognitive Abilities (IV), (Schrank, Mather, & McGrew, 2014), Scales of Traumatic Brain Injury (SCATBI), (Adamovich & Henderson, 1992), and the Pediatric Test of Brain Injury (PTBI), (Hotz, Helm-Estabrooks, Nelson, & Plante, 2010). Language specific tests can also be used and include the Boston Diagnostic Aphasia

Exam (BDAE-3), (Goodglass, Kaplan, & Baressi, 2001), and Western Aphasia Battery (WAB) (Kertesz, 2006). These language tests are generally not suitable for use in identifying post-concussion cognitive communication deficits, however, because these language specific tests assess microlinguistic ability, typically at the sentence level or word level; whereas persons with cognitive deficits after mild TBI tend to have difficulty with macrolinguistic abilities, such as discourse (Cannizzaro, Coelho, Youse, 2002; Frith, et al., 2014; Galetto, Andreeta, Zettin, & Marini, 2013; Marini, et al., 2017; Marini, Zettin, & Galetto, 2014).

Cognitive communication disorders can also be assessed using non-standardized assessment measures. These assessments include techniques such as discourse analysis, which can be useful because cognitive communication deficits may be identified better in functional situations, rather than during standardized testing environments. Standardized testing tends to be highly structured which can make it easier for a person with TBI to perform tasks in controlled situations as compared to everyday communication situations (Coelho, Ylvisaker, & Turkstra, 2005; LeBlanc, Hayden, Paulman, 2000; Stout, Yorkston, & Pimentel, 2000). Standardized testing also may allow comparison to responses expected for a group of similar individuals who are known not to have had concussion.

Discourse in Traumatic Brain Injury

Discourse analysis can be a sensitive tool to identify subtle cognitive and language deficits in persons with mild TBI that may be missed by standardized assessments (Biddle, McCabe, & Bliss, 1996; Chapman, et al., 2006; Galetto, Andreetta, Zettin, & Marini, 2013; Marini, et al., 2017; Marini, Zettin, & Galetto, 2014; Stout, Yorkston, & Pimentel, 2000; Tucker & Hanlon, 1998). Assessment of discourse skills following TBI can include conversation, personal and topic-specific narratives, picture description, story retell, and summarization tasks.

Persons with mTBI generally are spared from difficulties with lower level, or micro-linguistic language skills, such as giving back information in words or sentences (Lindfors, 1991; Vas, Chapman, & Cook, 2015). They are more likely to struggle with higher level, or macro-linguistic skills because these tasks require the participants to use highly integrated language and cognitive skills beyond simple use of the information that is given (Lindfors, 1991; Vas, Chapman, & Cook, 2015). Persons who sustain even a mild TBI can struggle with macro-linguistic skills years post-TBI (Bernstein, D., 1999; Hiploylee, et al., 2017; Hugenholtz, Stuss, & Stetham, 1988).

Story retell is one type of discourse that has been studied in children and adults following TBI. In story retell, a person listens to an unfamiliar story and is asked to repeat the story as closely as possible. This task can be completed immediately after hearing it, after a period of delay, or both. Story retell assesses several key cognitive and linguistic skills including: auditory comprehension, attention, memory, and verbal production, which can place greater demands on the speaker than narrative productions from pictures (Agresti, Corrigan, & Gribble, 1989; Hartley & Jensen, 1990; Stout, Yorkston, & Pimentel, 2000). Poor performance on story retell tasks have been found to be explained at least in part by deficiencies in working memory (Pratt, Boyes, & Robins, 1989). In studies of adults, persons who sustained TBI, even mild TBI, performed significantly worse on story retell tasks, when compared with age-matched controls who had not sustained a TBI (Agresti, Corrigan, & Gribble, 1989; Gallagher & Azuma, 2018), including up to 10 years post-injury (Stout, Yorkston, & Pimentel, 2000). Studies on children have found similar results, both in young children (Anderson, et al., 2001) and in older children and adolescents (Chapman, et al., 1992; Hotz, Plante, Helm-Estabrooks, & Nelson, 2014).

Notably absent have been studies that target the college-aged population (18-22), as well as studies that have focused exclusively on concussion in student-athletes. Early identification of concussion-induced cognitive deficits is imperative for collegiate student-athletes so that problems in school can be anticipated, rather than waiting for the student to fail, particularly when the demands and expense of college are great. For these reasons, this study aimed to determine if story retell is a sensitive tool for identifying concussion-induced cognitive communication changes in collegiate athletes following concussion. The research questions for this study include the following:

1. Do collegiate athletes who have reported sustaining a concussion demonstrate significantly lower scores on the MoCA and immediate and delayed story retell than collegiate athletes and non-athlete college students who report never having sustained a concussion?
2. Is there a difference between post-concussive cognitive and language abilities identified by immediate and delayed story retell vs. the MoCA?
3. Is there a correlation between immediate and delayed story retell scores and MoCA scores for all three groups?
4. Is there a correlation between self-reported academic difficulties and scores on story retell and the MoCA?

Methods

Research Design

This research was a cross-sectional study comparing three groups: collegiate athletes who reported having a concussion, collegiate athletes who reported never having had a concussion, and non-athlete college students who reported never having had a concussion. Having a control group that relies on athletes that report not having had a concussion may be problematic, owing to under-identification and under-reporting of concussions by athletes (CDC, 2017), thus a second control group consisting of non-athletes who do not participate in sports was included because they were less likely to have an unidentified or unreported concussion.

Participants

Participants included 61 college students who were divided into three groups. The first group (Group 1) included collegiate athletes who sustained at least one concussion in high school or college. The second group (Group 2) included collegiate athletes who reported no history of concussion. The final group (Group 3) included college students who did not participate in collegiate or competitive sports and had no history of concussion. Three non-athletes reported experiencing a concussion. These participants were placed in a fourth group (group 4) and excluded from all analysis except for those involving research question 3. All participants were between the ages of 18 and 23 and enrolled in a college or university in the greater Chicago metropolitan area. Institutional Review Board approval was obtained from two universities prior to data collection.

Research Protocol

The research protocol was conducted by the first author, who is a clinical faculty member and speech-language pathologist. Informed consent for participation in the study was obtained from each participant using approved procedures. Test administration took about 30 minutes and included the following:

1. Immediate Memory for Stories (Test of Memory and Learning, Second Edition (TOMAL2)) (Reynolds & Voress, 2007).
2. Interview, including demographic and academic information, medical history, and

concussion history.

3. Montreal Cognitive Assessment (MoCA) (Nasreddine et al., 2005).
4. Memory for Stories Delayed (TOMAL2) completed a minimum of 20 minutes after the Immediate Memory for Stories Test.

The MoCA was chosen as representative of screening tools often used to assess for cognitive deficits in the ER and acute care settings and includes visuospatial, executive functioning, language, attention, and memory tasks (Nasreddine et al., 2005). The TOMAL2 was chosen due to its correlation with measures of academic achievement (Saklofske, Schwean, & Reynolds, 2013), the length of the retell task, and its ability to assess functional deficits of cognition in the targeted population. Only the Memory for Stories and Memory for Stories Delay portions of the TOMAL2 were employed. The interview portion of the data collection consisted of questions that are shown in Appendices B and C. The Rivermead Post-Concussion Questionnaire (King et al., 1995) was used to detail symptoms of concussion for those participants who reported a concussion. A 7-point Lickert Scale was utilized for participants to quantify their academic difficulties that they experienced after their concussion. Participants were given a gift card for their time.

Data Analysis

Statistical analysis was conducted using IBM SPSS Statistics Version 24. Univariate analyses were performed to examine demographic information and the story retell and MoCA scores. One-way independent ANOVA was employed on the immediate and delayed story retell and the MoCA scores to identify differences in mean test scores between the three groups. Test scores from Group 1 participants, whose concussion was in the past 30 months (N=9), were compared with scores from Group 3, non-athlete control group, using an independent-samples t-test. The 30-month limit was chosen because when a histogram was made of the time since concussion as reported by participants, there was gap in the distribution at around 30 months, making it natural to split the concussions into these two groups, making it natural to define recent concussions as those occuring within the past 30 months. Because the MoCA and the TOMAL story retell tests are normalized tests, the underlying distribution of test scores is normal, and the independent-samples t-test can be used with this small sample size.

For group 1, athletes with a history of concussion, a repeated-measures t-test was used to compare the scores between immediate and delayed story retell tests with scores on the MoCA. This was achieved by converting the story retell and MoCA raw scores to percentile scores from a normal curve equivalent (NCE) using the TOMAL2 immediate and delayed story retell NCE conversion chart for ages 20-30 years old (Saklofske, Schwean, & Reynolds, 2013) and the MoCA normal curve mean and standard deviation data for adolescents and young adults (Pike, Poulsen, & Woo, 2017). Test scores from group 1 participants, whose concussion was in the past 30 months (N=9), were furthered evaluated to compare the scores for immediate and delayed story retell tests with scores on the MoCA using a repeated-measures t-test. The underlying distribution for these values was normal.

The Pearson Correlation Coefficient was used to evaluate correlation between the MoCA scores and the immediate story retell score, and the MoCA score and the delayed story retell score for all groups combined. The Pearson Correlation Coefficient was also used to identify a correlation between self-reported academic difficulties (as measured by a seven-point Likert scale) and scores on story retell and the MoCA. Correlations were examined between self-reported academic difficulties and immediate story retell scores, self-reported academic difficulties and delayed story retell scores, and self-reported academic difficulties and MoCA scores. In these analyses, the Likert-scale data for the self-reported academic difficulties were treated as interval data, as previous studies have supported this use, and the use of parametric tests for Likert-type scales has been shown to be robust to deviations of the data from the underlying assumptions (Carifio & Perla, 2008; Normal, 2010; Sullivan & Artino Jr., 2013). For all analyses, an α level of .05 was used.

Results

Participants

A total of 61 college students participated in the study. A summary of the demographic details of the participants is given in Table 5. Group 1 (athletes with concussion) had 20 participants, group 2 (athletes without concussion) had 13 participants, group 3 (non-athletes without concussion) had 25 participants. The total sample consisted of 47.5% men and 52.5% women. Participants were approximately evenly distributed between the four academic years and their reported mean GPA was 3.4. For college athletes with a history of concussion, the date of their last concussion ranged from 2 months ago to 90 months ago.

Table 5. Demographic Information of Participants

Groups	Percent	n
Athletes with concussion	32.8	20
one concussion		9
two concussions		6
three concussions		2
four or more concussions		3
Athletes without concussion	21.3	13
Non-Athletes without concussion	41.0	25
Non-Athletes with concussion	4.9	3

Table 5. Continued		
Gender		
Men	47.5	29
Athletes		20
Non-athletes		9
Women	52.5	32
Athletes		13
Non-athletes		19
College Sport		
Football	31.1	19
Soccer	8.2	5
Basketball	6.6	4
Softball	4.9	3
Other	3.3	2
None	45.9	28
Academic Year		
Freshman	26.2	16
Sophomore	19.7	12
Junior	29.5	18
Senior	24.6	15

Differences Between Groups on MoCA and Story Retell Test Scores

The mean test scores for the MoCA and the immediate and delayed story retell for three groups in this study (athletes with concussion, athletes without concussion, and non-athletes without concussion) are summarized in Table 6. To probe for differences in these scores between the three groups, one-way independent ANOVA was employed to compare the MoCA, immediate story retell, and delayed story retell mean scores for each of the three groups. Levene's test was not significant for any of the three tests, so equal variance between the two groups was assumed. The ANOVA showed no significant differences between the three groups for either the MoCA mean scores ($F(2,54) = 0.304$, p = .739), the immediate story retell mean scores ($F(2,54)=0.052$, $p = .949$), or the delayed story retell mean scores ($F(2,54) = 0.052$, $p = .949$).

Table 6. Summary of Aggregate Test Results for the MoCA and Immediate and Delayed Story Retell

Test	Group*	N	Mean	Standard Deviation	Mean Percentile**	Percentile St. Dev.
MoCA	1	20	27.95	1.61	52.4	27.0
	2	13	28.08	1.80	57.2	27.1
	3	25	28.32	1.52	59.5	24.6
	All	58	28.14	1.59	56.9	25.7
Immediate Retell	1	20	13.80	4.28	45.7	24.8
	2	13	13.82	4.41	46.9	25.5
	3	25	14.28	6.06	46.0	29.8
	All	58	14.03	5.07	46.1	26.3
Delayed Retell	1	20	13.85	3.94	61.9	22.5
	2	13	13.46	4.65	58.0	26.8
	3	25	13.84	5.26	59.5	25.4
	All	58	13.76	4.62	59.9	24.0

*Group 1 is athletes with concussion, group 2 is athletes without concussion, and group 3 is non-concussed non-athletes.
**Raw MoCA and retell scores were normalized to a percentile score based on the procedure described in the Methods section.

For the 20 participants who reported experiencing a concussion, the time post-concussion ranged from 2 months to 90 months. To assess if those participants whose concussion was more recent exhibited differences in mean test scores for the MoCA, immediate and delayed story retell, an independent samples t-test was run comparing test scores for athletes who experienced a concussion in the past 30 months (N=9) with non-athletes who did not report a concussion (N=25), and the results are summarized in Table 7. In all cases, Levene’s test for equality of variances was not significant, so equal variance between the two groups was assumed and standard one-way ANOVA was performed. For immediate story retell, the mean scores for athletes with recent concussion (12.67) was lower than that of non-athlete controls (14.28), however; this difference of 1.61 was found not to be statistically significant in an independent samples t-test ($t(30) = -0.73$, $p = .47$). Similarly, for delayed story retell, the mean scores for athletes with recent concussion (12.22) was lower than that of non-athletes controls (13.84), however; this difference of 1.62 was found not to be statistically significant in an independent samples t-test ($t(30) = -0.85$, $p = .40$). Finally, for the MoCA, the mean scores for athletes with recent concussion was 28.78 and that for the non-athlete controls was 28.32; this difference was found not to be statistically significant in an independent samples t-test ($t(30) = 0.80$, $p = .43$).

Table 7. Summary of Test Results for the MoCA and Immediate and Delayed Story Retell Between Athletes with Recent Concussion* (N=9) and Non-athletes with No Concussion (N=25)

Test	Group*	Mean	Standard Error	Difference	t(30) score	p
MoCA	Recent concussions	28.78	0.44	+0.46	0.80	0.43
	No concussions	28.32	0.30			
Immediate Retell	Recent concussions	12.67	1.43	-1.61	-0.73	0.47
	No concussions	14.28	1.23			
Delayed Retell	Recent concussions	12.22	1.16	-1.62	-0.85	0.40
	No concussions	13.84	1.06			

*Athletes with recent concussion are those athletes who reported a concussion in the past 30 months.

Comparison Between Story Retell and the MoCA for Athletes with Concussion

To determine if story retell is better able to identify potential post-concussive related deficits in athletes with concussion relative to the MoCA, the repeated-measures t-test was performed to compare the NCE percentile scores of athletes with concussion (group 1) between the MoCA and immediate story retell, and the MoCA and delayed story retell tests. No statistically significant difference was seen ($t(19) = 0.90$, $p = .378$). Similarly, a repeated-measures t-test was performed to compare the difference in the percentile ranking mean scores between the MoCA and delayed story recall test for athletes with concussion (group 1), and no statistically significant difference was seen ($t(19) = -1.21$, $p = .243$).

To assess if those participants whose concussion was more recent exhibited differences in mean test scores for the MoCA, immediate and delayed story retell, a repeated-measures t-test was run comparing test scores for athletes who experienced a concussion in the past 30 months (N=9), and the results shown in Table 8. The mean percentile for the immediate recall test (40.8) was lower than that of the MoCA (65.9) and this difference was statistically significant ($t(8) = 3.04$, $p = 0.016$). The mean percentile for the delayed recall test (53.8) was also lower than that of the MoCA (65.9); however, this difference was not statistically significant ($t(8) = 1.45$, $p = .186$).

Correlation Between the MoCA and Retell Tests

To determine the extent of correlation between normalized percentile scores among the MoCA and the immediate and delayed story retell scores, the bivariate correlation between the MoCA and each of the two story retell scores was determined using the Pearson correlation coefficient, using the pooled data from all of the groups (N=61). A statistically significant correlation was observed between the MoCA and the immediate story retell scores ($r = 0.303$,

p=0.018, R^2 = 0.091, 95% BCa CI [0.013, 0.548]). No statistically significant correlation was observed between the MoCA scores and the delayed story retell scores (r = 0.242, p = .060). Finally, a strong correlation was observed between immediate story retell scores and delayed story retell scores (r = 0.834, p<0.001, R^2 = 0.696, 95% BCa CI [0.718, 0.910]).

Table 8. Comparison of MoCA and Immediate and Delayed Story Retell Normalized Test Scores for Athletes with Recent Concussion* (N=9)

Test	Mean Percentile	Standard Error	Difference	t(8)	p
MoCA	65.9	7.4	25.1	3.04	0.016
Immediate Retell	40.8	8.5			
MoCA	65.9	7.4	12.1	1.45	0.186
Delayed Retell	53.8	8.2			

*Athletes with recent concussion are those athletes who reported a concussion in the past 30 months.

Correlation Between Academic Difficulties and MoCA and Retell Scores

As part of the data collection process, athletes with concussion (group 1) were asked to self-report on a seven-point Likert scale the impact of their most recent concussion on their academic performance in the 30 days following the concussion, with 1 being no impact and 7 being a major impact. The Pearson Correlation Coefficient was used to probe for correlation between the self-reported academic difficulties and each of the three test measures (MoCA, and immediate and delayed story retell). In these analyses, the Likert data was treated as interval data, as described in the methods section.

A statistically significant correlation was observed between the self-reported academic difficulties and the MoCA (r=0.454, p = .044, R^2 = 0.206, 95% BCa CI [-0.053, 0.792]). No significant correlation was observed between self-reported academic difficulties and either the immediate story retell scores (r = 0.067, p = .780) or the delayed story retell scores (r = -0.105, p = .660).

This analysis was repeated restricted to only those members of group 1 who had recent (past 30 months) concussions. No significant correlation was observed between self-reported academic difficulties and the MoCA (r = 0.611, p = .081), the immediate story retell scores (r = 0.599, p = .088) or the delayed story retell scores (r = 0.325, p = .393).

Discussion

Differences Between Groups on MoCA and Story Retell Test Scores

This study found no statistically significant differences in the mean tests score for the MoCA and story retell tests between the three groups of participants. This is in contrast with what was observed in other studies (Agresti et al., 1989; Anderson et al., 2017; Hotz et al., 2014; Stout et al., 2000). There are several possible reasons for the lack of a statistically significant difference in mean test scores in this study. First, the statistical tests used to probe for differences in the test scores among the three groups had low to moderate power, due to the sample size in this study. For example, for the independent samples t-test used to compare athletes with recent concussion against non-athletes without reported concussion, for α=0.05 and a large (0.8) effect size, the power of the test was only 0.62. Second, previous studies of story retell had participants with a range of TBI severity, from mild to severe TBIs and were not restricted to participants having only mild TBI (Agresti et al., 1989; Chapman et al., 1992; Hotz et al., 2014; Stout et al., 2000), so participants with more severe TBIs than concussions may have resulted in differences that were more easily detected. Third, participants in this study were college students, and years of education has been shown to be beneficial for recovery from TBI (Holland & Schmidt, 2015;

Kessler et al., 2003; Williams, 2015). Many of the athletes who sustained concussions in this study were several years post-concussion, so they may have completely recovered or learned to use strategies to help them with the skills used in story retell because they are like skills they use daily in the classroom. In any case, athletes with concussion did not perform significantly poorer on immediate or delay story retell tasks compared to athletes without concussion or non-athletes without concussion.

Deficits Identified by Story Retell Versus the MoCA

A comparison of the normalized mean MoCA scores and the story retell scores for all athletes with a history of concussion found no significant differences between them. When the group was further restricted to athletes with more recent concussions only (<30 months), a statistically significant difference was found with participants scoring lower on the immediate story retell tests than on the MoCA. Immediate story retell appeared to be a more sensitive measure of subtle cognitive and language differences in participants who had more recently sustained a concussion. The macro-linguistic abilities assessed in immediate story retell may not have fully recovered in those with more recent concussion, whereas the micro-linguistic skills found on tasks in the MoCA may have recovered. No difference was seen for delayed story retell and the MoCA. It is uncertain why significant differences were seen with immediate story retell for this subgroup but not with delayed story retell. In comparing immediate versus delayed retell, these two tasks may use differing amounts of short-term, long-term, and working memory skills (Cowan, 2008). Deficits from concussion may impact these types of memory differently, leading to differing performance in the immediate versus delayed retell tasks.

Correlation Between the MoCA and Retell Tests

The normalized scores for the MoCA and story retell tests were found to be largely uncorrelated, with the correlation between the normalized MoCA scores and the immediate story retell normalized scores indicating that less than 10% of the variance in the two measures were shared, and with no statistically significant correlation found between the MoCA and the delayed story retell. This lack of correlation likely reflects the fact that these tests are targeted to measure different aspects of cognition and language. The MoCA assesses cognitive deficits by testing domains including visual-spatial, memory, and attention skills, with only a minimal focus on language skills (Nasreddine et al, 2005). Conversely, story retell tasks are language-based tasks that target macro-linguistic skills. Story retell assesses key linguistic skills including auditory comprehension and verbal production, as well as cognitive skills such as attention and memory (Agresti, Corrigan, & Gribble, 1989; Hartley & Jensen, 1990; Stout, Yorkston, & Pimentel, 2000). As the MoCA and story retell emphasize and probe different aspects of cognition and language, it is not surprising that the correlation between them is weak or nonexistent.

A strong correlation was observed between the immediate and delayed story retell scores. This is not surprising and is expected, as both tests are probing similar linguistic and cognitive skills.

Correlation Between Academic Difficulties and MoCA and Retell Scores

No statistically significant correlation was seen between self-reported academic difficulties and either the immediate or delayed story retell tests. A significant correlation was seen between self-reported academic difficulties and the MoCA; however, this correlation is positive, which indicates that a higher MoCA score is correlated with increased academic difficulties.

The reason for the observed positive correlation between MoCA scores and self-reported academic difficulties is unclear. If the MoCA is a measure of cognitive impairment, one might expect that a higher MoCA score, which is indicative of little or no cognitive impairment, would be associated with lower self-reported academic difficulty ratings. One possible explanation for this reverse correlation might be that higher scores on the MoCA may be associated with higher academically performing students, and these high performing students might be very sensitive to even minor academic difficulties caused by their concussion. This positive correlation is an area that merits further investigation.

These results suggest that neither of these tests are accurate predictors or indicators of academic difficulties as quantified in this study. Although previous studies reported differences in immediate and delayed story retell scores in individuals post-mild traumatic brain injury (Agresti et al., 1989; Anderson et al., 2017; Hotz et al., 2014; Stout et al., 2000), difficulty on these specific task may not translate into academic difficulties. A systematic review of the effect of concussion on academic performance as measured by school grades found concussion to have minimal impact on school grades (Rozbacher, Selci, Leiter, Ellis, & Russell, 2017). Predicting academic difficulties following concussion likely depends upon a variety of factors. Half of the participants in this study reported that their concussion had no impact on their academics. This could be due to the low severity of their concussion and minimal symptoms experienced. These participants who reported no impact on their academics sustained their concussions four or more years prior to this study and may not have been able to accurately recall the affect their concussion had on their academics at an earlier point in the recovery process. A combination of measures, such as a change in grades over time, baseline testing that includes functional tasks, such as story retell, and self-reporting might be a better measure of academic difficulties than the self-report measure used in this study.

Limitations in This Study

No statistically significant differences were found between scores for the athletes with concussion group and the control group. These preliminary results have low statistical power due to small numbers in some of the groups. Group 1 in this study (athletes with concussion) had 20 participants; however, when the group was further restricted to only those athletes with recent concussions (30 months or less), the group size fell to nine. These low numbers reflect the difficulty in identifying suitable participants who are in college, have experienced a recent concussion, and were willing to participate in the research study. It would be beneficial to have a larger number of participants in each of the groups to confirm the study results. For the athletes who sustained a concussion, the time since concussion was spread out over a long period of time, from 2 months to over 7 years post-concussion. Future studies should look at story retell closer to the onset of concussion to determine if it is sensitive in identifying potential cognitive communication deficits. Finally, this study relied on subjective self-reporting of academic difficulties post-concussion, from months to years post. In future studies, it would be beneficial to use a variety of measures of academic performance for this comparison.

Conclusions

Early assessment for cognitive deficits in collegiate athletes following concussion is important to help these students continue to be successful in school. This study supports prior research which found significant differences between immediate story retell tests when compared to the MoCA for athletes several years post-concussion. These differences were not seen in collegiate athletes who were 3 or more years post-concussion which suggests that recovery of these skills occurs, or students learn strategies to overcome difficulties. The use of story retell tasks may have promise as a tool to assess subtle cognitive deficits and warrants further investigation.

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CHAPTER 4

CONCUSSION TREATMENT AND RECOVERY IN STUDENT ATHLETES EXAMINED VIA A CASE STUDY APPROACH

Concussion is a unique event for every individual who sustains one. Although most individuals have signs and symptoms that resolve within two weeks or less, others can have long-term sequelae from the injury persisting for one month or longer, in a condition termed post-concussive syndrome (PCS) (Bernard, Ponsford, McKinlay, McKenzie, & Krieser, 2017; Crowe et al., 2016; Ellis, Leddy, & Willer, 2016; Hiploylee et al., 2017; Mayo Clinic, 2015; Meehan et al., 2013; Miller et al., 2016; Moser, Schatz, & Jordan, 2005; Sohlberg & Ledbetter, 2016; Tapia & Eapin, 2017). Approximately 10-30% of persons with concussions experience the prolonged recovery times of PCS (Makdissi et al., 2013; McCrory et al., 2013).

The path to recovery for an individual with PCS is unique for each person. The work presented here consists of a descriptive case study detailing the recovery process of collegiate athletes who experienced PCS over a period of months and needed to reintegrate into their academic and athletic environments. A case-study methodology was employed to probe and document their experiences and reintegration processes.

PCS can have a detrimental effect on return to normal activities and can interfere with performance in school, the workplace, and social settings. Although it may seem obvious that cognitive symptoms of concussion can have an impact on performance in the classroom (Bernstein, 2002; Crowe et al., 2016; Ransom et al., 2015; Swanson, 2016), physical and behavioral symptoms also can affect learning. For example, headaches are the most common complaint of post-concussive syndrome, and chronic headaches can affect the student's performance in the classroom (Blume, 2015; Hiploylee et al., 2017; Lucas, 2015; Ransom et al., 2015; Swanson, 2016). Concentrating on school work can trigger headaches, and headaches can lead to difficulty with attention or remembering information (Blume, 2015; Lucas, 2015) which makes it challenging for the student to reintegrate into the classroom. Depression is the most common behavioral symptom associated with concussion (Chrisman & Richardson, 2014; Goldstein et al., 2001; Hiploylee et al., 2017; Mainwaring et al., 2004), and depression alone, and in combination with other symptoms, can affect academics.

In recent years, emphasis has been placed on the formal process of returning to school for a student athlete who has sustained a concussion, termed "return-to-learn," or "RTL" (Halstead, 2013). In the United States, many states have implemented legislation requiring primary and secondary schools to have formalized return-to-learn policies for student athletes (The Network for Public Health Law, 2016). Return-to-learn policies typically call for formation of a team consisting of teachers, school nurses, psychologists, social workers, speech-language pathologists, and other professionals, along with the student's physician. This team is then responsible for overseeing the gradual return of the student to all academic activities, using a variety of accommodations as needed, to minimize the recurrence of PCS symptoms (Halstead et al., 2013; Ellis, Leddy, & Willer, 2016). Typical accommodations that are used to manage cognitive demands include adjustments to attendance, time deadlines, curriculum, time spent on activities (i.e. screen time and physical activity), and environment (Baker et al., 2014; DeMatteo, McCauley et al., 2015; DeMatteo, Stazyk et al., 2015; Halstead et al., 2013; Master, Gioia, Leddy, & Grady, 2012; McGrath, 2010; Sady, Vaughan, & Gioia, 2011).

The best practice guidelines for return-to learn policies is to provide an individualized plan for the student that balances between cognitive and physical rest and activity (Arobast et al., 2013; Baker et al., 2014; Blackwell, Robinson, Proctor, & Taylor, 2017; DeMatteo et al., 2014; DeMatteo et al., 2015; Halstead et al., 2013; Master, Gioia, Leddy, & Grady, 2012; McGrath, 2010; Sady, Vaughan, & Gioia, 2011). An extended period of complete cognitive and physical rest is not desirable because the student is not making progress towards returning to regular activities. Conversely, if the student increases cognitive activities too abruptly, he or she might experience a worsening of symptoms and prolonged recovery time.

Return-to-learn legislation has mainly been targeted toward students at the primary and secondary school levels but return-to-learn for collegiate student athletes is equally important. The National Collegiate Athletic Association (NCAA) provides best-practice guidelines for return-to-learn (NCAA, 2017). Proper return-to-learn practices at the collegiate level are vital, as these students are often living away from parents for the first time, and they may not have proper support systems in place to independently manage their condition. Additionally, at the collegiate level, the cost of concussion-induced academic deficits is high, both financially and for future success. The NCAA (2017) recommends that return-to-learn protocols be handled by a multi-disciplinary team that includes physicians, athletic trainers, speech-language pathologists, academic personnel, (e.g., professors, deans, academic advisors), and office of disability services representatives.

Although legislation and guidelines for return-to-learn exist, the implementation of this legislation and guidelines has not been well studied. Despite the passage of legislation, students may not receive return-to-learn services following a concussion (Kasamatsu, Cleary, Bennett, Howard, & McLeod, 2016; Lyons et al., 2017). Researchers have found that, even with legislatively mandated requirements for concussion education and return-to-play and return-to-learn protocols, there are many challenges in implementation (Carroll-Alfano, 2017; Rivara et al, 2014). Even when protocols are implemented, student athletes have been shown to minimize or disregard the seriousness of concussion, and thus may not report symptoms in order for a return-to-learn protocol to be properly executed (Chrisman, Quitiquit, & Rivara, 2013; Kroshus, 2015; Register-Mihalik. 2013; Rivara et al, 2014)

Case study research can provide insight into the athlete's experiences, as well as beliefs and attitudes related to concussion that would not have been captured in a quantitative study. To further understand the problems faced by student athletes, it is useful to chronicle the specific experiences of student athletes who sustained a concussion, and detail the recovery process, including the return-to-learn process via a case study research methodology (Yin 2014). Individuals who have sustained concussions have a variety of experiences in relation to the nature of the symptoms, length of symptoms, and recovery process, and case study research is ideally suited to identify and characterize the individual experiences, recovery trajectories, and return-to-learn process of athletes post-concussion. Only limited research exists employing case studies to look at specific experiences of persons who have sustained concussion and PCS. A case study of post-concussive syndrome in a high school athlete showed that symptoms can last for up to two years, and that even mild deficits can have a significant effect on a student's life (Sasek & Rippee, 2015). In a case study of a collegiate basketball player, the player reported that she concealed her symptoms from the athletic trainer and coaches, returned to play with symptoms, and ignored the risks of continuing to play, ultimately receiving medical evaluation only after the season ended (Strand, 2013).

The work presented here investigates the experiences of collegiate athletes who experienced PCS following concussions received during a sports activity that caused a disruption of their academic studies. The purpose of this study was to gain an in-depth understanding of the experiences of collegiate athletes who sustained concussion with subsequent post-concussion syndrome, including the recovery process, how learning, sports, and daily activities were affected, and their perspective on the how the concussion and PCS affected their learning and return to play.

Methods

Participants

Participants included two women collegiate athletes, both aged 22, who experienced a concussion during a sports activity in college within the last 30 months, which led to symptoms lasting longer than one month. These two student athletes were identified from a larger population of 33 athletes who participated in a study of the effects of concussion on cognition because they reported experiencing PCS and fit the inclusion criteria for this study (collegiate athlete with concussion in past 30 months who experienced PCS). These two participants were informed of this study and invited to participate in this research study. Human Subjects Institutional Review Board approval from two universities was obtained for the study.

Data Collection and Analysis

The first author conducted both interviews for this study which included two parts. The first part consisted of collection of information about demographics, academics, sports participation, and concussion history. Specific questions were asked to obtain details such as date of birth, academic year, major/minor, GPA, sport played, general medical history, number of concussions, and dates of concussions. Additionally, the Rivermead Post Concussion Symptoms Questionnaire was completed, to obtain details about the symptoms experienced during their concussions (King et al., 1995).

The second part of the data collection process consisted of semi-structured interviews. The interview included open-ended and follow-up questions as deemed appropriate based on previous studies in the literature (Abrahamson, Jenson, Springett, & Sakel, 2016; Bush et al., 2016; Nardone et al., 2015; Todis & Glang, 2008). The questions were asked to allow the participants to tell the story of their concussion experiences to gain an in-depth understanding, including the recovery process, how learning, sports, and daily activities were affected, and their perspective on the how the concussion and PCS affected their learning and return to play. Follow-up questions were used to obtain more details about a topic as needed. These open-ended questions were used as an interview guide; however, the interviewer allowed each participant to continue her narrative and deviate from the structure as appropriate. Internal validity was maintained by having the same interviewer complete both the interviews and both participants were asked the same questions initially, according to the interview guide.

Data collection took place at the university clinic where the first author was a clinical faculty member. Interviews took place in a single interview period of about one hour. Participants were given a gift card to thank them for their time. Participant interviews were audio recorded and coded without names to ensure confidentiality.

The data were analyzed as a multiple case study using a case description framework (Yin, 2014). Data analysis began with transcription of the interviews. Thematic content analysis was conducted to identify patterns in each participant's personal narrative. Following the individual analysis, cross-case analysis was conducted to look for common themes between the two participants. These themes were derived via an inductive approach using information obtained from the individual case study narratives as concussion recovery can be different for everyone.

Case Studies

Student A

Student A was a woman student who participated in NCAA Division II intercollegiate basketball. As a sophomore, she sustained a concussion following a collision with another player during a basketball game. This was the third concussion she had received playing basketball in a span of five years, with her previous two concussions occurring in high school. Student A reported that she did not lose consciousness during the third event, but experienced immediate symptoms of feeling dizzy, confused, and having a severe headache. She was treated by an athletic trainer and removed from the game. She did not immediately seek treatment from a physician or go to an emergency room.

Student A stated that with each subsequent concussion that she sustained, the symptoms seemed to persist longer, lasting for about week in her first concussion, two to three weeks with her second concussion, and eight weeks for the most recent concussion. She described post-concussion syndrome with symptoms of headaches and extreme sensitivity to light and sound persisting for approximately eight weeks.

The athletic department and the disabilities services office initiated a return-to-learn process to manage her concussion, and the faculty teaching her classes were notified. She missed one week of classes, and the following week was spring break. Thus, she returned to her classes two weeks after receiving the concussion, but then she had to make up the work and examinations that she had missed. She stated that her teachers were accommodating and allowed her to make up the work at her own pace; however, she found the experience to be overwhelming and highly stressful, owing to the need to make up previous work while simultaneously keeping up with her current work.

Several weeks after the concussion, Student A saw a physician who specialized in concussion management because her symptoms persisted. She was given information about concussion and how to manage symptoms, such as taking breaks while studying if she developed a headache. She was also given migraine medication and told to take Tylenol as needed to help her headaches. Student A reported that she self-managed her symptoms based on the information she was provided.

Student A missed a total of eight weeks of the basketball season. She said that she experienced pressure from coaches to return to sporting activities. She tried to attend basketball practices to watch and listen, however; this would cause headaches due to her sensitivity to sound. She began to wear noise-cancelling headphones during the practices to reduce the sounds. She stated that her coaches asked her to dress for games, work the scoreboard at the scorer's table, and failed to understand that she was not capable of doing these things. She stated, "My coaches were antsy for me to return to basketball."

"Socially I felt very isolated for a while. I stayed in my room and missed basketball practices. My friends would hang out and watch TV and movies and I couldn't do those things due to headaches and sensitivity to sounds and light." She reported that she spent a great deal of time alone in her room. She stayed off electronic devices as well, which led to more isolation.

Student A reported that the post-concussion symptoms that she experienced had an adverse effect upon her academic studies. The sensitivity to sound and light, as well as headaches, made it difficult for her to focus and concentrate, and she found it difficult to read a book or work on a computer. She did not experience any cognitive symptoms during her PCS, such as memory loss. She reported that she had experienced depression and anxiety prior to the concussion, and these continued after the concussion; however, they did not get any worse.

During this eight-week period, she reported feeling frustrated, and wanted her life to return as it was before the concussion. Student A stated about her recovery, "It was frustrating, but it is important to give yourself enough time to recover from a concussion. It is really hard nowadays to avoid electronics because they are everywhere, but you have to give yourself rest and take breaks."

Student B

Student B was a woman college student who participated in NAIA intercollegiate soccer. As a freshman, she sustained a concussion during a soccer game when she fell to the ground and was accidentally struck in the back of the head by the knee of an opposing player. This was the fourth concussion that she had experienced since entering high school. She said that she did not lose consciousness and, after a few minutes of rest, attempted to continue playing, but she felt that she was unable to continue and voluntarily removed herself from the game. She was treated by an assistant coach, who was a nurse, and an athletic trainer. Immediate symptoms included headache, nausea, and dizziness.

Student B had follow up care with the athletic trainers daily but never saw a physician. Within several days, the nausea and dizziness went away; however, she experienced post-concussion symptoms that included headache, difficulty concentrating, word retrieval difficulty, and sleep disruption. Her sleep disruption consisted of having difficulty falling asleep, but once she had fallen asleep, she would sleep for a very long time and had trouble waking up. Additionally, she experienced greater impulsivity, especially with regards to talking and shopping. She reported feeling less happy but said that she did not experience depression. Student B reported experiencing social difficulties from the concussion. She continued to spend time with her teammates after the concussion, but she said that she felt like she had a difficult time connecting with people socially.

Student B reported that her symptoms persisted for approximately six months, after which time they largely subsided, but she continued to experience academic difficulties. She felt that she was not the same student that she was prior to the concussion, even two years post. In high school, she was an “A” student and did not have to work hard to get good grades. In college, she was a pre-medical/biology major and received good grades, however; after the concussion, school work became increasingly difficult for her. Before her last concussion, she reported being good at memorizing information and retrieving it on demand. After the concussion, she had to change how she studied, and must work much harder to learn and retain the information. Courses with abstract concepts are more difficult for her than more practical concrete areas such as anatomy or laboratory activities. Additionally, she had experienced occasional word-retrieval difficulties. She has had more difficulty with cognitive tasks such as word puzzles. She stated that “I can see it in my head but can’t explain it”.

Student B reported that her grades have dropped. Before her last concussion, she was getting A’s in all her classes. She’s now gets primarily B’s and C’s, and even got a D in a class the semester she had the concussion. She stated that she must work much harder to achieve grades that are not as good as those she received before the concussion.

Following her concussion, Student B was referred by the athletic department to the disability services office at her university for assistance. The office stated that they were unable to help her without a letter from a physician. She had visited a physician during some of her prior concussions, but she did not see a physician after the last concussion. She did not pursue accommodations through the disability services office, but instead performed her own research on strategies that could be used to manage her academic difficulties. She contacted her professors and told them about her concussion. She met with them during their office hours, explained the academic difficulties she was experiencing, and set up time outside of class to meet with her professors and get extra assistance. She reported that one professor was very helpful to her. She set up a schedule for herself and would study for an hour, and then take a 20-minute break. To cope with her diminished ability to memorize and retrieve information, she now writes and re-writes repeatedly any information that she is trying to memorize.

The concussion also had a significant impact on her participation in her sport. Her concussion occurred near the end of the season. She attempted to be with the team during the last few games, but her sensitivity to light and sound made it difficult to be on the sideline. She felt that her coach was understanding. He wanted her to return for the soccer season the next year, so he allowed her to abstain from most of the spring practices, so she could fully heal. During her sophomore season, she lost her starting position on the team. “When I played I was concerned about protecting my head, but I didn’t want fear to get ‘into my head.’ I lost confidence in myself and was nervous about getting hit.” She also experienced a knee injury during this season which limited her playing time. She stated that she had had many different injuries throughout her athletic career, but this last concussion was the one that caused the most fear of re-injury after returning to play. By her junior year season, she felt as if she had returned to normal on the soccer field, and she regained her starting position.

Student B reported that she still feels emotional distress resulting from the aftermath of the concussion. She stated that she loved going to school, but her work and grades do not reflect that. School used to be easy for her, but now it is hard. She stated, “It is disheartening that I used to be good at school, but now I am not. It’s frustrating that there was no one to help me.”

Discussion

PCS Symptoms

Both students in these case studies experienced PCS, where concussion symptoms persisted for months after the concussion event. In both cases, the students reported a change in symptoms between the acute and PCS symptoms. They reported typical acute concussion symptoms (headache, dizziness, confusion, and nausea). After these acute symptoms resolved, Student A reported PCS symptoms of headaches and sensitivity to light and sounds, whereas Student B reported headaches and a constellation of cognitive symptoms (difficulty concentrating, word retrieval difficulty, and memory difficulty). Headache was the one physical symptom that persisted between the acute and PCS symptoms. The changes in symptoms with time post-concussion reported by both students is consistent with patterns that have been reported elsewhere (Lovell, et al. 2006).

Effect of PCS Symptoms on Daily Activities

Both students experienced significant disruptions to their daily activities because of their concussions. Participation in sports-related activities was affected for some period for both. Student A was unable to participate in basketball practices and games, even as a spectator, because of her sensitivity to light and sound. This caused her difficulties due to the pressure she experienced from her coaches to attend practices and games, since her coaches did not understand why this was difficult for her. Student B also was unable to participate in her sport immediately following her concussion; however, due to the timing of her concussion at the end of the season, she did not miss much of that season, and did not experience much pressure from her coaches during the offseason. She did report that she was not at her best the next season.

Academic difficulties were reported by both students following their concussions. Student A's physical symptoms of sensitivity to light and sound, along with the added pressure of catching up on missed school work, made return to academic work difficult. The experiences of Student A illustrate that it is possible to have physical symptoms which lead to academic difficulties. This type of negative impact of physical symptoms on academic performance has been reported elsewhere in the literature (Blume, 2015; Hiploylee et al., 2017; Lucas, 2015; Ransom et al., 2015; Swanson, 2016).

Within several weeks, Student A was able to get caught up on her school work and did not report long-term problems with academic work. Conversely, student B reported serious academic challenges persisting over two years after the concussion event. These impairments may exert a potentially large detrimental impact on her ability to pursue graduate education in the future. The long-term impact of concussion on academic studies, even years post-concussion, is consistent with what has been reported elsewhere (Bernstein, 2002; Crowe et al., 2016; Ransom et al., 2015; Swanson, 2016).

Both students reported social difficulties after the concussion. Student A reported feeling social isolation in the months following the concussion, as she spent a great deal of time alone due to her sensitivity to light and sound. Student B also reported social difficulties, although she was able to spend more time with her teammates after her acute symptoms of sensitivity to sound subsided. This shows how concussion symptoms are interrelated, and physical, cognitive, and behavioral symptoms can have social consequences.

Medical Interventions and Therapy

Both students received minimal medical interventions and neither received any therapy. Several weeks post-concussion, Student A saw a physician who specialized in concussion and he provided education and prescribed migraine medications. Student B was never treated by a physician after her concussion. Each student was followed by her athletic trainer.

Both students, but particularly Student B, would likely have benefited from various types of therapy post-concussion. Student B likely should have received some type of cognitive therapy, to help her adapt and manage her cognitive deficits. As Student B was still reporting cognitive issues at the time the interviews were conducted for this study, she was given a referral for speech-language intervention to aid her with these issues.

Return-to-Play Experiences after Concussion and PCS

Even though Student A appeared to participate in a more comprehensive recovery program than Student B, she experienced greater pressure to return to sports participation. Student A reported pressure to attend practices and games, even when she was experiencing headaches and sensitivity to light and sound and participating made her symptoms worse. She felt that her coaches did not understand the difficulties that attendance at practices and games caused her. Conversely, Student B, who did not have a well-implemented recovery program, did not attend final games of the season due to her sensitivity to sound, but she felt that her coach understood. Thus, even having return-to-play guidelines (NCAA 2017) does not insulate athletes from pressure to return to participation before they are comfortable in doing so. Ultimately, one of the most important factors that lead to premature return to sports is the attitude of the coaches (Chrisman, Quitiquit, & Rivara, 2013; Kroshus, et al.,2015). It is important when designing formalized return-to-play policies that student-athletes be given supports and mechanisms designed to counter this type of pressure from coaches, who are strong authority figures in the lives of student-athletes.

The experiences reported by Student B illustrate how long the return-to-play process can be following concussion. It took Student B nearly two years before she felt that her game was back to normal on the soccer field. While the physical recovery from the concussion needed to occur before Student B could return to athletic activities, Student B also needed to work through the emotional and psychological difficulties that resulted from the concussion, such as fear of re-injury and loss of confidence, before she could return to playing at the level she was capable of pre-concussion.

Return-to-Learn Experiences after Concussion and PCS

Both students reported difficulties returning to academic activities following the concussion. NCAA concussion management guidelines specify that a student-athlete's return-to-learn following concussion should be managed by a multi-disciplinary team that includes physicians, athletic trainers, coaches, psychologists/counselors, neuropsychologists, administrators, professors, and representatives from the office of disabilities (NCAA 2017). The goal of this team is to reintegrate the student into his or her academic studies in a stepwise manner, where an individual gradually resumes academic activities at whatever pace they can sustain.

Student A appeared to participate in a return-to-learn process that seemed to align with the NCAA guidelines (NCAA, 2017). The athletic trainer, university disability services representatives, and the student's professors were all involved in the return-to-learn process, although Student A had a role in managing the process herself. On the contrary, Student B did not report any type of formal return-to-learn process in the immediate aftermath of the concussion. She experienced academic difficulties, and largely had to work through her issues by herself, working with her professors without the benefit of formal accommodations. This is an example of how even though the NCAA guidelines outline the creation of a return-to-learn team for athletes who sustain concussion, effective implementation of these guidelines may not occur. Part of the challenge for collegiate athletes is that because they are over 18, they are considered adults and ultimately, they must advocate for themselves, compared with student athletes in high school and younger, who have state laws and parents who can advocate for their children. Student B did not receive services that she was eligible to receive because she did not pursue them further, due to possible lack of knowledge and guidance.

Both students used accommodations and strategies that have been recommended in the literature as being useful in return-to-learning after concussion, such as taking scheduled breaks when studying, stopping studying when symptoms return, and seeking extra time and assistance from professors with their coursework (Baker et al., 2014; Blackwell et al., 2017; DeMatteo et al., 2015; Halstead et al., 2013; McGrath, 2010). Student A received suggestions from a physician including working at her own pace, stopping studying if she had a headache, and taking medication to help manage her headaches. Student B had much less guidance and assistance in developing accommodations and strategies and was forced to do her own research on how to best adapt and cope with the cognitive problems she experienced post-concussion. As these cognitive difficulties persisted, she made changes in how she studied, and continued to use these strategies in her academic work.

Limitations

This study detailed the experiences of two women collegiate athletes from universities in the Midwest. The results of this study may not generalize to other collegiate athletes who experienced a concussion. Further investigations should include athletes who participate in different divisions of collegiate play, as well as a variety of sports. Experiences of male collegiate athletes should also be studied since the literature has shown differences in recovery between men and women athletes (Frommer et al., 2011; Styrke et al., 2013, Tanveer et al., 2017). This study was retrospective and relied on the athlete's ability to accurately recall the details of their concussion and post-concussion events. A prospective study that follows collegiate athletes during the concussion recovery process can provide additional details and allow for timely referrals.

Conclusions

This multiple case study investigation demonstrates the challenges faced by two collegiate athletes who sustained concussions with subsequent PCS. Student-athletes' journeys to return-to-play and return-to-learn following concussion vary, and can result in a variety of physical, cognitive, and behavioral symptoms that can impact learning, play, and social activities. Guidelines to standardize recovery protocols when a student-athlete sustains a concussion can be helpful, but the needs of everyone must be assessed on a case-by-case basis. Pressure from coaches for premature return to play is an on-going issue, as noted with Student A, and supports must be provided to student-athletes to counter this type of pressure. Coaches may need additional education regarding concussion and the recovery process. Full recovery from concussion and PCS can take years, as noted with Student B, and supports must be available to students potentially years later, long after the concussion event is forgotten by coaches and disability centers.

In these two case studies, despite the attempted utilization of best-practice protocols, there was a breakdown in the return-to-learn and return-to-play process. Student A was pressured by coaches to return to sports activities before she was ready, and Student B failed to receive academic accommodations that might have helped her in her return to academic studies. This breakdown may be a result of poor implementation of the best practice guidelines by the university or may stem from lack of acceptance of these guidelines by key stakeholders, such as coaches, athletic trainers, or student-athletes themselves. Additionally, these guidelines may assume a level of maturity and independence that college students are not ready for due to the complexity of concussion management.

This investigation highlighted the experiences of two women collegiate athletes who sustained concussions with subsequent post-concussion syndrome. They provided a unique perspective into the personal experiences of recovery from concussion. These cases also support the importance of coordination among disciplines to help collegiate athletes who sustain concussions to ensure that they can achieve optimal recovery and return to learning and sports.

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CHAPTER 5

CONCLUSIONS

"I knew I had sustained a concussion, but I kept playing. It was an important game and I didn't want to sit out. I had a bad headache but kept playing through it". Senior football player

"I sustained two concussions within 3 months. My memory is not as good as it used to be after the concussions and I've struggled in school since. I haven't been assessed or gotten any help". Freshman softball player

"The coaches knew I had a concussion and couldn't play, but they wanted me to come to practices, dress for games, and work the clock. They didn't really understand that I couldn't do those things". Junior women's basketball player

All three of these collegiate athletes have something in common. They sustained a concussion during athletic play. They also have something else in common. Their stories highlight deficiencies in concussion education and management for collegiate athletes. The first student did not report his concussion and continued to play, rather than immediately notify team athletic trainers. The second student was not assessed for cognitive symptoms and is not getting the services she needs to help with her recovery. The third student was pressured by the coach and the return-to-play protocol was not correctly followed. Had different education, assessment, or treatment been provided, each may have had different experiences following her concussion. Although much has been written, laws passed, and suggestions made for management of concussion in student athletes, there remains more to learn about concussion education, assessment, and recovery, particularly in the collegiate athlete population.

The research presented in this dissertation was conducted to gain insights into aspects of concussion among student athletes from a variety of perspectives, including education, assessment, and recovery. All three of these perspectives have an important role to play to address the public health issue of concussion in student athletes.

Study 1. Concussion Education for Student Athletes: Who Is Getting It? What Kind? Does It Matter?

The first quote, by the senior football player, highlights a deficiency in concussion education. He knew he had sustained a concussion; however, he chose to continue to play and not seek treatment for his symptoms. Study 1, in Chapter 2, investigated concussion education, including whether athletes received it, who and how it was presented, and whether education improved athletes' knowledge of concussion symptoms.

Results indicated that despite legislative mandates, 20% of student-athletes reported that they did not receive concussion education in high school. Females were more likely to report not receiving education than males. It would be expected that the passage of legislation requiring concussion education would bring the number of athletes who report not receiving concussion education close to zero; however, over the five years since legislation was passed, many athletes still report not receiving education.

This study investigated the different types and providers of concussion education that collegiate athletes reported receiving. The most common method for education reported was casual conversation, followed by formal group training, and watching videos. Two-thirds of participants reported that an athletic trainer provided education. In this study, no type of training or provider was linked to better outcomes, i.e. better ability to name a diversity of concussion signs and symptoms (physical, cognitive, and behavioral).

Finally, most athletes identified that a concussion is a brain injury. Whether this is due to concussion education or more attention to concussion in the popular media is unknown. Athletes continue to have a poor awareness of cognitive and behavioral signs and symptoms of concussion. Athletes who received concussion education were not better at naming a variety of signs and symptoms of concussion than those who received no education.

The results of this study indicated that there continues to be a need to improve concussion education, including delivery and content. This education should be provided to all athletes per legislative mandates. There needs to be continued research to determine the best manner and provider of concussion education to ensure that it is delivered in a manner that can be remembered and reported by all athletes and that awareness of the wide variety of signs and symptoms of concussion, especially cognitive and behavioral symptoms, are known by athletes. Education should also emphasize the potential consequences of concussion symptoms and their impact on future learning and athletic play.

Study 2. Assessment of Concussion in Collegiate Athletes Using Story Retell

The second quote, by a freshman softball player, highlights the need for better assessment following concussion, particularly of linguistic-cognitive difficulties that might exist. Study 2, described in chapter 3, presented an investigation examining the use of story retell as an assessment tool for identifying linguistic-cognitive deficits in student athletes who have sustained concussions. Assessment of concussion can occur at many different times, from baseline testing completed before a concussion occurs, to testing completed following a concussion. With respect to cognition, the challenge of concussion assessment is that following concussion, the person often reports difficulties in functioning that assessment tests may not be sensitive enough to identify. This study aimed to determine if story retell was a sensitive tool for identifying concussion-induced linguistic-cognitive changes in collegiate athletes following concussion because it probes cognitive and macro-linguistic skills such as auditory comprehension, attention, memory, and verbal production, and these are skills that collegiate athletes use in the classroom.

No statistically significant differences were seen on the MoCA, immediate story retell, and delayed story retell mean scores for each of the three groups. Athletes with recent (<30 month) concussions performed worse on the immediate story retell than on the MoCA. Little or no correlation was seen between the MoCA and either the immediate or delayed story retell tests. Finally, no correlation was seen between the self-reported academic difficulties of athletes with concussion with either the immediate or delay story retell tasks.

Immediate story retell appeared to be a more sensitive measure of subtle cognitive and language differences that presented in participants who sustained a recent concussion (<30 months). The macro-linguistic abilities assessed in story retell may not have fully recovered in those with more recent concussion, whereas the micro-linguistic skills found on tasks in the MoCA may have recovered. The lack of correlation between the MoCA and story retell tests suggests that these tests targeted different aspects of cognition and language. The MoCA has a minimal focus on language skills, whereas, story retell tasks are language-based tasks targeting higher-level macro-linguistic skills (Agresti, Corrigan, & Gribble, 1989; Hartley & Jensen, 1990; Nasreddine et al, 2005; Stout, Yorkston, & Pimentel, 2000). The results of this study suggest that story retell has the potential to be a sensitive assessment tool for identifying concussion induced cognitive communication deficits in the early stages post-concussion and further research is warranted.

Study 3. Concussion Treatment and Recovery in Student Athletes Examined via a Case Study Approach

The third quote, by a women's basketball player, highlights the need for better management during recovery from concussion. Study 3, presented in chapter 4, was a descriptive case-study examining the experiences of two student athletes who sustained concussions. In the United States, many states have implemented legislation requiring schools to have formalized return-to-learn policies for student athletes (Halstead, 2013; The Network for Public Health Law, 2016). The National College Athletic Association (2017) has best practice recommendations for collegiate athletes as they return to play and return to academics. Recovery from concussion is individualized with most athletes recovering within 10-14 days; however, some athletes take a month or longer to recover and experience post-concussion syndrome (PCS).

This study chronicled the experiences of two collegiate athletes who experienced PCS following concussions received during play. The purpose was to gain an in-depth understanding of the experiences of collegiate athletes who sustained a concussion with subsequent post-concussion syndrome, including the recovery process, how learning, sports, and daily activities were affected, and their perspective on how PCS affected their learning and return to play.

Both students reported experiencing disruptions to their learning and athletic activities, as well as daily socialization because of their concussions. Student A experienced pressure from her coach to return to play before she felt she was ready. Student B reported that her concussion had a long-lasting impact on her academic studies. Both students reported frustration, social difficulties, and feelings of isolation. Despite an attempt to follow best practices in concussion management, both students experienced breakdowns in the return-to-learn and return-to-play processes. The findings of these case studies suggest that recovery from concussion is a unique journey for everyone. Concussion management guidelines can be helpful; however, guidelines may not always be followed. Continued efforts are needed so that consistent supports are provided for collegiate athletes recovering from concussion.

Summary

Concussion in student athletes is a complex health problem. Successful management of concussion requires a coordinated sequence of steps to occurs over a period of days to months to ensure that student athletes achieve the best possible recovery. When a student athlete first sustains the concussion, everyone involved should recognize the signs and symptoms of a concussion and the student athlete removed from play. Next, the student athlete should then be assessed for a concussion and directed towards appropriate medical treatment. Finally, for the duration of the concussion symptoms, the student athlete should follow the protocol and procedures that have been recommended so that he can recover and return to academics and play.

The research presented in this dissertation examined key steps in this process of concussion management in student athletes, from a variety of perspectives. Prevention of concussion via education is important because it provides athletes with knowledge of concussion signs and symptoms, so they can identify concussions in themselves and seek treatment. This research found that there are still problems with implementation of concussion education, even with legislation, and that the education that is being provided may not be effective. Continued research is needed on concussion policy and the best way to provide education.

Assessment of linguistic-cognitive deficits following concussion is critical, as it aids in identifying potential problems early and treating them immediately, rather than waiting until the student athlete is struggling in their academic studies. This research studied immediate and delayed story retell as an assessment tool to identify potential linguistic-cognitive deficits following concussion. Only the immediate retell task was sensitive and only in the early months (less than 30) following concussion. Still, based on prior research, story retell tasks may have promise as a tool to assess subtle cognitive deficits and this topic warrants further investigation.

Finally, management of the recovery process, including following appropriate return-to-play and return-to-learn policies and best practices is important for collegiate athletes so they can receive the support they need, especially since these young adults are often on their own and required to make health care decisions for themselves for the first time. This research studied the challenges faced by two collegiate athletes who sustained concussions in their journey to recovery. This study found that return-to-play and return-to-learn policies were not implemented effectively, and continued efforts need to be made to ensure that these policies and best practices are available to recovering student athletes.

Concussion is a complicated public health issue, particularly for the collegiate athlete. Research has provided us with better information about what should be done before and after a student athlete sustains a concussion; however, challenges remain when it comes to implementation of education and best practices regarding prevention, assessment, and recovery. Although much more work remains to be done, this research provided additional information to our knowledge about concussion education, assessment, and recovery for collegiate athletes.

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APPENDICES

Appendix A

Data Collection Instrument

1. Academic Year: Freshman Sophomore Junior Senior

2. Sex: Male Female

3. Intercollegiate Sport(s): ____

4. High school graduation year: ______________

5. In what state(s) did you attend high school? _________________________

6. Have you attended training or received information regarding concussions?

Yes No

If you answered "yes" to question 6, please answer the following questions about your previous training:

a. Where did you receive the training? (circle all that apply)

Middle School/Jr. High High School College Other___________

b. What kind of training did you receive? (circle all that apply)

1. Attended formal group training (20 minutes or more)
2. Casual coach/trainer conversation
3. Watched video and/or slide presentation on own
4. Given hand-outs without presentation
5. Signed a form without a presentation
6. Other training (please specify)____

c. Who provided the training? (circle all that apply)

1. Coach 2. Athletic Trainer 3. Athletic Director

4. Doctor 5. Nurse 6. Other _____

7. Please name some symptoms of Concussion: ____

____

____

8. Have you ever had a concussion? Yes No

9. If you had a concussion, did you seek medical treatment? Yes No

10. Is a concussion a brain injury? Yes No

Appendix B

Athlete Interview

1. Demographic information

Gender: Male Female

City/State of Residence: ____________________________________

City/State of High School: ____________________________________

Date of birth:

Year of High School graduation: _______________

Collegiate Sport: __________________________________

How many years playing sport/s: __________________________________

Other sports played: ____

How many years played sport/s: _____________________________________

Did you receive concussion education in high school? Yes No

Did you receive concussion education at any other time? _________________________

2. Academic information

Academic Year: Freshman Sophomore Junior Senior

Year you entered college: _________________

Major/Minor: ____________________________________

GPA: _____________________

Course load each semester: ____

Current course load: ____

Have you had any academic difficulties? _______________________________________

Have you received any special services in school? ________________________________

3. Medical History

Do you currently have any medical conditions that are being treated by a physician?

____

Do you currently take any medications? ____

Do you have a history of depression/anxiety, etc.? ____________________________________

4. Concussion history (If sustained a concussion)

Have you ever had a concussion? _________________________

How many concussions have you had? _________________

Date or how many years ago: ___________________________

How did it occur? _______________________________________

Did you lose consciousness? _______________________________________

What were your immediate symptoms? ____

Who assessed you? ____

Were you assessed in the emergency room? ____

What other symptoms did you have following the concussion?

____

How long did the symptoms last?____

Did you receive treatment for your concussion? ____

Did you receive treatment from any of the following? AT PT OT ST Psych

Details of treatment: ____

Rivermead Post-Concussion Symptoms Questionnaire (Attached separately)

(Time of concussion/current)

5. Impact of concussion on academic performance (If sustained a concussion)

How did the concussion affect your academic work? (Grades?)

____

Did symptoms affect your ability to attend class, study, take exams, complete homework?

____

Did you receive any accommodations in school? How long?

____

On a scale from 1 to 7, with 1 being no impact and 7 being major impact, how would you rate the impact of the concussion on your academic performance (<30 days following)

1 2 3 4 5 6 7

Repeat questions for section 4 and 5 for each concussion

Appendix C

Non-Athlete Interview

1. Demographic Information

Gender: Male Female

City/State of Residence: ______________________________________

City/State of High School: ______________________________________

Date of birth:

Year of High School graduation: ________________

Do you/did you play sport/s: ____________________________________

How many years did you play sport/s: ____________________________________

Did you receive concussion education in high school? Yes No

Did you receive concussion education at any other time? __________________________

2. Academic information

Academic Year: Freshman Sophomore Junior Senior

Year you entered college: ______________

Major/Minor: ______________________________________

GPA: ______________________

Course load each semester: ____

Current course load: ____

3. Medical History

Do you currently have any medical conditions that are being treated by a physician?

____

Do you currently take any medications? ____

Do you have a history of a learning disability? ____________________________________

Do you have a history of depression/anxiety, etc.? __________________________________

Have you ever had a concussion? ______________________

When did you have a concussion? _____________________

How did the concussion occur? ______________________

Appendix D

HSIRB Approval Letter

WESTERN MICHIGAN UNIVERSITY

Human Subjects Institutional Review Board

Date: November 1, 2017

To: Linda Shuster, Principal Investigator
Miriam Carroll-Alfano, Student Investigator for dissertation

From: Amy Naugle, Ph.D., Chair

Re: HSIRB Project Number 17-09-50

This letter will serve as confirmation that your research project titled "Supports for Collegiate Athletes Who Sustain Concussion: Education, Assessment, and Recovery" has been **approved** under the **expedited** category of review by the Human Subjects Institutional Review Board. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the application.

Please note: This research may **only** be conducted exactly in the form it was approved. You must seek specific board approval for any changes in this project (e.g., ***you must request a post approval change to enroll subjects beyond the number stated in your application under "Number of subjects you want to complete the study***)." Failure to obtain approval for changes will result in a protocol deviation. In addition, if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the HSIRB for consultation.

Reapproval of the project is required if it extends beyond the termination date stated below.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: **October 31, 2018**

1903 W. Michigan Ave., Kalamazoo, MI 49008-5456
PHONE: (269) 387-8293 FAX: (269) 387-8276
CAMPUS SITE: 251 W. Walwood Hall