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Concussions in female collegiate diving: an exploratory study

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CONCUSSIONS IN FEMALE COLLEGIATE DIVING: AN EXPLORATORY STUDY

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Abstract

An abundant amount of research is being put into sports-related concussions. A vast majority of the research is being done on high-contact sports such as football, ice hockey, rugby, basketball, and soccer. The purpose of this study was to examine the prevalence of concussions in women's collegiate diving and examine the diver's readiness to return to competitive sport. Twenty-four Division I divers from different Midwestern universities completed a survey that included prevalence questions, a checklist of symptoms that they experienced, and several questions regarding confidence to return to play. The data showed that 54.2% of the participants have had a diving-related concussion. The three most common symptoms reported were headache, dizziness, and difficulty concentrating, all occurring in 91.7% of the concussions. On average it took 23.09 day for the divers to return to practice. Most divers reported being unconfident about performing the dive that resulted in their concussion again. This study revealed that collegiate female springboard and platform divers are in danger of sustaining concussions. It is important for divers, coaches, and athletic trainers for diving teams to be aware of this risk.

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CHAPTER 1

Introduction

Statement of Problem

Sports-related concussions are receiving increasing public and media attention. There has been extensive research on concussions in the last two decades, increasing knowledge of the topic rapidly. However, there is a gap in the research on concussions in sports that are not thought of as traditional contact sports. A vast majority of researchers focus on the prevalence of concussions in high-contact sports such as football, ice hockey, rugby, basketball, and soccer (Giza et al., 2013; Majerske et al., 2008; Meier et al., 2014; Moser, 2007). Competitive springboard and platform diving is not typically thought of as a contact sport. The average diver performs 50-60 dives during a two to three hour practice and each dive places a certain amount of force on the diver's body. When done incorrectly, that force could potentially result in a concussion. Because of the number of impacts at high velocities that a diver sustains each day, the chance of concussion may be quite large. The purpose of this study was to examine the prevalence of concussions in women's collegiate diving and examine the diver's readiness to return to competitive sport.

Research Questions

1. What is the prevalence of diving-related concussions, diagnosed and undiagnosed, in collegiate women's diving?
2. What is the length of time from most recent concussion to returning to play for the divers?
3. In regards to readiness to return to the sport, how confident are divers to participate in diving following a concussion?

Significance

Millions of sports-related concussions occur each year. A majority of the research on sports-related concussions is focused on contact sports. Although diving is not traditionally thought of as a contact sport, the impact with the water upon entry is enough to cause a concussion. Due to the large number of impacts performed during a practice it is possible that there is a high prevalence of concussions in diving. Additionally the symptoms may be different due to the significant amount of rotation and twisting involved in the sport. Divers who sustain concussions deserve the most accurate diagnoses and treatments available. Athletes, coaches, and athletic trainers should understand the risk for divers, and be prepared to help them. Because of the nature of the sport, a diver may experience increased fear related to returning to the sport after a concussion. A diver may be especially wary when re-attempting the dive that resulted in the concussion. This would be important information for coaches to be aware of when a concussed athlete is recovering so that they can gradually increase the diver's confidence to execute the dive.

CHAPTER II

Review of Related Literature

A concussion is defined as a complex pathophysiological process affecting the brain, induced by biomechanical forces (Mccrory et al., 2013). It can be caused by a direct blow to the head, neck, face, or anywhere else on the body that transmits an impulsive force to the head. A concussion usually results in symptoms of neurological impairment that quickly appear and last several days. In some cases symptoms gradually develop over several minutes to hours. Most of the time the symptoms resolve spontaneously. It is agreed that concussions are a functional disturbance of the processes that occur in the brain rather than a structural issue (Brown, Elsass, Miller, Reed, & Reneker, 2015; Giza et al., 2013; Makdissi, Davis, & McCrory, 2014). The injury may result in neuropathological changes, however no abnormalities are seen on structural neuroimaging tests.

Concussion and mild traumatic brain injury (mTBI) are terms that are often used interchangeably. However, concussion is a subset of mTBI, which includes other forms of brain injury as well (Mccrory et al., 2013). There are a wide variety of accepted clinical symptoms that characterize a concussion. Included are somatic, cognitive, and emotional symptoms, physical signs, behavioral changes, cognitive impairment, and sleep disturbances (Williams, Puetz, Giza, & Broglio, 2015). If any of these domains are present, a concussion should be suspected and the individual should be evaluated further. Wasserman et al. (2015) stated that headache is the most common reported symptom and occurs in 93% of concussions, followed by dizziness (68.9%) and difficulty concentrating (58.3%). Even when typical concussion symptoms are not present, any report of an athlete who do not seem right or is not themselves after a traumatic event should be suspected of

having a concussion (Makdissi et al., 2014). It is crucial that athletes, coaches, and health care professionals understand the diverse presentations of a concussion and what signs and symptoms to look for after an impact in order to properly diagnose and treat concussions.

Prevalence of Sports-Related Concussions

On average, a college-level contact athlete sustains 470 impacts of various severities per season (Porcher & Solecki, 2013). Not every impact will result in a concussion but the higher number and greater intensity of impacts suggests a higher probability. According to Giza et al. (2013), it is estimated that there are between 1.6 million to 3.8 million sports-related concussions per year in the United States. This number varies because not all concussions are diagnosed. Giza et al. (2013) researched and reported the frequency of concussion incidences in collegiate competitions among commonly played sports. The authors found that males playing American football had the highest prevalence with 3.02 concussions per 1,000 games. Risk increased depending on the position played. Running backs and tight ends are the most likely to get a concussion (Nathanson et al., 2016).

The study also found that the rates for men's ice hockey, soccer, basketball, and baseball were calculated to be 1.96, 1.38, 0.45, and 0.23 concussions per 1,000 games, respectively (Giza et al., 2013). Body checking in ice hockey is very likely to increase the risk of concussion. In Giza's study, women's soccer was found to have the highest rate of concussions among female sports with 1.80 concussion per 1,000 games. Women's basketball and softball were also calculated and are 0.85 and 0.37 concussions per 1,000 games, respectively. The authors found that compared to men playing the same sports, the concussion risk is greater in women playing basketball and soccer. Brown et al. (2015)

found that females are 43% more likely to report symptoms of concussion than men. This suggests that there may be less unreported concussion cases in females compared to males, which could explain why the probability is higher for women in the same sports as men. However, the authors found that the relation between gender and concussion rates depends on the sport (Giza et al., 2013). Gender may be a risk factor for injury or severity of injury but it is probably a more complicated issue (Brown et al., 2015).

Diagnosis and Assessment of Concussions

The sports-related concussion definition and protocol was discussed extensively at the 4th International Conference on Concussion in Sport held in Zurich in November 2012. Three other conferences were held prior, each one building on the other with new research that was published. The members of the conference put together a consensus statement on the current standard of prevention, assessment, diagnosis, and treatment of sports-related concussions. They provided this document and several diagnostic tools as a way to unify the management of concussions in athletics (Mccrory et al., 2013).

Diagnosing a concussion can be difficult. The consensus statement established three main challenges to diagnosing a concussion. First, there are a wide variety of signs and symptoms related to the injury (Mccrorry et al., 2013). No two concussions act the same and symptoms can change rapidly and evolve over time. Second, many of these symptoms are not specific to concussions (Mainwaring et al., 2004). Headaches, irritability, insomnia, and other symptoms can be attributed to a number of other conditions an athlete may have. Because of this it may be difficult to rule out other illnesses when dealing with a potential concussion. Third, there is no test or marker that is 100% reliable for a diagnosis ("Sport Concussion," 2013). Some athletes will score well on all diagnostic tests yet still

have symptoms of a concussion. The complexity of the injury causes diagnosis to be perplexing (Makdissi et al., 2014). Because of these challenges, the diagnosis of a concussion is a clinical judgment. No tool can be used without consulting a trained clinician ("Sport Concussion," 2013). Because diagnosis is so challenging, many concussions go unreported or undiagnosed. The consensus statement was created as a standard for the diagnosis and treatment of concussions to aid health care providers.

Assessment tools commonly used when an athlete is suspected of having a concussion are the post concussion symptom scale (PCSS), a graded symptom checklist (GSC), the standardized assessment of concussion (SAC), neuropsychological testing, the balance error scoring system (BESS), the sensory organization test (SOT), and the sports concussion assessment tool 3 (SCAT 3). Giza et al. (2013) recommends that a combination of these tools be used when assessing a sports-related concussion. There in insufficient evidence, however, about what combination is ideal (Giza et al., 2013).

The SCAT 3 is a standardized instrument used in assessing a sports-related concussion used by the Fédération Internationale de Football Association (FIFA), the International Olympic Commission (IOC), the International Rugby Board (IRB), and the International Ice Hockey Federation (IIHF) as the primary assessment tool of concussions ("Sport Concussion," 2013). It can be used on anyone over the age of 13 (Mccrory et al., 2013). The committee that met during the 4th International Conference on Concussion edited previous versions of the document. Only medical professionals should administer the SCAT 3. Preseason baseline testing can be useful for comparison to post-concussion results. A baseline is also advantageous when determining one's progress towards

recovery. It is important to note that even if the SCAT 3 test results are "normal," the athlete may still have a concussion ("Sport Concussion," 2013).

The National Collegiate Athletic Association (NCAA) adopted its concussion policy and legislature in 2010 (Baugh, Kroshus, & Daneshvar, et al., 2014). The policy requires every school to have a concussion management plan that includes four parts. Each school must educate student-athletes annually about the signs and symptoms of a concussion. It must also include a process for removing athletes from play to be examined by a medical professional if they show any of the signs and symptoms of a concussion. Third the school must ensure that an athlete diagnosed with a concussion cannot return to play on that calendar day. The last part of the policy states that an athlete must be cleared to play by a physician or certified athletic trainer. Although this plan has been in place for four years, the concussion policy is being inconsistently implemented at member institutions (Baugh, Kroshus, Bourlas, & Perry, 2014). A study by Kerr et al. (2015) established that only 43.7 percent of universities conformed completely to NCAA recommendations for preparticipation assessments.

Recovery

Approximately 70 percent of athletes will recover from a concussion in under 10 days (Resch, Macciocchi, Cullum, Blueitt, & Ferrara, 2015). A recent study reported that the proportion of sports related concussions that required greater than one week of recovery increased from 42.7% in 2009 to 70.2% in 2014 (Wasserman et al., 2015). This may suggest that the severity of concussions is increasing, but more likely it is the result of improved symptom monitoring and ensuring that safety regulations are closely followed. Still, in 6.2% of concussions the symptom resolution time is greater than four weeks

(Wasserman et al., 2015). The current standard for treatment includes a period of physical and cognitive rest to facilitate recovery, a monitoring of post-concussion symptoms and signs to assess recovery, neuropsychological tests to estimate recovery of cognitive function, and a graduated return to activity with monitoring for recurrence of symptoms (Mccrory et al., 2013).

Resting post-concussion is important because physical activity, physiological stress, and cognitive loads can worsen symptoms and interrupt recovery (Makdissi et al., 2014; Moser, Glatts, Schatz, 2012). The SCAT3 can be used to evaluate symptoms following a concussion and provides a basic assessment of recovery ("Sport Concussion," 2013). According to Williams et al. (2015), the average college athlete will report being symptom-free six days after a concussion. The resolution of symptoms may not always correlate with the results of the neuropsychological testing. Using neuropsychological testing allows the detection of cognitive deficits, which tend to outlast reported symptoms (Doolan, Day, Maerlender, Goforth, & Brolinson, 2012). Once symptoms resolve and cognitive function returns to baseline, an athlete should gradually return to play (Makdissi et al., 2014). Each step of this gradual progression takes 24 hours. An athlete must remain asymptomatic in each step or else they revert back to step one. The return to play protocol decided by McCrory et al. (2013) is as follows.

Day 1. No activity, complete physical and cognitive rest until asymptomatic.

Day 2. Light aerobic exercise to increase heart rate.

Day 3. Sport-specific exercise, drills to add movement.

Day 4. Non-contact training drills, may add resistance training, adds coordination and cognitive load.

Day 5. Full contact practice, restore confidence and assess functional skills.

Day 6. Return to play.

According to Doolan et al. (2012), there have been more than 25 different approaches to grading concussions and making return to play decisions since 2001. Similar to diagnosis, there is no gold standard method of concussion management. Every concussion is unique, so the return to play decision must be individualized to each athlete and a variety of physiological factors and diagnostic modalities need to be taken into consideration (Elbin, Schatz, Laowder, & Kontos, 2014; Lear & Hoang, 2012). In a unanimous decision, the 4th International Conference on Concussion decided that no athlete with a suspected concussion is permitted to return to play on the same day of injury (Mccrory et al., 2013). Unfortunately, a small percent of athletes are resuming activity on the day of their concussion. Wasserman et al. (2016) reported that 5.5% of sports related concussions resulted in athletes returning to play in less than twenty-four hours after a concussion. Returning on the same day increases the chances of second impact syndrome (Cantu & Register-Mihalik, 2011). This occurs when an athlete sustains a second impact shortly after the initial impact (typically a concussion) when the brain is still vulnerable. Second impact syndrome is extremely dangerous with rates of 50% mortality and 100% morbidity (Doolan et al., 2012). Due to the brain's vital role in preserving a good quality of life, a more conservative approach to management is recommended (Gardner, 2013).

Because of the dangers of returning to play too soon after a concussion, there are a number of considerations that physicians and athletic trainers must pay attention to before clearing an athlete. Four factors will be considered here. It is important to be aware of an athlete's concussion history. Cantu and Register-Mihalik (2011) suggested that the

severity and the recovery period of past concussions must be examined. A lengthened recovery may be due to the brain being more susceptible to the stresses put on it from sport, meaning it requires more time to recover. Experts understand that repetitive concussions have been associated with serious neurocognitive deficits, however no number has been established as need for retirement (Doolan et al., 2012). Second, a person's age is another factor to consider. It is recommended to use a more conservative approach with younger athletes because their brains are not fully developed and to prevent future injuries. (Doolan et al., 2012).

A third factor to consider before clearing an athlete is post-concussion syndrome. Post-concussion syndrome is defined as the presence of signs and symptoms directly related to a head injury that lasts longer than 3 months (Dean, O'Neill, & Sterr, 2011). Prolonged symptom presentation can complicate the return to play decision. Dean et al. (2011) recommended that further testing be done to rule out any other potential causes. Severe cases of post-concussion syndrome may be reason for retirement from sport (Gardner, 2013). Fourth, neuropsychiatric tests may also be necessary to identify coexisting conditions such as depression. Doolan et al. (2012) found that there is a positive correlation between concussion and depression, which may persist longer than physical symptoms. The athlete should not be cleared to play until all symptoms, including psychological, have resolved and all testing has reached their baseline. The four factors listed previously are signs that a prolonged recovery may be necessary. Although there are special cases where an extended recovery is needed, in most concussion cases the symptoms will resolve in several days. The primary consideration for health professionals in these individuals is that athletes should not return to play if they are still symptomatic.

Eighty percent of concussed college athletes will fail to report one or more concussion-related symptoms (Williams et al., 2015). If athletes report concussion symptoms, they may risk being removed from play. Some athletes would rather push through the symptoms than have to sit out of practice and potentially competitions (Bailey, Echemendia, Arnett, 2006; Mainwaring et al., 2004). This helps explain William's data. The stigma associated with certain symptoms, especially psychiatric symptoms, may also prevent athletes from reporting the severity of symptoms fully (Meier et al., 2014). Because of this false self-reporting, 40% of athletes have ongoing cognitive impairment after they report being asymptomatic (Williams et al., 2015). This results in premature return to play decisions by clinicians. Similarly Meier et al. (2014) found that up to 60% of cleared athletes had at least mild symptoms nine days post-concussion. Even though these athletes have been cleared to participate, they are still experiencing symptoms.

Kroshus et al., (2015) researched whether or not physicians and athletic trainers feel pressured by athletes and coaches to prematurely clear an athlete to play after sustaining a concussion. They found that more then half of the clinicians had experienced pressure from coaches or an athlete to return an individual to play sooner than the clinicians felt was appropriate (Kroshus et al., 2015). Although the frequency and intensity of this pressure is unknown, it is a concerning finding due to the dangers of returning to activity prematurely.

Retiring from sport due to any injury is a complicated decision. The long-term effects of repeated concussions are still being researched which makes the question of how many concussions is too many a very difficult one to make. The National Football League currently consults with an independent physician who specializes in sports related

concussions with athletes considering retiring (Doolan et al., 2012). The authors created suggestions to help sports physicians with this difficult decision. Doolan and colleagues advised that any prolonged post concussion symptoms, three or more concussions in a single season, decreased academic or athletic performance, or clinically relevant imaging abnormalities are signs that an athlete should take the rest of the season off of their sport. They recommend that an athlete retire if pathologic abnormalities, intracranial hemorrhage, clinically relevant imaging abnormalities, diminished cognitive abilities, persistent prolonged post-concussion syndrome, decreased threshold for concussion, or Chronic Traumatic Encephalopathy are present (Doolan et al., 2012).

Psychological Readiness to Return

It is very important for coaches, athletic trainers, and sports physicians to understand the psychological recovery process in order to ensure that athletes are not only physically ready but also psychologically ready to deal with the mental and emotional aspects of sport. There is a lack of research on readiness to return from a concussive injury. Because of this, the rest of this section will address returning from an injury in general, not specifically concussion. Psychological readiness has a range of implications for athletes' return to play. Between 5% and 19% of injured athletes report psychological distress levels similar to individuals who are receiving treatment for mental health problems (Glazer, 2009). This number depends on the injury sustained and the length of recovery. Injured athletes regain their confidence to play again at different times during their recovery. It is perhaps more important to understand the process of psychological recovery in order to determine athletes who are not ready to return (Podlog, Banham, Wadey, & Hannon, 2015). Premature return to play can lead to increased fear, anxiety, re-

injury, injury to other body parts, depression, and a decrease in performance (Podlog et al., 2015). Athletic trainers or sports physicians need to monitor athletes' psychological well being during the recovery process. The Injury-Psychological Readiness to Return to Sport (I-PRRS) scale provides a series of questions relating to confidence in themselves, their return, and their injured body part that can be useful in making the decision to return (Glazer, 2009).

Podlog et al. (2015) found that confidence is one of three key dimensions of readiness to return following an injury. They suggested three components of confidence: the belief in one's rehabilitation program, the belief that one's injured body part is fully healed, and the belief in one's performance capabilities. In order for athletes to have the best transition back into competition they must trust that their medical staff is knowledgeable and that they are making progress in their rehabilitation program. It is also important to make sure that athletes' fear of re-injury does not interfere with their confidence in performing at the highest standard possible (Podlog et al., 2015).

A second dimension of readiness to return is having realistic expectations of one's capabilities. Injured athletes must understand that they will most likely not be able to perform at the same level they previously have right away. A coach can establish building blocks to help the athletes reach their previous performance standard with time (Podlog et al., 2015). The third dimension involves making sure that the athletes are motivated to regain the level of performance that they were at pre-injury. The athlete will not reach their prior performance standard if they lose motivation to work harder than they did before the injury (Podlog et al., 2015). Positive psychological responses including motivation, confidence, and low fear levels were associated with a greater likelihood of

returning to pre-injury levels of participation and competition. Making sure that athletes are psychologically ready to return to their sport after a concussion is crucial for a successful transition from rehabilitation to practice and competition.

The Gap in the Research

Significant research has been done on concussions in the last two decades. Thus, knowledge and understanding about the prevalence, risk factors, diagnosis, and recovery of concussions in athletes has greatly increased (Giza et al., 2013; Makdissi et al., 2014; Mccrory et al., 2013). Concussion is one of the most complex injuries an athlete can sustain. There is great variability in the symptoms that a concussion may present with ("Sport Concussion," 2013). Because of this, diagnosis and treatment can be challenging for athletic trainers and physicians (Doolan et al., 2011).

The majority of the research has been conducted on sports-related concussions involving high contact sports such as football, hockey, and rugby. Basketball and soccer have been studied as well. There is no research conducted on the prevalence of concussions in competitive diving. Although it is not thought of as a typical contact sport that involves collisions with other people, divers sustain an average of 50-60 headfirst impacts per practice. These impacts on divers' heads differ in intensity due to several factors including the height that the diver is diving from, the strength of the diver, and the techniques that she uses during the dive. The greater the height that a dive is performed from the greater the impact severity will be. The strength of the diver also plays a role in intensity of the impact. Divers with strong wrists and shoulders will be able to tolerate larger forces and protect their head. The main technique that a diver will use to lessen the force on her head is to grab her hands together and face her palms to the water right before

she enters the water. As her hands enter the water she will release them and break the surface of the water to lessen the impact felt on the head during the dive while also decreasing the splash. Even with this technique to decrease the impact, a free falling diver can reach speeds of up to 30 mph ("Comparing Cliff Diving," 2015). When performed correctly, it is not likely for an athlete to get a concussion. However, it is common for a dive to not go as planned during practice or a competition. This is especially true when learning new dives. If a diver enters the water wrong this can cause parts of the body to be jerked in different directions, including the head. Entering the water at 30mph can cause whiplash effect on the brain as the body decelerates when it hits the water incorrectly. This can easily result in a concussion. There are no previous studies researching the prevalence of concussions in the sport of diving. This study was intended to begin filling the gap in the research on concussion prevalence in smaller sports, such as diving, and examine the athletes' readiness to return to practice.

CHAPTER III

Methodology

Research Design

This study examining the prevalence of concussions in female collegiate divers and their readiness to return to sport after injury utilized survey methodology.

Research Participants

The target population was female collegiate divers from Midwest Division 1 teams. Ten different coaches gave permission to use their divers in the study and out of those schools twenty-four participants completed the questionnaire. The average age of the participants was 20 years old and ranged from 18-24. Participants ranged from freshmen to fifth-year seniors. The average number of years the divers have participated in diving is 7.94 years with a standard deviation of 2.767 years. One diver was on full scholarship, 17 were receiving a partial scholarship, and 6 did not receive any scholarship.

Instrumentation

The instrumentation used for this study included demographics questions and a survey including prevalence questions, symptoms questions, and confidence to return to play questions. In order to understand characteristics of the target population, general demographic questions, for example age and years of participation in diving, were included in the survey. Next the participants answered a series of informational questions examining prevalence of concussion adapted from Carson et al., (2014). A sample question is "have you ever had a concussion (diagnosed or undiagnosed) while participating in the sport of diving?" The questions were individualized to the sport of diving and some that were not applicable to diving were excluded. After those questions, the participants chose

the symptoms that they experienced from a list provided by the SCAT3 ("Sport Concussion", 2013). The last set of questions regarding confidence to return to play was adapted from the Injury-Psychological Readiness to Return to Sport (I-PRRS) scale (Glazer, 2009). One of the questions on the survey was "how confident were you to complete the dive that resulted in the concussion?" The participants answered using the Likert scale with 1 being very unconfident and 5 being very confident. The full survey is included in Appendix I.

Procedures for Collecting Data

After Institutional Review Board (IRB) approval, the researcher contacted the head coaches of each potential institution to ask for permission to use his/her athletes as participants. If permission was granted, the researcher sent an email with an explanation of the research and a link to the Qualtrics survey to each coach to forward on to his/her athletes.

When an athlete opened the survey, they were presented with an informed consent form. At this time the participants were informed that the research study was being conducted to examine the prevalence of concussion in women's collegiate diving, the recovery time for concussions, and psychological readiness to return to sport. They were also informed that the information in this study is confidential and no incentives were provided for participation. By clicking the "yes I agree" button on the survey, they agreed to participate and began to complete the survey questions.

After the initial email was sent out, a follow up email was sent 10 days later to each coach. A reminder of the importance of the study was included at the beginning of the email. The rest of it was identical to the original one sent.

CHAPTER IV

Results

Statistical analyses and techniques using the Statistical Package for Social Sciences (SPSS) were used to answer the research questions. Preliminary analyses were conducted to report frequency distributions of the categorical data and descriptive statistics of the interval data.

Prevalence

The data showed that 54.2% (n=13) of participants have had a diving-related concussion, while 45.8% (n=11) reported never having sustained a concussion while diving. Of those who stated that they have had a concussion, 84.6% (n=11) of the concussions were diagnosed by a health care provider. Fifteen percent (n=2) of the concussions were undiagnosed. The mean number of concussions reported was 1.6 with a standard deviation of 1.08. The maximum number of concussions was 4. The average amount of time the participants waited until they sought medical help was 12.15 hours with a standard deviation of 16.29 hours. All of the non-diagnosed concussions did not seek medical help. Data from the diagnosed and undiagnosed concussions were combined for the rest of the analysis. Seventy-five percent (n=9) of the concussions occurred while diving off of the 3-meter springboard, while 16.7% (n=2) and 8.3% (n=1) occurred while diving off of the 1-meter springboard and 10-meter platform, respectively. The most common type of dive a diver was attempting when she sustained a concussion was a forward flipping dive (50%), specifically front three and a half somersaults in the tuck position (25%). The concussion was caused by hitting the head on the water in 83.3% (n=10) of the concussions. The board or platform accounted for 8.3% (n=1) of concussions.

Symptoms

The three most common symptoms were headache, dizziness, and difficulty concentrating with 91.7% (n=11) of all divers reporting these symptoms regardless of whether of not the concussion was diagnosed or undiagnosed. The prevalence of each of the 21 symptoms is available in Table 1. Only one diver lost consciousness due to the concussion and was unconscious for 5 minutes. The mean number of days it took for the divers to be asymptomatic was 15 days with a standard deviation of 19.03 days. The maximum number was 60 days. About 64% (n=7) of the divers reported being asymptomatic in less than 10 days, where in 18.18% (n=2) of the participants this took longer than 4 weeks. An athletic trainer was the health care professional that cleared 100% of the divers to return to practice. Twenty-five percent (n=3) of the divers experienced a recurrence of symptoms while they were diving after they were cleared by an athletic trainer to practice.

Table 1

Symptoms reported

Symptom	Yes		No	
	n	%	n	%
Headache	11	91.7	1	8.3
Neck Pain	6	50.0	6	50.0
Nausea or vomiting	4	33.3	8	66.7
Dizziness	11	91.7	1	8.3
Blurred vision	4	33.3	8	66.7
Balance problems	9	75.0	3	25.0
Sensitivity to light	7	58.3	5	41.7
Sensitivity to noise	8	66.7	4	33.3
Feeling slowed down	7	58.3	5	41.7
Feeling "in a fog"	7	58.3	5	41.7
"Don't feel right"	10	83.3	2	16.7
Difficulty concentrating	11	91.7	1	8.3
Difficulty remembering	3	25.0	9	75.0
Fatigue or low energy	9	75.0	3	25.0
Confusion	5	41.7	7	58.3
Drowsiness	7	58.3	5	41.7
Trouble falling asleep	5	41.7	7	58.3
More emotional	5	41.7	7	58.3
Irritable	5	41.7	7	58.3
Sadness	3	25.0	9	75.0
Nervous or anxious	5	41.7	7	58.3

Recovery

Approximately 17% (n=2) of the participants continued diving the same day that they received their concussion. On average it took 23.09 days for the divers to return to practice, with the standard deviation being 26.43 days. The maximum number was 80 days. Confidence to return to diving post-concussion was measured using a Likert scale. The scale is 1-very unconfident/very afraid, 2-unconfident/afraid, 3-neutral, 4-confident/not very afraid, and 5-very confident/not afraid at all. The results can be found in Table 2. The least confident response was to the question, how confident were you to

complete the dive that resulted in the concussion? Most responses were relatively neutral. The largest standard deviation occurred with the question, how afraid were you of receiving another concussion while diving?

Table 2

Confidence to return to play

Question	Mean Response	Standard Deviation
How confident were you to return to practice?	3.17	0.72
How confident were you to return to competition?	3.00	1.00
How confident were you to complete the dive that resulted in the concussion?	2.45	1.29
How afraid were you of receiving another concussion while diving?	2.82	1.33
How confident were you to dive without symptoms?	3.73	1.27
How confident were you that you could regain previous performance standards?	3.42	1.17

CHAPTER V

Discussion

The purpose of this study was to look at the prevalence of concussion in women's collegiate diving and examine the diver's readiness to return to competitive sport. Specifically, this study examined (a) the prevalence of diving-related concussions, diagnosed and undiagnosed, in collegiate women's diving, (b) the length of time from most recent concussion to returning to play for the divers, and (c) how confident the divers were to participate in diving following a concussion. Twenty-four female divers from various universities in the Midwest participated in the study. Participants completed a survey that included a consent form, demographics questions, prevalence questions, a symptom checklist, and questions that dealt with readiness to return to diving.

Prevalence

The first research question asked about the prevalence of diving-related concussions in female collegiate divers. It was found that 13 of the 24 participants (54.2%) sustained a concussion while participating in the sport of diving. Two of the thirteen stated that their concussion was undiagnosed by a certified healthcare provider. These numbers are unexpected. The sport with the highest number of reported concussions is consistently found to be American football. According to Guskiewicz et al. (2000), 5.5% of collegiate football players will sustain at least one concussion during their career. This number is likely closer to 10-15% now due to an increase in diagnosis of concussions. Still, this number is much lower than the 54.2% of divers who reported having a concussion in this study. It is possible that divers who sustained a concussion in the past were more likely to participate in the study than those who have not, thus skewing the data.

A potential explanation for why diving has never received attention despite the high prevalence of concussions found in this study is that it is generally lumped in with swimming. Wasserman et al. (2016) stated that swimming and diving had a very low incidence of concussion. In NCAA athletics, swimming and diving are included on the same team. However, the two sports have very little in common. Divers generally make up less than 20% of athletes on those teams. Because concussions are not common in swimmers, prevalence numbers of concussions that group swimmers and divers may disguise the high prevalence in divers. It is likely that the majority of the concussions that occur on a swimming and diving team may be reported by the divers. Therefore, it is important that future studies continue to separate concussion prevalence in swimmers and divers.

Another statistic found in this study was that divers waited an average of 12.15 hours to seek medical help. This suggests that concussions are not being recognized right away by athletes and coaches. It is important for all athletes and coaches, regardless of risk, to know the signs and symptoms of a concussion in order to prevent further complications. The two divers who reported having an undiagnosed concussion during their diving career were asked why they did not seek medical help. One stated that she did not think she had a concussion and the other did not want to have to sit out of practice.

A majority of the concussions occurred while diving off of the 3-meter springboard (75%). Many NCAA pools only have 1-meter and 3-meter springboards. Only four of the universities that the survey was sent to had a platform of any kind and one participating school has a full 10-meter platform setup. If the study was limited to teams that have a full 10-meter platform, more concussions would probably occur at the 5, 7.5, and 10-meter levels. The higher up someone falls from, the larger speeds they will reach in the air. A

diver can reach speeds of up to 30mph when they reach the water after diving off the 10-meter platform ("Comparing Cliff Diving," 2015). Speeds reached when diving off of the 1 and 3-meter springboards are not as high. Therefore if concussions occur when diving off of these lower heights, they will likely occur more often when diving from the higher levels where greater speeds are reached.

The front category of dives was by far the most prevalent type of dive to be performing when sustaining a concussion (n=6). One hypothesis for this is that front flipping dives typically have the quickest rotation that a diver performs in a meet. If something goes wrong in the dive, (i.e. a hand slips off of the shin causing the diver to release the tuck), the diver can hit the water very hard while rotating very fast. Other categories of dives being performed that were represented in the study are backward (n=3), twisting (n=2), and inward (n=1).

Hitting the board/platform with the head is not very common, although can be tragic when it happens. One diver in my study stated the board was the cause of her concussion. More often, concussions result from hitting the water at high speeds while unprepared for the impact. To the researcher's knowledge, no other study has examined how the level diving from, the type of dive being performed, or the mechanism of concussion affects the risk of sustaining a concussion.

Symptoms

The three most common symptoms in all sports-related concussions are headache (92.2%), dizziness (68.9%), and difficulty concentrating (58.3%) (Wasserman et al., 2016). The results of this study support that conclusion as can be seen in Table 1. Headache was reported in 91.7% of the concussions in this study, which is very similar to Wasserman's

study. However the other two symptoms, dizziness and difficulty concentrating were also reported in 91.7% of the concussions. These numbers are significantly larger than the values the previously mentioned study established. One reason for dizziness being higher may be that the sport of diving requires significant amounts of flipping and twisting. Because of this, an athlete might notice the dizziness more than if they were participating in a sport that involves running and jumping. The lone diver who reported losing consciousness also reported hitting her head on the board to cause the concussion. This supports that hitting the board or platform can be more serious than getting a concussion from the water.

In this study, the mean number of days it took for the divers to be asymptomatic was 15 days with a standard deviation of 19.026 days. It was found that 63.63% of the participants reported being without symptoms under 10 days after their concussion. This is slightly lower than the 70 percent Resch et al. (2015) found. Although that number is similar to previous studies, the data showed that 18.18% of the concussions, the symptoms took longer than four weeks to resolve. This is three times greater than the value that Wasserman et al. (2016) found which was 6.2%. The two divers who had undiagnosed concussions both returned to practice before their symptoms resolved completely.

An athletic trainer was the health care professional that cleared all of the divers to return to practice. Twenty-five percent of the divers experienced a recurrence of symptoms while they were diving after they were cleared by an athletic trainer to practice.

Recovery

It was unanimously agreed upon at the 4th International Conference on Concussions that an athlete with a suspected concussion should not return to practice or a competition

the same day of the concussion (Mccrory et al., 2013). However, it was found that two divers did return to play the same day that they received a concussion. Returning on the same day increases the chances of an athlete having second impact syndrome. This occurs when an athlete sustains a second impact shortly after the initial concussion when the brain is still vulnerable. Second impact syndrome is extremely dangerous with rates of 50% mortality and 100% morbidity (Doolan et al., 2012). Because of the danger of returning to play too soon, it is essential for coaches and athletic trainers to not allow an athlete return to play that day if there is a remote chance that the athlete has a concussion. Wasserman et al. (2016) reported that in 5.5% of sports-related concussions the athlete returns to play the same day of the concussion. In this study that value is 17%. More research is needed to determine if the cause of this number is due to a lack of knowledge about the signs and symptoms of a concussion, athletes lying about symptoms so they do not have to sit out, or delayed onset of concussion symptoms. The two divers in this study who reported that they continued diving after they received a concussion waited 20 and 48 hours to seek medical help. Perhaps these cases involved a delay in symptom presentation so the divers did not know they had a concussion until a day or two later.

The second research question regarded the average amount of time it took for divers to recover and return to practice. On average it took 23.09 days for the divers to return to practice, with a large standard deviation of 26.43 days. The average number of days before the participants returned to practice is a full week longer than the average number of days it took for the symptoms to resolve. This statistic follows the concussion management procedure used in most NCAA universities involving a seven day, gradual, return to play protocol that begins after all symptoms have resolved (Mccrory et al., 2012).

The third research question explored divers' psychological readiness to return to their sport. As expected, the participants of this study reported a variety of experiences with regards to psychological readiness to return. No trend was found in the responses. The individual variation that was observed from the data may be the result of several factors. People handle the stress of being injured and the process of returning differently due to their personalities. One person might be able to deal with the adversity like a challenge and return stronger than they were before. Another person who has a more anxious personality, however, may be more cautious after an injury. Social support is another factor that could play a role in an athlete's confidence to return to practice after a concussion. Having a support system that is confident about an athlete's return could in turn make the athlete more confident. Positive encouragement from trusted people in their life may also cause the athletes to believe in themselves during the process of returning, specifically interactions with the coach may influence an athlete's confidence. Negative exchanges regarding the concussion, recovery process, or return to play may cause the athlete to be increasingly apprehensive. A third factor is whether or not an athlete has ever been injured before. Previous experience with concussions or injuries in general could make an athlete more confident about returning because they have been through the process before.

A series of questions about confidence in one's self, returning to sport, and the injured body part were adapted from the Injury-Psychological Readiness to Return to Sport (I-PRRS) scale and were included in the survey used in the current study. The most unconfident response came from the question regarding confidence to complete the dive that resulted in the concussion again. Coaches should be aware of this as the diver is

beginning to practice. Having the diver perform a large amount of lead up drills is one way a coach can help the diver gain confidence to perform the dive again. Also mental visualization of the dive could help build a diver's confidence about the dive.

Implications of Results

This study showed that collegiate female springboard and platform divers are in danger of sustaining concussions. A large number of resources are being poured into research on concussions right now. It is concerning when reading the current literature regarding sports-related concussions that a gap exists with sports that are not as popular. Although it is not traditionally thought of as a contact sport, divers regularly sustain intense impacts with the water at speeds up to 30mph. As the results of this study revealed, the sport of diving may have a greater incidence of concussions than other sports.

Furthermore, it is important for divers, diving coaches, and athletic trainers of diving teams to be aware of the risk of concussion. The average time a diver waited to seek medical help was 12.15 hours according to this study. Concussions are not being recognized right away in divers and that can have serious consequences such as worse symptoms, second impact syndrome, and post-concussion syndrome. More attention needs to be placed on both the knowledge of the signs and symptoms of concussion and being able to recognize a concussion when it happens.

Limitations

The current study included several limitations. First, getting participants to complete the survey was a limitation. Several schools declined participation and the response rate from participating universities was about half. Twenty-four athletes filled out the survey. Division I athletic teams are often solicited for participation in studies so

coaches are cautious about which studies to allow participation. Additionally, divers who have not sustained a concussion may not have participated because they believed the survey wasn't relevant to them. All of the participants attended different Division I universities primarily in the Midwest. Divers in different in different regions may have different results. The athletes' ability to remember lengths of time, symptoms they experienced, and psychological readiness to return during their concussion is another constraint.

Future Recommendations

This study was intended to begin closing the gap in the research on concussions in traditionally non-contact sports. A larger scale prevalence study needs to be performed on collegiate divers to more accurately assess the risk that divers face. The current study revealed that divers are at risk of sustaining concussions but more research should be done to reliably quantify that risk.

It is also recommended that future researchers look at prevention of concussions in diving. Although it is unlikely that protective head equipment be developed for the sport of diving, different techniques should be examined to see if they could lessen the risk on concussions in the sport. These techniques could range from rule changes about the ideal distance to be from the end of the board when performing a dive to requiring pools to install a system that breaks the surface of the water, lessening the impact.

An increase awareness of the risks associated with diving is crucial. Divers, coaches, and athletic trainers need to be cognizant of the possibility of concussion. This will allow quicker recognition of concussion in the athletes and proper a proper management plan be put into place. Both of these are critical steps to avoid future issues (i.e. second impact

syndrome, post-concussion syndrome, and chronic traumatic encephalopathy) that an athlete may face if they continue to receive blows to the head with an untreated concussion.

More research needs to be done about readiness to return to sports after concussions. A study looking at how personality, social support, and previous injuries impacts an athlete's readiness to return to their sport would give insight into how to help the athlete's psychological recovery.

Conclusion

This study showed that collegiate female springboard and platform divers are in danger of sustaining concussions. A large amount of resources are being poured into research on sports-related concussions right now. It is concerning when reading the current literature regarding concussions that a gap exists with sports that are not as popular. Although it is not traditionally thought of as a contact sport, divers regularly sustain intense impacts with the water at speeds up to 30mph. As the results of this study revealed, the risk of concussion in diving is serious. Divers deserve the most accurate diagnoses and treatments available so it is critical that Athletes, coaches, and athletic trainers understand the risk of concussion in the sport of diving.

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APPENDIX A

UNIVERSITY OF NORTHERN IOWA HUMAN PARTICIPANTS REVIEW
INFORMED CONSENT

Project Title: Concussions in female collegiate diving: An exploratory study.

Name of Principal Investigator(s): Sarah Kemp

Invitation to Participate: You are invited to participate in a research study conducted through the University of Northern Iowa. The University requires that you give your consent to participate in this study. The following information is provided to help you make an informed decision about whether or not to participate.

Nature and Purpose: The current study looks at the prevalence of concussions in female collegiate divers and examines their psychological readiness to return to sport.

Explanation of Procedures: Participation in this study requires you to complete a one-time, online survey. Completion of the survey will take approximately 10 minutes. Participation is voluntary and you may stop taking the survey at any time.

Discomfort and Risks: There are minimal risks for participation in this study. Beyond the time it takes to complete the survey, it is possible that some psychological risks may occur. You will be answering questions about a previous injury. In some cases, you may potentially have negative emotional responses to the memory of your injury.

Benefits: There are no direct benefits for participating in this study.

Confidentiality: Information obtained during this study that could identify you will be kept strictly confidential. Your confidentiality will be maintained to the degree permitted by the technology used. No guarantees can be made regarding the interception of data sent via the Internet by any third parties. The summarized findings with no identifying information may be published in an academic journal or presented at a scholarly conference.

Right to Refuse or Withdraw: Your participation is completely voluntary. You are free to withdraw from participation at any time or to choose not to participate at all, and by doing so, you will not be penalized or lose benefits to which you are otherwise entitled.

Questions: If you have any questions about the study or desire information in the future regarding your participation, you can contact Sarah Kemp at 515-520-1772 or at skemp94@uni.edu. You can also contact the office of the Human Participants Coordinator, University of Northern Iowa, at 319-273-6148, regarding questions about rights of research participants and the participant review process.

Agreement:

I am fully aware of the nature and extent of my participation in this project as stated above and the possible risks arising from it. I hereby agree to participate in this project. I acknowledge that I have received a copy of this consent statement. I am 18 years of age or older.

Clicking the start button means I agree to participate in the study.

APPENDIX B

Demographic Questions

1. Age
2. Years participating in diving
3. Year in school? (based on athletics)
    - Freshman
    - Redshirt Freshman
    - Sophomore
    - Junior
    - Senior
    - 5th Year Senior
4. Scholarship?
    - Full
    - Partial
    - None

Survey Questions

1. Have you ever had a concussion (diagnosed or undiagnosed) while participating in the sport of diving?
    - Yes
    - No

If you answer Yes to #1…

2. Was the concussion diagnosed by a health care provider (physician, athletic trainer)?
    - Yes (Answer questions in section A)
    - No (Answer questions in section B)

If you answer No to #1… done.

SECTION A (DIAGNOSED)

For all remaining questions, answer according to your most recent concussion.

1. How many diving related concussions have you had?
    - Type #
2. How old were you when you sustained your 1st concussion?
    - Type age in years
3. How old were you at most recent concussion?
    - Type age in years

4. What dive were you performing when you got a concussion?
    - Type dive number
5. What level did you perform the dive from?
    - 1 meter
    - 3 meter
    - 5 meter
    - 7.5 meter
    - 10 meter
    - Other
6. Did the concussion result from hitting the board, water, or other?
    - Board/Platform
    - Water
    - Other
7. Did it occur during practice/ home/ away meet?
    - Practice
    - Home meet
    - Away meet
8. Did you lose consciousness? If so, how long in minutes?
    - Type minutes
    - I did not lose consciousness
9. Check all symptoms that you had.
    - Headache
    - Neck pain
    - Nausea or vomiting
    - Dizziness
    - Blurred vision
    - Balance problems
    - Sensitivity to light
    - Sensitivity to noise
    - Feeling slowed down
    - Feeling "in a fog"
    - "Don't feel right"
    - Difficulty concentrating
    - Difficulty remembering
    - Fatigue or low energy
    - Confusion
    - Drowsiness
    - Trouble falling asleep
    - More emotional
    - Irritability
    - Sadness
    - Nervous or anxious
10. How long until you saw medical help?
    - Type number of hours

11. Did you return to play the same day of your concussion?
    - Yes
    - No
12. In days, how long did it take for you to be asymptomatic?
    - type # of days
13. In days, how long until you returned to practice?
    - type # of days
14. Who cleared you to return to practice?
    - Physician
    - AT
    - Coach
    - Self
    - Other (type)
15. At any point after you returned to practice did you have a recurrence of symptoms?
    - Yes
    - No
16. If yes, did they reoccur while you were diving?
    - Yes
    - No

For the following questions, use the likert scale to answer.

1. Very unconfident/Very afraid
2. Unconfident/Afraid
3. Neutral
4. Confident/Not very afraid
5. Very confident/Not afraid at all

17. How confident were you to return to practice?
18. How confident were you to return to competition?
19. How confident were you to complete the dive that resulted in the concussion?
20. How afraid were you of receiving another concussion while diving?
21. How confident were you to dive without symptoms?
22. How confident were you that you could regain previous performance levels?

SECTION B (UNDIAGNOSED)

1. What dive were you performing when you got a concussion?
    - Type dive number
2. What level did you perform the dive from?
    - 1 meter
    - 3 meter
    - 5 meter
    - 7.5 meter

- 10 meter
- Other

3. Did the concussion result from hitting the board, water, or other?
    - Board/Platform
    - Water
    - Other
4. Did it occur during practice/ home/ away meet?
    - Practice
    - Home meet
    - Away meet
5. Did you lose consciousness? If so, how long in minutes?
    - Type minutes
    - I did not lose conciousness
6. Check all symptoms that you had.
    - Headache
    - Neck pain
    - Nausea or vomiting
    - Dizziness
    - Blurred vision
    - Balance problems
    - Sensitivity to light
    - Sensitivity to noise
    - Feeling slowed down
    - Feeling “in a fog”
    - “Don’t feel right”
    - Difficulty concentrating
    - Difficulty remembering
    - Fatigue or low energy
    - Confusion
    - Drowsiness
    - Trouble falling asleep
    - More emotional
    - Irritability
    - Sadness
    - Nervous or anxious
7. Did you seek medical help?
    - Yes
    - No
8. If yes, how long until you saw medical help?
    - Type hours
    - I did not seek medical help
9. If no, why did you not see medical help?
    - I did not think that I had a concussion
    - I did not want to have to sit out of practice

- Other

10. Why was the concussion not diagnosed?
    - I did not seek medical help
    - The medical professional I saw did not diagnose it as a concussion
    - Other
11. Did you return to play the same day of your concussion?
    - Yes
    - No
12. In days, how long did it take for you to be asymptomatic?
    - Type # of days
13. In days, how long until you returned to practice?
    - Type # of days
14. At any point after you returned to practice did you have a recurrence of symptoms?
    - Yes
    - No
15. If yes, did they reoccur while you were diving?
    - Yes
    - No

For the following questions, use the likert scale to answer.

1. Very unconfident/Very afraid
2. Unconfident/Afraid
3. Neutral
4. Confident/Not very afraid
5. Very confident/Not afraid at all

20. How confident were you to return to practice?
21. How confident were you to return to competition?
22. How confident were you to complete the dive that resulted in the concussion?
23. How afraid were you of receiving another concussion while diving?
24. How confident were you to dive without symptoms?
25. How confident were you that you could regain previous performance levels?