The Effects of Multiple Concussions on Recovery Time in NCAA Division II Collegiate Athletes

By

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THE EFFECTS OF MULTIPLE CONCUSSIONS ON RECOVERY TIME IN NCAA DIVISION II COLLEGIATE ATHLETES

A thesis prepared by Megan Leigh Ulery

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Abstract

Concussions due to participation in athletics have become a vital topic in athletic medicine over the past decade. It has been estimated that anywhere from 1.6 to 3.8 million concussions occur each year from sport-related incidents (Covassin, Moran, & Wilhelm, 2013). Concussions can occur in athletes from any sport: from collision sports such as football, hockey and lacrosse, contact sports like soccer and basketball, and non-contact sports such as swimming, baseball, softball and track and field. A concussion for the purpose of this study will use the same definition the National Athletic Trainers' Association (NATA) uses, which defines a concussion as "a trauma-induced alteration in mental status that may or may not involve a loss of consciousness (LOC)" (Broglio et al., 2014). Athletes, coaches, and medical professionals alike have a multitude of resources available to them for education on concussions. The primary purpose of this study was to determine the relationship between a history of concussions and recovery time in NCAA Division II male and female collegiate athletes. The secondary purpose was to determine if there is a difference in gender when it comes to concussion recovery. This was a cohort study conducted over a period of 16 weeks. The participants in this study were male (N=3) and female (N=4) student-athletes, ages 18-21 years, who had been evaluated by a Certified Athletic Trainer and deemed as having sustained a concussion. The independent variables for this study were the concussed athletes, concussion histories of student-athletes and their gender. The dependent variables for this study were scores on the Standard Assessment of Concussion (SAC) test, and Balance Error Scoring System (BESS) test, and the Graded Symptom Scale Checklist from baseline, post-injury, and return-to-baseline testing, and recovery time. When a student-athlete was diagnosed with a concussion, the team's assigned ATC reported the concussion to the researcher. The researcher recorded the student-athlete's history of

concussions and then monitored how long their recovery took. Full clearance would be granted when the athlete returns to within two points of their baseline levels of the SAC and BESS tests, and reports absolutely no symptoms on the Graded Symptoms Scale Checklist, reports no use of pain medication, completes the final day of the return to play (RTP) protocol, and reports no concussion symptoms 24 hours after the last day of the RTP protocol. The findings show that there was no significant difference ($p<0.05$) between history of concussion and recovery time. The findings also show that there was no statistical difference between gender and recovery time ($p<0.05$). The results from the Mann-Whitney U test testing concussion history and time out of sport showed that there was no significant difference between recovery time and history of concussion ($p=0.571$). The results from the second Mann-Whitney U test showed that there was no significant difference between gender and recovery time ($p=0.057$). Female participants averaged 21.33 ±9.29 days missed from sport with a range of 15-32 days, and the male participants averaged 10.25 ±2.63 days missed from sport with a range of 8-14 days. The average number of days missed from sport for those with a concussion history was 12.60 ±3.91 days, with a range of 8-17 days. The average of days missed for those without a concussion history was 21.00 ±15.56 days, with a range of 10-32 days missed. Though there was no significance between gender and recovery time, the outcome approaches significance, showing that women were taking longer to recover than men. This study can be used to add to the ever growing collection of concussion data. Athletic trainers and other health care professionals can use the data collected in this study to better treat concussions in their athletes. Having the knowledge of average recovery time (7-10 days) from concussions, dependent on gender and concussion history, will allow medical professionals to better educate athletes, coaches and parents about what they can expect.

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Chapter 1: Introduction

Over the span of only a few years athletic concussion awareness has increased immensely (Chertok, 2013; Lynall, Laudner, Mihalik, Stanek, 2013). Athletes, coaches, and medical professionals alike have a multitude of resources available to them for the education on concussions. Organizations like the Centers for Disease Control, and the Brain Injury Association of America are either in part or wholly dedicated to the spreading of concussion awareness and education ("' Injury prevention & control,"' 2014; "'Living with brain injury,"' 2012). Recurring concussions have also become a hot topic among athletes and medical professionals alike. It has been shown however, that a history of even just one previous concussion will put an athlete at risk of sustaining another concussion (Guskiewicz, McCrea, Marshall, Cantu, Randolph, Barr, Onate, 2003). Studies have also shown that a history of concussions will increase recovery time to baseline (Broglio, Cantu, Gioia, Guskiewicz, Kutcher, 2014; Castile, Collins, McIlvain, Comstock, 2012; Nelson, Janecek, McCrea, 2013). Athletes that have had previous concussions have performed more poorly on computer-based neurocognitive testing than their non-concussed counterparts (Colvin, Mullen, Lovell, West, Collins, Groh, 2009). It was hypothesized by Guskiewicz and colleagues (2003) that a slower recovery time after previous concussions could be due to vulnerability of one's neurons. Although it has only been proven in animal studies, it has been shown that there is disrupted cellular metabolism and decreased cerebral blood flow for up to ten days post-concussion

(Guskiewicz et al., 2003). This combination leaves the neurons more vulnerable until homeostasis is regained after recovery from the concussion.

There is also evidence that gender has an impact on concussions. It has been shown that in sports with similar rules for both male and female sports, such as basketball and soccer, females have a higher incidence of concussions (Harmon, Drezner, Gammons, Guskiewicz, Halstead, Herring, Kutcher, 2013). Females also tend to report a higher number of symptoms initially after diagnosis, which has been linked with a longer concussion recovery time (Scopaz & Hatzenbuehler, 2013).

The most effective ways to assess if an athlete has a concussion is to test multiple aspects of the brain (Guskiewic & Mihalik, 2010). Multifaceted neurocognative testing can be done through balance testing, memory and concentration testing and self-reported symptoms from the athlete. The Balance Error Scoring System (BESS) test, Standardized Assessment of Concussion (SAC) test and the Graded Concussion Symptoms Checklist are all valid and reliable ways to assess concussion status, as well as monitor recovery throughout the healing process (Broglio et al., 2014; Giza, Kutcher, Ashwal, Barth, Getchius, Gioia, Gronseth, 2013).

The assessing of a concussion needs to be performed by a medical professional who has been trained in the evaluation and assessment of concussions. As a part of their schooling, Certified Athletic Trainers all "receive comprehensive didactic and clinical training in concussion management (including assessments)...and are integral in the postinjury management and return to play decision-making process (Broglio et al., 2014)."

After an athlete has been evaluated by a Certified Athletic Trainer or appropriately trained physician, and had been given the assessment of having a concussion, a return to play protocol should be followed. This protocol varies based on where the athlete participates in athletics, as there is no definitive National Collegiate Athletic Association (NCAA) wide concussion policy. The general outline of a return to play protocol should be graduated and increase in exertion and sport related skill each day that the athlete reports a lack of concussion symptoms (Broglio et al., 2014). This is to ensure the safest manner of full recovery and return to activity. With progressed return to play, health care professionals can closely monitor any signs or symptoms the athlete may be experiencing. This monitoring is aided by a mandatory 24 hours between steps of the return to play protocol (Broglio et al., 2014; Giza et al., 2013; Harmon et al., 2013).

Purpose

The primary purpose of this study was to determine the differences between a history of concussions and recovery time in NCAA Division II male and female collegiate athletes. The secondary purpose was to determine if there is a difference in gender when it comes to concussion recovery.

Hypotheses

It was hypothesized, based on previous but limited research, that a history of concussions in collegiate athletes would extend the recovery time from the most recent concussion. It was also hypothesized that women would be given the assessment of a concussion in greater numbers than men, and their recovery would take longer than their male counterparts.

Delimitations

All student-athletes that participate in this study were from Adams State University, an NCAA Division II institution located in Alamosa, Colorado, sitting an elevation of 7,544 feet above sea level. Athletes both in and out of season were included in this study.

The study took place during the winter and spring athletic seasons for the 2014-2015 academic year. Only student-athletes enrolled at Adams State University participated in this study.

Participants that were excluded from this study were athletes that were currently ineligible for any reason from collegiate athletics. Participants were also excluded if they have a history of diagnosed mental disease, as this could affect the outcomes of their concussion recovery.

Limitations

One limitation of this study would be a lack of concussion injuries. If there are no injuries this study would not be able to take place.

Athletes that are out of season were also included in this study. As the off-season is often less intense than the regular season, out of season athletes may be less prone to concussion.

Assumptions

It was assumed that all administered testing was done in a standardized fashion by trained medical professionals. It was also assumed that Athletic Trainers in the state of Colorado are considered medical professionals. As a part of Colorado law, athletic training includes: the recognition, assessment, treatment, management, prevention, rehabilitation, reconditioning, and appropriate referral of injuries and illnesses (Athletic Trainer Practice Act of 2009). It was assumed that the evaluation, assessment, and management of athletic concussions fall within the scope of athletic training in the state of Colorado.

It was also assumed that the Adams State University Return to Play protocol is valid and reliable. This was assumed because it is based off of the National Athletic Trainers' Association Position Statement on Concussions. It was assumed that the Standardized Assessment of Concussion test, the Balance Error Scoring System test, and the Graded Symptom Scale Checklist are all reliable and valid tests to assess concussions and monitor recovery (Bell, et al., 2013; Giza et al., 2013; Lear, Houang, 2013; Lynall, Laudner, Mihalik, Stanek, 2013)

The researcher assumed that the participants were truthful in reporting their symptoms throughout the study. The researcher also assumed that the participants were compliant with any instructions given to them from the Return to Play protocol.

Definition of Terms

A Certified Athletic Trainer was defined as a person registered to practice athletic training in the state of Colorado (Athletic Trainer Practice Act, 2009).

For the purpose of this study a concussion was defined as "a trauma-induced alteration in mental status that may or may not involve a loss of consciousness (LOC)" (Broglio et al., 2014).

A history of concussion was defined as one or more concussions, sports related or not, and assessed by a trained medical professional.

Recovery from concussion was defined as full clearance by an ATC or qualified physician. Full clearance was be granted when the athlete returns to baseline levels of the SAC and BESS tests, and the graded concussion symptoms checklist, reports no use of pain medication, completes the final day of the RTP protocol, and reports no concussion symptoms 24 hours after the last day of the RTP protocol.

The recovery time period included time from post-injury concussion testing to the completion of the RTP protocol.

Post-injury concussion testing took place after the student-athlete had a concussive episode, and a concussion is suspected. This testing took place within 24 hours of the concussive episode, but as soon as possible within the 24 hours.

A student-athlete was defined as a college-aged person currently enrolled in any athletic program, and specifically for this study, enrolled at Adams State University.

Chapter 2: Review of Literature

Concussion Background

Concussions due to participation in athletics have become a vital topic in athletic medicine over the past decade. It has been estimated that anywhere from 1.6 to 3.8 million concussions occur each year from sport-related incidents (Covassin, Moran, & Wilhelm, 2013). This number may be a low estimate as underreporting concussions is still a big problem in all levels of athletics. Whether this is due to ignorance of concussion signs and symptoms, or an intentional concealing of injury remains to be seen, but is most likely a combination of both (Colvin et al., 2009).

Concussions have been quite prevalent in the news lately. The National Football League (NFL) has been the most prominent organization to address concussions ("NFL Concussions," 2013). There is even a pending lawsuit from the NFL players. They feel that they were not properly educated on the risks to their health from repeated blows to the head. Some feel they were allowed to return to play too quickly, or without proper diagnosis, therefore not allowing complete recovery. They are aiming to link improper recovery from a concussion with their long term health issues ("NFL concussion fast facts," 2014).

Famous athletes such as Pat LaFontaine from the National Hockey League (NHL) and Troy Aikman from the NFL, both retired from professional athletics, cite concussions as the reason for their early retirements. There were also numerous suicides by current and former NFL players that were attributed to concussions or residual effects from multiple concussions ('concussion fast facts," 2014). These actions only furthered pleas from athletes and medical professionals alike for further concussion research. Proper education, prevention and recovery from concussions will only benefit athletes in the long run.

Concussions can occur in athletes from any sport: from collision sports such as football, hockey and lacrosse, contact sports like soccer and basketball, and non-contact sports such as swimming, baseball, softball and track and field. A concussion for the purpose of this study will use the same definition the National Athletic Trainers' Association (NATA) uses, which defines a concussion as "a trauma-induced alteration in mental status that may or may not involve a loss of consciousness (LOC)" (Broglio et al., 2014). This alteration in mental status can be caused by a blow to the head or to the body (Lear & Hoang, 2012).

The reason that it takes time for individuals to recover from concussion injuries is there is a disturbance on a neurological level (Giza & Hovda, 2001). When the head or body sustains a blow, the brain absorbs some of that force, called a sheering force. This force affects the brain's ability to function normally. The brain needs to be repaired on a cellular level to return to homeostasis, but it needs increased energy to do so, and with the interruption of normal function comes a decreased cerebral blood flow (Giza & Hovda, 2001). This decreased blood flow impedes the brain's ability to provide more energy for healing. This also leaves the brain vulnerable to further injury while recovering (King, Brughelli, Hume, Gissane, 2014).

Concussions can present themselves in many different ways. The most common symptoms that accompany a concussion are LOC, headache, nausea, vomiting, dizziness, attention problems (often delayed answers to questions, being easily distracted, and a vacant stare), amnesia (retrograde or antrograde), and balance disturbances (Harmon et al., 2013). Other symptoms include seizures, and emotional instability and inappropriateness (laughter or crying) (Harmon et al., 2013; McCrory, Meeuwisse, Echemendia, Iverson, Dvorak, Kutcher, 2013). Concussion symptoms manifest differently for each individual and can be different for each concussion an individual sustains. For this reason each concussion should be treated on an individual basis (Harmon et al., 2013). Generalized grading of concussions have shown poor prediction of severity of concussion as well as poor prediction of recovery time from the concussion (Scopaz & Hatzenbuehler, 2013).

Historically, concussions have been graded based on a three level scale. There were four types of grading scales, but in all four, a grade 3 concussion was the most severe. Recently though, it has been shown that each concussion should be treated on an individual basis, without grading (Broglio et al., 2014; Iverson, 2007). This gives the athlete a more customized recovery and modified return to play when necessary (i.e. longer time when needed).

Concussion Assessments

It is vital for the health of athletes if there is a suspected concussion that an assessment is done as quickly as possible. This is so acute trauma can be evaluated and managed immediately (Broglio et al., 2014). For this reason there have been multiple assessments created specifically for use on sidelines. These tests include: the Standardized Assessment of Concussion (SAC) test, the Sport Concussion Assessment Tool 2 (SCAT 2), and the National Football League (NFL) Sideline Assessment Tool (Harmon et al., 2012). The SAC test measures orientation, such as knowing the month, date, and time, immediate memory, delayed recall, muscular strength, coordination and concentration, such as reciting the months of the year backward. The SCAT2 assesses the number of concussion symptoms present, orientation, through the Glasgow Coma Scale and Maddocks Score, balance, coordination and also incorporates the entire SAC test. The NFL Sideline Assessment Tool measures orientation, immediate and delayed memory, concentration, balance, and also includes a symptom checklist. When these tests are given as a baseline, as well as post-injury, they can be used to show when an athlete has returned to "normal" (for them personally) during recovery from a concussion.

Concussion Return to Play

When an athlete is diagnosed with a concussion, either by a physician or a Certified Athletic Trainer (ATC), there is a protocol that must be followed before the athlete can safely return to practice and/or competition. The specific protocol depends on the institution that the athlete attends and specific sport, but all protocols should follow a gradual return to activity that begins with light exertion and ends with intense sport specific activity. The protocol may only begin once the athlete has been symptom free for 24-48 hours (Broglio et al., 2014). For example, the exact return to play (RTP) protocol used at Adams State University, a National Collegiate Athletic Association (NCAA) Division II institution where the study will take place, is as follows: The athlete must be symptom free for 24-48 hours and not taking any pain medication for that long as well. The athlete must then meet their pre-season baseline score on the Standardized Assessment of Concussion (SAC) test (Giza et al., 2013) and the Balance Error Scoring System (BESS) test (Bell, Guskiewicz, Clark, Padua, 2013). Once this is achieved, the athlete is allowed to begin the first day of the RTP program. The first day involves cognitive stressors. This is done through the playing of computer (such as minesweeper or spider solitaire) games for 30 minutes. The purpose of these games is to make the athlete concentrate and focus. If no symptoms, such as headache, dizziness, nausea, difficulty concentrating, or memory impairment return with cognitive stress, or in the 24 hours following the cognitive stress, day two of the protocol can be administered. The purpose of day two is for physical exertion. The athlete performs a warm up on the bike for ten minutes, alternate 30 seconds of hard biking intervals and 30 seconds of easy biking intervals for ten minutes, and ten sets of ten repetitions of push-ups, jumping jacks, and crunches. This is all monitored by a certified athletic trainer. If the athlete remains symptom free 24 hours after day two, he or she can progress to day three which is when sports specific exercises and drills begin. The athlete will participate in a non-contact practice with the team. If there are contact portions of the practice the athlete may condition during those times. Once again, if the athlete remains symptom free for 24 hours he or she moves on to day four of the protocol. Day four consists of a full contact practice with their team. If the athlete maintains a lack of symptoms 24 hours after day four they can be cleared for full participation once again. This protocol has been determined by the institution's head athletic trainer, based off the NATA position statement on concussions (Broglio et al., 2014), as there is no NCAA mandated return to play protocol after concussions.

If there were a standardized return to play protocol used across the NCAA, it would potentially make concussion diagnosis easier. There would be less variation from institution to institution. All athletic trainers and medical professionals in general, would be able to begin on the same page. It should be noted, though, that every concussion injury is different and a standardized protocol would be a starting point. Every concussion should be treated on an individual basis (Broglio et al., 2014; Iverson, 2007).

Concussion Recovery

Although each concussion is different and each athlete responds to concussions uniquely, it has been shown that most athletes (80-90%) have a complete resolution of symptoms within 7 days (Harmon et al., 2013; McCrea, Guskiewicz, Marshall, Barr, Randolph, 2004). The prolonged duration of concussion symptoms that last longer than expected can be classified as postconcussion syndrome (Jotwani & Harmon, 2010). This syndrome can last for weeks to months. The signs and symptoms are the same as a typical concussion but last for an extended period of time, with absolutely no resolution of symptoms. There is not a definitive treatment for postconcussion syndrome at this time other than just treating the symptoms as needed. The concussed athlete should also have a physician monitor his or her level of physical activity (Anderson, Parr, Hall, 2009). The concern with a history of concussions is potentially longer recovery, and therefore having the athlete develop postconcussion syndrome.

If it is shown that a history of concussions extends recovery time of recurring concussions, and if postconcussion syndrome occurs, it can greatly impact the life of an athlete. The impacts on a student-athlete can include: difficultly in school, trouble concentrating on homework/ studying, insomnia, and psychological abnormalities, such as depression, anxiety, and irritability (Harmon et al., 2013).

Effects of Multiple Concussions

It has been shown that once an athlete has had a concussion they are at a higher risk for another concussion (Iverson, 2007). Football players with a history of concussions are 3.5 times more likely to sustain another concussion than athletes with no concussion history (Broglio et al., 2014). Non-football athletes with a concussion history are 2.8 times more likely to sustain another concussion than non-concussed athletes (Broglio et al., 2014). There is a lack of research though, on the effects of multiple concussions; specifically the effects of multiple concussions on recovery time. It was hypothesized that a history of concussions will lead to a prolonged recovery time, based on several studies reviewed below (Castile, Collins, McIlvain, Comstock, 2012; Colvin, Mullen, Lovell, West, Collins, Groh, 2009; McCrea, Guskiewicz, Randolph, Barr, Hammeke, Marshall, Powell, 2013; Nelson, Janecek, McCrea, 2013).

One study, performed by Castile and colleagues (2012) found that athletes who had sustained recurring concussions took longer to heal than athletes with newly sustained concussions. The researchers collected concussion data from high schools across the nation that agreed to participate in the study. To be invited to participate in the study, the high school must have had a Certified Athletic Trainer on staff and that staff member must have a valid email address. One hundred schools were selected to participate. The information was collected from online injury databases, and was compiled over a five year period. Data was gathered from both boys and girls sports, including football, soccer, basketball, baseball, wrestling, volleyball and softball; 2417 concussions were reported from those sports. There were a few interesting results from this study. First, the researchers found that females had a higher prevalence of concussion. They also found that athletes who were diagnosed with a previous concussion had symptoms for longer, and were therefore held out of their sport for a longer period of time than athletes with no history of previous concussions. Less than 1% (0.6%) of new concussions took greater than one month to resolve, and 6.5% of recurrent concussions took greater than one month to resolve (Castile et al., 2012).

Another study, by Colvin et al. (2009), found that a history of concussions was related to soccer players to perform more poorly on post-concussion reaction testing than those without a concussion history. This study looked at both male and female soccer athletes. The participants were baseline tested with a computer program that tests memory, reaction time and concentration. When participants were diagnosed with a concussion, they were tested again using the same technology. This study also showed that women were diagnosed with concussions in general with a greater frequency than men. It was also shown that the participants with a history of concussions had a slower reaction time on the testing post-concussion than those with no history of concussions. The authors concluded that a previous history of concussions may lead to long-term cognitive impairments with recurrent concussions (Colvin et al., 2009). Based on these studies, future studies should also consider a history of concussions, as it may lead to a longer recovery time in subsequent concussions.

One study by McCrea, Guskiewicz, Randolph, Barr, Hammeke, Marshall, and Powell (2013), was contradictory to the previous two studies though. McCrea et al. studied over 18,000 athletes at the high school level. They gathered data on concussions between the years 1999 and 2008. All of their participants were baseline tested and then monitored to determine total recovery time once a concussion was diagnosed. This study found that a history of concussion does not lead to a longer recovery time, though no residual effects were found in the long term (45-90 days post-injury). The researchers also showed that a more severe concussion (i.e. high amount of symptoms or loss of consciousness) led to a longer recovery time. The longer recovery group was still showing symptoms on day 7 of recovery, while the typical recovery group has returned to baseline numbers by day 2 of recovery. There were no significant differences between groups by days 45 and 90 of recovery. This finding may be due to the fact that high school athletes have been shown to take longer to recover from concussions, compared to their collegiate equivalents. A history of concussions may not necessarily add to the already prolonged time to full recovery (McCrea et al., 2013).

A review of multiple studies done by Nelson, Janecek, and McCrea (2013) concluded that there is initial evidence that a history of concussion may lead to a more prolonged recovery time than a lack of concussion history. They also pointed out that some other studies may be biased due to retrospective athlete reporting symptoms and recovery times. Athletes may not remember exactly how long they were out of participation or how many symptoms they exhibited. This would then skew the results of the study in which they were participating. Nelson et al. suggested therefore, that it is in the interest of the researcher to take the data given at the time of injury instead of having it reported at a later date.

A study by Guskiewicz et al. used football players to research the effects of concussions. The researchers used nearly 3,000 participants from 25 colleges and universities and followed them over a three year period. They found that once a football player was diagnosed with a concussion, they were at a three-fold greater risk of another concussion. They also found that participants with a history of previous concussions had a longer recovery time (i.e. longer than 7 days post-injury) with recurring concussions. They hypothesized that this was due to vulnerable neurons that were damaged in previous injuries. As mentioned previously, though it has only been found in animal studies, it has been shown that there is disrupted cellular metabolism and decreased cerebral blood flow for up to ten days post-concussion (Guskiewicz et al., 2003).

Concussion and Gender

It has been widely shown that gender has an effect on concussions. Most studies have shown that females have a higher frequency of concussions in general (Bloom, Loughead, Shapcott, Johnson, Delaney, 2008; Castile et al., 2012; Colvin et al., 2009; Scopaz & Hatzenbueleher, 2013). There are a couple of theories about these findings. One theory is that, due to lower muscle mass overall, females have weaker necks, therefore less ability to control the head when a traumatic blow occurs. The lack of control makes it easier for the brain to be forcefully moved inside the skull, thus resulting in a concussion (Castile et al., 2012).

Another theory is that females report concussion symptoms more commonly than males do (Colvin et al., 2009). Females tend to be more verbal than males so the communication of abnormal symptoms is more natural to females (Colvin et al., 2009). Also, male sports tend to emphasize the need for "toughness" and "masculinity" so admitting to feeling pain or not feeling right may be discouraged; therefore males may be underreporting concussions or concussion symptoms (Bloom et al., 2008).

Finally, Scopaz and Hatzenbuehler (2013) showed that gender also had an effect on recovery time. They found that women report higher numbers of concussion symptoms, and a higher number of reported symptoms leads to a longer recovery. Again, this could be due to multiple factors that include women being more outspoken about symptoms, as well as a general decreased muscle mass in the neck. Therefore, based on this research women with concussions will likely take longer to recover than men, after a concussion.

Concussion and Age

Many studies have shown that age is a factor in concussion recovery. High school athletes have been shown to take longer to recover than their collegiate or professional equivalents, though there is no difference in instances of concussion (Bloom et al., 2008; Eisenberg, Andrea, Meehan, Mannix, 2013; Harmon et al., 2013). It has been hypothesized that this is due to the immature brains of the younger athletes (Harmon et al., 2013). Very young athletes were shown to recover faster than their high school counterparts (Eisenberg et al., 2013). The "magic age," according to Eisenberg et al. (2013), is 13 years of age. Athletes under the age of 13 recovered in a shorter amount of time (11 days) than athletes over the age of 13 (15 days) (Eisenberg et al., 2013). Based on these findings, using collegiate athletes who are well over the age of 13, would show recovery times in line with other collegiate and professional studies. This would mean that average recovery time should be within 7-10 days post-injury (Harmon et al., 2013; McCrea et al., 2004).

Summary

After reviewing current literature, it has been shown that there are many facets to concussions. Tools for retaining a baseline as well as post-injury scores are vital in athletics. In order to make a safe assessment of concussions and return to play decisions, precise means of measurements need to be available (Broglio et al., 2014). Also, having a regulated and standardized return to play protocol is essential for the well-being of any athlete (Broglio et al., 2014).

Average adult recovery from a concussion is within 7-10 days after the concussion occurs (Harmon et al., 2013; McCrea et al., 2004). It has been shown in multiple studies that an athlete with a history of recurring concussions will take longer to fully recover from concussions (one day to one week for first time concussions, versus up to one month longer for recurring concussions) (Castile et al., 2012; Colvin et al., 2009; McCrea et al., 2013; Nelson et al., 2013).

Other factors that affect concussion recovery time are age and gender. Athletes under the age of 13 will typically recover in about 11 days. Athletes between 13 and 18 will take an average of 15 days to recover. Athletes 18 and older will recover in about 7-10 days (Eisenberg et al., 2013; Harmon et al., 2013; McCrea et al., 2004). Females have been shown to take longer to recover from concussions than males. This may be due to genetics, or rate and accuracy of reporting concussions (Bloom et al., 2008; Castile et al., 2012; Colvin et al., 2009).

This study attempted to address some of these issues by hypothesizing that there is a relationship between a history of concussions and recovery time in NCAA Division II male and female collegiate athletes. The researcher also attempted to determine if there is a difference in gender when it comes to concussion recovery.

Chapter 3: Methods

Setting

The setting where this study took place was in the Athletic Training Room at Adams State University (ASU), a small rural NCAA Division II institution in Alamosa, Colorado. The Athletic Training Room is located in Plachy Hall (the athletics building) on the ASU campus.

Population

The participants in this study were male (N=3) and female (N=4) student-athletes, ages 18-21 years, at ASU that had been evaluated by a Certified Athletic Trainer and deemed as having sustained a concussion during the winter or spring athletic seasons of the 2014-2015 academic year at ASU. They were athletes from many different sports, including softball, men's lacrosse, women's soccer, and baseball. The concussions could have been athletic in nature or may have been sustained elsewhere, such as at home or at work. Participants ranged in level of sport experience from freshman to redshirt seniors (Freshmen N= 3, Sophomores N=3, Juniors N=1, Seniors N=0). The participants had varied concussion histories. Some had never experienced a concussion, and others had sustained multiple concussions. Five participants had a history of concussions, and two participants had no prior history. The participants all gave written consent (Appendix A) to be included in this study, prior to participation. The Adams State University Institutional Review Board reviewed this study for approval prior to the study. All athletes in this study were given baseline concussion testing before the onset of their participation.

Instrumentation

Several instruments were used in this study. They include:

*The Standardized Assessment of Concussion (SAC) test (*Appendix B*)*: This is a neurocognitive test that assesses immediate and delayed recall, concentration, strength and simple balance (Giza et al., 2013; Lear, Houang, 2013).

*The Balance Error Scoring System (BESS) test (*Appendix C*):* This is a balance test that assesses balance while standing in a parallel stance, tandem stance, and single, non-dominant foot stance while on a flat surface as well as a foam surface, all while the participants' eyes are closed, to disrupt proprioception (Bell et al., 2013).

*The Graded Symptom Scale Checklist (*Appendix D*)*: This is a list of questions that the participant will answer to allow the researcher to know if the participant is experiencing any concussion symptoms. It is comprised of 26 symptom options and the participant will grade each symptom severity on a scale of 0-6, where zero signifies no symptom at all, and six means the symptom could not be worse (Broglio et al., 2014; Lynall, Laudner, Mihalik, Stanek, 2013).

*The Rate of Perceived Exertion Scale (*Appendix E*):* This is a scale that allows a participant to indicate their level of exertion during a certain activity. The scale ranges from 6 to 20, where 6 denotes no exertion at all, and 20 denotes maximal exertion. While the participant is exercising on the bicycle, they can point to the number they are experiencing as the descriptions of the numerical scale is written on the chart (Stamford, 1976).

These tests are widely available to health care professionals and are being used for an educational purpose in this study. Therefore no copyright permission was needed.

Baseline Testing

All athletes at ASU, therefore all athletes included in this study, were baseline tested prior to their season of athletic participation. This was done after they report for the season, and not as a part of their pre-participation physical, which is completed in the summer before the approaching school year. This testing was done in the athletic training room. Each participant was either baseline tested by the researcher or another ATC at ASU. Baseline testing included the Standardized Assessment of Concussion (SAC) test (Appendix B) (Giza et al., 2013; Lear, Houang, 2013), the Balance Error Scoring System (BESS) test (Appendix C) (Bell, et al., 2013), and a Graded Symptom Scale Checklist (Appendix D) (Lynall et al., 2013).

The SAC test included sections that test immediate recall memory, delayed recall memory and concentration. Muscular strength and coordination were also tested in the SAC test. The SAC test has been shown to be valid and reliable in assessing concussions in athletics (Giza et al., 2013). Balance was tested during the BESS test. This was done through balance on both feet standing parallel, tandem and on one foot. This was first done on the hard ground, then on a foam pad, measuring 10"x10"x2.5", so as to disturb the flat surface. Both tests combined took about 10 minutes to administer. The BESS test has shown poor validity and reliability in diagnosing concussions, but has shown moderate to good validity and reliability in assessing postconcussion balance changes, once the concussion has been diagnosed (Bell et al., 2013). That is why the BESS test was included in the baseline testing.

A graded concussion symptom checklist was used to assess any concussion symptoms the participant may be experiencing. The checklist was numbered 0-6, zero signified no existence of that symptom, and six suggested the worst that symptom could possibly be. This let the researcher know if any symptoms may be typical when the participant was healthy. On this form the assessor also noted if the athlete had a history of concussions, and if so, how many they have experienced. Use of such a tool is recommended by the NATA in its position statement on concussions (Broglio et al., 2014).This position statement was a collaboration of Certified Athletic Trainers and physicians who are considered experts in the field of concussions.

Procedures

When a student-athlete at ASU was evaluated by an ATC or qualified physician, and diagnosed with a concussion, the team's assigned ATC reported the concussion to the researcher. The researcher then asked the student-athlete if they would volunteer for the study, and if so, the researcher recorded the student-athlete's history of concussions and then monitored how long their recovery took. For the purpose of this study, recovery meant full clearance by an ATC or qualified physician. Full clearance would be granted when the athlete returns to within two points of their baseline levels of the SAC and BESS tests, and reports absolutely no symptoms on the Graded Symptoms Scale Checklist, reports no use of pain medication, completes the final day of the RTP protocol, and reports no concussion symptoms 24 hours after the last day of the RTP protocol. This was made the standard for the Adams State University RTP protocol, though this is not necessarily the standard for other institutions.

The participant followed the Adams State University RTP protocol as follows:
"Once a student-athlete has been given the assessment of a concussion they will refrain from all physical activity until symptoms have resolved. This includes, but is not limited to practices, competitions, weight lifting, physical education classes, etc. They are to report to their assigned athletic trainer daily (who will then report findings to the researcher), so their symptoms may be

closely monitored. Once the athlete reports no symptoms on the Graded Symptom Scale Checklist, reports a lack of pain medication use, as well as reaching baseline scores on the SAC and BESS tests, they must wait 24-48 hours to begin the return to play protocol.

The return to play protocol was as follows:

- Day 1: Cognitive Stressors
    - 30 minutes of supervised cognitive testing done through computer gaming.
    - Either Minesweeper or Spider Solitaire will be played to induce concentration from the student-athlete
    - Athlete will take the SAC and BESS tests and the Graded Symptom Scale Checklist to ensure they are back to their baseline scores, or within 2 points on each test (Return-to-baseline testing). The SAC and BESS tests are performed on day 1 of the RTP, as long as they are passed. The Graded Symptom Scale Checklist is repeated daily.
- Day 2: Exertional Stressors
    - 10 minutes of moderate effort on the stationary bike- the Athletic Trainer will determine what is a moderate effort based on a Rate of Perceived Exertion (RPE) Scale (Appendix E) ranging from 6 (easy) to 20 (maximal exertion)
        - Moderate effort ranges from 12-14 on the RPE scale
    - 10 minutes of: 30 seconds maximal effort while biking followed by 30 seconds of minimal effort while biking
    - 10 sets of 10 repetitions of push-ups, jumping jacks then sit ups (body weight squats may be substituted for push-ups if the student-athlete's arms become fatigued, thus breaking good form)

- Day 3:
  - Non-contact practice with their team
  - There should be no chance that the head will be hit again during this practice
- Day 4:
  - Full contact practice with their team
  - Any drills the team does, the recovering student-athlete should participate in
  - If applicable, there needs to be contact drill done this day
- Day 5:
  - Full clearance

Each step of the return to play can be administered only if the student-athlete has been symptom free for 24 hours at least, therefore each phase needs to be administered at least 24 hours apart" (Concussion Management and Return to Play Policy, Adams State University, 2014).

When an ASU athletic trainer deemed that an athlete has a concussion, they informed the researcher. The researcher then met with the concussed athlete. The athlete was then asked to participate in the study. If they agreed they were given the informed consent form to read and sign. Once this had been completed, they were retested to verify the results from the initial exam. Concussed athletes were to check in daily with their assigned athletic trainer as a part of the concussion protocol at ASU. When the assigned athletic trainer judged the participant had returned to their baseline measurements, they were again referred to the researcher. The researcher then administered the SAC and BESS tests and Graded Symptom Scale Checklist. If they were found to be eligible to begin the ASU RTP protocol, they were referred back to their assigned athletic trainer to complete the protocol. Once the protocol was successfully completed, the date of clearance was reported to the researcher so a total number of days they were withheld from their sport could be recorded, and later analyzed.

Research Design

This was a cohort study conducted over a period of 16 weeks. Any student-athlete that was given the assessment of a concussion during the period of study, and met the study criteria, was asked to participate in the study.

The independent variables for this study were the concussed athletes, concussion histories of student-athletes and their gender.

The dependent variables for this study were scores on the SAC and BESS test, and the Graded Symptom Scale Checklist from baseline, post-injury, and return-to-baseline testing, and recovery time.

These tests were administered before the student-athlete's competitive season began, and then once symptoms subsided after a concussion. These testing periods were referred to as "baseline testing", which took place before the competitive season, and "post-injury concussion testing," which took place once a concussion was suspected. These scores were used to help determine recovery time from concussions.

The timeline of the concussion return to play protocol was as follows:

- Baseline testing using the SAC and BESS tests, and the Graded Symptom Scale Checklist before the competitive season begins
- Concussive episode occurs
- Athlete is assessed by an ATC, using the SAC and BESS tests and the Graded Symptom Scale Checklist and it is determined the athlete sustained a concussion (Post-injury concussion testing)

- The athlete rests from all activity aside from activities of daily living, and checks in with the researcher daily to monitor the athlete's symptoms, using the Graded Symptom Scale Checklist
- When the athlete reports no symptoms for 24 hours or more, they may begin the ASU RTP protocol
- The athletes will be tested again using the SAC and BESS test, and the Graded Symptom Scale Checklist (Return-to-baseline testing) on day 1 of the RTP protocol
- Once the athlete successfully completes the ASU RTP protocol, they will be considered fully recovered and will be released for full participation in their sport
- Time to recovery will be recorded from the time of post-injury concussion testing to the completion of the RTP protocol.

The researcher hoped to have at least 10 participants in this study. Due to the unpredictable nature of athletics, only 7 participants were available for testing during the Spring semester of 2015.

Reliability/Validity

The SAC test has been shown to be valid and reliable in assessing concussions in athletics (Giza et al., 2013). Sensitivity of diagnosing concussions with the SAC test is 80-94%, and specificity was found to be 76-91%. The BESS test has shown poor validity and reliability in assessing concussions, but has shown moderate to good validity and reliability in assessing postconcussion balance changes, once the concussion has been diagnosed (Bell et al., 2013). Interrater reliability averaged between nine different studies was found to be between .44 and .96. Bell et al. (2011) showed that the BESS test does not discriminate between athletes with or without concussions. The BESS ($p=0.87$) could not detect differences in 247 high school athletes with and without concussions. For these reasons, the SAC and BESS tests were be used in conjunction with one another so as to test both balance and cognitive abilities before and after concussions. Using the two tests combined allowed the researcher to see the whole physiological picture of ways the athlete may be affected by a concussion, as multiple aspects of the brain are being tested.

The Graded Symptom Scale Checklist was deemed a useful tool by the National Athletic Trainers' Association (NATA). The NATA was informed by a panel of Certified Athletic Trainers as well as physicians, all experts in the field of concussions, that the checklist is valuable in assessing concussion symptoms in athletes (Broglio et al., 2014). Therefore this test is valid and reliable, as stated by experts in the medical field.

The ASU RTP protocol has not been tested for validity or reliability, but has been created following the guidelines set out by the NATA. These guidelines were established by a team of athletic trainers and physicians using the most current research on concussions (Broglio et al., 2014).

Treatment of Data/ Statistical Analysis

The collected data was compiled in an Excel spreadsheet. The data gathered though concussion testing and post-concussion monitoring was run through SPSS, version 23, 2015. Non-parametric Mann-Whitney U tests were used to determine the differences between concussion history and recovery time, and gender and recovery time. Statistically significance was determined at $p<0.05$. Descriptive statistics were also run on test scores from baseline, post-injury, and return to play testing and reported as mean plus or minus the standard deviation. This data was then split and compared against gender and concussion history.

Chapter 4: Results

Descriptive Statistics

No participants that agreed to participate in the study needed to be excluded. All the participants were actively enrolled in ASU, active and eligible athletes with the ASU athletic department, and they had no history of mental disease. There were a total of seven participants (four females and three males). Five participants had a history of previous concussion, two had no prior history. The participants were from a variety of athletic teams including women's soccer (N=2), men's lacrosse (N=2), baseball (N=1), and softball (N=2). The ages of the participants ranged from 18 years old to 21 years old. Three participants were Freshmen, three participants were Sophomores, and one participant was a Junior.

Descriptive statistics were run on the baseline, post-concussion, and return to play SAC, BESS and Graded Symptom Scale Checklist tests (Appendix F). The total possible scores for the tests were 30, 60, and 156 respectively. The mean SAC scores (out of a total possible score of 30) were as follows: at baseline testing 26.86 ± 1.57, at post-injury testing 25.43± 2.76, and at return to play testing 26.71 ± 1.49. The mean BESS scores (out of a total possible score of 60) were as follows: at baseline testing 13.29 ± 5.28, at post-injury testing 22.71 ± 10.92, and at return to play testing 11.00 ± 5.74. The mean Graded Symptom Scale Checklist scores (out of a total possible score of 156) were as follows: at baseline testing 1.14 ± 2.61, at post-injury testing 33.57 ±8.84, and at return to play testing 3.68 ±5.52. There is not a "normal" score that a medical professional would look for. This is why baseline testing is done, so that there is a "control" number for athletic trainers and researchers to work off of. Athletes are compared to the baseline numbers if a concussion is suspected and the post-injury numbers are then compared to their baseline numbers, which represent their individual "normal." Finally, the mean number of days out of sport was N=15.00 ±8.20 days. The range of days missed from sport was 8 to 32 days.

The data was then split by gender to compare all the testing scores and days missed from sport. Descriptive statistics on that data (Appendix F) showed that on the SAC testing, the female participants (n= 3) scored an average of 28.00 ± 1.00 on baseline testing and the male participants (n= 4) scored an average of 26.00 ±1.41. For post-injury SAC testing, females scored an average of 27.33 ±0.57 and males scored an average of 24.00 ±2.94. Finally, for the SAC test, females scored an average of 7.33 ±2.08 on RTP testing and males scored an average of 26.25 ±0.95.

On BESS testing, the females scored an average of 17.00 ±6.08 on baseline testing and males scored an average of 10.50 ±2.64. For post-injury BESS testing, females averaged a score of 29.00 ±12.28 and males averaged a score of 18.00 ±8.28. Lastly, for the BESS test, females scored an average of 13.67 ±8.50 on RTP testing and males averaged 9.00 ±2.30.

On Graded Symptom Scale Checklist testing, the female participants scored an average of 5.00 ±7.81 on baseline testing and males scored an average of 3.00 ±4.24. Females scored an average of 27.00 ±3.60 on post-injury testing on the Graded Symptom Scale Checklist and males averaged 38.50 ±8.50 on post-injury testing. Females averaged 0.00 ±0.00 and males 2.00 ±3.36 on RTP testing with the Graded Symptom Scale Checklist.

Female participants averaged 21.33 ±9.29 days missed from sport with a range of 15-32 days, and the male participants averaged 10.25 ±2.63 days missed from sport with a range of 8-14 days. These numbers are not statistically significant (p=0.057), but they are approaching significance.

The data was also split to compare concussion history and time missed from sport (Appendix F).The SAC scores for participants with a history of concussion (n=5) were 26.60 ±1.51 at baseline testing and those without a concussion history (n=2) scored an average of 27.50 ±2.12. Those with a history of concussions scored an average of 24.80 ±3.11 at post-injury testing and those without a history of concussions scored an average of 27.00 ±0.00. Those with a concussion history averaged 26.40 ±1.67 at RTP testing while those without a concussion history scored 27.50 ±0.70.

Average BESS scores for participants with a history of concussions were 13.20 ±6.45 at baseline and for those without a history of concussions, the average score was 13.50 ±0.70. Participants with a concussion history scored an average of 19.40 ±7.66 at post-injury BESS testing, while those without a history of concussion scored an average of 31.00 ±16.97. Finally, at RTP participants with a history of concussions scored an average of 11.20 ± 6.57 and those without a concussion history scored an average of 10.50 ±4.95 on the BESS test.

For participants with a concussion history, the Graded Symptom Scale Checklist scores were 4.80 ±6.38 at baseline testing and 1.50 ±2.12 for those without a concussion history. At post-injury testing, those with a concussion history scored an average of 33.20 ±10.52 on the Graded Symptom Scale Checklist, and those without a concussion history scored an average of 34.50 ±4.95. Finally, on the Graded Symptom Scale Checklist those with a history of concussions scored an average of 1.60 ±3.05 at RTP testing, while those without a concussion history scored an average of 0.00 ±0.00.

The average number of days missed from sport for those with a concussion history was 12.60 ±3.91 days, with a range of 8-17 days. The average of days missed for those without a concussion history was 21.00 ±15.56 days, with a range of 10-32 days missed.

Data Analysis

Data was analyzed using SPSS version 23, 2015, with significance set at $p<0.05$ (Appendix F). Mann-Whitney U tests were run to determine significance between concussion history and time out of sport, and gender and time out of sport. The results from the Mann-Whitney U test comparing recovery of student-athletes with a concussion history to those without and time out of sport showed that there was no statistically significant difference between recovery time and history of concussion ($p=0.571$) (Table 1). The results from the second Mann-Whitney U test showed that there was no significant difference between gender and recovery time ($p=0.057$) (Table 2).

Though there is no statistical significance between gender and recovery time, the outcome is approaching significance ($p=0.057$). These results may be clinically significant. In the current study, males took an average of almost 10 days less to recover than females. Ten days in the athletic setting can mean an additional 1-3 competitions. This is very important to athletes, as well as coaches. This is a "clinically significant" or meaningful finding, even though it is not statistically significant.

Differences in recovery time in respect to history of concussions were also not statistically significant. However, this may be "clinically significant." Those without a history of concussions took an average of 12.60 ± 3.91 days to recover while those with a history of concussions took an average of 21.00 ± 15.56 days to recover. That is a difference of almost 9 full days in recovery times. Again, this would be an important difference in time to athletes and coaches.

***Table 1**. Descriptive Statistics History of concussion data (yes, n=5; no, n=2)*

*significance level $p<0.05$

History of Concussion		Mean	SD
Yes	Baseline SAC	26.00	1.51
Yes	Post-injury SAC	24.80	3.11
Yes	RTP SAC	26.40	1.67
No	Baseline SAC	27.50	2.12
No	Post-injury SAC	27.00	0.00
No	RTP SAC	27.50	0.70

History of Concussion		Mean	SD
Yes	Baseline BESS	13.20	6.45
Yes	Post-injury BESS	19.40	7.66
Yes	RTP BESS	11.20	6.57
No	Baseline BESS	13.50	0.70
No	Post-injury BESS	31.00	16.97
No	RTP BESS	10.50	4.95

History of Concussion		Mean	SD
Yes	Baseline GSSC	4.80	6.38
Yes	Post-injury GSSC	33.20	10.52
Yes	RTP GSSC	1.60	3.05
No	Baseline GSSC	1.50	2.12
No	Post-injury GSSC	34.50	4.95
No	RTP GSSC	0.00	0.00

Table 2. *Descriptive Statistics Gender data (female, n=3; male, n=4)*

*significance level $p<0.05$

Gender		Mean	SD
F	Baseline SAC	28.00	1.00
F	Post-injury SAC	27.33	0.57
F	RTP SAC	27.33	2.08
M	Baseline SAC	26.00	1.41
M	Post-injury SAC	24.00	2.94
M	RTP SAC	26.25	0.95

Gender		Mean	SD
F	Baseline BESS	17.00	6.083
F	Post Injury BESS	29.00	12.288
F	RTP BESS	13.67	8.505
M	Baseline BESS	10.50	2.646
M	Post Injury BESS	18.00	8.287
M	RTP BESS	9.00	2.309

Gender		Mean	SD
F	Baseline GSSC	5.00	7.810
F	Post Injury GSSC	27.00	3.606
F	RTP GSSC	0.00	0.000
M	Baseline GSSC	3.00	4.243
M	Post Injury GSSC	38.50	8.505
M	RTP GSSC	2.00	3.367

Chapter 5: Discussion

Discussion and interpretation of findings

The findings show that there was no statistical significance between a history of concussion and recovery time. The results of the Mann-Whitney U test was p=0.571, which is not close to statistical significance. This is most likely due to a small population size of seven participants. Studies performed by Castile et al. (2010), Guskiewicz et al. (2003), and Nelson, Janecek, and McCrea (2013), all show that there is a relationship between previous concussions and a longer recovery. This means that if an athlete has had a previous concussion and sustains another one, they have a higher chance of a longer recovery than an athlete who sustains a concussion with no prior history of concussions. All of these studies had much larger numbers of participants, with Castile et al. (2010) studying over 2400 participants, and Guskiewicz et al. (2003) studying 2905 participants. It is possible that with a larger number of participants, the current study would have shown similar results. Previously mentioned studies have shown that 31% of concussed athletes recovered within a day, 60% of athletes recovered in 1-7 days, and 11% of athletes took longer than a week to recover (Guskiewicz, et al., 2003).

The lack of statistical significance between a history of concussion and recovery time may also be due to one of the two participants without a concussion history having an extremely extended recovery time (32 days), also known as post-concussion syndrome. This, in addition to the uneven numbers of participants with (N=5) and without (N=2) concussion histories, may have contributed to the Mann-Whitney U test being so far from statistical significance. A study by Castile, Collins, McIlvain, Comstock (2012) showed that sustaining a recurrent concussion will result in a longer time out of sport. These authors had a total of 2,417 participants. Another study by Covassin, Moran and Wilhelm (2013) also showed that a history of concussion would lead to a longer recovery. They used 598 participants in their study. Both of the aforementioned studies also took participants from a vast number of athletic disciplines including football, basketball (male and female), soccer (male and female) and volleyball (male and female). The current study lacked participants from football which historically has the highest percentage of concussions of all sports (Lincoln et. al., 2011). Soccer was also in the off-season during the current study so there were not as many concussions as there may have been if they were in-season. Women's soccer has one of the highest percentage of concussions in athletics, so had that sport been in-season, there may have been more concussions to study (NCAA, 2009).

The findings show that there was no statistical difference between gender and recovery time. Although there is not a statistical significance, there is most likely a clinical/ practical significance. The results of the related Mann-Whitney U test was $p=0.057$, which is close to the statistical significance set at $p<0.05$. The recovery times between the genders were approaching significance at 21.33 ± 9.29 days for females, and 10.25 ± 2.63 days for males. This difference, though not statistically significant, would allow male athletes back to competing almost 10 days before their female counterparts.

If there were a larger sample size, the results may have been statistically significant. Studies such as those performed by Colvin, Mullen, and Comstock (2009) and Scopaz and Hatzenbuehler (2013), showed that females took longer to recover than males. Their studies also had a much larger sample size than the current study. Females have been shown to report more symptoms during a concussive episode when compared to males, so this could be a reason why they take longer to recover. Women tend to report more symptoms than men, which may be due to the belief that women are more communicative, as well as men feeling the need to be masculine and mask or downplay pain (Harmon et. al., 2013). When there are more symptoms to recover from, more time would be needed to complete the recovery and begin the RTP.

It should be noted that athletes with a history of concussions scored better on the BESS test than those without a history of concussions (13.20± 6.45, 19.40± 7.66 vs. 13.50± .707, 31.00± 46.97 respectively). This could be because there were 5 participants in the history of concussion group, and only 2 without a concussion history. The outcome may have been different if there was a larger population or balanced groups. There also may be a "learning curve" for athletes who have taken the BESS test before (i.e. those who have a history of concussion, and therefore have taken the BESS test multiple times). There is limited research on the BESS test, so additional research on the test, and any of the flaws it may have is suggested.

Another reason for differences in the current study and other studies cited could be due to protocol. While the NATA has put out recommendations and guidelines, there is not a standard RTP protocol across the board for all schools, institutions, and sports. There can be variances in recovery timelines, criteria for when an athlete can begin the protocol, and what activities are carried out in the recovery. These inconsistencies can all be included in different RTP protocols while still following guidelines set out by experts. Slight differences in protocols among studies may affect the outcome and length of recovery of athletes. Differences in concussion RTP protocols from the other studies may be a reason why the current study found no statistically significant differences. A study by Iverson (2007), as well as a position statement by Harmon et al. (2013), stated that all athletes need to be treated on an individual basis when it comes to concussions. These individual differences can account in differences in statistical findings.

Recommendations

There still needs to be more information collected to really understand concussions and their effects on athletes. That would be the first recommendation to come out of this study. Concussions are very complex and unique to each individual that sustains one, making them more difficult to study than other injuries. The more data there is, the better concussions can be understood and treated. With a better, clearer understanding of concussions, athletes and the general population can be better treated and prepared for a concussion recovery. This would lead to better overall treatment and quality of life. If people were more aware of what concussions are, how they can affect a person, and what the consequences are of ignoring them, they may be more likely to treat them properly. It has been previously shown that males are more likely to underreport symptoms of concussion, but if they knew the consequences, they may be more likely to speak up (Bloom et al., 2008).

Another recommendation is that future researchers should use more participants. More participants would make the data even stronger and more reliable. It would also lead to potentially more balanced and representative data in terms of gender, concussion history and sport discipline. To achieve this, it is suggested that future researchers collect data over a longer period of time. In the current study, data was only collected during the spring semester. To gather a greater amount of data, it is suggested that future studies collect data over both fall and spring semesters. This will allow more time for concussions to occur as well as allowing more sports to be studied, including the seasons of both football and women's soccer. This would be beneficial as these sports have some of the highest percentages of concussion (Gassel et al., 2007).

Future researchers should have equal groups of athletes with and without a concussion history so there will be no skewing of the data. This study had five participants with a history of concussion, and only 2 participants without a concussion history. There should continue to be a variety of sports used in future research so there is not a bias toward one discipline or another. There are already many studies that involve sports most prone to concussions, such as football and soccer (Giza et al., 2013; Linoln et al., 2011). If there were more studies that incorporated a wider variety of sports, data and understanding of concussions would be far greater. Once again, the more data there is available, the more knowledgeable health care professionals and the general public can be.

The researcher would recommend that the same tests used in this study be used in future studies. The tests used in this study (SAC, BESS, and GSSC tests) covered most areas that concussions can affect. The tests covered cognitive ability, balance, and physical signs and symptoms. This allowed the researcher to have a more well-rounded picture of how the concussion was affecting the athlete, as well as when they were back to baseline, or their individual "normal." The only change in testing the researcher would recommend would be to use a computer-based program for the testing, such as the ImACT test. This would aid in ease of use, administering the tests, and storage of the tests.

It would also be advised for future studies to take into consideration the mental readiness to return to play. The psychological aspects of a concussion should not be overlooked. These aspects can range from feeling alienated from the team due to the need for rest, depression, loss of identity as an athlete, and fear of re-injury (Chertok, 2013). These factors can manifest physically through tense muscles, increased heat rate, and sleep disorders (Chertok, 2013). Athletic trainers are trained in basic counseling, but there should be help from a more qualified source if mental health issues are suspected. There should also be more research done in this area so that medical professionals know what to look for, and how to better assist athletes.

Though the idea of a "common" or "universal" protocol may seem like something that should have been put into place long ago, it still may not be practical. Due to the wide and varying nature of athletics- youth, high school, recreational, semi-professional, professional, different athletic disciplines- there may not be one singular way to encompass everything necessary to ensure all involved are returned to play safely and effectively. The best way to make sure this is done is to stay on top of the most recent research and professional recommendations from governing boards, such as position statements from the NATA and the American Medical Society for Sports Medicine (Broglio et al., 2014; Harmon et al., 2013).

Chapter 6: Summary and Conclusions

The purpose of this study was to determine the differences between a history of concussions and recovery time in NCAA Division II male and female collegiate athletes. The secondary purpose was to determine if there is a difference in gender when it comes to concussion recovery. It was hypothesized, based on previous but limited research, that a history of concussions in collegiate athletes would extend the recovery time from the most recent concussion. It was also hypothesized that women would be given the assessment of a concussion in greater numbers than men, and their recovery time would be longer than their male counterparts. The data showed that there was no statistical significance ($p > 0.05$) in concussion recovery time in relation to a concussion history or gender.

It was concluded from this study that there were no statistical differences in recovery time in regards to concussion history or gender, though gender differences approached significance ($p = 0.057$) in the current study. These results in regards to gender may be clinically significant. Females averaged a longer recovery time than males did: 21.33 ±9.29 days and 10.25 ± 2.63 days, respectively. The range of female recovery was 15 to 32 days, whereas males recovered from 8 to 14 days. In regards to concussion history (both male and female), those with a history of concussion were out of sport for 12.60 ± 3.91 days and those without a concussion history were out of sport 21.00 ± 15.56 days. The range of days missed for those with a concussion history was 8-17 days, and 10-32 days for those without a concussion history.

Practical Applications

This study can be used to add to the ever growing collection of concussion data. Athletic trainers and other health care professionals can use the data collected in this study to better treat concussions in their athletes. Having the knowledge of average recovery time from concussions, as well as how it relates to gender and concussion history, will allow medical professionals to better educate athletes, coaches and parents about what they can expect. They will know what an average recovery time period should be, and based on this study, will be able to adjust according to gender. They will also know if and when the recovery period has moved into post-concussion syndrome (symptoms lasting longer than seven days), and need to seek additional help. This should help put parents and athletes at ease about their recovery, and it could also help coaches plan better for future competitions. They would have an idea of when the athlete would be able to possibly return to play so they would know if they needed to bring someone else into that position for the long term or not.

It would also be beneficial to any athletic department to have a campus wide concussion protocol. This would help get all athletic trainers, coaches, and athletes on the same page. All parties involved would know what to expect if and when a concussion occurs. Athletes should complete baseline testing before their season begins, so there is something to compare to if a concussion is suspected. There should also be a graduated return to play program that addresses multiple aspects of the concussion, such as cognitive ability, balance, and physical signs and symptoms (Broglio et al., 2014). Having a regulated system should help ensure that no athlete is returned to sport before they are ready, putting them at risk for more severe injury, like second impact syndrome, that can lead to extreme mental impairment or usually death ("Concussion complications", 2014).

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Appendix A

Informed Consent

You are being asked to participate in a research study. This form provides you with information about the study. The researcher and/or a qualified representative will also describe this study to you and answer any questions you may have. Please read the information below and ask for clarification for any parts on which you have questions. Your participation in this study is completely confidential and voluntary. You may refuse to participate or withdraw at any time without penalty.

Title of Research Study: The Effects of Multiple Concussions on Recovery Time in Division II Collegiate Athletes

Principal Researcher: Megan Ulery, Masters Student, Department of Human Performance and Physical Education, (708)-703-117, uleryml@grizzlies.adams.edu

Thesis Advisor: Dr. Tracey Robinson, Professor, Department of Human Performance and Physical Education, (719) 587-7663, tlrobins@adams.edu

Purpose of Study: The primary purpose of this study is to determine the relationship between a history of concussions and recovery time in Division II male and female collegiate athletes. The secondary purpose is to determine if there is a difference in gender when it comes to concussion recovery.

Participation in Study:

You will be assessed daily by a Certified Athletic Trainer to monitor progress with your concussion. You will be tested on memory, concentration, balance, and asked about symptoms you may be feeling. Once you have been symptom free for 24 hours, you will begin a return to play protocol that has been set in place by the Head Athletic Trainer at Adams State University. This involves:

- Day 1: Cognitive Stressors
    - 30 minutes of supervised cognitive testing
- Day 2: Exertional Stressors
    - 10 minutes of moderate effort on the stationary bike- the Athletic Trainer will determine what is a moderate effort
    - 10 minutes of: 30 seconds maximal effort while biking followed by 30 seconds of minimal effort while biking
    - 10 sets of 10 repetitions of push-ups, jumping jacks then sit ups (body weight squats may be substituted for push-ups if the student-athlete breaks good form)
- Day 3:
    - Non-contact practice with their team
    - There should be no chance that the head will be hit again during this practice
- Day 4:
    - Full contact practice with their team
    - Any drills the team does, the recovering student-athlete should participate in
    - If applicable, there needs to be contact drill done this day

- Day 5:
    - Full clearance

Risks and Discomfort:

There are no known additional risks or discomforts with participation in this study.

Benefits:

Participation in this study will benefit others through an addition of knowledge in the area of concussions, as well as an increased personal knowledge of concussions.

Compensation:

At this time, there will be no compensation for participation in this study.

Withdrawing:

You may choose to withdraw from this study at any time, without penalty.

Questions about Withdrawing:

You may withdraw from this study at any time. Please let the Principal Researcher know in person, by phone, or by email as soon as possible.

Privacy:

Your privacy is always the number one concern. All data files will be stored in a locked filing cabinet in the Adams State Athletic Training Room. Only the primary researcher will have access to the files. Names/identities will never be revealed even at the conclusion of the study. Any written or oral publication and/or presentation of this research will only show group data; you as an individual subject will not be identified.

You have been informed about this study's purpose, procedures, possible benefits and risks, and you have received a signed copy of this form. You have been given the opportunity to ask questions before you sign, and you have been told that you can ask other questions at any time. By signing this form, you have chosen to voluntarily participate in this study. By signing this form, you are not waiving any of your legal rights.

____

Printed Name of Subject Date

____

Signature of Subject Date

____

Signature of Principal Researcher Date

ADAMS STATE COLLEGE
INSTITUTIONAL REVIEW BOARD
Approved on: 12-19-14
Expires on: 12-19-15

Appendix B

Standardized Assessment of Concussion test

Standardized Assessment of Concussion (SAC)

ORIENTATION Score: ___ / 5

What month is it?	0 ☐	1 ☐
What is the date?	0 ☐	1 ☐
What day of the week is it?	0 ☐	1 ☐
What year is it?	0 ☐	1 ☐
What time of day is it? *(w/in 1 hour)*	0 ☐	1 ☐

IMMEDIATE MEMORY Score: ___ / 15

Form A	Form B	Form C	Form D
Elbow	Candle	Baby	Monkey
Apple	Paper	Monkey	Penny
Carpet	Sugar	Perfume	Blanket
Saddle	Sandwich	Sunset	Lemon
Bubble	Wagon	Iron	Insect

	Trial 1	Trail 2	Trail 3
Word 1	0 ☐ 1 ☐	0 ☐ 1 ☐	0 ☐ 1 ☐
Word 2	0 ☐ 1 ☐	0 ☐ 1 ☐	0 ☐ 1 ☐
Word 3	0 ☐ 1 ☐	0 ☐ 1 ☐	0 ☐ 1 ☐
Word 4	0 ☐ 1 ☐	0 ☐ 1 ☐	0 ☐ 1 ☐
Word 5	0 ☐ 1 ☐	0 ☐ 1 ☐	0 ☐ 1 ☐

NEUROLOGIC SCREENING

Loss of Consciousness: *(occurrance, duration)*

Retrograde Amnesia

Antegrade Amnesia

Strength

Sensation

Coordination

CONCENTRATION: *Digits Backwards* Score: ___ / 5

Form A			
4-9-3	6-2-9	0 ☐	1 ☐
3-8-1-4	3-2-7-9	0 ☐	1 ☐
6-2-9-7-1	1-5-2-8-5	0 ☐	1 ☐
7-1-8-4-6-2	5-3-9-1-4-8	0 ☐	1 ☐
Form B			
5-2-6	4-1-5	0 ☐	1 ☐
1-7-9-5	4-9-6-8	0 ☐	1 ☐
4-8-5-2-7	6-1-8-4-3	0 ☐	1 ☐
8-3-1-9-6-4	7-2-4-8-6-5	0 ☐	1 ☐
Form C			
1-4-2	6-5-8	0 ☐	1 ☐
1-8-3-1	3-4-8-1	0 ☐	1 ☐
4-9-1-5-3	6-8-2-5-1	0 ☐	1 ☐
3-7-6-5-1-9	9-2-6-5-1-4	0 ☐	1 ☐

Months in Reverse Order

Dec_Nov_Oct_Sept_Aug_ Jul_Jun_May_Apr_Mar_Feb_Jan

0 ☐ 1 ☐

DELAYED RECALL Score: ___ / 5

Word 1	0 ☐	1 ☐
Word 2	0 ☐	1 ☐
Word 3	0 ☐	1 ☐
Word 4	0 ☐	1 ☐
Word 5	0 ☐	1 ☐

SCORE TOTALS

Orientation = ___ / 5

Immediate Memory = ___ / 15

Concentration = ___ / 5

Delayed Recall = ___ / 5

Overall Score / 30

https://www.greenhosp.org/upload/docs/SAC%20form.pdf

(Giza et al., 2013)

Appendix C

Balance Error Scoring System

The Balance Error Scoring System (BESS)

Obtain Preseason Baseline Score; Compare with Post-Concussion Score[33-34]

The Balance Error Scoring System[33-34] provides a portable, cost-effective and objective method of assessing static **postural stability.** The BESS can be used to assess the effects of mild head injury on static postural stability. Information obtained from this clinical balance tool can be used to assist clinicians in making return to play decisions following mild head injury. The BESS can be performed in nearly any environment and takes approximately 10 minutes to conduct.

The balance-testing regime consists three stances on two different surfaces. The three stances are **double leg stance, single leg stance** and **tandem stance**. The two different surfaces include both a **firm** (ground) and **foam** surface. **Athletes' stance should consist of the hands on the iliac crests, eyes closed and a consistent foot position depending on the stance.** Shoes should not be worn.

In the **double leg stance**, the feet are flat on the testing surface approximately pelvic width apart.

In the **single leg stance** position, the athlete is to stand on the non-dominant leg with the contralateral limb held in approximately 20° of hip flexion, 45° of knee flexion and neutral position in the frontal plane.

In the **tandem stance** testing position, one foot is placed in front of the other with heel of the anterior foot touching the toe of the posterior foot. The athlete's non-dominant leg is in the posterior position. Leg dominance should be determined by the athlete's kicking preference.

Administering the BESS: Establish baseline score prior to the start of the athletic season. After a concussive injury, re-assess the athlete and compare to baseline score. Only consider return to activity if scores are comparable to baseline score. Use with Standardized Symptom Scale Checklist.

Scoring the BESS: Each of the trials is **20 seconds.** Count the number of errors (deviations) from the proper stance. The examiner should begin counting errors only after the individual has assumed the proper testing position.

Double Leg Stance Firm Surface | Single Leg Stance Firm Surface | Tandem Stance Firm Surface | Double Leg Stance Foam Surface | Single Leg Stance Foam Surface | Tandem Stance Foam Surface

Errors:
- **Moving the hands off the hips**
- **Opening the eyes**
- **Step, stumble or fall**
- **Abduction or flexion of the hip beyond 30°**
- **Lifting the forefoot or heel off of the testing surface**
- **Remaining out of the proper testing position for greater than 5 seconds**

The maximum total number of errors for any single condition is 10.

If a subject commits multiple errors simultaneously, only one error is recorded.

B.E.S.S. SCORECARD

Count Number of Errors max of 10 each stance/surface	FIRM Surface	FOAM Surface
Double Leg Stance (feet together)		
Single Leg Stance (non-dominant foot)		
Tandem Stance (non-dominant foot in back)		
TOTAL SCORES: total each column		
B.E.S.S. TOTAL: (Firm+Foam total)		

http://knowconcussion.org/wp-content/uploads/2011/06/BESS.jpg

(Bell et al., 2013)

Appendix D

Graded Symptoms Checklist Scale

Graded Smyptom Scale Checklist						
Symptoms	Baseline	Post-injury	Date	Date	Date	Date
Blurred Vision						
Dizziness						
Drowsiness						
More Sleep than Usual						
Easily Distracted						
Fatigue						
Feeling "In a Fog"						
Headache						
Unusually Emotional						
Irritabilty						
Loss of Consciousness						
Loss of Orientation						
Memory Problems						
Nauseus						
Nervousness						
Personality Changes						
Poor Balance						
Ringing in Ears						
Sadness						
Seeing Stars						
Sensitivty to Light						
Sensitivty to Noise						
Sleep Disturbances						
Vacant Stares						
Vomiting						
Total Symptom Score						

(Broglio et al., 2014)

Appendix E

Rate of Perceived Exertion

Rating	Perceived Exertion
6	No exertion
7	Extremely light
8	
9	Very light
10	
11	Light
12	
13	Somewhat hard
14	
15	Hard
16	
17	Very hard
18	
19	Extremely hard
20	Maximal exertion

http://www.thehubsa.co.za/forum/topic/131403-berg-and-bush-2013/page-19

(Stamford, 1976)

Appendix F

Raw Data and Statistical Analysis

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Number of days out of sport	7	8	32	15.00	8.206
Valid N (listwise)	7				

Descriptive Statistics

	N	Range	Minimum	Maximum	Sum	Mean	Std. Deviation	Variance
Baseline SAC score	7	5	24	29	188	26.86	1.574	2.476
PostInjury SAC score	7	8	20	28	178	25.43	2.760	7.619
RTP SAC score	7	4	25	29	187	26.71	1.496	2.238
Valid N (listwise)	7							

Descriptive Statistics

	N	Range	Minimum	Maximum	Sum	Mean	Std. Deviation	Variance
Baseline BESS score	7	16	8	24	93	13.29	5.282	27.905
Post-injury BESS score	7	37	6	43	159	22.71	10.920	119.238
RTP BESS score	7	17	5	22	77	11.00	5.745	33.000
Valid N (listwise)	7							

Descriptive Statistics

	N	Range	Minimum	Maximum	Sum	Mean	Std. Deviation	Variance
RTP GSSC score	7	7	0	7	8	1.14	2.610	6.810
Post-injury GSSC score	7	23	24	47	235	33.57	8.848	78.286
Baseline GSSC score	7	14	0	14	27	3.86	5.521	30.476
Valid N (listwise)	7							

Descriptive Statistics

Gender		N	Minimum	Maximum	Mean	Std. Deviation
Female	Baseline SAC score	3	27	29	28.00	1.000
	PostInjury SAC score	3	27	28	27.33	.577
	RTP SAC score	3	25	29	27.33	2.082
	Valid N (listwise)	3				
Male	Baseline SAC score	4	24	27	26.00	1.414
	PostInjury SAC score	4	20	27	24.00	2.944
	RTP SAC score	4	25	27	26.25	.957
	Valid N (listwise)	4				

Descriptive Statistics

Gender		N	Minimum	Maximum	Mean	Std. Deviation
Female	Baseline BESS score	3	13	24	17.00	6.083
	Post-injury BESS score	3	20	43	29.00	12.288
	RTP BESS score	3	5	22	13.67	8.505
	Valid N (listwise)	3				
Male	Baseline BESS score	4	8	14	10.50	2.646
	Post-injury BESS score	4	6	24	18.00	8.287
	RTP BESS score	4	7	11	9.00	2.309
	Valid N (listwise)	4				

Descriptive Statistics

Gender		N	Minimum	Maximum	Mean	Std. Deviation
Female	Baseline GSSC score	3	0	14	5.00	7.810
	Post-injury GSSC score	3	24	31	27.00	3.606
	RTP GSSC score	3	0	0	.00	.000
	Valid N (listwise)	3				
Male	Baseline GSSC score	4	0	9	3.00	4.243
	Post-injury GSSC score	4	27	47	38.50	8.505
	RTP GSSC score	4	0	7	2.00	3.367
	Valid N (listwise)	4				

Descriptive Statistics

Gender		N	Minimum	Maximum	Mean	Std. Deviation
Female	Number of days out of sport	3	15	32	21.33	9.292
	Valid N (listwise)	3				
Male	Number of days out of sport	4	8	14	10.25	2.630
	Valid N (listwise)	4				

Descriptive Statistics

History of concussion		N	Minimum	Maximum	Mean	Std. Deviation
Yes	Baseline SAC score	5	24	28	26.60	1.517
	PostInjury SAC score	5	20	28	24.80	3.114
	RTP SAC score	5	25	29	26.40	1.673
	Valid N (listwise)	5				
No	Baseline SAC score	2	26	29	27.50	2.121
	PostInjury SAC score	2	27	27	27.00	.000
	RTP SAC score	2	27	28	27.50	.707
	Valid N (listwise)	2				

Descriptive Statistics

History of concussion		N	Minimum	Maximum	Mean	Std. Deviation
Yes	Baseline BESS score	5	8	24	13.20	6.458
	Post-injury BESS score	5	6	24	19.40	7.668
	RTP BESS score	5	5	22	11.20	6.573
	Valid N (listwise)	5				
No	Baseline BESS score	2	13	14	13.50	.707
	Post-injury BESS score	2	19	43	31.00	16.971
	RTP BESS score	2	7	14	10.50	4.950
	Valid N (listwise)	2				

Descriptive Statistics

History of concussion		N	Minimum	Maximum	Mean	Std. Deviation
Yes	Baseline GSSC score	5	0	14	4.80	6.380
	Post-injury GSSC score	5	24	47	33.20	10.521
	RTP GSSC score	5	0	7	1.60	3.050
	Valid N (listwise)	5				
No	Baseline GSSC score	2	0	3	1.50	2.121
	Post-injury GSSC score	2	31	38	34.50	4.950
	RTP GSSC score	2	0	0	.00	.000
	Valid N (listwise)	2				

Descriptive Statistics

History of concussion		N	Minimum	Maximum	Mean	Std. Deviation
Yes	Number of days out of sport	5	8	17	12.60	3.912
	Valid N (listwise)	5				
No	Number of days out of sport	2	10	32	21.00	15.556
	Valid N (listwise)	2				

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Number of days out of sport is the same across categories of Gender.	Independent-Samples Mann-Whitney U Test	.057[1]	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

[1]Exact significance is displayed for this test.

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Number of days out of sport is the same across categories of History of concussion.	Independent-Samples Mann-Whitney U Test	.571[1]	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

[1] Exact significance is displayed for this test.