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Accuracy of Concussion Reporting upon Completion of a Collegiate Athletic Career

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ACCURACY OF CONCUSSION REPORTING UPON COMPLETION OF A COLLEGIATE ATHLETIC CAREER

by

TRACY LLEWELLYN

(Under the Direction of Thomas Buckley)

ABSTRACT

Context: Underreporting of concussions remains a large concern in the sports medicine community as previous studies have identified a 50 – 80% unreported rate. Further, previous studies have also suggested a lack of awareness of concussion symptoms. However, these studies tend to evaluate a single season of competition and many were amongst high school student-athletes. Objective: The purpose of this study was to explore the current reported, unreported, and potential unrecognized concussion rates among collegiate student-athletes who have completed their collegiate athletic career. Design: Cross sectional survey. Setting: Private setting within the respective host institutions athletic training room. Patients or Other Participants: 161 collegiate athletes who have completed their collegiate athletic career from 10 institutions were included in this study. The questionnaire, either pen and paper or online, was developed for this study and was based on previous findings on reasons for not reporting concussions and concussion misconceptions. Face validity was established with experts in the field and the internal reliability of this questionnaire was established (Cronbach’s Alpha = .68) through pilot testing. Main Outcome Measures: The dependent variables included the participants’ concussion self-reported rate, self-identified underreported concussion rate, main reasons for not reporting these concussions, and the potential unrecognized concussion rate. The reported and unreported rates were determined by a self-reported number. The potential unrecognized rates were identified by acknowledgement of common concussion symptoms.
which were not reported. All of these variables were reported with descriptive statistics.

**Results:** Of all respondents, 33.5% (54/161) identified suffering at least one reported concussion during their collegiate athletic career. The acknowledged unreported rate was 11.8% (19/161) with the most common reasons being they didn’t know it was a concussion and they didn’t want to be pulled from future games/practices. The potential unrecognized concussion rate was determined to be 26.1% (42/161). Overall, 49.7% (80/161) endorsed at least 1 of the 3 main dependent variables. **Conclusion:** The results of this study suggest that collegiate student athletes may remain reluctant to report concussions and be unaware of common concussion symptoms. This study will assist athletic trainers in being able to better gear their athlete’s concussion education process to specific areas such as symptom recognition and potential consequences.

INDEX WORDS: Concussion, Reporting, Underreporting, Unrecognized
ACCURACY OF CONCUSSION REPORTING UPON COMPLETION OF A COLLEGIATE ATHLETIC CAREER

by

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ACCURACY OF CONCUSSION REPORTING UPON COMPLETION OF A COLLEGIATE ATHLETIC CAREER

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CHAPTER 1
INTRODUCTION

Concussions can be defined as a complex pathophysiological process affecting the brain, which is caused by a direct or indirect blow to the head.\(^1\) It has been estimated that 1.6 to 3.8 million sports related concussions occur annually, including those who did not seek medical attention.\(^2\) Most findings suggest that, on average, about 5-6% of collegiate student-athletes report that they have experienced a concussion in a given season.\(^3-7\) However, approximately 10 years ago, it was suggested that up to 53% - 80% of athletes may not report their concussion.\(^7-9\) From 1988-2004 concussion reporting has shown an average annual increase of 7.0%.\(^10\) With the majority of concussions being unreported in the early 2000s, there is a need to investigate the current concussion reporting rates, and common reasons as to why concussions are not being reported.

Challenges to accuracy in concussion reporting are likely multi-factorial, with lack of awareness, underestimating the significance of symptom reporting, and the desire to continue participating all contributing to the low reporting rates. Further, and potentially more concerning, 28% to 76% of athletes self-reported remaining in the game or practice despite experiencing concussion symptoms, and about 1/4\(^{th}\) of athletes thought that a player with a concussion should play in an important game.\(^7,11-13\) Many athletes fail to report concussions because they don’t find them to be serious (60% - 94%), feel like concussions are part of game (55% - 89%), don’t want to leave the game (41% - 67%), don’t know they had a concussion (36% - 67%), and don’t want to let their teammates down (up to 32% - 39%).\(^7-9,11\) Finally, almost of half of athletes (43%) may be unaware of complications associated with concussions.\(^12\) All of these previous studies suggest that concussions are unreported for a multitude of reasons,
all stemming from the fact that either the athlete was unaware they had suffered a concussion, or they did not want to be held out of their respective sports. Therefore, awareness of the common concussion related misconceptions may play a vital role in improving appropriate concussion management.

Many coaches, parents, and athletes have varying view points and knowledge regarding concussions, which has lead to several misconceptions on the topic. While many coaches most often associate confusion/disorientation, loss of consciousness, and headache with concussions, they fail to acknowledge symptoms such as sleep disturbances, nausea, and blurred vision. Further, coaches, parents and the general public subscribe to many concussion related misconceptions, including that concussions are not serious enough to hold an athlete out of activity (66.4% - 94.4%), most concussions are rarely or only sometimes reported to medical personnel (76%-92%), symptomatic athletes can return to participation (30%), and that loss of consciousness is required for a concussion to have occurred (2.7%-42%). Alarmingly, 42% of the Rhode Island public reported that receiving a second blow to the head can help a person remember things they have forgotten, and 50% of hockey athletes think that prescription medicine and physical therapy is the correct way to treat a concussion. Other athletes feel that the symptoms of their concussions are not serious enough to report, or are simply unaware that continuing to play with concussion symptoms has potential consequences. With many coaches, athletes, and parents unaware of the proper way to identify and manage a concussion, it may contribute to the low reporting rates often found in literature. Recently, Kerr found an increased number of self-reported concussions in the same retired professional football players from 2001-2010, which suggests that the news and sports media may have sensitized these retirees to the significance of concussions, which may also be influencing the changes in
concussion knowledge and reporting.\textsuperscript{18} Despite the increase in media coverage in the past few years, there are still unreported and unrecognized concussions among athletes.\textsuperscript{7,13,18} Providing effective educational resources to parents, coaches, and athletes is vital to decrease the number of unreported concussions that occur annually.

Lack of concussion symptom reporting potentially exposes the student-athlete to both short-term and long-term complications. Indeed, 91\% of athletes who sustained a repeat concussion in the same season experienced their second concussion within the first 10 days of the first concussion.\textsuperscript{19} In addition, there is a potential dose-response relationship which suggests that the more concussions an individual suffers, the more likely they are to suffer an additional future concussion, as well as have each concussion present worse and take longer to recover.\textsuperscript{4,20-23} Athletes who sustain a second concussion while still recovering from a previous concussion may be at risk for second impact syndrome, which, while exceedingly rare, may have a 50\% mortality rate.\textsuperscript{24} Further, individuals who have sustained multiple concussions in their life may have an elevated risk of clinically diagnosed depression,\textsuperscript{25} mild cognitive impairment,\textsuperscript{26} earlier onset of Alzheimer’s disease,\textsuperscript{25,26} chronic traumatic encephalopathy,\textsuperscript{27} and Amyotrophic Lateral Sclerosis.\textsuperscript{28} Therefore, accurate and prompt concussion recognition may be of critical importance in the short and long-term health of the student-athlete. Overall, unreported and potentially unrecognized concussions continue to be problem in concussion management, and knowledge of concussion symptoms and potential consequences still need to be improved upon.

Over half of the concussions may remain unreported in high school athletes in the early 2000s; however, no studies have investigated current trends in collegiate athletes, especially in those who have completed their collegiate athletic career. Therefore, the purpose of this study was to explore the current reported, unreported, and unrecognized concussion rates among
collegiate student-athletes who have completed their collegiate athletic career. The research questions of this study were: 1) how many self reported concussions occur throughout the college career, 2) what is the self identified underreporting rate of concussions during college, and what are the main reasons for not reporting, and 3) how many concussions are potentially unrecognized in collegiate athletics?
CHAPTER 2

METHODS

Subjects

Potential respondents were recruited from 10 colleges and universities across the United States. The inclusion criterion for participation in this study included student-athletes who had completed their intercollegiate athletic career, regardless of whether or not their eligibility was completed. We chose to only include collegiate student athletes who had completed their collegiate athletic career in order to try to gain the most accurate reporting rate possible. Our logic was that by implementing this inclusion criterion, they wouldn’t subconsciously worry about potentially being punished for endorsing an unreported and/or unrecognized concussion by either their coach or athletic trainer. The exclusion criterion for this study included student-athletes who had not completed their collegiate athletic careers. As per IRB protocols, a signed letter from a representative of the institution and approval from the institutions IRB board was included with a request to modify of the current IRB at GSU prior to collecting data from these cooperating institutions. All respondents provided informed consent prior to participating in this study.

Instrumentation

The questionnaire contained 21 primary questions, in addition to follow-up questions, pertaining to injuries that the respondent had experienced during their collegiate athletic career, with a special focus on concussions (Appendix C). The questionnaire was available in a paper and pencil format, as well as an online format (SurveyMonkey.com, LLC; Palo Alto, CA) and
took approximately 5 minutes to complete. All questionnaires were devoid of identifying characteristics and no names, social security numbers, or student identification numbers were collected. The questionnaire requested the respondent to answer a series of questions regarding injuries they suffered during their collegiate athletic career. The questions involved common orthopedic injuries such as sprains, strains, and fractures. It also included 6 questions related to concussion reporting and recognition, which were used to determine current concussion reporting rates, unreported concussion rates, potential unrecognized concussion rates, and reasons why student-athletes do not report concussions. The orthopedic injuries served as distracters in the study and were not further analyzed. Face validity was established with experts in the field, and a Cronbach’s Alpha of .68 was found for our questionnaire.

Procedures

The recruitment of potential participating schools occurred from Spring 2011-Winter 2012. Once a school agreed to participate, arrangements were made regarding which format of the survey the host athletic trainer preferred to use. There were 3 schools who opted for the paper and pencil format, 6 who opted for the online version, and 1 that was split.

Respondents were recruited voluntarily via their athletic trainer during their medical exit screening or via an e-mailed survey link. Athletic trainers were given the option to administer the questionnaire online, either in person or with an e-mailed link, or as a paper and pencil document in person, depending on their preference. For the online versions of the questionnaire, when the respondents clicked on the URL, they were taken to the informed consent page. If they provided informed consent, they were linked directly to the questionnaire. Upon completion of
the questionnaire, the browser closed, and the responses were collected and stored within SurveyMonkey.

In the paper and pencil format of the questionnaire, the student-athlete was provided with the informed consent form first. If they provided consent, they returned the signed consent form to their respective athletic trainer, who then provided the respondent with the questionnaire and a blank envelope. Upon completing the questionnaire, the student-athlete was asked to put it in the envelope, seal it, and sign “completed” along the seal. Once this was done, the questionnaire was returned the sealed envelope to the respective athletic trainer. Once the athletic trainer had collected all of their eligible student-athletes’ completed questionnaires, they were then returned unopened to the primary investigator.

Data Analysis

The independent variables in this study included gender, type of sport, years of experience, age and division of competition. The dependent variables in this study included reporting rates, unreported rates, and unrecognized rates of concussions. The self-reported concussion rate was based on the respondents’ response to question number 4 on the paper and pencil version, and question numbers 16-19 on the online version which stated, “have you ever suffered a concussion?” The recognized but unreported concussion rate was based on the respondents’ response to question number 5 on the paper and pencil version, and question number 20 on the online version which stated, “did you ever suffer from a concussion and not tell anyone?” Further, the respondents’ were asked to select all of the reasons that applied regarding the reasons for not reporting as a follow-up to question number 5 on the paper and pencil version, and question number 21 on the online version. To determine the potential
unrecognized rate questions 10, 12, and 20 on the paper and pencil version were analyzed, which corresponded with questions 29-31, 34-36, and 53-57 respectively. Question number 10 asked, “have you ever been knocked out while playing sports,” question number 12 asked, “have you ever been ‘knocked silly/seen stars’ (confused/disoriented) while playing sports,” and question number 20 asked, “have you ever been hit so hard you lost your memory while playing sports?” If the respondent answered “yes” to any of these questions, and endorsed that it had not been diagnosed as a concussion in the follow-up question, it was counted as a potential unrecognized concussion. In addition to the potential unrecognized questions, question number 18 on the paper and pencil (questions 49 and 50 on the online version), was a hypothetical question for all student-athletes to answer which asked, “following a blow to the head, if you had experienced a headache, dizziness, or confusion would you report it to your athletic trainer.”

Statistical Analysis

Descriptive statistics were used to analyze the all variables. Chi- Squares analyses were performed to investigate the association between gender and each of the variables.
CHAPTER 3
RESULTS

Demographics

Questionnaires were provided to ten universities and a total of 170 questionnaires were returned; however, only 161 (94.7%) were complete and therefore used in the analysis. There were a total of 17 sports and 4 levels of competition represented (NCAA Division I = 5, Division II = 2, Division III = 1, and NJCAA = 2). The respondents were 56.5% female, mean age was 21.5 ± 1.3, and their mean “years of participation” was 3.7 ± 1.0. (Appendix D; Table 1 and Figure 1)

Self-Reported Concussion Rate

The participant’s self-reported concussion rate was 33.5%, (54/161) over the duration of their collegiate athletic career. Of these 54 respondents, 51.9% (28/54) were male, 72.2% (39/54) were Division I athletes (Appendix D; Table 2), and the sports with the highest rate of self-reported reported concussions were women’s soccer (37%; n=20) followed by both men’s soccer and football (22.2%; n=12). (Appendix D; Figure 2A-2B) Among the respondents who self-reported experiencing a concussion, most reported only one concussion (51.9%; 28/54) however, 22.2% (12/54) self-reported three or more. (Appendix D; Figure 2C) There was no difference for the self-reported rate by gender ($\chi^2 (1) = .641; p = .423$). (Appendix D; Figure 3)
Unreported Concussion Rate

The participant’s acknowledged unreported concussion rate was 11.8% (19/161). Of the 19 respondents, 57.9% (11/19) were female, 73.7% (14/19) were Division I athletes, and over half of the respondents competed in their respective sport for 4 years (57.9%; 11/19) (Appendix D; Table 3). Women’s soccer represented the highest number of unreported concussions among all sports with 42.1% (8/19), which included 24.2% (8/33) of all women’s soccer players. (Appendix D; Figure 4A-4B) The two most common reasons endorsed for not reporting a concussion were; 1) the respondents did not know it was a concussion (52.6%; n=10) and, 2) they did not want to be pulled from future games or practices (52.6%; n=10). (Appendix D; Figure 4C) There was no difference for the unreported rate by gender (χ² (1) = .024; p = .878). (Appendix D; Figure 3)

Potential Unrecognized Rates

The overall potential unrecognized concussion rate was 26.1% (42/161), with 42 respondents endorsing at least one of the three concussion related symptom questions (Appendix D, Table 4). Among those who endorsed experiencing a given variable (both recognized and unrecognized), the most common concussion related symptom not recognized was being “knocked silly/seen stars”, (67.9%; 38/56) (Appendix D; Table 5), followed by being “knocked out” (33%; 6/18) (Appendix D; Table 6) and “memory loss” (20%; 3/15) of those who lost their
memory were not recognized as a potential concussion (Appendix D; Table 7). Additionally, 26.1% (42/161) of the respondents reported that they would not report to a coach or athletic trainer if they experienced a headache, dizziness, or confusion following a blow to the head. (Appendix D; Table 8) Of those who are more likely to report headache, dizziness, or confusion, they are 2.4 times more likely to be female ($\chi^2(1) = 5.934; p = .015; \text{odds ratio} = 2.428$). The percentage of respondents who acknowledged a potential unrecognized concussion did not differ by gender (knocked out: $\chi^2(1) = 2.107; p = .349$, knocked silly or seen: $\chi^2(1) = 3.684; p = .159$, losing memory: $\chi^2(1) = .142; p = .931$). (Appendix D; Figure 3)

Combined Rates

Overall, 49.7% (80/161) of athletes endorsed at least 1 of the 3 main dependent variables (reported, unreported, unrecognized) in this study, suggesting an actual or potential concussion. There were 29.8% (48/161) who endorsed 1 of the 3 variables, while 16.8% (27/161) endorsed 2 of the 3 variables, and 1.9% (3/161) endorsed 3 of 3 variables. We also found that 11.8% (19/161) of athletes did not endorse having a reported concussion or an unreported concussion, but they did endorse having an unrecognized potential concussion. (Appendix D; Figure 10)
CHAPTER 4
DISCUSSION

The last decade has seen a substantial increase in concussion research and extensive media coverage; however, unreported and unrecognized concussions likely remain a problem. The results of this study suggest that about half (Appendix D; Figure 10) of all respondents endorsed at least 1 potential concussion, either reported, unreported, or unrecognized, over their collegiate athletic careers. About 1/4th of all respondents, which includes about half of these potential concussions, were not recognized as such by the respondents, which is of greater potential concern to sports medicine clinicians. The self reported concussion rate was 33.5%, with 22.2% of these self-reporting 3 or more concussions. With such a high potential concussion rate among respondents, it is important for sports medicine clinicians to educate athletes on the concussion symptoms, as well as the potential consequences that could occur if concussions are not reported.

Many misconceptions about concussions may play a factor in potential unrecognized concussions. Many coaches and athletes are unable to accurately identify common concussion related symptoms. As many as 50% of athletes are unable to identify more than 1 concussion symptom, while 56% are unaware of potential consequences. Many coaches believe that loss of conscious is required for a concussion to occur. The results of this study indicated that a little over 1/4th of all potential concussions were unrecognized by the respondent. This is consistent with the approximated 27.1% of potentially unrecognized concussions from previous research. It is important to note that these are being classified as “potential concussions” because the simple presence of a given symptom, for example a headache, does not, in and of itself, guarantee that a concussion had occurred. For instance,
Sallis found that 85% of football players will experience a headache during at least 1 game during the season, which could have been potentially linked to neck pathology, stress/tension, dehydration, fatigue, or migraines rather than a concussion. Among our respondents, we found that over 2/3rds (67.9%; 38/56) of the respondents who had reported being “knocked silly/seen stars”, had not self-reported a potential concussion. While many athletes continue to potentially not recognize concussion symptoms, it is important to try to divulge the reasons behind why they are not being detected.

In some sports, such as football and soccer, many athletes and coaches associate a “bell ringer” as a normal occurrence which they do not consider to be a concussion. As suggested by the National Athletic Trainers’ Association in the Sports Concussion position statement, the colloquial terms “bell ringer” and “dings” are not recommended to be used, as they may convey a message to athletes, coaches, and parents that these injuries are not serious. The commonly referred to “bell ringer” or “ding” follows the typical symptom pattern of a minor concussion, which should not be taken lightly. Since some athletes may consider this part of the game, it is not surprising that they would be unlikely to report the symptoms to an athletic trainer. With an alarming number of people believing that “bell ringers” are not concussions, and others believing that loss of consciousness is required for a concussion to occur, it is important for the sports medicine community to continue to educate the athletic community about concussions. One focus should be to encourage all athletes and coaches who suspect a “bell ringer” to get evaluated by a sports medicine professional. It has also been suggested to include questions using the lay terms “bell ringer” and “ding” on preparticipation physical exams in order to more accurately identify potential concussions until they become more widely accepted as concussions to the public.
In the current study, we found that just over 1/4\(^{th}\) (26.1%; 42/161) of the respondents said they would not report common concussion signs and symptoms (headache, dizziness, or confusion) to their athletic trainer after a blow to the head. This is particularly concerning because previous investigations have identified that 25%-86.4% of athletes did not report their concussions or continued to play with concussion symptoms.\(^8,12,22,33\) Among athletes who suffered from a catastrophic head injury, 38.9% were suffering from residual neurological symptoms at the time of their catastrophic head injury.\(^33\) Our respondents were also asked why they would not report these symptoms, and of those who provided responses, 70% (7/10) wanted to stay in the game, and/or didn’t think it was serious. Of further interest, the percentage of athletes who fail to report a concussion in order to stay in the game continues to increase, with 41% in the early 2000s, and 66.7% in the late 2000s.\(^7,9\) Also, something interesting to note is that of those student-athletes who were most likely to report these symptoms, they were 2.4 times more likely to be female (Appendix D; Figure 3). In previous studies, females have been found to report more concussion symptoms and to be treated more conservatively compared to males.\(^34,35\) Some possible reasons for this stem from the socio-cultural structure in that society is more protective of females, it is socially acceptable for females to express their feelings, and males are taught that being hurt is a sign of weakness.\(^35\) However, there also may be physiological different as well as past studies have found that females may be more likely to experience more concussions due to smaller size, greater angular acceleration and displacement of the head and neck, and weaker neck muscles compared to males, which may contribute to our findings.\(^3,5,6,36\) Overall, our results suggest that many athletes may still be unaware of common concussions symptoms and/or the potential consequences of concussions.
In this study, we found the current unreported concussion rate to be 11.8% among collegiate student athletes, with women’s soccer and football representing 42% and 32%, of sport specific respondents, respectively. Encouragingly, this is much lower than the previous 53 – 62% previously reported. Part of this substantial reduction may be explained by the increase in concussion coverage in the scientific, medical, and popular media, increased knowledge and awareness of concussion symptoms among athletes and athletic trainers, and possible increased awareness of the consequences associated with concussions. Kerr suggests that the affect of the media on concussion reporting rates can potentially be explained by 1) heavy coverage of concussions in the media, which in return causes the public to perceive concussions to be important, 2) individuals gaining knowledge about concussions through others and by observing others, and 3) heavy media viewers are more likely to adopt the views the media is projecting, thus potentially increasing concussion awareness. Some of our most commonly endorsed reasons for not reporting concussions in this study coincide closely with McCrea’s study, and were significantly lower than those found in Italian youth soccer players (Appendix D; Figure 11). Over half of our respondents, who endorsed an unreported concussion (52.3%; 10/19) failed to do so because they were unaware it was a concussion, and/or they didn’t want to miss future games/practices. While McCrea did not ask about future games/practices, he did find that almost half of his respondents did not want to be pulled out of the current game/practice, which is similar to our finding regarding future games/practices. Interestingly, we found a 24.3% and 52.3% absolute decrease in athletes who didn’t think concussions were serious compared to McCrea and Broglio respectively. This finding suggests that collegiate athletes today may be more aware of concussion consequences compared to athletes from the past. However, we are still faced with the apparent challenge that some athletes still fail to report their concussions
because they don’t want to miss playing time, which presents clinicians with a challenge. The NCAA currently attempts to encourage concussion reporting with the slogan, “it’s better to miss a game then the entire season” and “when in doubt, get it checked out”.40

In 2011, the NCAA required that every member institution must have a concussion policy in which the athlete must be cleared by a physician before returning to participation.40 The 3rd International Consensus Statement suggests a minimum of one week rest after a concussion with the use of a graduated return to participation (RTP) protocol.1 However, there were no specific requirements from the NCAA, other than no same day return, on the timeline of RTP, which may have an impact on the number of unreported concussions identified in this study. Each institution participating in this study may have utilized a different concussion RTP protocol which could influence the participant’s willingness to report the potential concussion. While we are unable to compare the individual responses to their institutions policy, due to participation anonymity, the concussion policies of participating institutions ranged from symptom free plus a 3 day graded exercise protocol to symptom free plus a 7 day graded exercise protocol. Therefore, some respondents may have chosen not to report their symptoms in fear that they would miss a week or more of activity and one or more games.

Over the duration of a collegiate athletic career (3.8 ± 1.0 years), we found a 33.5% (54/161) concussion reported rate. Previous studies have found annual collegiate and high school concussion rates to be between 5%-6%.3-5,7,19 This elevated rate may be related to an increased awareness on the part of the student-athlete, increased suspicion on behalf of athletic trainers and physicians, or from the drop in underreporting rates we observed. While finding a higher concussion reporting rate may suggest that more concussions are occurring with the increased competition and skill levels, it may also suggest that there was always a higher rate of
concussions that just weren’t being diagnosed or recognized as concussions before. From 1980 to 1999, approximately 5 times the amount of concussions were seen in the emergency room, and has increased another 60% over the last decade. Consistent with previous epidemiology studies, we found women’s soccer, football and men’s soccer to be the most prevalent sports to experience a concussion in. Further, we found that female soccer players were more likely to experience a concussion than males.

We also found that 22.2% of our respondents who endorsed a self-reported concussion have experienced 3 or more concussions. This is of importance because trends with 3 or more concussions include: 1) being 3-6 times more likely to experience another concussion, 2) having subsequent concussions present worse, 3) having a delayed recovery time, and 4) being at an increase risk for long term conditions such as clinically diagnosed depression, mild cognitive impairment, early onset of Alzheimer’s disease, chronic traumatic encephalopathy and amyotrophic lateral sclerosis. These long term consequences have been observed in retired football players and boxers who experienced multiple concussions during their career. When looking at our reported and unreported rates combined, we found a rate of 45.3% over the collegiate athletic career, while McCrea found an approximate rate of 23.1 over the course of a year among high school students.

The results of our study are limited by the inevitable risks of survey research. First, we relied on the athletes to self-report their concussion history from their entire collegiate athletic career accurately. A recent study by Kerr found concussion self-reporting to be moderately reliable; however, validity of concussion self-report has not been established. In an abstract identifying at potential validity of comparing concussion self-reported numbers versus a medical file, Hecht found that about half of the athletes failed to report the same number of concussions
as was listed in their medical file; however, athletes were just as likely to underreport as they were to overreport. Another inherent limitation of our study is that each school enforces different policies when it comes to concussions, therefore, concussions may be diagnosed and treated differently at each institution. These differing policies may contribute to an increased unreported rate in schools with more conservative protocols. Finally, when looking at the breakdown of particular questions, especially the optional follow up questions, we had a low number of respondents, which may have limited some of our results.

Opportunities for future studies should focus more on reasons why concussions are potentially unrecognized to gain a better idea on whether unawareness or compliance is a bigger factor on these potentially unrecognized concussions. Another opportunity could include follow up, “why” questions for each concussion question to gain a better idea of why athletes report, underreport, or unrecognized their concussions, which could potentially be accomplished through a qualitative approach of interviewing student-athletes at the conclusion of their careers. It would also be interesting to see how each institutions policy affects how their athletes report, or fail to report, their concussions and the reasons why. Along the same path, it would be interesting to do a similar study in which respondents completed a questionnaire about reporting rates, and then had it cross referenced to their medical file. Other future studies should focus on the current concussion reporting, unreported, and unrecognized rate among high schools athletes, as well as amongst full athletic careers

In conclusion, about half of collegiate student athletes may suffer a concussion over the duration of their collegiate athletic career. In addition, about a quarter of our respondents endorsed symptoms consistent with a potentially unrecognized concussion, however they were not reported. However, we found a substantial decrease in the percentage of unreported
concussions compared to past literature. Some of the differences in the concussion rates we observed may have potentially changed because of influences from the media, increased knowledge and research on concussions, and more conservative concussion policies have been implemented. With all of these factors, it is suggested that we continue to educate our athletes on the common symptoms and potential consequences of concussions, as well as to continue to develop better diagnostic tools for diagnosing concussions and determining return to play guidelines. With about half of our respondents endorsing a self-reported concussion, an unreported concussion, or a potential unrecognized concussion, it is important for athletic trainers to remain vigilant when diagnosing and managing concussions.
References


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APPENDIX A

RESEARCH QUESTIONS, DELIMITATIONS, AND ASSUMPTIONS
Research Questions

I. How many self reported concussions occur throughout the college career?

II. What is the self identified underreporting rate of concussions during college and what are the main reasons for not reporting?

III. How many concussions are potentially unrecognized in collegiate athletics

Delimitations

I. Collegiate athletes who have completed their collegiate athletic career

II. Only using schools who agree to participate

Assumptions

I. Athletes will answer truthfully, to the best of their knowledge

II. Questionnaires will be completed in privacy
APPENDIX B

LITERATURE REVIEW ON CONCUSSIONS
In the past decade, concussions have become a very prevalent topic in the athletic world. To put some perspective on things, when looking at the total number of publications related to sport concussion, those written from 2000 to 2006 easily surpassed those written from 1980 to 2000\textsuperscript{[44]}. The year 2001 can be coined as the turning point of concussion awareness for the majority of athletes, athletic trainers, neuropsychologists, and physicians\textsuperscript{[45]}. As stated by Bailes and Cantu in 2001, “the current realization that mild traumatic brain injury or concussion represents a major health consideration with more long-ranging effects than previously thought…we no longer consider the “dinged” states of athletic concussion to have the benign consequences they had in the past\textsuperscript{[46]}.”

Concussion can be defined as a complex pathophysiological process affecting the brain, which is induced by traumatic biomechanical forces directly to the head or indirectly to other parts of the body\textsuperscript{[47]}. The most common symptoms reported include headache, dizziness, confusion, and fatigue\textsuperscript{[4,5,12,20,22,48]}. When looking at overall prevalence, it has been estimated that 1.6 to 3.8 million sports related concussions occur each year, including those who do not seek medical attention\textsuperscript{[2]}. On average, regardless of gender, sport, or level of competition, it appears that an athlete has about a 5% chance of sustaining a concussion during a given season\textsuperscript{[45]}. While many aspects of concussions remain a mystery to researchers, one thing that everyone agrees on is that an athlete should be asymptomatic before returning to play. Throughout this review, many topics will be discussed, including: the neurometabolic cascade, history, epidemiology, symptoms, assessment, concussion recovery, return to play, athletic training practice patterns, concussion awareness, reporting issues, athlete response, gender factors, cumulative effects, post concussion syndrome, long term effects, biomechanics of a concussion, and prevention.

Before delving too far into the literature, it is important for readers to understand Giza’s neurometabolic cascade, because it helps to explain the physiology behind a concussion. When a concussive blow is experienced, there is an immediate neuronal depolarization due to a sudden release of excitatory neurotransmitters and a massive efflux of potassium and influx of calcium\textsuperscript{[49]}. In an effort to restore the normal neuronal membrane potential the sodium potassium pump works overtime, which
requires increased amounts of ATP\textsuperscript{49}. This increased need for ATP triggers hyperglycolysis and lactate accumulation\textsuperscript{49}. Hyperglycolysis sends the concussed brain into a period of depressed metabolism and diminished cerebral blood flow, which is thought to contribute to the postconcussive vulnerability\textsuperscript{49}. On average, the cerebral blood flow is impaired for up to 10 days\textsuperscript{49}. If the calcium remains unchecked it can continue to exacerbate problems by impairing mitochondrial oxidative metabolism, which in return will worsen the energy crisis, and directly activate pathways leading to cell death\textsuperscript{49}.

On a related note, Papa found that the protein Ubiquitin C-terminal hydrolase-L1 (UCH-L1) was significantly elevated in human cerebrospinal fluid following a severe traumatic brain injury, and remains significantly elevated for at least 7 days\textsuperscript{50}. Papa also found that UCH-L1 levels remained elevated in patients who experienced post-injury complications, and may have added value in the management of severe traumatic brain injuries in the intensive care unit. The findings of this study have inspired researchers to continue to search for a biomarker that can detect mild concussions. Currently, the Army is in the process of getting approval from the FDA to begin a study that they hope will lead us in the right direction to find a blood biomarker that can be detected in concussed individuals\textsuperscript{51}. If this study is successful, it has the potential to change the way athletic trainers and physicians assess and manage concussions.

Despite the huge advancement of concussion research in the past decade, the history of head injuries and concussions dates back to ancient times. In ancient Greek medicine, Hippocrates became the first person to document his comments on the clinical symptoms of a brain injury saying, “…in cerebral concussion, whatever the cause, the patient becomes speechless…falls down immediately, loses their speech, cannot see and hear…”\textsuperscript{52}. On another account, Celsus (25 BC-50AD) noted that dizziness was a symptom after head injury\textsuperscript{52}. The first person to clearly describe the entity of a concussion was Rhazes (850 AD-923 AD), who distinguished a difference between concussion as an abnormal physiological state rather than a severe brain injury\textsuperscript{52}. Lastly, in 1687, one of the final historical descriptions of concussion came from the Learned Doctor Read, who described the clinical stages of a concussion as, “a singing of
the ears after the wound is received, falling after the blow, swooning for a time, slumbering after the
wound is received, dazzling of the eyes, and a giddiness which passes rapidly. Interestingly enough, all
of these accounts suggest that a concussion is a functional disturbance, rather than a structural
disturbance, which researchers are still debating about today.

The CDC estimates that there are approximately 300,000 concussions with loss of consciousness
each year in the United States. It is important to note that these 300,000 concussions are not solely sport
cancellations, but that they also include falls and accidents. When looking at sport concussion incidence
rates this number falls between 57,200 and 395,200, and does not require loss of consciousness to
occur. In one study using football players, Guskiewicz found that the incidence rate for high school was
5.6%, while Division I was 4.4%. Similarly, Gessel found that the high school incidence rate was 8.9%,
while the college incidence rate was 5.8%. Some of the main explanations for the higher incidence rate
in high school are that they have lower quality protective equipment, lower skill levels, and many times,
high school athletes play both sides of the ball in football, which leads to more playing time and more
chances to suffer from a concussion. Gessel also stated that the overall rate of concussion was higher in
college, but comprised a greater proportion of HS injuries. Looking at the difference between high
school and college athletes, they also found that high school athletes may demonstrate a slower acute
recovery after a concussion compared with college athletes. Gessel also stated that the overall rate of concussion was higher in
college, but comprised a greater proportion of HS injuries. Looking at the difference between high
school and college athletes, they also found that high school athletes may demonstrate a slower acute
recovery after a concussion compared with college athletes. Also, an alarming statistic for college
athletic trainers to take into account is that 30% of high school athletes have already had at least 1
concussion, while 7.7% have experienced multiple concussions.

In a study looking at high school female athletes, they found an incidence rate of 4.3% for soccer
and 3.6% for basketball. Another study looking at basketball and soccer found the concussion rate to be
5.9% of all injuries. A retrospective study by Delaney dealing football and soccer players found that
62.7% of soccer players had sustained a concussion, while 70.4% of football players had sustained a
concussion. It is important to note that in this study if an athlete reported that they had a headache,
regardless of being hit in the head or not, it was considered a concussion. While it is believed that many
athletes underreport their concussions, this study by Delaney still seems astoundingly high. When comparing the incidence rates between games and practices, an athlete is at a higher risk to suffer a concussion during a game than during practice\cite{3,5,20,53}. According to Guskiewicz, an athlete is 8.5% more likely to suffer a concussion in a game than they are in practice\cite{20}.

When determining if an athlete suffered a concussion one of the first steps is to ask the athlete if they are experiencing any symptoms. The most common symptoms experienced after a concussion include: headache\cite{3,5,12,20,22,35,48,57,58}, dizziness\cite{4,5,12,20,22,35,48,57,58}, confusion/disorientation\cite{4,5,22,35,48,58}, fatigue\cite{3,4,5,57}, balance problems\cite{20,57,58}, feeling in a fog/slowed down\cite{20,59}, concentration difficulties\cite{35}, nausea\cite{3,57}, blurred vision\cite{4,58}, and posttraumatic amnesia\cite{4,5,20,42,48,58,60}. Another sign/symptoms of a concussion is loss of consciousness, however this is not as common as the previous symptoms mentioned. In general, with sport concussions, if an athlete does experience loss of consciousness it is for a few seconds at most\cite{19}. When looking at sport concussions, most studies have found the loss of consciousness rate to be below 10%. More specifically, Guskiewicz found the loss of consciousness rate to be 8.9%\cite{4} in one study and 6.3%\cite{20} in another, Delaney found it to be between 4.4%--4.8%\cite{56}, Gessel found it to be 3.9%\cite{5}, McCrea found it to be 7.7%\cite{60} in one study and 6.4%\cite{19} in another, and Zemper found it to be 3.3%\cite{21}.

One of the other hallmarks of a concussion is posttraumatic amnesia. Posttraumatic amnesia, also referred to as anterograde amnesia, is defined as the inability to form new memories after an accident\cite{61}. Many times an athlete experiencing posttraumatic amnesia will ask repetitive questions, such as what the score is or who is winning. Guskiewicz found the average posttraumatic amnesia rate to be between 24.1%\cite{20} and 27.7%\cite{4}, while Iverson found it to be 21%\cite{42}. Collins found that athletes who presented with worse symptoms were ten times more likely to have experienced retrograde amnesia, inability to recall events before the impact\cite{61}, and four times more likely to have experienced posttraumatic amnesia\cite{62}. He also found that amnesia may be more predictive of postconcussion outcomes than loss of consciousness\cite{62}. Similarly, Erlanger found that memory dysfunction at 24 hours, rather than brief loss of consciousness,
predicts a more severe concussion\textsuperscript{48}. Erlanger also found that history of concussion was not associated with the number of symptoms during the sideline assessment, and that loss of consciousness was not associated with the number of symptoms at follow-up or for the overall duration\textsuperscript{48}. Contrary to these findings, Guskiewicz found that both presence of loss of consciousness and amnesia tended to be associated with a slower recovery\textsuperscript{20}. In general, symptoms tend to resolve within 1 week. Erlanger found the average duration of symptoms to be about 6 days\textsuperscript{48}, while McCrea found it to be between 5-7 days\textsuperscript{19}, and Guskiewicz found it to be 3-5 days, with 87.7\% of them being fully resolved within one week\textsuperscript{20}. When an athlete reports concussion symptoms to an athletic trainer, physician, coach or parent, he/she should be assessed via a battery of concussion evaluation tools.

The concussion testing battery should include a self reported symptom checklist, postural control assessment, and neurocognitive assessment\textsuperscript{57,63-65}. Many practitioners have also started including neuropsychological tests, such as ImPACT, HeadMinder CRI, and ANAM, as part of their testing battery\textsuperscript{48,54,66-68}. Sometimes these tests are considered by the practitioner to be a neurocognitive test, even though they are actually neuropsychological tests\textsuperscript{57}. When looking at the entire testing battery together, Broglio found that the sensitivity ranged from 89-96\%\textsuperscript{57}. In another study by Broglio he found that the complete testing battery accurately identified over 90\% of concussed athletes\textsuperscript{64}. All components of the concussion battery should be given during preseason, while athletes are not concussed, in order to gather baseline data\textsuperscript{54}. Baseline data should also be conducted in the same setting that post-tests will occur\textsuperscript{63,69}. Baseline data is important because it allows the practitioner to have a normal value on each athlete to compare post-concussion tests with in the event that they experience a concussion. An athlete is generally not allowed to return to play until all of their tests have reached or surpassed their baseline scores.

Generally, the self reported symptom checklist is either done through a computerized neuropsychological test or it is a Likert scale survey with a list of common concussion symptoms. Regardless of which checklist is used, the athlete is asked to rate the severity of each symptom they are
experiencing at the time. In a study looking at symptom reporting, Piland found that athletes with a concussion history reported higher composite scores for symptom duration and symptom severity than those without a concussion history. While honest symptom reports are incredibly important for the proper management of a concussion, athletes have a tendency to underreport their symptoms. For this reason, more objective tests such as postural control assessments, neurocognitive assessments, and neuropsychological assessments are often utilized.

Two commonly researched postural control assessments include the Sensory Organization Test (SOT) and the Balance Error Scoring System (BESS). Between the two, BESS is more well known, and is used more frequently by athletic trainers. The SOT requires a special platform machine, which is not very mobile. In a study looking at both SOT and BESS, Guskiewicz found that SOT returned to baseline between 1-3 days, while BESS took an average of 3 days to return to baseline. The BESS test is much more realistic for athletic trainers. All it requires is a foam Airex pad, which has an uncompressed density of 70.389kg/m³ and is 41.6cm x 50.1cm x 6.1cm in diameter. In the BESS test is made up of 3 different stances (double leg, single leg-non dominant, and tandem) on two different surfaces (firm and foam), in which the person being tested must remain as still as possible for 20 seconds with his/her eyes closed and his/her hands on his/her hips. The reliability of the BESS test is questionable. Finnoff looked at the difference between the intrarater and interrater reliability of the BESS test and found that they both fell below the acceptable score, with intrarater at .74 and interrater at .57. With this being said, it still remains the most popular postural control test used by athletic trainers in the clinical setting. Hunt did a study on the modified BESS test, which takes out the two double foot stances, and found that it was more reliable than the traditional BESS test. Two interesting studies by Fox and Onate looked at different aspects of clinical application of the BESS test. Onate looked at the differences in BESS scores done in a quiet, controlled setting and compared them to BESS scores done in the dugout at baseball practice. He found that 76% of the subjects did worse in the dugout compared to the controlled locker room setting on the single leg and tandem foam stances. From this study he suggested that baseline test
be taken in the same setting that follow up tests will be conducted. If that is on the sideline, then the baselines should be done on the sideline; if that is in a controlled, quiet setting, then the baselines should be done in a controlled, quiet setting. In Fox’s study, he was looking at how fatigue plays a factor in the BESS test. He found that fatigue generally lasts up to 8 minutes after both aerobic and anaerobic exercise, and that postural control returned to normal between 8-13 minutes. With his findings, he recommends waiting at least 13 minutes after activity before administering the BESS test. Both of these studies have clinical application to athletic training, because when a concussion occurs and the BESS test needs to be used on the sideline, the athlete will most likely be fatigued from activity, and will not be in a quiet, controlled setting. As with most tasks, the BESS test has an apparent practice effect. Valovich found a significant practice effect at both 5 and 7 days compared to the baseline. She also noted that these effects returned to the normal baseline after two weeks of no exposure to the BESS test. Looking at more advanced postural control tests, Slobounov found that subjects demonstrated worse postural control during a dynamic task compared to a static stance both before and after a concussion. His test was able to find subtle differences that would have gone undetected with the BESS test.

Another aspect of the concussion testing battery includes neurocognitive assessment. The most common neurocognitive test is the Standardized Assessment of Concussion (SAC) test. The SAC test assesses orientation, concentration, immediate memory, and delayed recall through a brief 30 point test. The test requires subjects to recall the day, year, month, and time, as well as repeat back a list of 5 words, say the months backwards, and repeat a list of numbers backwards. McCrea found that the SAC test is good at detecting a concussion, but is not effective as a follow-up assessment. He found significant differences in the baseline test scores compared to tests conducted at the time of injury, however there were no differences in scores after 48 hours, which may have been contributed to by a practice effect. The Maddocks questions also fall into the neurocognitive category, and are commonly used by athletic trainers during an initial clinical evaluation. The Maddocks questions deal with orientation and recent memory items. The orientation questions deal with items such as recalling your name, birthday, age,
year, day, date, and time. The recent memory items deal with items such as determining where the game is taking place, what quarter/period it is, how far into the quarter/period it is, who scored the last point, what team was played the previous week, and if the team won the previous game. He found that the recent memory items were more sensitive than the orientation questions.

The last component of the testing battery includes neuropsychological tests, which are often grouped in the same category as neurocognitive tests. These tests can either be conducted with pencil and paper or on the computer, which are more commonly utilized by today’s practitioners. The most commonly used computerized neuropsychological tests are ImPACT, HeadMinder CRI, and ANAM. The neuropsychological tests measure memory, learning, attention and concentration, speed of thinking and information processing, motor skills, and reaction time. Brown found that men tended to score higher than women on simple reaction time, however women tended to be more accurate than men. She also found that many factors such as time of day, fatigue, and motivation play a factor in baseline tests, therefore, the timing of baseline tests may be an important factor to account for. Geary found that subjects with a history of concussion perform worse on acquisition items compared to a control group. However, Brown found that there were no significant differences between those with a concussion history and no concussion history. When looking at loss of consciousness and neuropsychological tests, both Lovell and Broglio found no differences between the loss of consciousness and no loss of consciousness groups. Broglio did find that 38% of subjects showed impairment on the neuropsychological tests, despite reporting that they were asymptomatic. Fazio found similar results, in that symptomatic concussed individuals performed worse on ImPACT than asymptomatic concussed individuals, who performed worse than the control subjects. This tells practitioners that concussions may have lingering neurocognitive/neuropsychological effects even when an athlete reports that they are asymptomatic.

Another important aspect of the concussion assessment includes determining what grade of concussion the athlete has experienced. It is important to note that this is not an immediate decision, and that many practitioners don’t rate the severity of the concussion until the athlete has recovered. The 3
most commonly used grading scales are the Colorado Medical Society guidelines, American Academy of Neurology guidelines, and the Modified Cantu guidelines. The Colorado\textsuperscript{61} scale is as follows:

**Grade 1**: confusion without amnesia; no loss of consciousness

**Grade 2**: confusion with amnesia; no loss of consciousness

**Grade 3**: loss of consciousness.

The AAN\textsuperscript{61} guidelines are:

**Grade 1**: transient confusion; no loss of consciousness; concussion symptoms or mental status abnormalities on examination resolve in less than 15 minutes

**Grade 2**: transient confusion; no loss of consciousness; concussion symptoms or mental status abnormalities on examination last more than 15 minutes

**Grade 3**: any loss of consciousness; either brief (seconds) or prolonged (minutes).

And the Evidence Based Cantu\textsuperscript{61} guidelines are:

**Grade 1 (mild)**: No loss of consciousness; posttraumatic amnesia or postconcussion signs or symptoms lasting less than 30 minutes

**Grade 2 (moderate)**: loss of consciousness lasting less than 1 minute; posttraumatic amnesia or postconcussion signs or symptoms lasting longer than 30 minutes but less than 24 hours

**Grade 3 (severe)**: loss of consciousness lasting more than 1 minute or posttraumatic amnesia lasting longer than 24 hours; postconcussion signs or symptoms lasting longer than 7 days

Cantu is a strong supporter of grading concussions once the symptoms have cleared\textsuperscript{61,78}. He feels that severity cannot be determined until this point. One of the reasons behind modifying his scale was because he found it illogical to grade a concussion that had persistent post concussion symptoms that lasted for months or years without loss of consciousness to be less severe than a concussion with a brief loss of consciousness but resolution of all symptoms within a few minutes to hours after the injury\textsuperscript{61}.

On a related note, when mild concussion patients were seen in the emergency department, 56% of the cases that should have been classified as a concussion, according the CDC definition, were no
diagnosed by the emergency department physicians\textsuperscript{79}. Also, Bazarian found that in a study of MTBI ICD-9-CM codes, there were almost three times as many false positives (no concussion, but coded) as there were false negatives (concussion, but not coded)\textsuperscript{80}. Both of these studies were conducted in emergency departments, while utilizing emergency department records. While the emergency department is great at dealing with emergency situations, they do not appear to be as good at detecting mild concussions. Therefore, unless complications such as a subdural hematoma are suspected, athletes suffering from a mild concussion do not need to visit the emergency department.

Generally, recovery from a concussion occurs between 7-10 days\textsuperscript{19,81,82}. The typical recovery follows a checkmark pattern, meaning that the symptoms are significantly worse on day 1 and then symptoms start getting progressively better, with a large rebound around day 3\textsuperscript{81}. Majerske found that people who were participating in high activity levels during concussion recovery did worse than those who were participating in low/no activity\textsuperscript{83}. Her findings provide support towards a graded return to play protocol once the athlete is asymptomatic\textsuperscript{83}. McCrea argues that rapid recovery from a sport concussion is seen in the majority of athletes regardless of the fact that they observed a symptom free waiting period or not\textsuperscript{81}. Both Collins and Erlanger found that amnesia is a better predictor of the concussion recovery timeline than either loss of consciousness or history of concussion\textsuperscript{48,62}. Some argue that regardless of symptom resolution, the athlete is still at risk for up to 10 days post injury\textsuperscript{20,84}. Both Guskiewicz and Slobounov found that athletes are highly susceptible to future and more severe concussions within the 10 day window following a concussion\textsuperscript{20,84}. 

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Once an athlete has recovered from a concussion, a return to play decision is made. Below is a chart of a very typical return to play guideline:

<table>
<thead>
<tr>
<th>Grade</th>
<th>First Concussion</th>
<th>Second Concussion</th>
<th>Third Concussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 1 (mild)</td>
<td>May return to play if asymptomatic for 1 week</td>
<td>Return to play in 2 weeks if asymptomatic for 1 week</td>
<td>Terminate season; may return to play next season if asymptomatic</td>
</tr>
<tr>
<td>Grade 2 (moderate)</td>
<td>Return to play after asymptomatic for 1 week</td>
<td>Minimum of 1 month; may return to play then if asymptomatic for 1 week; consider terminating season</td>
<td>Terminate season; may return to play next season if asymptomatic</td>
</tr>
<tr>
<td>Grade 3 (severe)</td>
<td>Minimum of 1 month; may then return to play if asymptomatic for 1 week</td>
<td>Terminate season; may return to play next season if asymptomatic</td>
<td></td>
</tr>
</tbody>
</table>

*Asymptomatic in all cases means no postconcussion symptoms, including retrograde or anterograde amnesia, at rest or with exertion.

As Cantu stated in one of his reviews, “there is a unanimous agreement that an athlete still suffering postconcussion symptoms at rest and exertion should not return to contact or collision sports.” A step-by-day protocol once the athlete is asymptomatic is commonly utilized in today’s concussion management. An example of a step-by-day protocol is the Vienna Guidelines. With these guidelines, once the athlete is asymptomatic they will do some light aerobic exercise. If this goes well, the next day they will progress to non-contact sport specific exercises. Once again, if no symptoms return, they move onto non-contact drills on the 3rd day. The next step is to get medical clearance from the team physician to participate in full contact practice. If this goes well, they may return to normal activity and games.

Similarly, the Prague guidelines also follow this step-wise protocol. With the step-wise protocols, if any symptoms return, the athlete returns to the most recent asymptomatic step and waits a day before progressing again.

Over the past 10 years, there have been 3 major Athletic Training practice pattern surveys done. In 2001, Ferrara found that the majority of ATCs were using the Colorado scale and the most common evaluation tools were clinical evaluation and symptom checklist, while in 2005 the most common evaluation tools included a battery of clinical examination, physician recommendations, symptom checklists, and SAC. In 2009, the majority (90%) of ATCs were using a clinical examination, about 80% were using a symptom checklist, about half were using a concussion grading scale and SAC, and a third were using a computerized neuropsychological test as part of their evaluation. In 2001, 84% of
ATCs believed that standardized methods of concussion assessment would provide more information than a routine clinical or physical examination alone, compared to 68% in 2005. The majority of ATCs said that they would not return a symptomatic athlete, or an athlete who had any abnormal tests. The 2009 survey also looked at what was being taught to undergraduate students. The NATA position statement was taught 80% of the time, followed by Cantu at 61%, Colorado at 52%, and AAN at 42%. Of those surveyed, 66% of ATCs had never heard of the Vienna Guidelines, and 86% did not use them. However, once presented with the guidelines, 73% of the ATCs agreed with them, 68% said they would use them, and 84% said they would start teaching them.

Concussion awareness by the coaches, athletes, and parents, is also an important factor in assessing and managing a concussion. If an athlete isn’t aware of the common concussion symptoms, they won’t know when to report them to the athletic trainer. On a similar note, if coaches and parents don’t recognize these common symptoms, they may not know when it is important to refer their children/athletes to a doctor. In 2007, there were two studies done that looked at concussion symptom awareness in coaches. They found that coaches who participated in a coaching education program were significantly better than those who didn’t at recognizing concussion symptoms, and that the Heads-up CDC kit was most often rated as very helpful for coaches. Overall she found that over 60% of coaches correctly identified amnesia, confusion, dizziness, headache, and loss of consciousness as concussion related symptoms, however they were less likely to identify symptoms such as sleep disturbances, vision problems, and nausea. Similarly, Guilmette found that when coaches were asked to list concussion symptoms, most were able to list at least 2 or 3. The most common answer was confusion/disorientation, followed by dilated pupils, headache, and memory loss. In Valovich’s study, 42% of the coaches thought that loss of consciousness was necessary for a concussion to have occurred, and 36% didn’t think that a grade 1 concussion required the athlete to be removed from the game or competition. Both studies found that about 30% of the coaches would consider letting a symptomatic athlete participate in activity. Another study found that 92% of coaches and athletes believed that
bellringers were different injuries than concussions. Finally, Guilmette found that coaches believed that only 8% of athletes often report their concussions, 51% sometimes reported their concussions, and 41% rarely reported their concussions. Following along with these findings, Yard found that almost half of all high school athletes failed to comply with the return to play guidelines. In a study dealing with New Zealand Rugby parents, the concussion awareness appeared to be much higher. They were able to correctly identify the most common concussion symptoms, 95% knew that an athlete didn’t need to experience loss of consciousness to have experienced a concussion, 96% believed that continuing to play after a concussion could lead to serious health consequences, and most importantly 99% said that they would not let their child play or practice if they reported headaches and/or dizziness after experiencing a concussion. The coach’s surveys are very alarming for the athletic training profession, and the well being of the athlete.

One of the major problems with athletes being naive to concussion symptoms is the fact that it leads to reporting issues. McCrea found that 53% of high school football players did not report their concussion, and that 1/3 of these players didn’t report it. The most common reasons athletes gave for not reporting their concussion were that they weren’t aware that they had experienced a concussion, they didn’t think it was serious enough, they didn’t want to leave the game, or they didn’t want to let down their teammates. In surveys that assessed concussion reporting tendencies, Sefton found that 80% of head injuries went unreported to coaches or ATCs, and that coaches underestimated the underreporting by 91% while the ATCs underestimated it by 82%. Sye found that 61% of athletes reported that they understood what the term concussion meant, 60% were able to correctly identify proper return to play guidelines, and that 25% thought that loss of consciousness was the best descriptor of a concussion. Sye also found that 77% of athletes agreed that a player should not return to play if they were symptomatic, and that 27% thought that a player with a suspected concussion should play in an important game. Another study looked at how accurately the hockey governing bodies were at reporting concussions.
compared to those that were self-reported. They found that the self-reports from the athletes had a much higher concussion rate than the official injury reports produced by the governing body\textsuperscript{89}.

The athlete’s response to a concussion is also a very interesting phenomenon. It doesn’t come as a surprise that a concussed athlete will experience emotional disturbances following their injury. Concussed athletes display higher levels of fatigue and lack of energy\textsuperscript{90}, as well as depression\textsuperscript{91,92}. Hutchinson also found that most concussed athletes returned to play before their emotional functioning returned to baseline, hinting that there may be physiological reasons such as the neurometabolic cascade that cause this depression\textsuperscript{90}. Similarly, Chen found that there was a reduced dopamine level in the cortico-striato-thalamic system in concussed athletes who were experiencing depression\textsuperscript{92}. This helps to support the findings from Hutchinson’s study.

Gender differences are also present in concussion assessment and management. According to most researchers, females are at a higher risk for concussion than males\textsuperscript{3,5,36}. However, Langlois found that males are about twice as likely as females to experience a concussion\textsuperscript{2}. Some of the most common explanations given for the higher rate of concussion in females are that females : a) have a smaller head to ball ratio\textsuperscript{3,5}, b) have weaker neck musculature\textsuperscript{3,5,36}, c) have greater angular acceleration and displacement of the head and neck\textsuperscript{5,36}, d) experience cultural differences\textsuperscript{5}, and/or e) may head the ball more than males\textsuperscript{3}. The most common cultural difference mentioned in the literature is the fact that women tend to be treated more conservatively than men\textsuperscript{35}. Females also have a tendency to report more symptoms than males, which plays a factor in the higher concussion rate\textsuperscript{34,35}. When looking at neuropsychological and neurocognitive tests, Covassin found that females with 3+ concussions performed better than males with 3+ concussions on visual and verbal memory tasks\textsuperscript{93}. With this information they presented the idea that estrogen and progesterone may have neuroprotective effects\textsuperscript{93}. However, other researchers have found that females perform worse than males on neurocognitive and neuropsychological tests following a concussion\textsuperscript{34,36,94}. 
A major area of concussion research deals with the cumulative effects that may occur. In general, having multiple concussions is thought to be bad, according to a number of researchers. Researchers have found that between 68% and 73% of athletes have concussion histories as a college athletes. Looking at the probability to sustaining another concussion, Guskiewicz found that athletes with a history of 3+ concussions are 3 times more likely to suffer another concussion. Zemper found that the risk of getting a concussion is 5.8 times greater for athletes with a history of concussion within the previous 5 years. Valovich found that athletes with a concussion history have a 4-6 times greater risk of sustaining another concussion, and are 3 times more likely to have this concussion occur within the same season.

Similarly, Collins found that athletes with 3 or more concussions are 6.7 times more likely to experience loss of consciousness after a concussion, and 9.3 times more likely to demonstrate 3-4 abnormal on-field markers. Another interesting finding is that those with a multiple concussion history perform worse on neuropsychological and neurocognitive tests. Athletes with a concussion history tend to have a longer recovery period, and are at an increased level of susceptibility within the first 10 days following their return to play. Athletes with a concussion history tend to present worse upon the on-field assessment, and they tend to report more symptoms on their baseline as well as 1 week post injury compared to those without a concussion history.

Athletes with multiple concussions are also more susceptible to post concussion syndrome. The physiological reasoning behind post concussion syndrome is still largely unknown. Yang found that dizziness was the single symptom reported by people experiencing post concussion syndrome at two weeks post injury, which may help to predict future post concussion cases. Generally concussion symptoms resolve within a week of the injury, however a person suffering from post concussion syndrome may experience symptoms for weeks, months, or even years after the injury. On average, post concussion syndrome effects about 10% of the concussed population. In one study, 44% of people were still experiencing at least 1 or more symptoms after 3 months post injury. Another interesting phenomenon related to post concussion syndrome is the “good-old-days” bias, which refers to the
tendency of viewing yourself as being healthier than you really were in the past, leading to underestimated past problems. As expected by this phenomenon, people in the concussion group reported fewer preinjury symptoms than the control group did.

Other people with a history of multiple concussions may experience long-term effects later in life. Some of these long-term effects include depression, mild cognitive impairment (early dementia), and Alzheimer’s disease. One study found that retired football players who reported a history of 3+ previous concussions were 3 times more likely to be diagnosed with depression, and those who reported 1 or 2 previous concussions were 1.5 times more likely to be diagnosed with depression. Another study that didn’t discriminate between the number of previous concussions found a 1.5 times increased risk for depression. Guskiewicz also found that retired football players with a history of 3+ concussions are 5 times more likely to have a prevalence of early dementia. In a study looking at the risk for developing Alzheimer’s disease, they found that there was no association between the number of concussions and developing Alzheimer’s disease. Another study found that those who had a history of a moderate concussion were at a 2.3 times increased risk for Alzheimer’s disease, while those with severe concussions were at a 4.5 times increased risk. With these potential effects, it raises the question about when an athlete should retire. Cantu stated that retiring is not based off a set number of concussions, instead it depends on how the person reacts to each concussion, and how long it takes them to recover from each concussion.

Another complication that is being found in retired football players and boxers is a condition called chronic traumatic encephalopathy (CTE). Simply put, CTE is a chronic, progressive atrophy of the brain. It has been reported that 17% of individuals who have had multiple or repetitive concussions develop CTE. Currently, 90% of the documented cases have occurred in athletes. Some common symptoms of CTE include memory loss, irritability, outbursts of aggressive/violent behavior, confusion, speech and gait abnormalities, decline in cognitive performance, unsteadiness, headaches, and Parkinsonism. Some of the common neurological findings found during an autopsy include reduced
brain weight, enlarged lateral and 3rd ventricles, thinning of the corpus callosum, fenestrations in the cavum septum pellucidum, and scarring and neuronal loss of the cerebellar tonsils27. Of those athletes who have experienced CTE, 1/3 were symptomatic at retirement, and ½ were symptomatic within 4 years of their retirement27. Many times people with CTE die tragic deaths, such as committing suicide or doing something irrational that ends up killing them27. One of the most unique cases of CTE occurred in a 33 year old dwarf who worked for 15 years in the circus as a clown. During his circus days he participated in dwarf-throwing events, and was knocked unconscious multiple times27.

With all of the complications that can occur from multiple concussions, researchers have been working hard to develop preventative equipment, such as better helmets. A lot of research has been done regarding head impacts in football, most using the HITS system100-103. The HITS system uses accelerometers that are embedded into the helmet, and the information is sent to a central computer on the sidelines to record all of the impacts100. The average concussive blow is between 98g100,104 – 102g101. The average g force of a hit to the helmet in Division I football is about 20g100,102. On average, players who receive a concussion experienced 27.7 impacts during the practice/game in which they were injured101. When impacts occurred to the top of the helmet, the g force was significantly higher102. With all of the research dealing with head impacts, other researchers are working on creating better helmets. One study by Collins compared the Riddell Revolution helmet with the traditional Riddell helmet105. In the Revolution helmet, they extended the exterior shell anterior to and distal to the traditional helmet along the mandible105. They also added new padding over the zygomatic bone and lateral mandible105. They found that the rate of concussion was significantly lower with the Revolution helmet compared to the traditional helmet, and the relative risk reduction associated with wearing the Revolution helmet was 31%105. A myth among football players is that mouthguards help prevent concussions. Mihalik found that this was not the case, and that there were no observable differences in neurocognitive performance following a concussion in those players who were wearing a mouthguard and those who were not106. Perhaps the most important way to prevent long term effects or complications from concussions is to
listen to the doctor’s advice\textsuperscript{107}. 4 out of 5 athletes who returned to activity even though they were advised not to, continued to suffer from post concussion symptoms for up to 2 years post injury\textsuperscript{107}.

In conclusion, concussions are not an injury to just ignore and play through. It is important to make sure athletes, coaches, and parents are educated on the signs and symptoms of a concussion to help prevent unwanted complications. As the research shows, 3 or more concussions appear to be the magic number towards long-term effects. Athletes who are suspected of having a concussion should be put through an entire battery of concussion evaluation tools to achieve optimal sensitivity. All athletes should be asymptomatic before beginning a day-by-day protocol, and should also be cleared by a physician before returning to play. While concussion assessment, management, and awareness have come a long way in the past decade, it will only continue to improve.
References


Injury History Questionnaire

Directions: Please answer the following questions regarding your collegiate athletic career to the best of your knowledge. Your answers will remain confidential and will NOT be shared with your coaches or athletic training staff.

Demographics

Gender: M / F Age: ______ Academic year in school: FR SO JR SR 5th
Sport(s): ___________________________ Position in Sport: ___________________________
How many years did you participate in your sport at the collegiate level? ______
Which Division? I II III NJCAA other

Injury History

1. Have you ever sprained your ankle? YES NO
   a. Was the ankle sprain reported to a healthcare provider? YES NO
   b. Did you complete a rehabilitation program, either on your own or with a health care provider? YES NO
      i. if not, why _______________________________________________________

2. Have you ever injured a ligament or cartilage in your knee? YES NO
   a. If Yes: Circle which ones: Meniscus Cartilage MCL ACL LCL PCL

3. Have you ever sprained any other joints (shoulder, wrist, etc) while playing sports? YES NO
   a. If Yes: What body part(s)? __________________________________________________________

4. Have you ever suffered a concussion? YES NO
   a. If Yes: How Many? ______
   b. If Yes: Approximately when were they? (month and year to the best of your memory)
   c. If Yes: When was your last concussion? ________________________________

5. Did you ever suffer from a concussion and not tell anyone? YES NO
   a. If yes, why? (check all that apply)
      1. Did not think it was serious?
      2. Did not know it was a concussion?
      3. Did not want to be pulled out of the game/practice?
      4. Did not want to be pulled from future games/practices?
      5. Did not want to let your teammates down?
      6. Would have if it was a less important game/practice?
      7. Other? If so why? _____________________________________________

6. Have you ever hurt your back? YES NO
   a. If Yes: Please Explain _____________________________________________

7. Have you ever broken a bone? YES NO
8. Have you ever dislocated your shoulder?  YES  NO

9. Have you ever pulled, strained, or torn your rotator cuff or any other structure in your shoulder?  YES  NO
   a. If Yes: Briefly explain? __________________________________________________________

10. Have you ever been knocked out while playing sports?  YES  NO
    a. If Yes: How many times? ______________________________________________________
    b. If Yes: How many were diagnosed as a concussion? ______________________________

11. Have you ever pulled, badly strained, or torn a muscle?  YES  NO
    a. If Yes: which muscle(s)? ______________________________________________________

12. Have you ever been “knocked silly/seen stars” (confused/disoriented) while playing sports?  YES  NO
    a. If Yes: How many times? ______________________________________________________
    b. If Yes: Did you tell your coach, athletic trainer, or parent? Which one? ______________
    c. If Yes: How many were diagnosed as a concussion? ______________________________

13. Have you had multiple ankle sprains?  YES  NO
    a. how many? ______

14. Have you had any episodes of your ankle giving way?  YES  NO
    a. How many? ____

15. Do you have any current residual (lingering) symptoms regarding your ankle sprains?  YES  NO
    a. If Yes: What are they? _________________________________________________________

16. Have you ever experienced any season ending injuries?  YES  NO
    a. If Yes: What was/were your injury(ies)? __________________________________________
    b. If Yes: Did you get surgery on any of these injuries? Which ones?__________________

17. During your collegiate athletic career did you ever have any orthopedic surgeries?  YES  NO
    a. If Yes: On what? ______________________________________________________________

18. Following a blow to the head, if you had experienced a headache, dizziness, or confusion would you report it to your athletic trainer?  YES  NO
    a. If No: Why? __________________________________________________________________

19. Have you ever had any injuries that you did not tell your athletic trainer about?  YES  NO
    a. If Yes: What? __________________________________________________________________

20. Have you ever been hit so hard you lost your memory while playing sports?  YES  NO
    a. If Yes: How many times? ______________
    b. If Yes: Did you tell your coach, athletic trainer, or parent? Which one? ______________
c. If Yes: was it diagnosed as a concussion? 

21. During your collegiate athletic career do you feel like you had a good relationship with your athletic trainer? 
   YES    NO
1. Informed Consent

1. Dear Student-Athletes,

The Athletic Training education program at Georgia Southern University invites you to participate in a research study entitled, “Accuracy of Injury Reporting upon Completion of a Collegiate Athletic Career” after you have completed your collegiate athletic career.

Participation in this research will include taking a questionnaire which should take less than 5 minutes to complete. This survey is intended for any collegiate student-athlete who has completed their athletic career. The purpose of this study is to determine how accurately student-athletes report their injuries upon completing their athletic career.

There is no compensation or reward for participating in this study and there is no punishment or disadvantage to not participating in this questionnaire. There is minimal risk associated with participating in this study and no service of any kind, to which you are otherwise entitled, will be lost or jeopardized if you choose to “not participate” in the study. If, for any reason, there are any questions that make you uncomfortable or that you do not wish to answer, you may skip those questions. Although the results of this study may be published, no information that could identify you will be collected or included. We will ask you to identify the division, sport, and primary position you participated in, but no information which could identify either you or your institution will be collected.

Your consent is being given voluntarily by completing this questionnaire. You may refuse to participate in the entire study or in any part you do not choose, as you have the right to not answer any questions you do not wish. The completion of the survey implies that you agree to participate in the study and your data may be used in this research. If you decide to participate in the study, you are free to withdraw at any time without any negative ramifications. You must be 18 years of age or older to consent to participate in this research study.

Questions and comments about this research may be addressed to the primary investigator, Tracey Llewellyn (706) 965-8300 or trl1139@georgiasouthern.edu or her advisor Dr. Thomas Buckley (912) 478-5269 or tbuckley@georgiasouthern.edu. For questions concerning your rights as a research participant contact Georgia Southern University Office of Research Services and Sponsored Programs at 912-478-0843. This research has been reviewed and approved by the GSU IRB under protocol number H11375.
Thank you for completing this questionnaire, your assistance in this research is greatly appreciated.

☐ yes, I agree to participate. Please take me to the questionnaire.
☒ no, I do not agree to participate.

2. Demographics

Directions: Answer the following questions regarding your COLLEGIATE ATHLETIC CAREER to the best of your knowledge. Your answers will remain confidential and will NOT be shared with your coaches or athletic training staff.

2. What is your gender?

☐ Male
☐ Female

3. Demographics

3. How old are you?

☐ 18
☐ 19
☐ 20
☐ 21
☐ 22
☐ 23
☐ 24
☐ Other (please enter age)

4. Demographics
4. What is your academic year in school?
- Freshman
- Sophomore
- Junior
- Senior
- 5th Year
- Other

5. Demographics
5. Which collegiate Sport(s) did you participate in? (check all that apply)

- Football
- Soccer
- Basketball
- Baseball
- Softball
- Volleyball
- Track and Field
- Swimming and Diving
- Chuckie Ball
- Golf
- Wrestling
- Hockey
- Cross Country
- Fencing
- Gymnastics
- Ice Hockey
- Judo
- Skiing
- Water Polo
- Bowling
- Field Hockey
- Bowling

6. Demographics

6. What was your primary position?

7. Demographics
7. Which Division did your school compete in?
   - I
   - II
   - III
   - NJCAA
   - Other (please specify)

8. Demographics
   8. How many years did you participate in your sport at the collegiate level?
      - 1
      - 2
      - 3
      - 4
      - 5
      - Other

9. Injury History
   Directions: Please answer the following questions as honestly as possible. Your answers will remain confidential and will not be shared with your coaches or athletic training staff.
   9. Have you ever sprained your ankle?
      - Yes
      - No

10. Injury History
    10. Was the ankle sprain reported to a healthcare provider?
        - YES
        - NO

11. Injury History
11. Did you complete a rehabilitation program, either on your own or with a healthcare provider?
- [ ] YES
- [ ] NO

12. Injury History

12. Have you ever injured a ligament or cartilage in your knee?
- [ ] YES
- [ ] NO

13. Injury History

13. Which ones?
- [ ] ACL
- [ ] MCL
- [ ] LCL
- [ ] PCL
- [ ] Meniscus
- [ ] Cartilage
- [ ] Other (please specify)

14. Injury History

14. Have you ever sprained any other joints (shoulder, wrist, etc.) while playing sports?
- [ ] YES
- [ ] NO

15. Injury History

15. Which Body Part(s)?

16. Injury History
16. Have you ever suffered a concussion?
- Yes
- No

17. Injury History

17. How Many?
- 0
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- 11
- 12
- 13
- 14
- 15
- 16
- 17
- 18
- 19
- 20

18. Injury History

18. Approximately when were they? (month and year to the best of your memory)
### 19. Injury History

19. When was your last concussion? (month and year to the best of your memory)

### 20. Injury History

20. Did you ever suffer a concussion and not tell anyone?
- [ ] YES
- [ ] NO

### 21. Injury History

21. Why?
- [ ] Did not think it was serious?
- [ ] Did not know it was a concussion?
- [ ] Did not want to be pulled out of the game/practice?
- [ ] Did not want to be pulled from future games/practices?
- [ ] Did not want to let your teammates down?
- [ ] Would have if it was an important game/practice?
- [ ] Other (If so, why?):

### 22. Injury History

22. Have you ever hurt your back?
- [ ] YES
- [ ] NO

### 23. Injury History

23. Please Explain

### 24. Injury History
24. Have you ever broken a bone?
   - YES
   - NO

25. Injury History
   25. Which one(s)?

26. Injury History
   26. Have you ever dislocated your shoulder?
   - YES
   - NO

27. Injury History
   27. Have you ever pulled, strained, or torn your rotator cuff or any other structure in your shoulder?
   - YES
   - NO

28. Injury History
   28. Explain briefly

29. Injury History
   29. Have you ever been knocked out while playing sports?
   - YES
   - NO

30. Injury History
   30. How many times?

31. Injury History
<table>
<thead>
<tr>
<th>Question</th>
<th>Response Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>31. How many were diagnosed as a concussion?</td>
<td></td>
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<tr>
<td>32. Have you ever pulled, badly strained, or torn a muscle?</td>
<td>YES, NO</td>
</tr>
<tr>
<td>33. Which muscles?</td>
<td></td>
</tr>
<tr>
<td>34. Have you ever been &quot;knocked silly/seen stars&quot; (confused/disoriented) while playing sports?</td>
<td>YES, NO</td>
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<tr>
<td>35. How many times?</td>
<td></td>
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<tr>
<td>36. How many were diagnosed as a concussion?</td>
<td></td>
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<tr>
<td>37. Have you had multiple ankle sprains?</td>
<td>YES, NO</td>
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<tr>
<td>38. How many?</td>
<td></td>
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<tr>
<td>39. Injury History</td>
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</tr>
<tr>
<td>Question</td>
<td>Answer Options</td>
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<td>-------------------------------------------------------------------------</td>
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<tr>
<td>39. Have you had any episodes of your ankle giving way?</td>
<td>Yes, No</td>
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<td>40. Injury History</td>
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<td>40. How many?</td>
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<td>41. Injury History</td>
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<tr>
<td>41. Do you have any current residual (lingering) symptoms regarding your ankle sprains?</td>
<td>Yes, No</td>
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<td>42. Injury History</td>
<td></td>
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<tr>
<td>42. What are they?</td>
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<tr>
<td>43. Injury History</td>
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<tr>
<td>43. Have you ever experienced any season ending injuries?</td>
<td>Yes, No</td>
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<td>44. Injury History</td>
<td></td>
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<td>44. What was/were your injury/injuries?</td>
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<td>45. Injury History</td>
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<td>45. Did you get surgery on any of these injuries?</td>
<td>Yes, No</td>
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<td>46. Injury History</td>
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<tr>
<td>Question</td>
<td>Options</td>
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<td><strong>46. What were your surgeries?</strong></td>
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<td><strong>47. Injury History</strong></td>
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<tr>
<td>During your collegiate athletic career did you ever have any orthopedic surgeries?</td>
<td>YES, NO</td>
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<td><strong>48. Injury History</strong></td>
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<td>On what?</td>
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<td><strong>49. Injury History</strong></td>
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<tr>
<td>Following a blow to the head, if you had experienced a headache, dizziness, or confusion would you report it to your athletic trainer?</td>
<td>YES, NO</td>
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<td><strong>50. Injury History</strong></td>
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<td>Why?</td>
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<td><strong>51. Injury History</strong></td>
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<tr>
<td>Have you ever had any injuries that you did not tell your athletic trainer about?</td>
<td>YES, NO</td>
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<td><strong>52. Injury History</strong></td>
<td></td>
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<td>What were they?</td>
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<td><strong>53. Injury History</strong></td>
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<td>53. Have you ever been hit so hard you lost your memory while playing sports?</td>
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<td>YES</td>
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<tr>
<th>54. Injury History</th>
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<tr>
<td>54. How many times?</td>
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<tr>
<th>55. Injury History</th>
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<tr>
<td>55. Did you tell your coach, athletic trainer, or parent?</td>
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<tr>
<td>YES</td>
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<tr>
<th>56. Injury History</th>
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<tbody>
<tr>
<td>56. Who did you tell?</td>
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<tr>
<td>Coach</td>
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<tr>
<td>Parent</td>
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<tr>
<th>57. Injury History</th>
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<tr>
<td>57. Was it diagnosed as a concussion?</td>
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<tr>
<td>YES</td>
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<th>58. Injury History</th>
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<tbody>
<tr>
<td>58. During your collegiate athletic career do you feel like you had a good relationship with your athletic trainer?</td>
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<tr>
<td>YES</td>
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</tbody>
</table>
APPENDIX D

TABLES AND FIGURES
Table 1: Demographics

<table>
<thead>
<tr>
<th>Division (n=161)</th>
<th>Gender (n=161)</th>
<th>Age (n=160)</th>
<th>Years of Participation (n=158)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCAA I</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>74.5% (n=120)</td>
<td>Male 35.0% (n=56)</td>
<td>21.8 ± 1.1</td>
<td>4.0 ± 0.8</td>
</tr>
<tr>
<td></td>
<td>Female 39.4% (n=64)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NCAA II</td>
<td>Male 4.4% (n=7)</td>
<td>22.2 ± 0.8</td>
<td>3.9 ± 0.5</td>
</tr>
<tr>
<td>8.7% (n=14)</td>
<td>Female 4.4% (n=7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NCAA III</td>
<td>Male 0.6% (n=1)</td>
<td>21.8 ± 0.7</td>
<td>3.9 ± 0.5</td>
</tr>
<tr>
<td>5.0% (n=8)</td>
<td>Female 4.4% (n=7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NJCAA</td>
<td>Male 3.8% (n=6)</td>
<td>19.5 ± 0.5</td>
<td>1.9 ± 0.2</td>
</tr>
<tr>
<td>11.8% (n=19)</td>
<td>Female 8.1% (n=13)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>Male 43.8% (n=70)</td>
<td>21.5 ± 1.3</td>
<td>3.7 ± 1.0</td>
</tr>
<tr>
<td>100% (161/161)</td>
<td>Female 56.5% (n=91)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 1: Demographics

![Demographics: Sport](chart.png)
<table>
<thead>
<tr>
<th>Division</th>
<th>Gender</th>
<th>Age (n=53)</th>
<th>Years of Participation (n=54)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCAA I</td>
<td>Male</td>
<td>37.5% (21/56)</td>
<td>21.8 ± 1.3</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>28.1% (18/64)</td>
<td>4.0 ± 0.8</td>
</tr>
<tr>
<td>NCAA II</td>
<td>Male</td>
<td>28.6% (2/7)</td>
<td>22.8 ± 0.8</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>42.9% (3/7)</td>
<td>4.0 ± 0.7</td>
</tr>
<tr>
<td>NCAA III</td>
<td>Male</td>
<td>100% (1/1)</td>
<td>21.6 ± 0.5</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>57.1% (4/7)</td>
<td>3.8 ± 0.4</td>
</tr>
<tr>
<td>NJCAA</td>
<td>Male</td>
<td>33.3% (2/6)</td>
<td>19.6 ± 0.5</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>23.1% (3/13)</td>
<td>1.8 ± 0.4</td>
</tr>
<tr>
<td>Total</td>
<td>Male</td>
<td>37.1% (26/70)</td>
<td>21.7 ± 1.4</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>30.8% (28/91)</td>
<td>3.8 ± 1.0</td>
</tr>
</tbody>
</table>
Figure 2A: Reporting Rates by Sport – Number of Athletes

Figure 2B: Reporting Rates by Sport – Percentage of Athletes

* Some athletes competed in multiple sports

Figure 2C: Number of Concussions Reported

<table>
<thead>
<tr>
<th>Number of Concussions</th>
<th>Number of Athletes</th>
<th>Percentage of Athletes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>28</td>
<td>51.9%</td>
</tr>
<tr>
<td>2</td>
<td>13</td>
<td>24.1%</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>18.5%</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>3.7%</td>
</tr>
</tbody>
</table>
Figure 3: Chi-Squares

<table>
<thead>
<tr>
<th>Variable</th>
<th>Number of Athletes</th>
<th>Male (#)</th>
<th>Female (#)</th>
<th>$\chi^2$</th>
<th>$p$</th>
<th>Odds Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have you ever suffered a concussion?</td>
<td>161</td>
<td>YES 26</td>
<td>NO 44</td>
<td>YES 28</td>
<td>NO 62</td>
<td>.641</td>
</tr>
<tr>
<td>Did you ever suffer a concussion and not tell anyone?</td>
<td>161</td>
<td>YES 8</td>
<td>NO 62</td>
<td>YES 11</td>
<td>NO 79</td>
<td>.024</td>
</tr>
<tr>
<td>Have you even been knocked out while playing sports?</td>
<td>161</td>
<td>YESU 4</td>
<td>NO 60</td>
<td>YESU 5</td>
<td>NO 83</td>
<td>2.107</td>
</tr>
<tr>
<td>Have you even been “knocked silly/seen stars” (confused/disoriented)</td>
<td>161</td>
<td>YESU 22</td>
<td>NO 41</td>
<td>YESU 17</td>
<td>NO 62</td>
<td>3.684</td>
</tr>
<tr>
<td>Following a blow to the head, if you had experienced a headache, dizziness, or confusion would you report it to your athletic trainer?</td>
<td>156</td>
<td>YES 43</td>
<td>NO 25</td>
<td>YES 71</td>
<td>NO 17</td>
<td>5.934</td>
</tr>
<tr>
<td>Have you ever been hit so hard you lost your memory while playing sports?</td>
<td>161</td>
<td>YESU 1</td>
<td>NO 62</td>
<td>YESU 2</td>
<td>NO 80</td>
<td>.142</td>
</tr>
</tbody>
</table>
Table 3: Current Unreported Rates

<table>
<thead>
<tr>
<th>Division (n= 19)</th>
<th>Gender (n=19)</th>
<th>Age (n=19)</th>
<th>Years of Participation (n=18)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCAA I 11.7% (14/120)</td>
<td>Male 12.5% (7/56)</td>
<td>22.1 ± 0.8</td>
<td>4.3 ± 0.5</td>
</tr>
<tr>
<td></td>
<td>Female 10.9% (7/64)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NCAA II 7.1% (1/14)</td>
<td>Male 14.3% (1/7)</td>
<td>23</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Female 0.0% (0/7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NCAA III 25.0% (2/8)</td>
<td>Male 0.0% (0/1)</td>
<td>21.5 ± 0.7</td>
<td>3.5 ± 0.7</td>
</tr>
<tr>
<td></td>
<td>Female 28.6% (2/7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NJCAA 10.5% (2/19)</td>
<td>Male 0.0% (0/6)</td>
<td>19.5 ± 0.7</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Female 15.4% (2/13)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total 11.8% (19/161)</td>
<td>Male 10.0% (7/70)</td>
<td>21.7 ± 1.1</td>
<td>3.9 ± 0.9</td>
</tr>
<tr>
<td></td>
<td>Female 12.1% (11/91)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 4A: Unreported Rates by Sport – Number of Athletes

Figure 4B: Unreported Rates by Sport – Percentage of Athletes
Figure 4C: Reasons for Not Reporting

<table>
<thead>
<tr>
<th>Reason</th>
<th>Percentage</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did not know it was a concussion?</td>
<td>52.6%</td>
<td>10</td>
</tr>
<tr>
<td>Did not want to be pulled from future games/practices?</td>
<td>52.6%</td>
<td>10</td>
</tr>
<tr>
<td>Did not want to be pulled out of the game/practice?</td>
<td>42.1%</td>
<td>8</td>
</tr>
<tr>
<td>Did not want to let your teammates down?</td>
<td>42.1%</td>
<td>8</td>
</tr>
<tr>
<td>Did not think it was serious?</td>
<td>42.1%</td>
<td>8</td>
</tr>
<tr>
<td>Would have if it was a less important game/practice?</td>
<td>21.1%</td>
<td>4</td>
</tr>
<tr>
<td>Other?</td>
<td>5.3%</td>
<td>1</td>
</tr>
</tbody>
</table>
Table 4: Overall Potential Unrecognized Rates – Totals

<table>
<thead>
<tr>
<th>Division</th>
<th>Gender</th>
<th>Age (n=41)</th>
<th>Years of Participation (n=41)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCAA I</td>
<td>Male</td>
<td>39.3%</td>
<td>22.0 ± 1.5</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>20.3%</td>
<td></td>
</tr>
<tr>
<td>NCAA II</td>
<td>Male</td>
<td>28.6%</td>
<td>21.3 ± 0.6</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>14.3%</td>
<td></td>
</tr>
<tr>
<td>NCAA III</td>
<td>Male</td>
<td>0.0%</td>
<td>21.0 ± 0.0</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>14.3%</td>
<td></td>
</tr>
<tr>
<td>NJCAA</td>
<td>Male</td>
<td>0.0%</td>
<td>19.3 ± 0.6</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>23.1%</td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td>Male</td>
<td>34.3%</td>
<td>21.7 ± 1.5</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>19.8%</td>
<td></td>
</tr>
</tbody>
</table>
Figure 5A: Potential Unrecognized Rates- Totals (Number of Athletes)

Potential Unrecognized Rates - Totals by Sport

Number of Athletes

Football  Soccer M  Soccer W  Cheerleading  Track and Field  Cross Country  Volleyball  Lacrosse  Field Hockey

16  7  6  5  4  3  2  2  1

Figure 5B: Potential Unrecognized Rates- Totals (Percentage of Athletes)

Potential Unrecognized Rates - Totals by Sport

Axis Title

Football  Cheerleading  Cross Country  Track and Field  Soccer M  Lacrosse  Volleyball  Soccer W  Field Hockey

55.2% (16/29)  50.0% (5/10)  30% (3/10)  26.7% (4/15)  25.0% (7/28)  22.2% (2/9)  20.0% (2/10)  18.2% (6/33)  12.5% (1/8)
Table 5: Potential Unrecognized Rates – “Knocked Silly/Seen Stars”

<table>
<thead>
<tr>
<th>Division</th>
<th>Gender</th>
<th>Age Mean ± SD</th>
<th>Years of Participation Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCAA I</td>
<td>Male</td>
<td>21.8 ± 1.4</td>
<td>4.0 ± 1.1</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>17.2% (11/64)</td>
<td></td>
</tr>
<tr>
<td>NCAA II</td>
<td>Male</td>
<td>21.3 ± 0.6</td>
<td>4.0</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>14.3% (1/7)</td>
<td></td>
</tr>
<tr>
<td>NCAA III</td>
<td>Male</td>
<td>21</td>
<td>4.0</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>14.3% (1/7)</td>
<td></td>
</tr>
<tr>
<td>NJCAA</td>
<td>Male</td>
<td>19.3 ± 0.6</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>23.1% (3/13)</td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td>Male</td>
<td>21.6 ± 1.4</td>
<td>3.9 ± 1.1</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>17.6% (16/91)</td>
<td></td>
</tr>
</tbody>
</table>
Figure 6A: Potential Unrecognized Rates: “Knocked Silly/Seen Stars” by Sport (Number of Athletes)

<table>
<thead>
<tr>
<th>Sport</th>
<th>Number of Athletes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Football</td>
<td>13</td>
</tr>
<tr>
<td>Soccer M</td>
<td>7</td>
</tr>
<tr>
<td>Cheerleading</td>
<td>5</td>
</tr>
<tr>
<td>Soccer W</td>
<td>5</td>
</tr>
<tr>
<td>Track and Field</td>
<td>3</td>
</tr>
<tr>
<td>Cross Country</td>
<td>2</td>
</tr>
<tr>
<td>Lacrosse</td>
<td>2</td>
</tr>
<tr>
<td>Volleyball</td>
<td>2</td>
</tr>
<tr>
<td>Field Hockey</td>
<td>1</td>
</tr>
</tbody>
</table>

Figure 6B: Potential Unrecognized Rates: “Knocked Silly/Seen Stars” by Sport (Percentage of Athletes)

<table>
<thead>
<tr>
<th>Sport</th>
<th>Percentage of Athletes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cheerleading</td>
<td>50.0</td>
</tr>
<tr>
<td>Football</td>
<td>48.3</td>
</tr>
<tr>
<td>Soccer M</td>
<td>25.0</td>
</tr>
<tr>
<td>Lacrosse</td>
<td>22.2</td>
</tr>
<tr>
<td>Track and Field</td>
<td>20.0</td>
</tr>
<tr>
<td>Cross Country</td>
<td>20.0</td>
</tr>
<tr>
<td>Volleyball</td>
<td>20.0</td>
</tr>
<tr>
<td>Soccer W</td>
<td>15.2</td>
</tr>
<tr>
<td>Field Hockey</td>
<td>12.5</td>
</tr>
</tbody>
</table>
Table 6: Potential Unrecognized Rates – “Knocked Out”

<table>
<thead>
<tr>
<th>Division (n=6)</th>
<th>Gender (n=6)</th>
<th>Age (n=6)</th>
<th>Years of Participation (n=6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCAA I</td>
<td>Male</td>
<td>3.6% (2/56)</td>
<td>22 ± 3.0</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>4.7% (3/64)</td>
<td></td>
</tr>
<tr>
<td>NCAA II</td>
<td>Male</td>
<td>0.0% (0/7)</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>0.0% (0/7)</td>
<td></td>
</tr>
<tr>
<td>NCAA III</td>
<td>Male</td>
<td>0.0% (0/1)</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>0.0% (0/7)</td>
<td></td>
</tr>
<tr>
<td>NJCAA</td>
<td>Male</td>
<td>0.0% (0/6)</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>7.7% (1/13)</td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td>Male</td>
<td>1.4% (1/70)</td>
<td>21.5 ± 2.9</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>5.5% (5/91)</td>
<td>3.5 ± 1.6</td>
</tr>
</tbody>
</table>

N/A = Not Applicable
Figure 7A: Potential Unrecognized Rates – “Knocked Out” by Sport (Number of Athletes)

![Bar chart showing the number of athletes 'knocked out' by sport.]

Figure 7B: Potential Unrecognized Rates – “Knocked Out” by Sport (Percentage of Athletes)

![Bar chart showing the percentage of athletes 'knocked out' by sport.]

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Table 7: Unrecognized Rates – “Lost Memory”

<table>
<thead>
<tr>
<th>Division</th>
<th>Gender</th>
<th>Age</th>
<th>Years of Participation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NCAA I</strong></td>
<td>Male</td>
<td>1.8% (1/56)</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>1.6% (1/64)</td>
<td></td>
</tr>
<tr>
<td><strong>NCAA II</strong></td>
<td>Male</td>
<td>0.0% (0/7)</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>0.0% (0/7)</td>
<td></td>
</tr>
<tr>
<td><strong>NCAA III</strong></td>
<td>Male</td>
<td>0.0% (0/1)</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>0.0% (0/7)</td>
<td></td>
</tr>
<tr>
<td><strong>NJCAA</strong></td>
<td>Male</td>
<td>0.0% (0/6)</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>7.7% (1/13)</td>
<td></td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td>Male</td>
<td>1.4% (1/70)</td>
<td>21.3 ± 1.2</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>2.2% (2/91)</td>
<td></td>
</tr>
</tbody>
</table>
Figure 8A: Potential Unrecognized Rate: “Lost Memory” by Sport (Number of Athletes)

![Bar chart showing the number of athletes with lost memory by sport.]

Figure 8B: Potential Unrecognized Rate: “Lost Memory” by Sport (Percentage of Athletes)

![Bar chart showing the percentage of athletes with lost memory by sport.]

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Table 8: Potential Unrecognized Rates- would not report headache, dizziness, or confusion

<table>
<thead>
<tr>
<th>Division (n= 42)</th>
<th>Gender (n=42)</th>
<th>Age (n=42)</th>
<th>Years of Participation (n=41)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCAA I 30.0% (36/120)</td>
<td>Male 42.9% (24/56)</td>
<td>21.9 ± 1.1</td>
<td>4.1 ± 0.7</td>
</tr>
<tr>
<td></td>
<td>Female 18.8% (12/64)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NCAA II 7.1% (1/14)</td>
<td>Male 0.0% (0/7)</td>
<td>22</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Female 14.3% (1/7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NCAA III 12.5% (1/8)</td>
<td>Male 0.0% (0/1)</td>
<td>21</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Female 14.3% (1/7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NJCAA 21.1% (4/19)</td>
<td>Male 16.7% (1/6)</td>
<td>19.8 ± 0.5</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Female 23.1% (3/13)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Totals 26.1% (42/161)</td>
<td>Male 35.7% (25/70)</td>
<td>21.7 ± 1.2</td>
<td>3.9 ± 0.9</td>
</tr>
<tr>
<td></td>
<td>Female 18.7% (17/91)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 9A: Potential Unrecognized Rate: “Would You Report?” by Sport - (Number of Athletes)

Figure 9B: Potential Unrecognized Rate: “Would You Report?” by Sport - (Percentage of Athletes)
Figure 10: Permutations

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>negative reported+ positive unreported+ negative unrecognized</td>
<td>1</td>
<td>0.6%</td>
</tr>
<tr>
<td>negative reported+ positive unreported+ positive unrecognized</td>
<td>6</td>
<td>3.7%</td>
</tr>
<tr>
<td>negative reported+ negative unreported+ negative unrecognized</td>
<td>80</td>
<td>49.7%</td>
</tr>
<tr>
<td>negative reported+ negative unreported+ positive unrecognized</td>
<td>19</td>
<td>11.8%</td>
</tr>
<tr>
<td>positive reported+ positive unreported+ positive unrecognized</td>
<td>3</td>
<td>1.9%</td>
</tr>
<tr>
<td>positive reported+ positive unreported+ negative unrecognized</td>
<td>9</td>
<td>5.6%</td>
</tr>
<tr>
<td>positive reported+ negative unreported+ positive unrecognized</td>
<td>12</td>
<td>7.5%</td>
</tr>
<tr>
<td>positive reported+ negative unreported+ negative unrecognized</td>
<td>28</td>
<td>17.4%</td>
</tr>
<tr>
<td>At Least 1 Variable</td>
<td>80</td>
<td>49.7%</td>
</tr>
</tbody>
</table>
Figure 11: Unreported Rates Compared to Previous Literature

<table>
<thead>
<tr>
<th>Reason</th>
<th>McCrea 2004</th>
<th>Broglio 2010</th>
<th>Current Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did not think it was serious?</td>
<td>66.4%</td>
<td>94.4%</td>
<td>42.1%</td>
</tr>
<tr>
<td>Did not know it was a concussion?</td>
<td>36.1%</td>
<td>66.7%</td>
<td>52.6%</td>
</tr>
<tr>
<td>Did not want to be pulled out of the game/practice?</td>
<td>41%</td>
<td>66.7%</td>
<td>42.1%</td>
</tr>
<tr>
<td>Did not want to be pulled from future games/practices?</td>
<td>N/A</td>
<td>N/A</td>
<td>52.6%</td>
</tr>
<tr>
<td>Did not want to let your teammates down?</td>
<td>22.1%</td>
<td>38.9%</td>
<td>42.1%</td>
</tr>
<tr>
<td>Would have it was a less important game/practice?</td>
<td>N/A</td>
<td>N/A</td>
<td>21.1%</td>
</tr>
<tr>
<td>Concussions are part of the game?</td>
<td>N/A</td>
<td>88.9%</td>
<td>N/A</td>
</tr>
<tr>
<td>Other?</td>
<td>9.8%</td>
<td>N/A</td>
<td>5.3%</td>
</tr>
</tbody>
</table>