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Post-Concussion Symptom Reporting: Is Gender a Factor in the Adolescent Population? A Systematic Review and Meta-Analysis

Jessica Dunne
University of Nevada, Las Vegas, jadatc13@outlook.com

POST-CONCUSSION SYMPTOM REPORTING: IS GENDER A FACTOR IN THE ADOLSECENT POPULATION? A SYSTEMATIC REVIEW AND META-ANALYSIS

By

Jessica A. Dunne

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Western Illinois University

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Jessica A. Dunne

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Kara Radzak, Ph.D.
Examination Committee Chair

Julia Freedman Silvernail, Ph.D.
Examination Committee Member

Tedd Girouard, M.S.
Examination Committee Member

Du Feng, Ph.D.
Examination Committee Member

Merrill Landers, Ph.D.
Graduate College Faculty Representative

Kathryn Hausbeck Korgan, Ph.D.
Graduate College Interim Dean

Abstract

The participation in high school athletics among the adolescent population has continued to rise over the past few years. Concussion research has grown and evolved due to an increase in awareness of the seriousness of this injury based on the increase in quantity studies being produced. The research conducted to determine if differences occur between high school athletes and collegiate athletes and if a difference is observed between the genders, has being to grow. Although there has been an increase in research for this injury, the understanding of how this injury affects the adolescent population and how this injury differs between the genders, is still widely unknown. Therefore, the objective of the current meta-analysis and systematic review is to evaluate the literature and determine if a relationship exists in post-concussion symptom reporting between male and female adolescent athletes. An extensive search of PubMed, SPORT Discs, Web of Knowledge, Cochrane Library, ProQuest and Google Scholar was undertaken. The specificity of search terms was based on the individual database. Once the inclusion criteria was met, a quality assessment of the included studies was completed and those studies were included in the current meta-analysis and systematic review. A total of three articles were included in the current meta-analysis. To examine the hypothesis of the current meta-analysis and systematic review a significance test for proportion between two independent groups was conducted along with the calculation of z-scores, using a two-tailed test. The organization and analysis of the included data was completed using Microsoft Excel and the alpha level was set at $p<.05$. The results of the current meta-analysis indicate that a significant difference within the reporting of commonly reported post-concussion symptoms exists between the genders in the adolescent population.

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Dedication

To the students who don't think they would ever be able to write a thesis. If I can do it, you can do it!

To my undergraduate program directors and professors.

To myself, my friends and loved ones.

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Chapter 1: Introduction

In the 2013-2014 school year the number of participants in high school athletics increased for the 25th consecutive year to a record total of almost 7.8 million participants.[21] An estimated 1.6 to 3.8 million sport-related concussions are sustained every year.[26] High school athletes alone, sustain concussions at an estimated rate of 2.5 concussions per 10,000 athletic exposures.[28] A concussion is a pathophysiologic injury caused by biomechanical forces to the head, neck or body, resulting in a disruption of normal brain function and causes a cascade of symptoms that range from mild to severe.[30, 35] Concussion diagnosis is based mainly on visible signs (balance difficulties, loss of consciousness, vomiting, etc.) and symptoms (headache, feeling in a fog, mentally groggy, etc.) reported by the injured athlete. Self-reported symptom resolution is also used as an indicator of an athlete's recovery.[4, 30]

The 2012 consensus statement on concussions, states that an athlete suspected of having a concussion may experience symptoms in all or some of the following four clinical domains: somatic, cognitive, behavioral, and sleep disturbances.[30] The somatic domain includes such symptoms as headache, dizziness, nausea and sensitivity to light or sound.[30, 35] The cognitive domain includes symptoms that cause an athlete to "feel out of it", have difficulty concentrating or display decreased reaction time.[30, 35] Mood or behavioral changes may also occur, which are categorized as behavior domain symptoms.[30, 35] Athletes with behavior domain symptoms may feel anxious, irritable or sad.[35] Sleep disturbances or dysregulation may also occur, which may cause the athlete to suffer from insomnia or sleeping too much.[16, 35] Despite the use of clinical domains, no two concussion symptom presentations are alike and individual athletes experience a varying quantity, duration and intensity of symptoms .[3, 6, 7, 18, 19]

Despite the individuality of every concussion, previous studies have indicated that patient demographics, particularly age and gender, may influence symptom presentation. Females report a greater quantity of symptoms than males.[6, 34, 40] Symptom presentation within the four different domains

also appears to be different between genders.[11] Concussion differences are also shown to exist between athletes of varying ages, specifically adolescents and young adults.[12, 16, 41] One theory for this occurrence, is that an immature brain may experience prolonged and diffuse cerebral swelling after a traumatic brain injury.[35] This prolonged cerebral swelling in younger populations may lead to a longer recovery time and a higher risk of secondary injury, when compared to adults.[16, 27, 35]

A multitude of research has been conducted on concussions, both in athletes and non-athletes of varying ages and gender. The adolescent population is of particular interest due to the rates of athletic participation and concussions increasing.[21, 26, 28] Adolescent athletes show a pronounced memory decline, at least, seven days post injury, whereas college athletes only suffered memory deficits within the first 24 hours of injury.[16] Neurocognitive testing indicates that adolescent athletes take several days longer than collegiate athletes for neurocognitive scores to return to baseline measurements.[41] Systematic reviews have previously summated research regarding both concussion incidence differences between adolescent and collegiate athletes and gender differences in symptom reporting, incidence, and rate of recovery.[7, 39] Despite previous meta-analyses evaluating gender differences in symptom reporting, results were reported in combined age groups and not specifically focused on adolescent athletes or collegiate athletes.[7, 39] There remains a need to specifically evaluate the currently available findings on gender differences in the adolescent population. Therefore, the objective of the current meta-analysis and systematic review is to evaluate the literature and determine if a relationship exists in post-concussion symptom reporting between male and female adolescent athletes. Specifically, the current meta-analysis and systematic review will aim to determine if the percentage of individuals who report symptoms of interest, are different between the genders in adolescent athletes. We hypothesize that there will be a significant difference in the percentage of the population (gender specific) reporting common post-concussive symptoms between male and female adolescent populations.

Chapter 2: Literature Review

The objective of the current meta-analysis and systematic review is to evaluate the literature and determine if there is a difference in post-concussion symptom reporting between male and female adolescent athletes. The following research discusses the pathophysiology, incidence rates and the signs and symptoms that occur once a concussion has been sustained. The guidelines for returning an athlete to participation has evolved with an increase in the concussion research will also be discussed. The adherence to a proper protocol has allowed for a safe return to participation for an injured athlete and remains an important piece of concussion management. The main topics of this literature review will be: 1) adolescent athletes and their comparison to collegiate athletes post-concussion, 2) if gender differences in symptom presentation occur post-concussion. The following research discusses why the adolescent population needs to be viewed separately from the young adult and even child populations, along with research on concussion gender differences. To determine the proper methodology, including the use of an appropriate quality assessment tool and statistical analysis tools, research was conducted to make an accurate determination.[24, 37, 38] Appropriate quality assessment tools and systematic review and meta-analysis guidelines of various disciplines was also reviewed.[1, 7, 32, 38, 39,] Research of varying systematic reviews and meta-analyses was completed to determine the appropriate reporting guideline to be used, and systematic reviews and meta-analyses in the health care field were referenced to determine how systematic reviews and meta-analyses are being conducted within a similar discipline.[7, 39]

Concussion Overview

Concussion research has evolved over the last 20 years and the interest in adolescent and gender-specific outcomes has grown substantially. The increase in concussion awareness in professional sports has resulted in increased awareness and a need for additional research on this still highly misunderstood and complicated injury. With the advancement of technology within the healthcare field and the desire

for knowledge, primary research studies on concussive injuries and incidence rates among various sports populations and age levels has increased. Research has produced a more concise understanding of what is occurring in the brain after a concussion occurs. This enhanced understanding has allowed researchers and clinicians the ability to modify guidelines and return to participation protocols, which provides better and more accurate protection and care for athletes. The following section of the current literature review summarizes how an increase in incidence rates, the adaptations in the current literature and how those adaptations have changed the definition of a concussion, the brains response to the concussive injury and how the guidelines and protocols have changed to better protect athletes.

A concussion, as defined by the Consensus Statement on Concussions in Sport, is a complex pathophysiological process affecting the brain, induced by biomechanical forces.[30] Another way this injury can be described is when a force is transmitted to the head, by a jolt to the head or body, that causes the head to move forward, backward or side to side.[18] This movement of the head results in a "shaking" or movement of the brain inside the skull.[30] A review of concussion literature produced by Grady, determined that a concussive injury can be thought of as a two-part process: the primary insult and the resulting inflammatory process.[18] Once the initial injury has occurred, amino acids are released, which causes a change in the pH composition of the cells within the brain.[18] The change in pH levels, causes damage to the cell, which if severe enough can lead to cell death.[18] If cell death does occur, those cells, release chemicals that enhance the inflammatory process.[18] Once the inflammatory process is complete, healing begins. During this stage, the cells require more glucose.[18] Cerebral circulation becomes critical during this phase, to allow for the necessary glucose to be delivered to promote healing.[18] However, due to the initial injury, the cells response to injury is to restrict blood flow, which results in a decrease of cerebral blood flow and the flow-metabolism is disrupted.[18] Due to this disruption of normal blood flow, the brain is more susceptible to additional stress.[18] If there is high demand for glucose, such as when an athlete is exercising, participating in cognitive tasks or even during normal daily activities, the brain will be placed under additional stress.[18] This will ultimately place the individual at an increased risk, for a

worsening of their symptoms or developing second impact syndrome,[35] because the demand for glucose by the brain cells is not being met.[18] This metabolic mismatch of increased cerebral glucose need and functionally decreased cerebral blood flow is the fundamental concept in acute concussion management.[18, 35] This injury process, from initial insult to inflammatory process, has been hypothesized to influence the symptoms an athlete experiences, including the possibility for symptoms to develop or worsen over the first 24 hours after the initial insult.[18, 35]

Incidence Rates

Each year the number of participants in high school athletics has increased[21] but this does not take into account the numerous club and traveling teams in which adolescent athletes participate. New methods to track and record adolescent concussions have been developed. Advancement in the ability to track concussion incidence allows Certified Athletic Trainers (ATCs) to provide better care for their athletes by gaining information about what sports may produce the most concussions.

Two studies researching the concussion incidence rates were completed by Lincoln et al.[26] and Marar, McIlvain, Fields and Comstock[28], in high school athletics between 1997-2008 and 2008 to 2010 respectively. Both studies used an online reporting system, which required participating ATCs to log-in and document concussion injuries that occurred during practices and competitions across six boys and six girls sports.[26, 28] The Lincoln et al. study indicated a rate of .24 cases per 1,000 athletic exposures.[26] The Marar and colleagues study resulted in a rate of 2.5 cases per 10,000 athletic exposures.[28] Comparing the results of these two studies indicates a small increase in concussion rates during the study periods and the number of athletes participating in high school athletics appears to be increasing. Both studies also indicated that concussions occurred at an increased rate during competition rather than practice (Marar;

practice 1.1 concussions per 10,000 and competition; 6.4 concussions per 10,000).[26, 28] Both of these studies also reported that girls' sports had a higher concussion rate than boys' sports.[26, 28]

The differences in concussion incidence between these two studies was an interesting finding. The difference between the two studies, is not very large, but may be due to the difference in reporting systems. The Marar and colleagues study used the High School Reporting Information Online System and the Lincoln et al. study used the Sports Injury Management System software as part of the participating ATCs job requirements.[26, 28] Another possible reason for the difference in concussion rates may be due to the years the studies were completed. The concussion rates in the more recent study may be due to the increase in concussion awareness and education. The increase in awareness and education of this injury allows for athletes and coaches to understand that the symptoms the athlete may be experiencing, is something that needs to be reported. Increased awareness and understanding of this injury may have been one cause for the increase in the reporting rate in the recent years. These two studies indicate that the rate of concussions in high school athletics has increased.[26, 28] Although this increase is small, it does indicate that the number of adolescent athletes is increasing and with the increase in athlete participation, an increase in concussion incidence rates may also increase as well.[26, 28] With this increasing injury rate, ATCs need to continue to provide education on concussive injuries to athletes and parents of athletes who participate in any form of athletic activity. Collaborating with parents, coaches and administration in concussion care and management will allow all individuals who will interact with the athlete to be aware of the management plan and how it needs to be executed. This will also allow for consistent and high quality of care for the injured athlete.

Concussion Symptoms

The self-reporting of symptoms is one of the main ways an ATC is able to diagnose concussions and track an athlete's recovery. While this method is highly used and relied upon, it does have some drawbacks. Athletes may not report their symptoms accurately or honestly, or may not even understand that the symptoms they are experiencing are the result of an injury or are severe in nature (this is of specific concern for the child and adolescent populations). Concussion symptoms can range anywhere from mild to causing an athlete significant disability or disruption to their daily lives. The most common signs and symptoms reported by athletes can be found in Figure 1.[4] The ability to understand the symptoms that athletes present with post-concussion will allow for more concise and consistent on-and-off the field management.

Symptom presentation and resolution will vary between athletes, but the symptoms that are reported will fall into four or five domains, based on the referenced literature.[30, 35] These domains include: Somatic (headache, dizziness, light and noise sensitivity), cognitive (feeling slowed down or in a "fog" and difficulty concentrating), sleep dysregulation (insomnia or sleeping more than normal), mood/behavioral changes (irritability, sadness, anxiety) and physical signs (loss of consciousness, and balance difficulty).[30, 35] The categorizing of concussion symptoms has allowed for the ATC and health care professional, to gain information about the complex areas of the brain that may be effected by the concussive injury, such as the vestibular system. It also allows for more consistent on-and-off- the field management.[35] Development of neurocognitive testing (such as ImPACT), has added to the ability to track progress of their athlete through the recovery process.[35] Neurocognitive tests have the ability to detect more subtle concussive effects such as an alteration in memory or a decrease in reaction time.[35] This comprehensive and sensitive tool has allowed for a more all-encompassing and structured return to play process. One main characteristic that may delay an athlete's return to play is the time until symptom resolution. Research has indicated that an athletes symptoms generally resolve within seven to ten days

or less.[24] Demographic factors such as age or gender may cause an athlete to have a prolonged or protracted recovery.[24] There is no clear or defined timeline as to when an athlete will experience a resolution of their symptoms due to the individuality of this injury.[24] The athlete should be monitored daily for any change in symptoms which may require additional medical evaluation.[24]

Figure 1: ***Common Signs and Symptoms of a Concussion***

Concussion Signs	Concussion Symptoms
Headache or a feeling of “pressure in the head.	Balance/coordination problems
Nausea or vomiting	Appears dazed or stunned
Vision changes, such as blurry vision or double vision	Appears confused about an assignment or position
Sensitivity to light	Is unsure of what is occurring in the game such as opponent and or score
Sensitivity to noise	Answers questions slowly
Feeling “out of it” or “slowed down”	Loss of consciousness (no matter how long)
Concentration or memory problems	Mood or behavior changes (overly emotional, angry)
Confusion	Inability to remember events prior to the injury (retrograde amnesia)
Not “feeling right or “feeling down”	Inability to remember events after the injury (anterograde amnesia)
Drowsiness	
Fatigue	
Ringing in the ears	
The presentation or reporting of symptoms will vary.	

Return to Play Guidelines

Advancements in concussion research has developed a number of tools to help determine when and how to safely return an athlete to competition.[4, 30] Along with return to play decisions, consideration must be made for when and how an athlete should be able to attend school and in what capacity return to cognitive activities should occur.[24] Laker suggests a reasonably rapid return to school with accommodations to allow for participation and educational growth, without overwhelming the student or increasing their symptoms.[24] Accommodations for returning to academic activity should be closely related to the severity and level of dysfunction caused by the athlete’s symptoms.[24]

Return to participation guidelines have existed for many years, but increased knowledge gained from advancing research has resulted in adaptations to the early guidelines. Early stages of the return to play guidelines were developed by researchers such as Cantu, The Colorado Medical Society, and the American Academy of Neurology.[35] These guidelines allowed an athlete to return to the same competition or competition within the same day if their symptoms resolved within a predetermined amount of time.[35] With the advancement of research it is now stated that, if an athlete is suspected of having sustained a concussion, they should be removed from competition and not allowed to return to participation until evaluated by a medical professional.[4, 30]

The Journal of Athletic Training states that physical exertion may only occur after the concussed athlete demonstrates a normal clinical exam, the resolution of concussion-related symptoms and a return to pre-injury score on a neurocognitive test.[4] A stepwise exertional progression protocol must be developed by the Athletic Trainer and shared with coaches and athletic administration.[4] By sharing this information with coaches and athletic administration, it will allow for overall consistency in treatment and care of the athlete. The developed stepwise exertional progression, may begin once an athlete has been symptom-free for 24 hours.[4, 30] The protocol slowly increases in difficulty and physical exertion to determine and assure that the athlete has no returning or residual symptoms that occur from an increase in physical exertion.[4] It is widely accepted that each stage of the exertional protocol occurs following a 24 hour period.[4, 30] For example, once an athlete participates in the first stage, which is typically low-level aerobic activity such as biking, that athlete should not progress to stage two for 24 hours.[30] Upon completing the protocol without a return of symptoms, the athlete may then be returned to full activity.[4, 30] When working with children or adolescent athletes special care needs to be taken during the return-to-play phase, so the injured athlete does no return to completion before their injury has resolved, due to the increased risk of second impact syndrome within the adolescent population.[35]

The increase and progression of concussion research has produced an awareness about the physiological process that occurs after a concussive injury, the resulting concussion symptoms, and the

proper care of the injured athlete.[4, 18, 30, 35] The current research states that an athlete suspected of sustaining a concussion may not return to competition until evaluated by a health care professional.[4, 30] A variety of symptoms will be experienced by each athlete and the resolution of symptoms may occur within one to two weeks for most athletes.[27] Once an athlete's symptoms have resolved and their neurocognitive score has returned to pre-injury levels, the athlete may then begin a progressive exertional protocol.[4, 30] Particular care and attention needs to be taken when working with children and adolescent athletes.[4, 27, 30, 35] Accommodations may be necessary for these athletes as they return to school after their injury.[24] The advancement in concussion research has provided ATC's and health care professionals with the knowledge and the ability to provide better and more comprehensive care for the athletes they treat.

Differences in Adolescent and Collegiate Athletes

The current meta-analysis and systematic review will be focusing specifically on the adolescent population. This subset of athletes continues to grow every year, as their participation in athletic activities increases.[21] Collegiate athletics and concussions have been studied extensively, but determining if there is a difference between adolescent and collegiate athletes has become a recent topic of interest.[11, 12, 39, 41] Researchers have compared the time to symptom resolution and neurocognitive performance between adolescent and collegiate athletes.[11, 12, 39, 41] If differences are present this may indicate that concussions need to be evaluated differently between these two subsets of athletes. In addition more specific and specialized return to participation protocol for the adolescent population may be needed.

Research evaluating adolescent concussions is undergoing rapid growth. Numerous studies have been conducted on this subject in the collegiate population and research is now expanding into the adolescent population. Research questions have been aimed at evaluating the difference in recovery rate between these two groups of athletes.[41] Also, if there is a difference in recovery, where is that difference

occurring?[11] Are differences due to symptom resolution or in the time taken for neurocognitive scores to return to baseline levels?[40] Gaining an understanding of these questions may indicate that recovery, and therefore treatment should vary between these two groups of athletes.

A number of research has been conducted to examine the differences between high school and adolescent athletes in terms of neurocognitive recovery and symptom resolution post-concussion.[16, 27, 39, 41] The results of these studies have indicated that verbal memory, visual memory and reaction time scores on the ImPACT test takes longer to return to baseline levels for adolescent athletes.[39] A decrease in neurocognitive function was seen in adolescent athletes for up to seven days, whereas a decrease in function was only seen for up to five days in collegiate athletes.[16] A meta-analysis was conducted specifically on the difference in the recovery time of adolescent and collegiate athletes.[39] The meta-analysis found that adolescent athletes do not report symptom recovery until 15 days post-concussion, whereas collegiate athletes report symptom recovery within seven days post-concussion.[39] A study conducted with adolescent athletes only, found that when comparing non-concussed athletes with concussed athletes, a significant difference was seen between the groups at 36 hours post-concussion.[27] This timeframe is very different than the studies comparing symptom recovery among collegiate and adolescent athletes.[16, 39, 41] When the two adolescent groups were compared to measure neurocognitive recovery the results indicated that a decline in neurocognitive memory scores were seen for up to seven days post injury.[27] The results of these studies indicate that adolescent athletes have a longer recovery time in terms of neurocognitive recovery and symptom resolution, despite the differences in the type of neurocognitive test performed and the timeframe for follow-up.[16, 27, 39, 41]

Concussion differences between adolescent and collegiate athletes is a topic currently being studied by researchers. The current research indicates that adolescent athletes experience a longer recovery time as well as endorsing more post-concussion symptoms, for a longer period than collegiate athletes (seven days versus three days).[16, 39, 41] Also, adolescent neurocognitive scores take longer to return to baseline levels post-concussion.[41] This delayed healing process may become difficult for an

athlete, who expresses concern and apprehension about returning to their desired sport. Constant communication and proper education of the athlete will help them gain an understanding of the seriousness of their injury and the need for proper rest. The results of the current research indicate that adolescent athletes may require a different set of treatment guidelines and return to play protocols.[16, 27, 39, 41] Adolescent athletes may require more time for cognitive and physical rest to allow for adequate healing.

Gender Differences

Gender differences in concussions has become a topic of interest with the increase in the number of female athletes participating in collegiate and high school athletics due to Title IX.[6] Researchers are currently evaluating length of recovery time between men and women, the symptom severity and the number of symptoms reported among these two groups of athletes. A variety of athletes, ranging from adolescent to adult, across a range of sports is included in the ongoing research. Determining if a gender difference exists may result in differences in evaluation and treatment techniques along with differences in how concussions are managed between the genders.

Neurocognitive Performance

With the development of computerized neurocognitive testing, it is now becoming commonplace that an athlete participating in any interscholastic activity perform a baseline neurocognitive test prior to the start of their athletic season. A study by Broshek et al. had their participants perform a baseline test, and then a post-concussion test once an injury occurred.[6] This is the only study included in the current literature review that indicated a baseline test was completed.[6] The results of a post-test are compared to the baseline test to determine the athletes' level of dysfunction and to track their progress through the recovery process.[6] With the development of this practice, researchers are now trying to determine if a difference in neurocognitive performance occurs between male and female athletes, at the baseline test

and the post-concussion test. For this purpose of the current literature review, the author will be focusing only on post-concussion research.

Studying the difference between male and female athletes, in regards to computerized neurocognitive testing is a relatively new endeavor, which continues to grow. Research conducted among the athletic population consists of athletes of varying ages and a wide array of sports. Research indicates that female athletes perform worse on certain neurocognitive tests, specifically reaction time ($p= .05$),[6] verbal memory ($p= .017$)[11] and visual memory ($p=.049$).[12] The differences in neurocognitive testing performance among the studies is an interesting finding. Each study indicated a different test was performed worse by female athletes.[6, 11, 12] This differences may be due to the individuality of the participants. Despite these differences, the overall outcome indicates that females perform worse on certain neurocognitive tests, when compared to male athletes.[6, 11, 12] When treating athletes that have sustained a concussion, what is equally as important as their neurocognitive score, is the time it takes for their overall score to return to pre-injury levels. One study indicates that the genders within the adolescent and young adult age group may have a longer recovery time than has previously been reported.[19] Henry, Elbin, Collins, Marchetti and Kontos[19] found that the participants of their study reported recovery between 21 to 28 days[19] which is longer than the original 7-14 day recovery period.[30] Due to the recent increase in primary research related to the differences in genders post-concussion, the number of participants among the studies may vary. The previous study, conducted by Henry and colleagues did not find statistical significance between the genders and the author stated that it may have occurred because of the small sample size (55 total participants participated in the follow up evaluation).[19]

With research stating that a longer recovery time may be possible[19], this may change the way concussions are approached in the athletic population. This finding is important for ATCs and healthcare professionals that are treating these athletes because, a female athlete may require a longer rest and recovery period to allow their neurocognitive results to return to their baseline levels and specific cognitive processes may be affected that may lead to problems in the classroom. Knowing that one

gender may need assistance during their recovery process may result in a smoother and more productive recovery which will result in a healthier and more positive athlete.

Symptoms

Symptom occurrence and resolution among athletes is a highly researched topic.[3, 6, 11, 19, 40] Researchers continue to study what symptoms occur after a concussion, and how long they last among a variety of athletes and age groups. With the high variability rate in the specific symptoms that are experienced by athletes, makes it difficult to gain a firm and concise understand as to what symptoms an athlete may experience and how long those symptoms will last. The following research aims to determine how symptoms are presented and the length of resolution between male and female athletes of varying ages.

Studying concussions among sports that have similar rules and equipment for males and females, provides an optimal research environment. Studies conducted within these environments indicate that females report a greater number of total symptoms[6] specifically in the sleep dysregulation domain ($p= .003$) and the migraine-cognitive-fatigue domain ($p= .001$).[11] Research conducted within the overall athletic population indicate that females have an increased total symptom score.[3, 19, 40] Current research also indicates that females have a prolonged recovery rate and report more symptoms post-concussion than males when evaluated three months post-concussion.[19, 34, 41] Preiss-Farzanegan, Chapman, Wong, Wu and Bazarian found that adult females are at a 2.89 times greater risk of increased post-concussion scores than female minors at three months post injury.[34]

During the initial on-field evaluation post-concussion, an athletes balance may be tested using the Balance Error Scoring System test.[11] A study conducted by Covassin, Elbin, Harris, Parker and Kontos found that collegiate females had poorer balance than their male counterparts.[11] This study also found that in the adolescent age group, the male athletes performed worse than their female counterparts.[11] The results of the Covassin and colleagues study are similar to a study conducted by

Henry and colleagues that indicated that females reported an increased level of dizziness post-concussion, along with an increased vestibule-oculomotor score when compared to males ($p = .001$).[19] Since the participants in the Henry and colleagues study consisted of adolescents and young adults, it is difficult to determine at what age an increased level of dizziness was indicated.[19] The differences found among the included studies indicate that overall, males report a lower total symptom score, recover faster than females post-concussion, and females suffer more symptoms, for a longer duration.[3, 11, 19] When providing care to an athletic population, it is imperative to understand that females may recover more slowly than males. This information will result in quality care for the athlete. The ATC will be able to communicate effectively with this subgroup of athletes, and this open communication could result in a more productive return to play protocol.

Concussion research has grown substantially in recent years, among such topics as the increase in adolescent concussion incidence[26, 28] and the effects a concussion has between genders.[6, 11, 12, 19, 34, 40] The research states that a concussion is a pathophysiological process, which occurs after an impulsive force is transmitted to the head.[4, 18, 30, 35] Which results in an initial injury and a resulting inflammatory phase that occurs shortly after the injury.[18] An athlete that is suspected of sustaining a concussion must be removed from play and evaluated by a health care professional.[4, 30] There are certain factors that may result in a protracted or difficult recovery such as young age and the female gender.[30] Research states that adolescent athletes take longer to recover than young adults and female athletes also have a longer recovery time and endorse more symptoms than male athletes.[3, 6, 11, 12, 19, 34, 40] Although the research states that females report more symptoms, the research is not clear as to, at what age that occurs. Therefore, the purpose of the current meta-analysis and systematic review is to determine if a relationship exists in post-concussion symptom reporting between male and female adolescent athletes.

Methodological Development

The following resources were used to develop inclusion criteria, quality assessments, and the appropriate methodology for the current meta-analysis and systematic review. Literature searchers were also conducted on reviews of topics similar to the current meta-analysis and systematic review, along with research information on statistical methods.

Exclusion Criteria

Due to the potential for differences in the effects of concussions on the brain in individuals with different baseline neurocognitive function, the exclusion of athletes diagnosed with Attention Deficit Hyperactivity Disorder (ADHD) or a learning disability (LD) was considered. Zuckerman, Lee, Odom, Solomon, and Sills,[42] evaluated the difference in baseline neurocognitive scores among high school athletes diagnosed with ADHD and/or an LD to athletes who did not have either disorder. The ImPACT test battery was used to administer the baseline test to the participants who were grouped into four categories based on a diagnosis of LD, ADHD, neither or both (407 (50%) neither, 90 (11.1%) LD, 262 (32.2%) ADHD and 55 (6.8%) both), 814 participants were administered the baseline test.[42] The results of this study indicate a significant differences among those with ADHD only and those with no history of LD or ADHD for all 6 composite scores: visual memory $p < .001$, verbal memory $p < .001$, visual motor speed $p = .002$, reaction time $p = .002$, impulse control $p = .008$ and total symptom score $p < .001$.[42] When comparing the groups diagnosed with an LD only, significant results were seen for all composite scores except impulse control.[42] These results provide information that those athletes with a diagnosis of an LD or ADHD will produce a lower score on the baseline neurocognitive test.[42] Lower scores on the baseline test may result in a prolonged and incorrect return to play protocol if an athlete sustains a concussion.[42] Studies that include LD or ADHD athletes in their data were excluded from the current study, due to the potential for those athletes diagnosed with an LD or ADHD to produce a lower baseline score, which may then skew the results of the concussion testing.

Review and Meta-Analysis Methodology

A review of a similar systematic review and meta-analysis written by Brown, Elsass, Miller, Reed and Reneker was used as a model for this current systematic review and meta-analysis.[7] This review was chosen because of the similar content of symptom evaluation between male and female athletes. The Brown and colleagues study included 21 studies, eight on the prevalence of individual symptoms and 15 on the total symptom score.[7] Eleven studies included only high school athletes, three studies included only collegiate athletes and seven studies included a combination of high school and collegiate athletes.[7] The results of this review stated that a significant difference exists in the prevalence of symptoms reported between male and female athletes at baseline testing, but this difference was not noticed post-concussion.[7] This result was within a margin of error, so a definite conclusion cannot be made.[7] The quality and the attention to proper structure in the Brown and colleagues study is the reason it was chosen as a model for the current meta-analysis and systematic review.

For the reporting of the current meta-analysis and systematic review, the Preferred Reporting Items for Systematic reviews and meta-analyses, the PRISMA statement was used.[32] The PRISMA was originally referred to as the QUOROM (quality of reporting of meta-analyses) statement.[32] This reporting method was developed to address the suboptimal reporting of meta-analyses that occurred.[32] The QUOROM was changed to the PRISMA to encompass both systematic reviews and meta-analyses.[32] The PRISMA consists of a 27 item checklist, and a four-phase flow diagram.[32] The flow diagram focuses on the literature search and requests information on the search process and phases of the review process.[32] To increase the usefulness of PRISMA, each item within check list includes an example of good reporting, a rationale for its inclusion and the supporting evidence.[32] The overall goal of the PRISMA is to increase the quality of reporting of systematic reviews and meta-analyses and therefore was used in the current study.[32]

Determining the quality of studies to be included in systematic reviews and meta-analyses is common practice to maintain the integrity of the meta-analysis and the high quality of information provided. To assess the quality of articles to be included in the current systematic review and meta-analysis, the Newcastle-Ottawa Scale was chosen due to the majority of studies of a non-randomized nature.[38] Currently, there is no recognized, standard tool used to measure non-randomized studies.[20] The Newcastle-Ottawa Scale was developed by Wells, O'Connell, Peterson, Welch, Losos and Tugwell to use in the assessment of non-randomized studies.[38] This scale does not give a rank or rating to the studies; instead it uses a 'star system' to judge a study on the selection of study groups, the comparability of the groups, and the ascertainment of either the exposure or outcome of interest for case-control or cohort studies respectively.[38] The validity of this tool has been established by its use in a previous meta-analysis by Anglemyer, Horvath and Rutherfod.[1] Anglemyer and colleagues completed systematic review and meta-analyses, to determine if an association exists between fire-arm accessibility and suicide or homicide victimization.[1] Although this study is unrelated to the current meta-analysis and systematic review, it was chosen because of the authors description of each section of the scale and how certain studies that were included in the review may have caused a source of bias in each of the sections.[1] The added detail and explanation of how the Newcastle-Ottawa Scale assess bias allowed for additional understanding and proper utilization of this quality assessment tool.

The Newcastle-Ottawa scale varies from the many other quality assessment tools available because it does not rank the studies assessed into a high or low-quality categories.[38] Research has been completed that states that the quality rating of studies does not influence the outcome of the studies.[14, 23] A study by Juni, Witschi, Bloch and Egger conducted a meta-analysis, using different scales to assess the quality of studies that were used previously in a meta-analysis.[23] None of the scales that were used yielded a significant difference in the summary scores and effect scores.[23] This study stresses the importance of the methodological aspects of a study rather than the quality score yielded. Emerson, Burdick, Hoaglin, Mosteller and Chalmers performed a similar study and the results were similar to the

Juni and colleagues study.[14] The quality ranking of the studies (high or low), did not affect the treatment outcome of the study being assessed.[14] These studies indicate that although assessing an article's quality is important, assessing the methodological and structural quality of a study may be equally as important.[14, 23] By doing so, an author can hope to provide a sound research study free of bias, which will produce accurate measures of outcome being addressed.

Conclusion

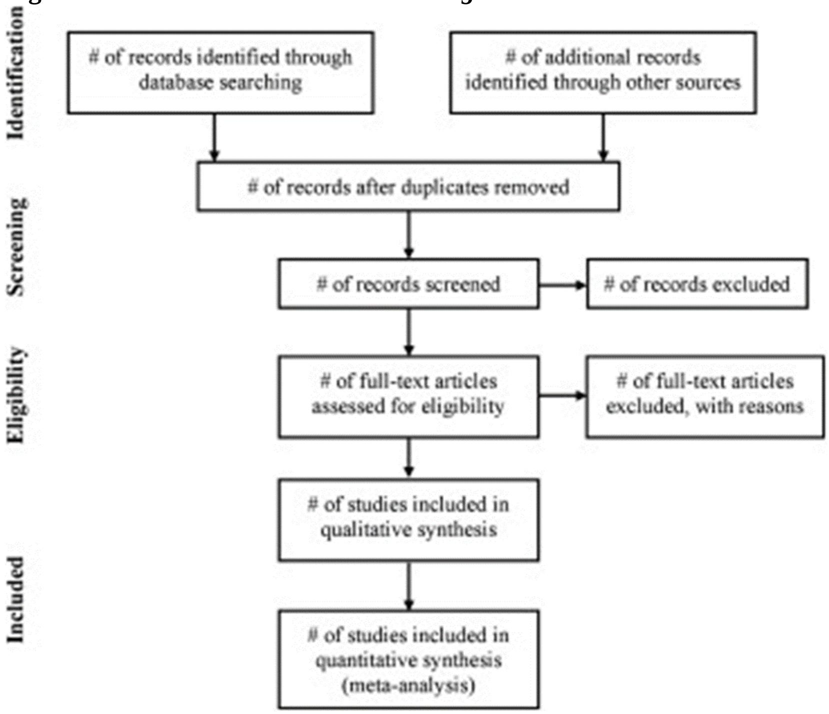
The topic of sports-related concussions has produced a multitude of research in recent years. After the completion of this literature review, the research indicates that females have a longer recovery time frame than males, and females report more symptoms both at baseline and post-concussion.[3, 6, 11, 12, 19, 34, 40] Research indicates that adolescent athletes have a protracted recovery when compared to collegiate athletes.[11, 12, 16, 27, 39, 41] The research completed on gender differences consists mainly of collegiate athletes or is combined with adolescent athletes. There are few studies dedicated to gender differences in sport-related concussions in the adolescent population.[3, 6, 11, 12, 34] The methodological section of this review included systematic reviews and meta-analyses of similar topics to comprise a complete and concise methodological outcomes.[1, 7] A majority of research conducted concerning the adolescent population does not specifically focus on just adolescent athletes. A majority of these studies combine adolescent athletes with children (under 12 years of age) and adults (over 18 years of age).[6, 11, 12, 34, 39, 40] With the larger number of adolescent athletes in the athletic community, there is a need for a summation of evidence in the adolescent population only. Therefore, the purpose of the current meta-analysis and systematic review is to evaluate the literature and determine if a relationship exists in post-concussion symptom reporting between male and female adolescent athletes.

Chapter 3: Methods

Research Design

The purpose of the current meta-analysis and systematic review was to evaluate the literature and determine if a relationship exists in post-concussion symptom reporting between male and female adolescent athletes. The focus of this review was on the individual symptoms reported by athletes of varying sports, who have suffered a concussive injury. To complete this meta-analysis and systematic review, an electronic search of the available literature was conducted. Once the literature was narrowed down by the inclusion criteria and search terms, the abstracts and titles of the literature, along with their references, were reviewed to determine inclusion into this review. The literature identified to fit all inclusion criteria was then read in full and assessed for quality. Once the final studies were selected, the Preferred Reporting Item for Systematic Reviews and Meta-Analyses (PRISMA) was used to correctly format the current meta-analysis and systematic review.[32] The PRISMA statement consists of a 27 item checklist and a four-phase flow diagram.[32] The item checklist describes criteria for reporting eligibility criteria, search strategy, data collection and results reporting.[32] The four-phase flow diagram indicates the collection of information during the different phases of the systematic review.[32] An illustration of the four phase flow diagram can be found in figure 2. Pertinent data was then removed from the included studies and entered into a Microsoft Excel spreadsheet, and analyzed to determine if the hypothesis of this review could be accepted or rejected.

Figure 2*: PRISMA Four Phase Flow Diagram*



Search Criteria

An electronic search of the literature was conducted in the PubMed, SPORT Discus, Cochrane Library and Web of Knowledge databases. A literature search was also carried out in the ProQuest database, and with Google Scholar. The ProQuest database contains un-published thesis and dissertation manuscripts. The literature searches conducted in ProQuest and with Google Scholar fulfilled the requirement of the PRISMA flow diagram, which consists of gaining information from "other" sources.[32] The search strategy was constructed with the help of a reference librarian. The search terms used varied based on the database being used. Due to the quantity of available research in the PubMed database, the search criteria was concise and was constructed to be specific to the primary outcome of the current meta-analysis and systematic review. The PubMed search was conducted using the All Fields search field and the MeSH terms or Medial Subject Heading search field. The Medical Subject Heading field, is a thesaurus on the PubMed online database and is a vocabulary that gives uniformity and consistency to the

indexing and cataloging of biomedical literature.[22] The literature search was completed using the following combination of All Fields terms and MeSH terms: "sports-related concussion" OR brain concussion OR mild concussion OR cerebral concussion OR mild traumatic brain injury AND adolescent OR high school athlete OR teenager AND gender differences OR male OR female OR female concussion AND symptom resolution AND brain concussion[MeSH Terms] OR mild concussion[MeSH Terms] OR cerebral concussion[MeSH Terms] AND gender[MeSH Terms] AND sex differences[MeSH Terms] OR gender differences[MeSH Terms] AND adolescent[MeSH Terms] OR female adolescent[MeSH Terms] OR male adolescent[MeSH Terms] AND brain concussion[MeSH Terms]. The literature search conducted on the Web of Knowledge, SPORT Discus, Cochran Library, ProQuest databases and, Google Scholar did not allow for the same amount of specificity as the PubMed database. The search terms for the following databases consisted of: Concussion AND Adolescent AND Symptoms.

Due to the wealth of research conducted on the topic of concussions and sport related concussions, limitations were placed on the literature search. The limitations consisted of: research conducted with humans, written in English, and published between the years of 1993 and 2016. In the PubMed database an age limitation was also placed on the search. The ages included children (6-12) and adolescent (13-18). This search limitation was only available on the PubMed database. When conducting the literature search with the Google Scholar search engine, the same limitations were put in place, along with an additional restriction. Due to the amount of research and information available with Google Scholar, the search terms were entered and were restricted to being included in the title only. The literature search was conducted by two independent authors (JD, KR). Once the duplicate research studies were removed, the title and abstracts where reviewed. The full text of an article was reviewed if the articles title and abstract contained adolescent athletes who sustained a concussion and mentioned symptom measurements. Full-text articles to be included in the current meta-analysis and systematic review were screened for quality if the inclusion criteria was met. An outside member would be

consulted on any disagreements between the two authors about inclusion or exclusion of an article for the final analysis.

Inclusion and Exclusion Criteria

Determination of a research studies inclusion into the current meta-analysis and systematic review was based on meeting the following seven criteria. 1) The studies are published in a peer-reviewed journal or an unpublished thesis or dissertation conducted on “sports-related concussions” in the adolescent population. 2) The studies are written in English. 3) The study sample included high school athletes, age 13-18 of either or both genders, who sustained a concussion. This may include athletes who sustained their concussion while participating in a high school sanctioned sport or outside a high school sanctioned sport; this may include participation in club sports, intermural activities or “pick-up games”. 4) Post-concussion symptoms were included, either self-reported or collected using neurocognitive testing. 5.) The symptoms reported were divided by gender. 6) The symptom data collection or study intervention was performed within a one-month period post injury. 7) The studies did not include participants who were diagnosed with a LD, ADD/ADHD or a psychiatric illness.[12, 30, 42] This is due to research indicating that athletes, diagnosed with these disorders produce a baseline score lower than other athletes, and this may result in a discrepancy in the return to play protocol.[42]

Literature that was not a full-length publication or unpublished thesis or dissertation, (such as poster presentations) were not included in this systematic review and meta-analysis. Studies reporting on traumatic brain injuries or severe concussive injuries which resulted in a protracted recovery (symptoms lasting longer than one month) were also excluded from this review. The main purpose of the current review was to determine differences in concussion symptoms in the adolescent athlete. If a study’s participants exceeded 18 years of age, were below 13 years of age, or if a large age group was studied and no subgroup of any combination of ages 13-18 was included, those studies were excluded from the

current meta-analysis and systematic review. Finally, research studies that did not list the individual symptoms reported were also excluded from this review.

Data Collection

The primary studies that meet the inclusion criteria were read in full for further determination if inclusion in this meta-analysis and systematic review was appropriate. Once a study met the inclusion criteria and was deemed appropriate by the authors conducting the literature search (JD and KR), data was then extracted from the remaining primary studies, by one of the authors (JD). Any questions about the data collected from the included studies was answered by two other authors of this meta-analysis and systematic review (KR and DF). The data variables of interest were extracted from the final primary studies. Variables of interest included: the total number of participants within the study, the number of males and the number of females that made up the total sample of study participants, a list of the individual symptoms reported by the participants and the number of times each symptom was reported by the participants within the study. The data was collected and inputted into an Excel spreadsheet (Microsoft Office, 2013) for organization and analysis. The variables of interest were left in their original, published form which included, the number of participants who reported that individual symptom(s) and the number of participants. If the data presented in the final inclusion study needed clarification or additional information was needed, such as the need of symptoms divided by gender, the corresponding author of that study was contacted in an to attempt to gain clarification of the published data.

Quality Assessment

Research studies that assess concussions and the resulting symptoms that occur are mainly non-randomized studies. As referenced by the Cochrane Handbook[20] there currently is no standardized and recognized tool used to assess the quality of non-randomized control studies.[20] A tool was developed by Wells et al.[38] for the quality assessment of non-randomized studies, called the Newcastle-Ottawa Scale. This scale, which can be used as a checklist, contains three categories including selection, comparability, and outcome or exposure, based on the type of non-randomized study.[38] The Newcastle-Ottawa Scale does not rank or rate the studies being assessed.[38] A star system was developed in which a study is judged on the three board categories: the selection of the study groups (selection), the comparability of the groups (comparability), and the ascertainment of either the exposure or outcome of interest for case-control or cohort studies respectively.[38] The studies assessed by this scale can receive up to nine total starts.[37] The quality assessment, with the use of the Newcastle-Ottawa Scale was completed by the primary author (JD). The information gathered from the quality assessment was used to gain an understanding of the structure of the primary studies and determine if the reporting quality is acceptable. The 'star assessment' of the included studies will not influence the studies inclusion into the current meta-analysis and systematic review. The findings from the quality assessment will be represented in table 1 and explained in the results section of the current meta-analysis and systematic review and.

The article's assessed for methodological quality in the current meta-analysis and systematic review were not given a rank or rating. This technique is also used in a previous meta-analysis on concussive injuries.[39] Previous research studies on the reliability and consistency of quality assessment in meta-analyses on the results of a treatment outcome have stated that the incorporation of quality scores as weights lacks statistical or empirical justification.[23] Emerson and colleagues determined after completing a study on the differences of quality scores on treatment outcomes that, components of quality scores do not predict the response to treatment.[14] This review does not state a lack of importance for the ranking and rating on the quality of research studies, or its use in previous, current and future meta-analyses.

Statistical Analysis

Specific variables were collected from the final studies, which included: the total number of participants in the studies, the sample size of male athletes and female athletes participating in the study, the specific symptoms reported and the number of times the symptom was reported within each gender group. Using a Microsoft Excel workbook (2013), the proportion of the symptoms reported between male and female adolescent athletes was calculated. This was done to determine if a difference occurs between male and female adolescent athletes in regards to the specific symptoms reported post-concussion. A significates tests for the proportion for two independent groups was calculated along with the z-scores, to evaluate the potential differences in symptom reporting between the genders. All tests were two-tailed and the alpha level was set at $p<.05$.

This systematic review and meta-analysis attempts to determine if a difference exists in symptom reporting between male and female adolescent athletes. The current meta-analysis and systematic review adhered to the PRISMA guidelines and reporting criteria.[32] A comprehensive search of the literature was conducted, on large databases with a particular search criterion and specific search terms, while adhering to the inclusion criteria and the limitations placed on the search. The research made available from the literature search was first assessed by reading the title and abstract. When the research was deemed appropriate, by their title and abstract those research studies were read in full. Once the research studies were found to be appropriate based on reading their full text and on the inclusion criteria, they were then assessed for quality, by the Newcastle-Ottawa scale[38], and then data was extracted. Using Microsoft Excel the extracted data, including the studies sample size, the sample size of male and female athletes and the sample size of athletes that experienced a certain symptom. The data was separated by gender and then a significances test to calculate the proportion for two independent groups was calculated to determine the proportion of symptoms that are experienced by male and female adolescent athletes after a

concussion has occurred. The results from the compressive literature search, the quality assessment and results are represented in the following chapter numerically and in table form.

Chapter 4: Results

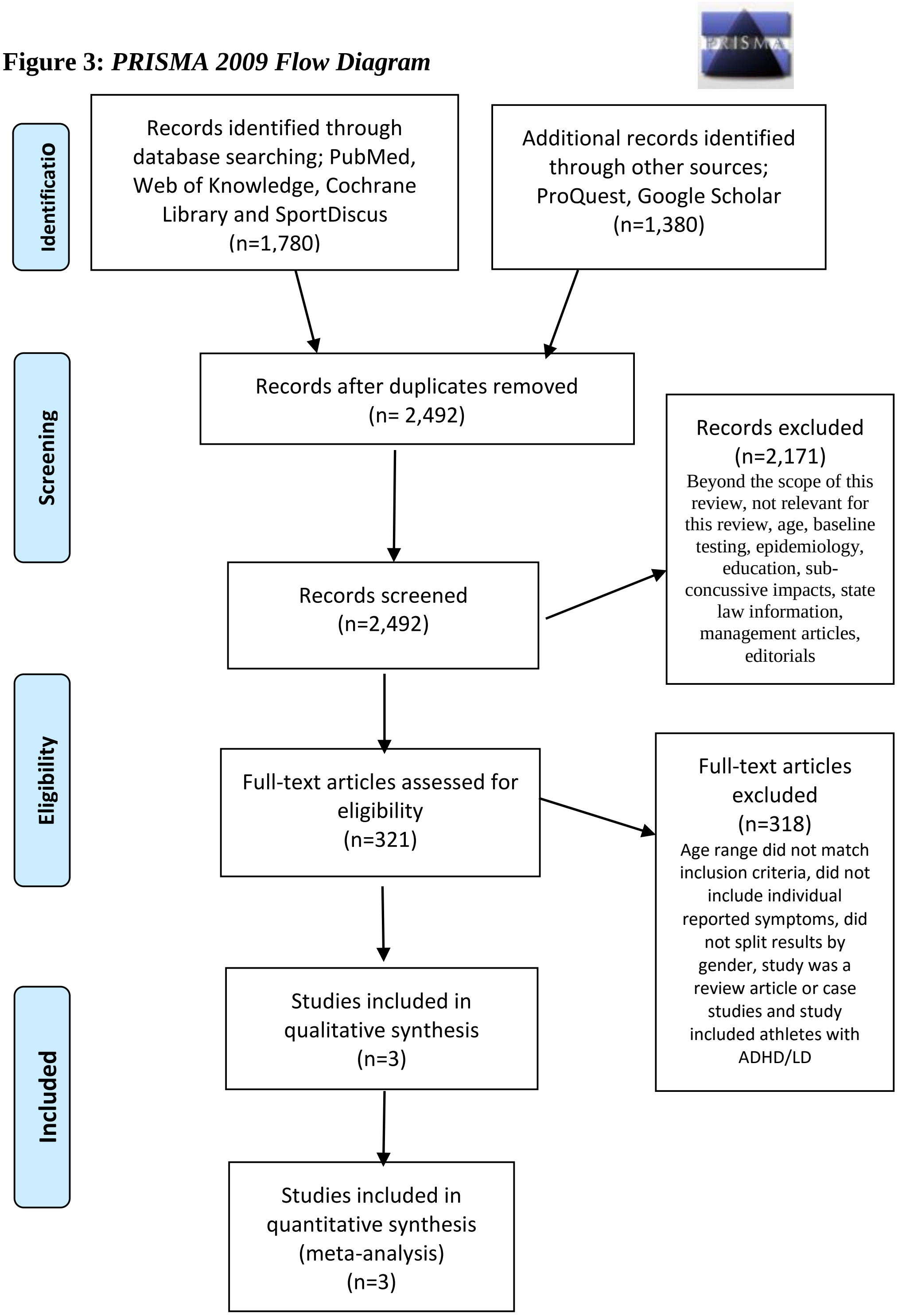
Literature Search Results

An electronic search of the literature was conducted in March of 2016, of the PubMed, Web of Knowledge, SPORT Discus, Cochrane Library, ProQuest and Google Scholar databases, presented in figure 3. An initial total of 1,780 relevant articles were found in the database search (PubMed, Web of Knowledge, SPORT Discus and Cochrane Library) and 1,380 relevant articles were found in the "other" databases (ProQuest and Google Scholar). Once the duplicates were removed a total of 2,492 articles remained. The title and abstracts of the remaining articles were then reviewed for additional relevance to the inclusion criteria. Once the title and abstracts were screened, 321 primary studies were included for full-text review. Articles were excluded during the abstract and/or full text review due to: the inability of additional data to be obtained from the corresponding authors, the concussive injury being studied was beyond the scope of the current review (concussions of a serious nature, such as concussions that resulted in bleeding within the brain, and concussive injuries that resulted in a hospital admittance), the concussive injury resulted in a protracted recovery (symptoms lasting longer than one month), age (above or below 13-18 years of age or did not provide a subgroup of athletes within the 13-18 age range), the studies did not include individual reported symptoms, the participants and/or reported symptoms were not spit by gender, the data included athletes with ADHD and/or a LD, baseline testing was only being studied, epidemiology of concussion incidence only, education (information on concussion laws or the education of athletes), sub-concussive impacts, management articles, review articles, and editorials.

The full-text review yielded two articles for inclusion into the current meta-analysis Frommer et al. (2011)[17] and Comstock, Currie, Pierpoint, Grubenhoff and Fields (2015).[9] In addition, full text review resulted in the identification of four studies that would potentially provide usable data for the current meta-analysis: Meehan, d'Hemecourt, and Comstock[31], Sady, Vaughan and Gioia[36], Chrisman, Rivara, Schiff, Zhou and Comstock[8], Lee, Odom, Zuckerman, Solomon and Sills.[25] The corresponding author for each of these four articles was contacted (by JD) to gain clarification or access to additional data that was

not included in the published study (participants and/or reported symptoms were not split by gender). Three of the contacted authors' responded.[9, 25, 36] The corresponding author to the publication by Lee, Odom Zuckerman, Solomon and Sills[25] was able to provide the additional information needed for the current meta-analysis and systematic and this additional data was included in the final analysis. The remaining three publications[9, 25, 36] were unable to provide information in the time frame that was necessary for the completion of this project in accordance by the institutions completion timeline and were subsequently omitted from the final analysis. Three studies were ultimately included in the meta-analysis.[9, 17, 25]

Figure 3: ***PRISMA 2009 Flow Diagram***



Characteristics of Included Studies

A summary of the included studies is listed in Table 1. Three studies were included in the current meta-analysis and systematic review: Frommer et al.[17] Comstock et al.[9] and Lee et al.[25] The sample size for the Frommer et al. study consisted of 421 athletes (327 male and 94 female)[17], the Comstock et al. sample size consisted of 876 athletes (368 male and 508 female)[9] and the Lee et al. sample size consisted of 124 athletes (57 male and 67 female).[25] All participants, in each of the three included studies, sustained a concussion within the high school setting. Although published data by Lee et al. included subjects in age ranges outside the scope of the current study, only athletes within the ages of 13-18 will be discussed and utilized for the purpose of the current study.[25]

The included studies were conducted between the years 2005-2014. Data collection in the Lee et al. study was completed with the use of the ImPACT test battery to gather baseline and post-concussion symptom scores using the total symptom score within the ImPACT test.[25] Once an athlete sustained a concussion, that athlete had to complete up to two post-concussion assessments. There was no specific post-concussion testing timeline, post-concussion testing was based on the clinical judgment of the treating ATC or physician.[25] The Comstock et al. and Frommer et al. studies gathered their concussion incidence, symptoms and participants using the High School Sport-Related Injury Surveillance System, RIO (Reporting Information Online, Columbus OH).[9, 17] This system requires the participating high school ATC to log on to the High School RIO website, to report athletic exposures and injury data.[9, 17] The software used drop-down menus which allowed the ATC to report information on the injured athlete's demographics and medical documentation of the concussion. [9, 17]

The included participants were collected differently among the included studies. The Lee study gathered athletes from western Pennsylvania only,[25] whereas Comstock et al. and Frommer et al. used high schools from all over the country.[9, 17] In the Frommer et al. and Comstock et al. study, all high schools in the United States were eligible for inclusion, if they had at least, one Board Certified Athletic

Trainer with a valid e-mail address.[9, 17] The high schools that responded to the request for inclusion in these studies were divided into eight strata based on geographic location (northeast, midwest, south and west) and the size of enrollment (< 1000 or ≥ 1000 students).[9, 17] Schools were randomly selected from the regional strata, to include 100 schools.[9,17] If a school dropped out, another school from a similar region and enrollment population was randomly selected to replace it.[9,17] The Frommer et al. and Comstock et al. studies required the ATC to record all symptoms reported by the injured athlete[9, 17] and the mechanism of the injury was reported only by Comstock et al.[9] For the purpose of this review, the mechanism of injury was not taken into consideration.

The inclusion criteria for the Frommer et al. study consisted of athletes who sustained concussions.[17] The Comstock et al. inclusion criteria included the following factors: 1) the injury occurred as a result of participation in a sanctioned soccer practice or competition, 2) the injury required medical attention from the team ATC or physician and 3) the injury restricted participation for more than one day or resulted in any fracture, concussion, or dental injury even if participation was not restricted.[9] For this study analysis was restricted to concussion data.

The inclusion criteria for the Lee et al study consisted of: 1) age 13-16 or 18-22 at the time of the concussion, 2) enrollment as a middle school, high school, or college athlete, 3) valid completion of up to two post-concussion ImPACT testing data points and 4) fluency in English.[25] The exclusion criteria for Lee et al. consisted of: 1) ages less than 13, equal to 17 or greater than 22 years, 2) self-reported history of special education, speech therapy, repeated year(s) of school, learning disability, attention deficit hyperactivity disorder, dyslexia, or autism, 3) self-reported history of brain surgery or seizure disorder and 4) self-reported history of treatment for drug/alcohol abuse or psychiatric illness.[25] The Frommer et al. study was the only study that included cofounding variables that were assessed within their study.[17] These variables included: regional strata, age, height, mass, by whom the concussion was assessed, whether the concussion took place during practice or competition, whether the concussion was a new or recurrent injury and whether the athlete was wearing personal protective equipment, such as a helmet,

mouth guard, and/or shin guards.[17] Within the Lee et al. study, the participants were matched with other participants on the number of prior concussions, gender and days to post-concussion test,[25] the Comstock et al. and Frommer et al. studies did not match athletes.[9, 17] The study by Comstock et al. included only soccer players.[9] In contrast Frommer et al. and Lee et al. included a variety of athletes across nine sports.[17, 25]

Table 1: ***Included Studies***

	Frommer et al. 2011	**Comstock et al. 2015**	**Lee et al. 2013***
Participants	N=421 M=327 F=94	N=876 M=386 F=508	N=124 M=57 F=67
Age range	High school athletes	High school athletes	13-16 and 18-22 years of age.
Reporting period	2005-2006 to 2006-2007	2005-2006 through 2013-2014	2009-2011
Reporting system	RIO	RIO	ImPACT Test
Study variables	Post-Concussion	Post-Concussion	Baseline and post-concussion
Mechanism of injury classification	No	Yes • Contact with another player • Contact with playing apparatus	No
Outcome variables	• Symptoms (frequency and total) • Symptom resolution time • Return to play time.	• New and recurrent concussions sustained by high school soccer players. • Mechanism of injury and resulting symptoms.	• Symptom presence • Symptom severity • Total symptoms
Sports studied	Boys: football, soccer basketball, wrestling and baseball. Girls: soccer, basketball, volleyball and softball.	Soccer	Varied, but did not specify

*****This data was gathered from the corresponding author of the study, S. Zuckerman

Quality Assessment

The methodological quality of the included studies was assessed using the Newcastle-Ottawa Scale, see appendix for Newcastle-Ottawa scale and associated coding form (Appendix).[38] The included studies were classified as cohort studies, therefore the Newcastle-Ottawa Scale questions associated with cohort studies was utilized.[38] Questions included in the Newcastle-Ottawa Scale evaluated the quality of the studies' selection, comparability and outcome.[38] Results of the quality assessment for the three included studies are presented in Table 2.

Table 2: ***Quality Assessment***

			Frommer et al.	Comstock et al.	Lee et al.
Selection	S1: Representativeness of the exposed cohort		X	X	X
	S2: Selection of the non-exposed cohort		X	X	X
	S3: Ascertainment of exposure		X	X	X
	S4: Demonstration that outcome of interest was not present at start of study.		X	X	X
Comparability	C1: Comparability of cohorts on the basis of the design or analysis	a). Study controls for most important factor.	X	X	X
		b). Study controls for any additional factors	X	X	X
Outcomes	O1: Assessment of outcomes		X	X	X
	O2: Was follow-up long enough for outcomes to occur				
	O3: Adequacy of follow up of cohorts				

Meta-Analysis Results

The results of the meta-analysis for the reported symptoms is included in Table 3. Forest plots for the significantly reported post-concussion symptoms are included in Figures 4-12. A significances test was conducted to determine the proportion of the reported symptoms for two independent groups. Among the three studies, the total number of athletes who sustained a concussion were 1,421 (752 males and 669 females).[9, 17, 25] The current meta-analysis found significant differences between genders in the percentage of the gender specific population that reported common post-concussive symptoms. Female adolescent athletes had a significantly higher percentage of concussed athletes who reported concentration difficulty (M=47%, F=55%; p=.005), drowsiness (M=21%, F=34%; p=.000), sensitive to light/visual disturbance (M=32%, F=38%; p=.017) and sensitivity to noise (M=12%, F=23%; p=.000) compared to male adolescent athletes. Male adolescent athletes had a significantly higher percentage of concussed athletes who reported amnesia (M= 21%, F= 14%; p=.000) and irritability (M=81%, F=12%; p=.031). There was no significant difference between genders for dizziness (M=70%, F=68%; p=.307) and nausea (M=27%, F=30%; p=.204). The proportion of males and females reporting headache post-concussion was almost reported equally between the gender populations (M= 88%, F=89%; p=.617).

The proportion of the total population, and sample size of four commonly reported symptoms, hyper-excitability, confusion/disorientation, loss of consciousness and tinnitus was smaller than the above symptoms. This was the result of how data was collected among the three included studies.[9, 17, 25] The ImPACT test symptom list used by Lee et al. contains a set criteria of symptoms, [25] where the RIO system used by Frommer et al. and Comstock et al. uses a different list of symptoms and relied on athletes self-reporting their post-concussion symptoms.[9, 17] The above symptoms were only listed within the Frommer et.al and Comstock et.al primary data.[9, 17] The total sample size for these symptoms included a total of 1,297 athletes (695 males and 602 females). Female adolescent athletes had a higher percentage of concussed athletes who reported hyper-excitability (M=2%, F= 28%; p=.342), but a significant result was

not found between the specific gender populations. Male adolescent athletes had a significantly higher percentage of concussed athletes who reported confusion/disorientation (M=46%, F=40%; p=.029), loss of consciousness (M=5%, F=2%; p=.036) and tinnitus (M=12%, F= 9%; p= .049) when compared to female athletes.

Table 3: ***Meta-Analysis Results***

Reported Symptoms	Males (n=752)		Females (n=669)			
	Total event size	Proportion	Total event size	Proportion	Z-score	p-value
Amnesia*	159	21%	90	14%	3.807	p=.000
Concentration difficulty*	345	47%	365	55%	-2.816	p=.005
Dizziness	528	70%	453	68%	1.017	p=.307
Drowsiness*	157	21%	227	34%	-5.531	p=.000
Headache	659	88%	592	89%	-0.497	p=.617
Irritability*	61	81%	77	12%	-2.159	p=.031
Nausea	202	27%	200	30%	-1.267	p=.204
Sensitivity to light or visual disturbance*	239	32%	253	38%	-2.387	p=.017
Sensitivity to noise*	89	12%	153	23%	-5.524	p=.000

*Symptom reporting was significantly different between males and females

Table 4: ***Meta-Analysis Results****

Reported Symptoms	Males (n=695)		Females (n=602)			
	Total event size	Proportion	Total event size	Proportion	Z-score	p-value
Confusion or Disorientation*	319	46%	240	40%	2.188	p=.029
Hyper-excitability	14	2%	17	28%	-0.952	p=.342
Loss of consciousness*	31	5%	14	2%	2.095	p=.036
Tinnitus*	82	12%	51	9%	1.970	p=.049

*Symptoms were only reported in two of the three included studies[9, 17]
*Symptom reporting was significantly different between males and female

Figure 4: ***Forest Plot, Amnesia***

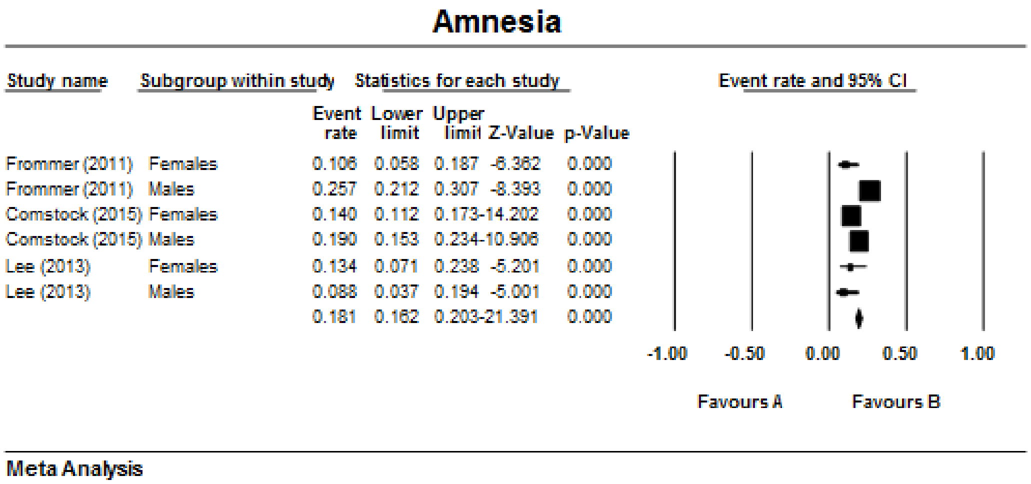


Figure 5: ***Forest Plot, Concentration difficulty***

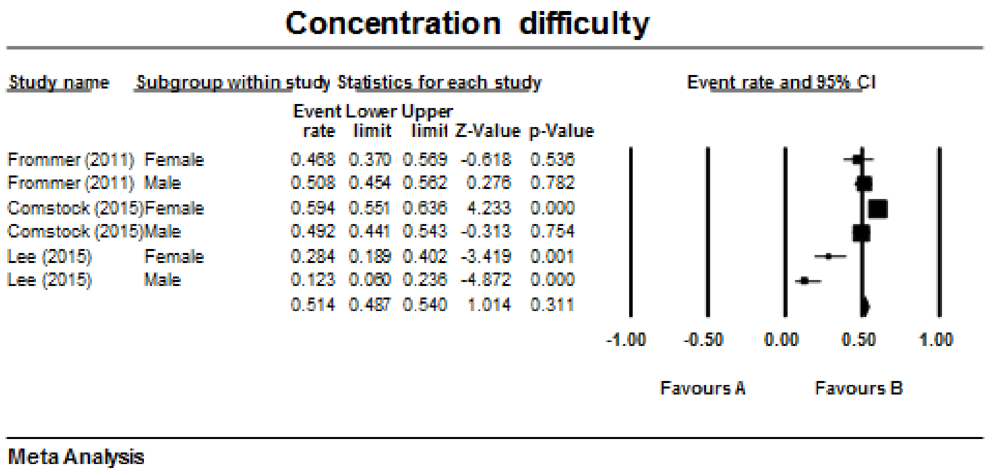


Figure 6: ***Forest Plot, Drowsiness***

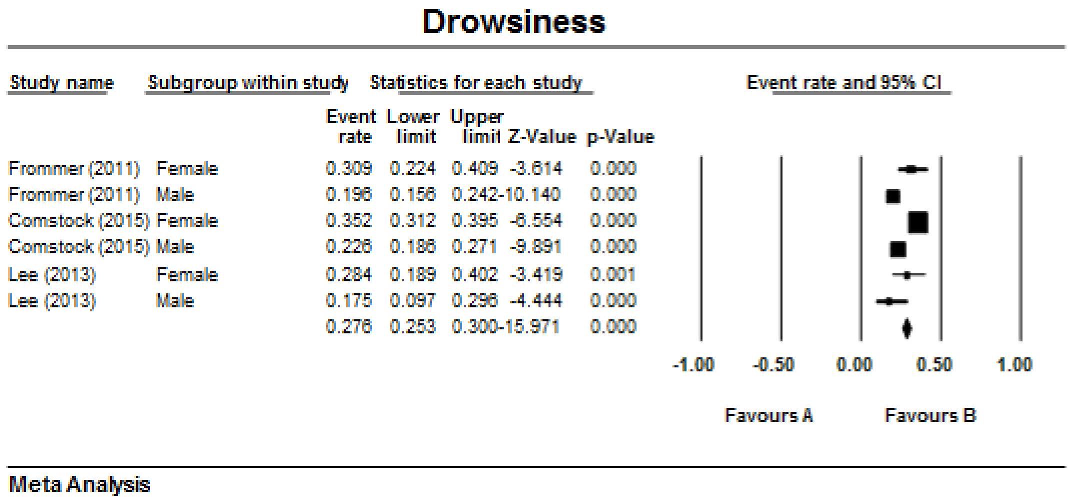


Figure 7: ***Forest Plot, Irritability***

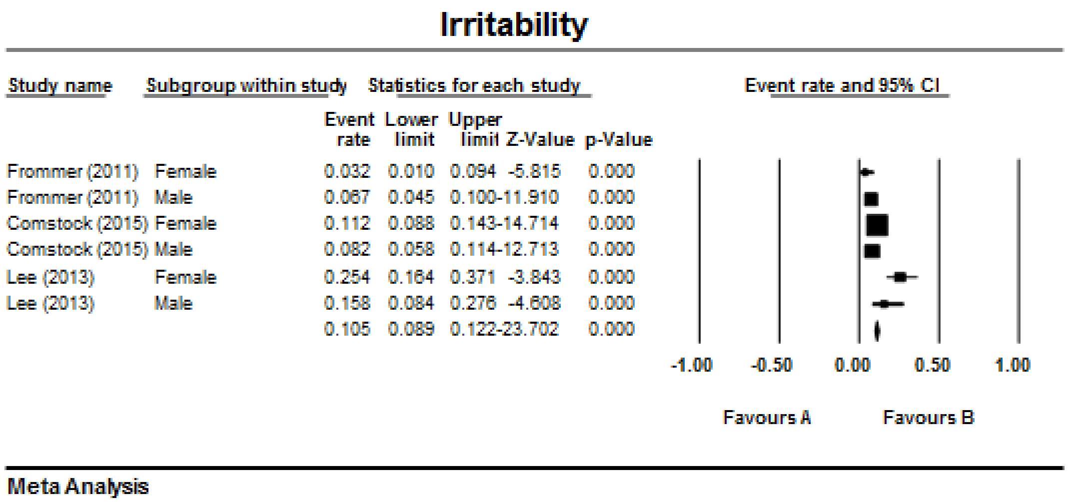
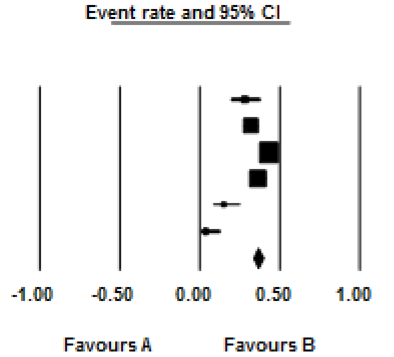


Figure 8: ***Forest Plot, Sensitivity to light/visual disturbance***

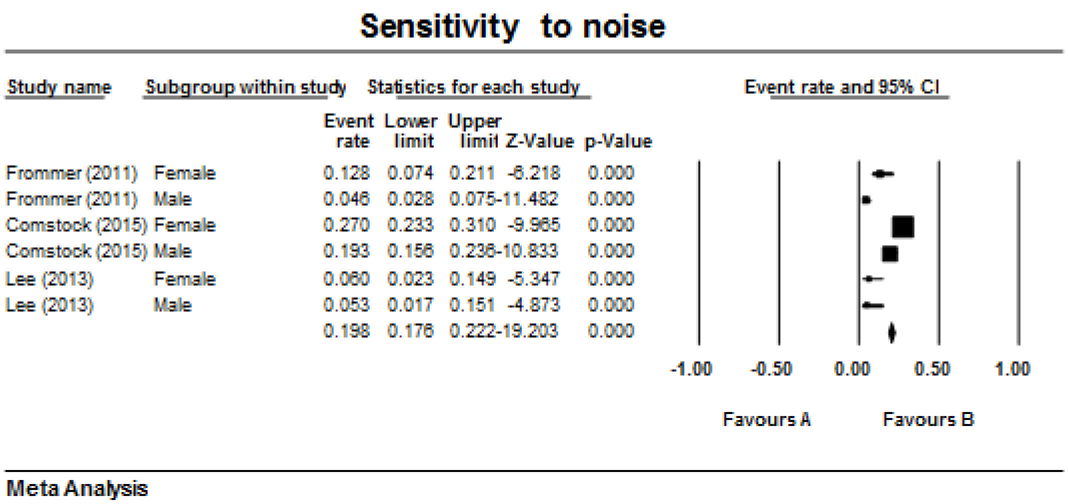
Sensitivity to light/visual disturbance

Study name	Subgroup within study	Event rate	Lower limit	Upper limit	Z-Value	p-Value
Frommer (2011)	Female	0.277	0.196	0.375	-4.170	0.000
Frommer (2011)	Male	0.315	0.267	0.367	-6.526	0.000
Comstock (2015)	Female	0.427	0.385	0.471	-3.271	0.001
Comstock (2015)	Male	0.364	0.317	0.415	-5.146	0.000
Lee (2013)	Female	0.149	0.082	0.256	-5.077	0.000
Lee (2013)	Male	0.035	0.009	0.130	-4.604	0.000
		0.360	0.335	0.386	-10.125	0.000



Meta Analysis

Figure 9: ***Forest Plot, Sensitivity to noise***



Study name	Subgroup within study	Event rate	Lower limit	Upper limit	Z-Value	p-Value
Frommer (2011)	Female	0.128	0.074	0.211	-6.218	0.000
Frommer (2011)	Male	0.046	0.028	0.075	-11.482	0.000
Comstock (2015)	Female	0.270	0.233	0.310	-9.965	0.000
Comstock (2015)	Male	0.193	0.156	0.236	-10.833	0.000
Lee (2013)	Female	0.060	0.023	0.149	-5.347	0.000
Lee (2013)	Male	0.053	0.017	0.151	-4.873	0.000
		0.198	0.176	0.222	-19.203	0.000

Figure 10: ***Forest Plot, Confusion/disorientation***

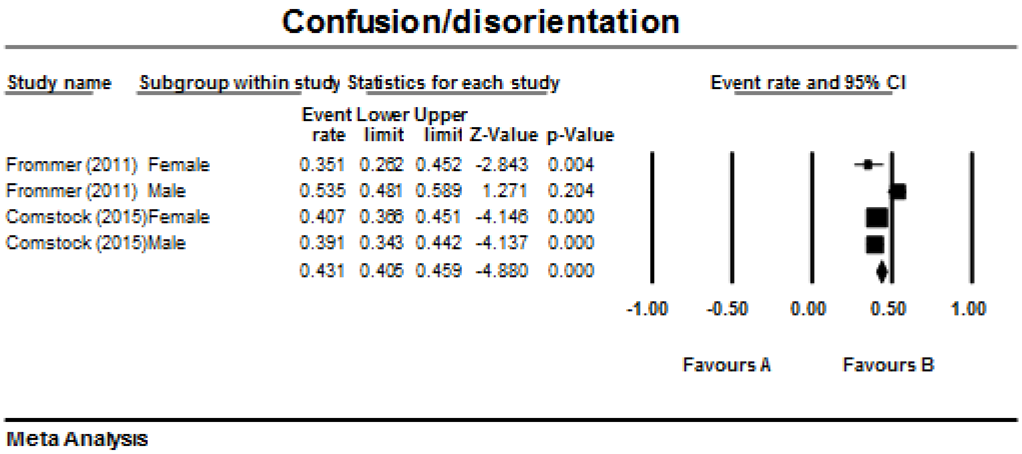


Figure 11: ***Forest Plot, Loss of consciousness***

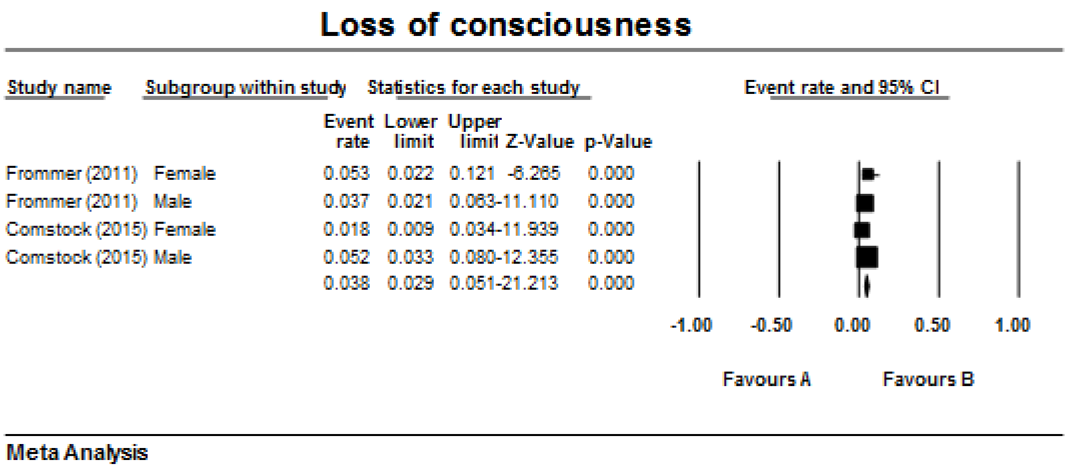
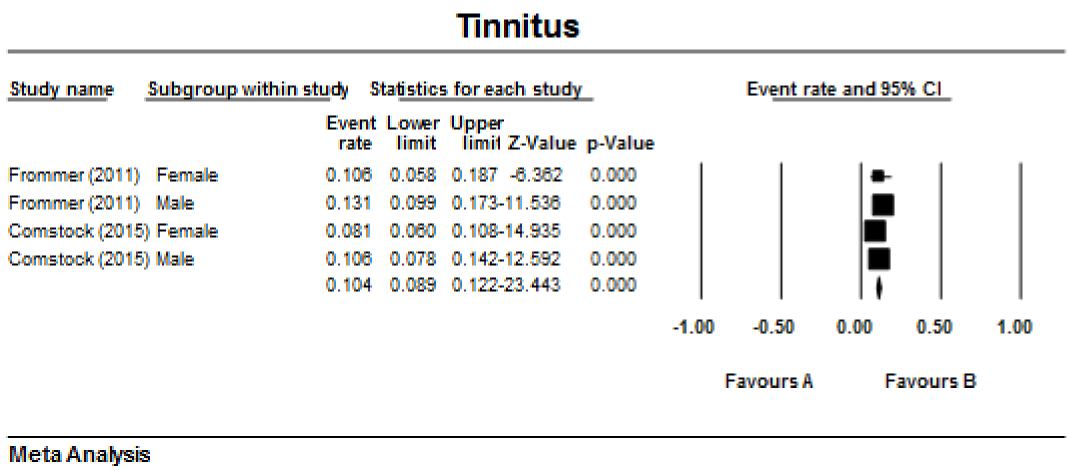


Figure 12: ***Forest Plot, Tinnitus***



Chapter 5: Discussion

The current meta-analysis-and systematic review evaluated the adolescent athletic population to determine if differences occur between the genders in terms of the symptoms that are reported post-concussion. To the author's knowledge, this is the first meta-analysis and systematic review that has specifically focused on the adolescent population, and specifically focused on the symptoms that are reported post-concussion. The current meta-analysis found significant differences between genders in the percentage of the gender specific population that reported common post-concussive symptoms. The literature search conducted by the current meta-analysis and systematic review produced two studies that met the inclusion criteria and contained the data necessary to evaluate the effects of concussion reporting between male and female athletes within the adolescent population.[9, 17] A third study was added after contacting the corresponding author of an additional study who produced additional data.[25] The primary findings of the current meta-analysis state that a difference is seen between the genders, in the adolescent population, in regards to certain commonly reported post-concussion symptoms. Although the number of included studies was small, the data collection methods within the included studies provided a representative sample for the meta-analysis. The three studies included utilized a wide range of high school athletes from various regions of the United States.[9, 17, 25] The timeframe of data collection between the studies, allows the current meta-analysis to report on data and results that are currently relevant for researchers and healthcare professionals.

The Newcastle-Ottawa Scale quality assessment conducted by the current meta-analysis and systematic review was used specifically because of the inclusion of non-randomized studies.[38] The three included studies received seven out of a possible nine total starts. The included studies can be interpreted as being of high methodological quality. However, this scale does not rank or rate the studies based on the number of starts received[38], the overall quality of the included studies is based on the judgement of the primary author. Previous authors have stated that the inclusion of non-randomized studies in a meta-

analysis may lead to an increased risk of bias due to lack of control groups, the absence of blinding of participants and researchers, and the presence of unreported confounding variables.[20]

Data from Comstock et al. and Frommer et al. was extracted from an on-line database which only collected information on athletes that sustained a concussion and did not compare those athletes to healthy controls.[9, 17] The Lee et al. study compared athletes based on the number of prior concussions but not to healthy controls.[25] However, the Lee et al. study did require their participants to perform a baseline ImPACT test, which could be seen as a control.[25] The lack of a control group among the studies may result in bias within the current meta-analysis and systematic review.[20] The reporting of confounding variables was only included in one study.[17] This may lead to bias within the comparability section of the Newcastle-Ottawa Scale.[38] The reporting of confounding variables allows for a determination to be made on the comparability of the gender groups.[38] The three included studies controlled for different variables, but only one study included all possible variables that may cause variability within the results.[17] Finally, absence of any indication of a follow-up period within the included studies is another factor that may lead to bias, specifically within the outcome section of the Newcastle-Ottawa Scale.[38] The current meta-analysis did not examine the severity of the reported concussion symptoms, or the length of recovery of the concussed athlete. Due to the hypothesis of the current meta-analysis and systematic review, a follow-up period was not relevant for the included data. The absence of a follow-up period within the included studies was not believed to decrease the quality of the current meta-analysis and systematic review. Due to the small number of studies included in this review, analyses for heterogeneity and publication bias were unable to be run.[20]

The results of the current meta-analysis indicate that a significant difference within the reporting of commonly reported symptoms post-concussion exists between the genders in the adolescent population. Female adolescent athletes reported concentration difficulty, drowsiness, sensitivity to light/visual disturbances and sensitivity to noise at a significantly higher percentage than the male athletes within the same population. Male athletes reported a significantly higher percentage of amnesia,

irritability, confusion/disorientation, loss of consciousness and tinnitus when compared to females within the same population. Among the specific gender populations dizziness, hyper-excitability, headache and nausea did not produce significant findings. The results of the current meta-analysis found that the reporting percentage of headache was very similar between the gender groups. The result of an almost equal percentage between the specific gender populations is an interesting finding. Due to the variability of the symptoms experienced by those who sustain a concussion, it was not thought that experiencing a headache would occur in an almost equal proportion between male and female adolescent athletes. Although headache is one of the most commonly reported post-concussion symptoms, based on experience of the primary author, it is of no surprise that headache was reported at the highest proportion between male and female adolescent athletes. We believe the almost equal proportion of a reported headache post-concussion, between the genders indicates that if an athlete is suspected of sustaining a concussion, and they report having a headache it may be reasonable to assume that the athlete may be suffering from a concussion.

The certain symptoms reported at a higher rate between the gender populations, in the current meta-analysis was a noteworthy finding. One question that arises when looking at the significant symptoms reported between the genders is, why are these specific symptoms being reported at a higher rate in males or females? This may be due to a cultural gender bias that is seen not only within the athletic population, but seen in the overall population as well. A common theme within the athletic culture, seen by the authors of the current meta-analysis, is that males are taught to play thought their pain. The opposite has been found in female athletes, who tend to show more concern for their future health.[10] From a very young age males are taught to be tough, and showing any emotion is seen as weakness. A parallel, theme is seen in female athletes, where when a female shows or expresses an emotion it may not be taken as seriously and may be associated with “just being a girl”. These gender roles that adolescent athletes are exposed to may be one reason why certain symptoms are reported more within the male population than they are reported in the female population. It may not be social

acceptable to express a certain symptom, such as irritability among female athletes, this symptom may have a negative connotation when expressed by a female athlete. Future research should be conducted in this area to evaluate male and female adolescent athletes post-concussion to determine if a gender bias occurs, which results in certain common post-concussion symptoms being reported at a higher percentage post-injury between the gender populations.

With a significant difference seen in symptom reporting between the genders in the adolescent population, the results of the current meta-analysis may provide ATCs or healthcare providers a different way to categorize the significantly reported common post-concussion symptoms. The categorizing of the significantly reported symptoms such as, sensitivity to noise and sensitivity to light/visual disturbances among female athletes may fall into a vestibular category.[13] The significantly reported symptoms of irritability and confusion/disorientation among the male athletes may fall into a physiological category.[13] This categorization of the significant symptoms describes two different sub-neurological systems that may be affected post-concussion. The categorizing of the significantly reported post-concussion symptoms found in the current meta-analysis, may allow an ATC or healthcare provider working within the adolescent population to determine if the reported symptoms are indicative of a more serious issue, such as impairments caused by continued alterations in global cerebral metabolism.[13] Future research in this area should be conducted to determine if a different categorization of post-concussion symptoms in the adolescent population can occur. This may lead to better management of post-concussion symptoms in the adolescent population, and provide those individuals suffering with categorized post-concussion symptoms the additional care that may be needed to help resolve their symptoms.

With the results of the current-meta analysis indicating a significant difference in the reporting of certain post-concussion symptoms, in the adolescent population between the genders may lead to a change in the way athletes are educated about concussion symptoms. Significantly reported symptoms such as irritability among males and sensitivity to noise among females, may allow for an athlete to be aware of the symptoms they may experience post-concussion. The increase in awareness may result in an

increase in concussion reporting, instead of the athlete "shaking it off" thinking they are not injured. The results of the current meta-analysis may be able to provide athletes with an idea of the symptoms that are commonly reported among the genders such as sensitivity to light/visual disturbances or amnesia that the athlete may not experience during their normal daily activities, like having a headache or drowsiness. If an athlete has the ability to understand what may occur or how they may feel if a concussion is sustained, this knowledge may allow the athlete to express the symptoms they are experiencing with more clarity or certainty. Future research in this area should be conducted to determine if an increase in education of the specific symptoms an athlete may experience post-concussion leads to an increase in symptom reporting and an enhanced on-the-field symptom evaluation post-concussion.

The onset or upswing in the occurrence in depression, has been found to occur during puberty for both male and female adolescents.[33] Many of the common symptoms that are experienced by adolescents suffering from depression or depressed feelings are similar to the post-concussion symptoms that the current meta-analysis found differences in between the gender populations. The symptoms of irritability, difficulty concentrating and drowsiness found to be significantly reported in the current meta-analysis are a few of the same symptoms commonly reported as signs of adolescent depression.[29] The similarities between the significantly reported symptoms of the current meta-analysis and the common depression symptoms seen among adolescents may indicate that similarities with how the brain functions post-concussion and during depression may be similar. Future research in this area should continue, within the adolescent population to determine if there is a similarity between how the brain functions during depression and post-concussion.

The results of the current meta-analysis supports our hypothesis that there would be a significant difference between genders in the percentage of individuals reporting common post-concussion symptoms in the adolescent population. The population of females who reported concentration difficulty, drowsiness, sensitivity to light/visual disturbances and sensitivity to noise was significantly increased compared to males. The population of males who reported amnesia, irritability, confusion/disorientation,

loss of consciousness and tinnitus was significantly increased when compared to females. Confusion/disorientation, loss of consciousness and tinnitus had a smaller population and sample size than the rest of the significantly reported symptoms, and were reported at a significantly higher rate among males. The results of the current meta-analysis provides clinically relevant information on differences in post-concussion symptom reporting between male and female adolescent athletes, for an ATC or a healthcare provider.

Limitations

Although the current meta-analysis and systematic review was completed in conjunction with the PRISMA guidelines[32] and an extensive search of the literature was completed, it is not without its limitations. One of the main limitations was the small amount of available research, which met the specific inclusion criteria. The specificity of the inclusion criteria can be seen as a limitation because, it included a specific population and separation of that population, which is not readily available in the current literature. Also, the inclusion of only the symptoms reported limited the research available for inclusion because a number of studies report on total symptom scores or total symptom severity. In an attempt to include more primary studies, additional corresponding authors whose research met a majority of the inclusion criteria were contacted.[8, 31, 36] Although some additional data was able to be added, the sample size of the included participants was very small compared to the actual number of adolescent athletes participating in athletic activities.

A sports-related concussion is complicated to diagnose and manage due to the individuality of this injury. There are a number of confounding variables that can cause differences in the outcome of a sports-related concussion. It is difficult to account for some of these confounding variables in a meta-analysis because primary authors may not account for them in their primary research. Confounding variables deemed to possibly affect the current meta-analysis results include: previous concussion history, sport participation such as contact versus non-contact, and the type of equipment worn during contact

sports. These confounding variables, if unaccounted for in the primary research may have led to a discrepancy in the results of the current meta-analysis.

The use of non-randomized studies has been stated by previous research to indicate that an increased risk of bias may result due to incomplete or improper recording by some non-randomized studies.[20] The inclusion of non-randomized studies, leads to an increased risk of bias because of the absence or inconsistent reporting of confounding variables, the lack of a control group and the absence of a follow-up period used during the study.[20] Due to the inconsistent reporting of these variables within the included studies may lead to an increased risk of bias in the current meta-analysis and systematic review.[20]

The included studies in the current meta-analysis and systematic review consisted of studies whose participants self-reported their concussion symptoms post-injury. The self-report of an athletes concussion symptoms is the main way an ATC can treat and athlete and measure their recovery. The self-reporting of post-concussion symptoms is based on an athlete's perception. An adolescent athlete may have difficulty when attempting to explain the concussive symptoms they are experiencing, due to an inability to accurately verbalize or explain how they are feeling. The perception and difficulty to express how they are feeling, may lead to discrepancies or inconsistencies in post-concussion symptom reporting in this athletic population.

Conclusion

The aim of the current meta-analysis and systematic review was to evaluate the literature and determine if a relationship exists in post-concussion symptom reporting between male and female adolescent athletes. An extensive literature search of varying publication databases yielded two studies that meet the specific inclusion criteria of the current meta-analysis and systematic review.[9, 17] A third study was included after contact with a corresponding author was made and additional data was provided.[25] Due to the inclusion of non-randomized studies, there is an increased risk of bias due to the

absence of a recognized and commonly used assessment tool.[20] The risk of bias is also increased due to the inclusion of non-randomized studies because of the disparity in the reporting within some primary studies.[20] The results of the current meta-analysis and systematic review indicate a difference in the reporting of post-concussion symptoms between males and females in an adolescent athlete population. This is an important finding for ATCs and healthcare professionals because the results may provide a different way post-concussive symptoms are categorized in the adolescent population between the genders. There is an increasing body of research investigating why females appear to report more symptoms than males, but research remains limited. In addition, this area of research has focused more on the adult population, on symptom severity and the resolution of symptoms. Future research within the adolescent population should continue to study how adolescent athletes respond to a concussive injury and why this group of athletes reports certain symptoms at a higher percentage than others between the specific gender populations. The current meta-analysis and systematic review provides evidence that certain post-concussion symptoms are going to be reported at a significantly higher percentage post-concussion, between the gender specific populations.

Appendix:

NEWCASTLE - OTTAWA QUALITY ASSESSMENT SCALE
CASE CONTROL STUDIES[38]

<u>Note</u>: A study can be awarded a maximum of one star for each numbered item within the Selection and Exposure categories. A maximum of two stars can be given for Comparability.

Selection

1) <u>Is the case definition adequate</u>?
   a) yes, with independent validation ♐●
   b) yes, eg record linkage or based on self reports
   c) no description

2) Representativeness of the cases
   a) consecutive or obviously representative series of cases ♐●
   b) potential for selection biases or not stated

3) Selection of Controls
   a) community controls ♐●
   b) hospital controls
   c) no description

4) Definition of Controls
   a) no history of disease (endpoint) ♐●
   b) no description of source

Comparability

1) Comparability of cases and controls on the basis of the design or analysis
   a) Study controls for _______________ (Select the most important factor.) ♐●
   b) study controls for any additional factor ♐● (This criteria could be modified to indicate specific control for a second important factor.)

Exposure

1) Ascertainment of exposure
   a) secure record (eg surgical records) ♐●
   b) structured interview where blind to case/control status ♐●
   c) interview not blinded to case/control status
   d) written self report or medical record only
   e) no description

2) Same method of ascertainment for cases and controls
   a) yes ♐●
   b) no

3) Non-Response rate

a) same rate for both groups ♐●
b) non respondents described
c) rate different and no designation

NEWCASTLE - OTTAWA QUALITY ASSESSMENT SCALE
COHORT STUDIES[38]

Note: A study can be awarded a maximum of one star for each numbered item within the Selection and Outcome categories. A maximum of two stars can be given for Comparability

Selection

1) Representativeness of the exposed cohort

a) truly representative of the average ________________ (describe) in the community ♐●
b) somewhat representative of the average _______________ in the community ♐●
c) selected group of users eg nurses, volunteers
d) no description of the derivation of the cohort

2) Selection of the non-exposed cohort

a) drawn from the same community as the exposed cohort ♐●
b) drawn from a different source
c) no description of the derivation of the non-exposed cohort

3) Ascertainment of exposure

a) secure record (eg surgical records) ♐●
b) structured interview ♐●
c) written self report
d) no description

4) Demonstration that outcome of interest was not present at start of study

a) yes ♐●
b) no

Comparability

1) Comparability of cohorts on the basis of the design or analysis

a) study controls for ______________ (select the most important factor) ♐●
b) study controls for any additional factor ♐● (This criteria could be modified to indicate specific control for a second important factor.)

1) Assessment of outcome

a) independent blind assessment ♐●
b) record linkage ♐●
c) self report
d) no description

2) Was follow-up long enough for outcomes to occur

a) yes (select an adequate follow up period for outcome of interest) ♐● b) no

3) Adequacy of follow up of cohorts

a) complete follow up - all subjects accounted for ☆●
b) subjects lost to follow up unlikely to introduce bias - small number lost - > ____ % (select an adequate %) follow up, or description provided of those lost) ☆●
c) follow up rate < ____% (select an adequate %) and no description of those lost d) no statement

CODING MANUAL FOR CASE-CONTROL STUDIES[38]

SELECTION

1) Is the Case Definition Adequate?

a) Requires some independent validation (e.g. >1 person/record/time/process to extract information, or reference to primary record source such as x-rays or medical/hospital records) ☆
b) Record linkage (e.g. ICD codes in database) or self-report with no reference to primary record
c) No description

2) Representativeness of the Cases

a) All eligible cases with outcome of interest over a defined period of time, all cases in a defined catchment area, all cases in a defined hospital or clinic, group of hospitals, health maintenance organization, or an appropriate sample of those cases (e.g. random sample) ☆
b) Not satisfying requirements in part (a), or not stated.

3) Selection of Controls

This item assesses whether the control series used in the study is derived from the same population as the cases and essentially would have been cases had the outcome been present.

a) Community controls (i.e. same community as cases and would be cases if had outcome) ☆
b) Hospital controls, within same community as cases (i.e. not another city) but derived from a hospitalized population
c) No description

4) Definition of Controls

a) If cases are first occurrence of outcome, then it must explicitly state that controls have no history of this outcome. If cases have new (not necessarily first) occurrence of outcome, then controls with previous occurrences of outcome of interest should not be excluded.
b) No mention of history of outcome ☆

COMPARABILITY

1) Comparability of Cases and Controls on the Basis of the Design or Analysis

A maximum of 2 stars can be allotted in this category

Either cases and controls must be matched in the design and/or confounders must be adjusted for in the analysis. Statements of no differences between groups or that differences were not statistically significant are not sufficient for establishing comparability. Note: If the odds ratio for the exposure of interest is adjusted for the confounders listed, then the groups will be considered to be comparable on each variable used in the adjustment.

There may be multiple ratings for this item for different categories of exposure (e.g. ever vs. never, current vs. previous or never) Age = , Other controlled factors = ☆

EXPOSURE

Ascertainment of Exposure

Allocation of stars as per rating sheet

Non-Response Rate

Allocation of stars as per rating sheet

CODING MANUAL FOR COHORT STUDIES[38]

SELECTION

1) Representativeness of the Exposed Cohort

Item is assessing the representativeness of exposed individuals in the community, not the representativeness of the sample of women from some general population. For example, subjects derived from groups likely to contain middle class, better educated, health oriented women are likely to be representative of postmenopausal estrogen users while they are not representative of all women (e.g. members of a health maintenance organization (HMO) will be a representative sample of estrogen users. While the HMO may have an under-representation of ethnic groups, the poor, and poorly educated, these excluded groups are not the predominant users of estrogen).

Allocation of stars as per rating sheet

Selection of the Non-Exposed Cohort

Allocation of stars as per rating sheet

Ascertainment of Exposure

Allocation of stars as per rating sheet

Demonstration That Outcome of Interest Was Not Present at Start of Study

In the case of mortality studies, outcome of interest is still the presence of a disease/ incident, rather than death. That is to say that a statement of no history of disease or incident earns a star.

COMPARABILITY

1) Comparability of Cohorts on the Basis of the Design or Analysis

A maximum of 2 stars can be allotted in this category

Either exposed and non-exposed individuals must be matched in the design and/or confounders must be adjusted for in the analysis. Statements of no differences between groups or that differences were not statistically significant are not sufficient for establishing comparability. Note: If the relative risk for the exposure of interest is adjusted for the confounders listed, then the groups will be considered to be comparable on each variable used in the adjustment.

There may be multiple ratings for this item for different categories of exposure (e.g. ever vs. never, current vs. previous or never)

Age = ☆, Other controlled factors = ☆

OUTCOME

1) Assessment of Outcome

For some outcomes (e.g. fractured hip), reference to the medical record is sufficient to satisfy the requirement for confirmation of the fracture. This would not be adequate for vertebral fracture outcomes where reference to x-rays would be required.

a) Independent or blind assessment stated in the paper, or confirmation of the outcome by reference to secure records (x-rays, medical records, etc.) ☆
b) Record linkage (e.g. identified through ICD codes on database records) ☆
c) Self-report (i.e. no reference to original medical records or x-rays to confirm the outcome)
d) No description.

2) Was Follow-Up Long Enough for Outcomes to Occur

An acceptable length of time should be decided before quality assessment begins (e.g.

5 yrs. for exposure to breast implants)

3) Adequacy of Follow Up of Cohorts

This item assesses the follow-up of the exposed and non-exposed cohorts to ensure that losses are not related to either the exposure or the outcome.

Allocation of stars as per rating sheet

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Curriculum Vitae

Jessica Dunne – Certified/Licensed AT

9490 Bermuda Rd. Apt 2182• Las Vegas, NV 89123 • Phone: (708) 707-8594 • jadatc13@outlook.com

Career Objective

Self-motivated, hardworking Athletic Trainer. Looking to advance my career and knowledge base to better serve the athletes I work with.

Education:

Masters of Science in Kinesiology, Major: Kinesiology Projected Completion: May 2016
University of Nevada – Las Vegas, Las Vegas, NV
Graduate Assistant – Athletic Trainer
Current GPA: 4.0/4.0 (Fall 2015 Semester)
Bachelor of Science in Kinesiology, Major: Athletic Training Completion: May 2009
Western Illinois University, Macomb, IL
Cumulative GPA: 3.6/4.0

Work Experience:

Graduate Assistant Athletic Trainer-University of Nevada Las-Vegas Summer 2014 – Present
Canyon Springs High School (Select Physical Therapy), North Las Vegas, IL
Head Athletic Trainer.
Completed similar responsibilities as Athletic Trainer at Glenbard East High School
Responsible for ordering supplies necessary for the athletic training room
Working with athletics staff on supplies budget
Working with team physician to complete athlete care.

Athletic Trainer at Glenbard East High School Fall 2009 – Summer 2014
Athletico Physical Therapy, Lombard, IL
Assisting Head Athletic Trainer with daily tasks of Athletic Training room.
Providing coverage for all athletic events and practices at Glenbard East High School.
Providing rehabilitation and treatment for all injured athletes.
Administering modalities available in the Athletic Training Room.
Documenting injury occurrences and treatment provided.
Referring athletes' to appropriate additional medical care.
Communication with Athletes' parents, Athletico's Managerial staff, and physicians in regards to patient care.
Working with team physician to complete athlete care.

Athletic Trainer- Summer Camp June 2011 – August 2011
Camp Walt Whitman, Piermont, NH
Providing coverage for daily activities for all campers and staff.
Providing rehabilitation, treatment, referrals for additional care, and thorough documentation for injured campers and staff.

Center of communication for injured campers and staff between their parents, camp directors, and physicians.

Extracurricular Activities:

Western Illinois University Fall 2006 – Summer 2009

Athletic Training - Student Mentor

Participate in the mentoring program for pre-admit athletic training students by being a mentor, introducing them to the athletic training program, being a resource for questions or concerns, and helping them develop their skills.

Athletic Training Student Association (ATSA)

Publicity Committee Chairperson – Fall 2007 to Fall 2008

Provide knowledge and information about ATSA and the athletic training profession.

Student Member – 2006 to 2008

Participate in service, fundraising, and social activities.

Proactive resolutions toward issues brought to the attention of the association.

Certifications

CPR/AED PR- American Red Cross- Current