# Analysis of Injury and Concussion of Fall Sports

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**Abstract**

Background: Injuries among high school athletes are an important health concern as it could lead to serious issues later on in life such as chronic injuries, depression, anxiety or death. We hypothesize that contact male sports such as Football and Soccer will have higher rates of total injury while Cheer and Tennis will have lower concussion and injury occurrences.

Methods: Pitt County Athletic Training collected data to record daily activities at high schools in the county from August 1, 2014 to December 3, 2014 to include fall and winter sports. The certified athletic trainers tracked and recorded the daily activities of five high schools in Pitt County. The database served as an injury tracker that recorded information such as date, sport, level, event, injury, illness, medical care and referral. The database was reviewed and analyzed by sport in terms of upper extremity, lower extremity and non-extremity injury, as well as illness. Concussions were analyzed by gender, season, event and sport. Upper extremity injuries include those to the hands, elbow, thumb, lower arm, fingers or shoulder, while lower extremity injuries consist of injuries to the ankle, knee, lower leg, thigh, gluteals, toe or foot. Non-extremity injuries are injuries that occur to the brain (concussion), cervical spine, lumbar spine, ear, nose, mouth, back abdomen or chest and illnesses were recorded when athletes were experiencing heat illness, skin infection, asthma, respiratory condition, diabetes, or stomach discomfort.

Results: 4,254 injuries occurred in 1,182 athletes among five of the high schools in Pitt County. Lower extremity injuries were the most prevalent with about 1,978 cases being reported, while only 1,524 cases of upper extremity injuries were reported. There were 361 cases of concussions, 239 injuries reported as other of other injuries (non-extremity injuries excluding the brain) and only 152 instances of an illness recorded. Varsity and junior varsity football reported the highest number of injuries among all five categories, while Track/Field/Cross Country had the next highest number of lower extremity injuries reporting 156 cases of this injury. Cheer also reported 59 incidents of concussion after both varsity and junior varsity football. Wrestlers reported 20 cases of illnesses while varsity football reported 84 and junior varsity football reported 41. More males experienced concussions than females and most concussions occurred at practice or during the regular season.

Conclusion: In contrast to our prediction, Cheer had one of the highest concussion incidences among the sports excluding Football, which did have the highest concussion and injury occurrence. Our results show that more safety should be implemented in all sports to prevent and avoid the possible development of a disability or death in severe cases.

Key Words: Gender, season, event, concussion, injury, sports

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**Introduction**

During the 2004-2005 school year, 53.4 percent of all high school students participated in high school athletics (Knowles et al 2006). Participation in high school sports is important because it protects against negative influences and promotes basic personal values (Russel et al 2000). Involvement in sports has shown improvements in mental and physical health for students such as increased strength, endurance and flexibility and improved self-esteem. Though there are positive health benefits to participating in sports, there is always the risk of injury. According to a study conducted in 2007, lower extremity injuries are the most common with two thirds occurring in individuals aged 5-24.

Over the last decade, sports related brain injury visits for children and adolescents in the United States to the emergency department has increased by 60% (Faul et al 2010). Sports-related concussions are a serious national health concern with the potential to initiate lifelong problems such as death or severe disability. For youth aged 15-24, sports are the second leading cause of traumatic brain injury following what? (Sosin 1996). Young athletes are susceptible to prolonged recovery and increased post-concussive symptoms, owing to altered impact response and recovery in a developing brain. Often athletes may experience a second concussion while the symptoms of the first concussion have not fully resolved. When this happen, it results in Second-Impact syndrome (Schulz 2004). It has also been found that vitamin D deficiency leads to a heightened brain injury. Prolonged recovery from symptoms interferes with athletes' ability to attend school and may progress to more serious mental health disorders such as depression and anxiety. It has also been noted that sports related concussion incidence is 3-6% at the high school level (Gessel 2007).

Recent studies have shown that athletes may not know they are experiencing concussion symptoms. McCrea found that about 66.4% of soccer players in high school didn't know that they needed treatment for the concussion symptoms (2004), while Delaney found that collegiate football players also didn't know they were experience concussion symptoms (2002). A study conducted by Tierney has found that female athletes are more likely to develop a concussion than their male counterparts due to their head-neck dynamic stabilization (2005). Women who experience concussions are more difficult to diagnose because they experience different symptoms and recovery patterns compared to men (Broshek 2005).

With the passage of Title IX in 1972, women have been promoted to participate in sports at similar numbers to males (Messner 1988). Furthermore, an interesting finding by Broshek was that those individuals with a learning disability or ADHD performed lower on the Concussion Resolution Index (2005). Also Broshek's study from 2005 indicated that female's experienced higher cognitive impairment. This could be because more aggressive sports require helmets such as football for males while soccer does not. It is also interesting to note that, unhelmeted mates did not suffer from cognitive impairment as much as unhelmeted females did.

Girls had a higher rate of concussion than boys in high school soccer and basketball, although softball and baseball players experienced a similar rate of concussion (Gessel 2007). A study conducted in 2011, states that accounted for more than fifty percent of all concussions (Lincoln et al 2011). Similar to Gessel's study, Lincoln's study reported that girls had a higher rate of concussions than boys in sports that were similar such as softball/baseball and basketball. According to Shields and Smith, 3.5 percent of cheerleading injuries were concussion or closed head injuries. Even in sports such as Track and Field, females were more likely to have an injury.

Studying injuries, notably concussions in young athletes is important because it can cause lifelong depression or anxiety. Injuries, especially concussions can affect students in many facets of daily life and activities such as performance in school. It is important to determine which sports have increased risk for developing concussions and injuries so that preventative measures can be put in place so that safety can be improved. This in turn will hopefully reduce the rates of injury and concussion among adolescent athletes. Minimizing the risk of mental and physical deficits in young athletes through safety is crucial to reducing the prevalence of mental and physical deficits after sports-related injuries and concussions. High school sport injuries not only affect the athlete but also families.

The purpose of this study is to review and analyze the occurrence of upper extremity, lower extremity and non-extremity injuries, as well as illnesses in terms of sport. Concussion prevalence was also analyzed by gender, season, event and sport.

Optimal vitamin D levels affect concussion resilience and recovery in high school athletes. Vitamin D's major role is to regulate inflammation, which could potentially provide resilience to concussion by limiting the inflammatory response following impact. The original plan of this study was to see how vitamin D deficiency prolongs recovery rate and increases the risk for post-concussive symptoms, but we were unable to recruit high school athletes in time. This would have been analyzed through vitamin D levels in the blood along with balance testing and the electroencephalogram. There has been much support for the role of vitamin D in cognitive function as there are vitamin D receptors have been identified in the brain.

**Methods**

Pitt County Athletic Training collected data to record daily activities at high schools in the county from July to December 3, 2014 including winter and fall sports. The certified athletic trainers tracked and recorded the daily activities of five high schools in Pitt County. Athletes with concussive symptoms were referred to a physician for consult within 24 hours of injury. The database served as an injury tracker that recorded Athletes ID, Race, date of data entry, year, school, data entry, sport, time, month, type, level, event, injury, illness, medical care, rehab, clinician and referral. The database was reviewed and analyzed by sport in terms of upper extremity, lower extremity and non-extremity injury, as well as illness. Upper extremity injuries include those to the hands, elbow, thumb, lower arm, fingers or shoulder, while lower extremity injuries consist of injuries to the ankle, knee, lower leg, thigh, gluteals, toe or foot. Non-extremity injuries are injuries that occur to the brain (concussion), cervical spine, lumbar spine, ear, nose, mouth, back abdomen or chest and illnesses were recorded when athletes were experiencing heat illness, skin infection, asthma, respiratory condition, diabetes, or stomach discomfort. Concussion prevalence was also analyzed by gender, season, event and sport. Concussions were determined to be either during the preseason or regular season. Preseason was from July to August 25$^{th}$ and regular season was when any injury or concussion occurred after August 25$^{th}$, which is the first day of school. Where the concussions occurred such as at a competition, practice or other was recorded under the event column and gender was separated my male, female and male or female sport. Male or female sport was included because some sports have both male and female players and the number of male or females in that roster was not recorded.

By filtering the data and using the subtotal function in excel, the number of injuries and concussions were found in terms of sport, gender, event and season. The injury data separated by sport

and concussion data by sport, gender, event and season were recorded in five different tables. The total number of athletes was calculated based on the roster for each high school sport. To compare the number concussions experienced by males or females: the number of concussions of each gender was divided by the total number of concussions of that gender and multiplied by 100 to get a percentage. Similarly, the percentages of concussions occurring at a competition, practice, other event, preseason or regular season were calculated. It was best to compare the number of concussions to the total number of concussions for gender, sport, event and season because some athletes experienced injuries more than once. With the data recorded, there was no way to determine how many athletes actually experienced concussions to compare to the total number of athletes.

**Results**

Four thousand two hundred and fifty four injuries occurred in 1,182 athletes among five of the high schools in Pitt County (Table 1, Table 2). Lower extremity injuries were the most prevalent with about 1,978 cases being reported, while only 1,524 cases of upper extremity injuries were reported. There were 361 cases of concussions, 239 instances of other injuries (non-extremity injuries excluding the brain) and only 152 instances of an illness recorded. Varsity and junior varsity football reported the highest number of injuries among all five categories, while Track/Field/Cross Country had the next highest number of lower extremity injuries reporting 156 cases of this injury. Cheer also reported 59 incidents of concussion after both varsity and junior varsity football. Wrestlers reported 20 cases of illnesses while varsity football reported 84 and junior varsity football reported 41. Varsity Sports had a higher prevalence of injury compared to their Junior Varsity counterpart. There are a higher number of injuries reported than number of athletes because many athletes had multiple injuries (Table 1, Table 4).

| Table 1. Number of Injuries by Sport | | | | | | |
|---|---|---|---|---|---|---|
| | Non Extremity | | | | | |
| **Sport** | **Brain** | **Other** | **Upper Extremity** | **Lower Extremity** | **Illness** | **Total Number of Injuries** |
| Boy's Basketball Varsity | 4 | 3 | 13 | 11 | 0 | 31 |
| Boy's Basketball Junior Varsity | 2 | 2 | 4 | 2 | 0 | 10 |
| Cheer Varsity | 59 | 4 | 8 | 9 | 1 | 81 |
| Cheer Junior Varsity | 5 | 1 | 0 | 0 | 0 | 6 |
| Football Varsity | 103 | 125 | 971 | 1167 | 84 | 2450 |
| Football Junior Varsity | 128 | 87 | 488 | 503 | 41 | 1247 |
| Girl's Basketball Varsity | 19 | 0 | 1 | 15 | 1 | 36 |
| Girl's Basketball Junior Varsity | 1 | 0 | 0 | 2 | 0 | 3 |
| Soccer Varsity | 15 | 5 | 8 | 70 | 1 | 99 |
| Soccer Junior Varsity | 6 | 1 | 1 | 8 | 1 | 17 |
| Track/Field/Cross Country Varsity | 11 | 7 | 4 | 156 | 2 | 180 |
| Volleyball Varsity | 7 | 0 | 11 | 21 | 1 | 40 |
| Wrestling Varsity | 1 | 4 | 15 | 14 | 20 | 54 |
| **Total Number of Injuries** | 361 | 239 | 1524 | 1978 | 152 | 4254 |

*Examples of each injury category. Brain-Concussion; Other-Back, Spine, Chest, Nose, Eyes; Upper Extremity-Thumb, Fingers, Elbow, Hand, Joints; Lower Extremity-Ankle, Knee, Thigh, Hip, Gluteals

Overall, we found a higher prevalence of concussions among males than females (Table 2). Thirty three point six percent of male athletes experienced a concussion, while only 29.6 percent of female athletes experienced a concussion. Table 3 shows concussions for each sport with Football Junior Varsity having the highest number of concussions, followed by Football Varsity and Cheer Varsity. Football players are more likely than any other athlete to get a concussion, while basketball players and wrestlers are least likely.

| Table 2. Number of Concussions by Gender | | | |
|---|---|---|---|
| **Gender** | **Number of Concussions** | **Total Number of Concussions** | **Percentage (%)** |
| Male | 259 | 361 | 71.7 |
| Female | 91 | 361 | 25.2 |
| Male or Female Sport | 11 | 361 | 3.1 |

| Table 3. Number of Athletes with Concussion by Sport | | | |
|---|---|---|---|
| **Sport** | **Number of Concussions** | **Total Number of Athletes** | **Percentage (%)** |
| Boy's Basketball Varsity | 4 | 70 | 5.7 |
| Boy's Basketball Junior Varsity | 2 | 50 | 4 |
| Cheer Varsity | 59 | 108 | 54.6 |
| Cheer Junior Varsity | 5 | 38 | 13.2 |
| Football Varsity | 103 | 275 | 37.5 |
| Football Junior Varsity | 128 | 118 | 108.5 |
| Girl's Basketball Varsity | 19 | 71 | 26.8 |
| Girl's Basketball Junior Varsity | 1 | 17 | 5.9 |
| Soccer Varsity | 15 | 131 | 11.5 |
| Soccer Junior Varsity | 6 | 25 | 24 |
| Track/Field/Cross Country Varsity | 11 | 104 | 10.6 |
| Volleyball Varsity | 7 | 74 | 9.5 |
| Wrestling Varsity | 1 | 101 | .99 |

Concussions were also more likely to occur at practice rather than at a competition (Table 4). 59.8 percent of the total concussions occurred at practice, while 28.8 percent of the concussions occurred at a competition and 11.3 percent of concussions occurred at other events. Concussions were more prevalent during the regular season rather than preseason (Table 5). 81.4 percent of total concussions occurred during the regular season.

| Table 4. Number of Concussions by Event | | | |
|---|---|---|---|
| **Event** | **Number of Concussions** | **Total Number of Concussions** | **Percentage of Concussions (%)** |
| Competition | 104 | 361 | 28.8 |
| Practice | 216 | 361 | 59.8 |
| Other | 41 | 361 | 11.3 |

| Table 5. Number of Concussions by Season* | | | |
|---|---|---|---|
| **Season** | **Number of Concussions** | **Total Number of Concussions** | **Percentage (%)** |
| Preseason | 67 | 361 | 18.6 |
| Regular Season | 294 | 361 | 81.4 |

*Preseason includes concussions before and on August 25th, while concussions after August 25th are considered to be in the regular season.

**Discussion**

Overall, we found highest total injures In Football athletes and highest concussions in Football athletes with higher prevalence of concussions in males. There was also a higher occurrence of concussions at practice v competition and during the regular season vs preseason. Our findings support other research studies, which indicate that male dominated sports such as football have the highest incidence of any injury (Knowles et al. 2006). A study conducted by Schulz et al. also shows that football has the highest number of concussions but that boy's soccer has the second highest incidence of concussion (Schulz 2005), while the data presented above indicates that cheerleading had the second highest. Other studies also show that males have a higher incidence of concussion compared to females (Gessel 2007, Schulz 2004). One study shows that males are almost four times more likely to develop concussions (Schulz 2004), while another indicates that males are three times more likely to develop concussions (Gessel 2007) which is similar to what was found in the data collected for Pitt County High Schools in the Fall of 2014.

Limitations of this study include a retrospective design based on injury database. Injury data could have been biased, as some athletic trainers are meticulous and detailed recording injury details while others were not. Injury rates by sport may be skewed because there are no data from the spring semester. Some sports not included in this study also reported concussions, but because the number of athletes on the roster was unknown they were left out of the study.

The data collected from this study can be used to determine where safety precautions could be implemented and taught in order to further protect the athletes. Further analysis could be achieved with this data to show the incidence of male and female injury in each particular sport by event or season.

Although this study did not analyze the effects of concussed athletes and neurocognitive function other studies have shown that concussed high school athletes performed worse on tests of attention and concentration than those who had never experienced a concussion (Moser 2005). There was also a correlation shows between lower cumulative academic grade point averages and athletes who had experienced a concussion two or more times (Moser 2005). It is important that we minimize the risk of concussion and post-concussive symptoms to limit the risk of mental and physical deficits in adolescent athletes. It is especially important to protect younger athletes (ages 13-16) who experience a

concussion because they are more likely to develop concussions in the future as they have prolonged recovery, which is to due their recovering developing brain (Zuckerman 2012).

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**References**

Aminmansour, Bahram, et al. "Comparison of the administration of progesterone versus progesterone and vitamin D in improvement of outcomes in patients with traumatic brain injury: A randomized clinical trial with placebo group." *Advanced biomedical research* 1 (2012).

Broshek, Donna K., et al. "Sex differences in outcome following sports-related concussion." *Journal of neurosurgery* 102.5 (2005): 856-863.

Delaney, J. Scott, et al. "Concussions among university football and soccer players." *Clinical Journal of Sport Medicine* 12.6 (2002): 331-338.

Faul, Mark, et al. "Traumatic brain injury in the United States: emergency department visits, hospitalizations and deaths 2002–2006." *Atlanta, GA: Centers for Disease Control and Prevention, National Center for Injury Prevention and Control* (2010): 2-70.

Fernandez, William G., Ellen E. Yard, and R. Dawn Comstock. "Epidemiology of Lower Extremity Injuries among U.S. High School Athletes." *Academic emergency medicine : official journal of the Society for Academic Emergency Medicine* 14.7 (2007): 641-5. Print.

Gessel, Luke M., et al. "Concussions among United States high school and collegiate athletes." *Journal of athletic training* 42.4 (2007): 495.

Knowles, Sarah B., et al. "A prospective study of injury incidence among North Carolina high school athletes." *American journal of epidemiology* 164.12 (2006): 1209-1221.

Lincoln, Andrew E., et al. "Trends in Concussion Incidence in High School Sports: A Prospective 11-Year Study." *The American journal of sports medicine* 39.5 (2011): 958-63. Print.

McCrea, Michael, et al. "Unreported concussion in high school football players: implications for prevention." *Clinical Journal of Sport Medicine* 14.1 (2004): 13-17.

Messner, Michael A. "Sports and male domination: The female athlete as contested ideological terrain." *Sociology of sport journal* 5.3 (1988): 197-211.

Moser, Rosemarie Scolaro, Philip Schatz, and Barry D. Jordan. "Prolonged effects of concussion in high school athletes." *Neurosurgery* 57.2 (2005): 300-306.

Pate, Russell R., et al. "Sports participation and health-related behaviors among US youth." *Archives of pediatrics & adolescent medicine* 154.9 (2000): 904-911.

Schulz, Mark R., et al. "Incidence and risk factors for concussion in high school athletes, North Carolina, 1996–1999." *American Journal of Epidemiology* 160.10 (2004): 937-944.

Shields, Brenda J., and Gary A. Smith. "Cheerleading-related injuries to children 5 to 18 years of age: United States, 1990–2002." *Pediatrics* 117.1 (2006): 122-129.

Sosin, Daniel M., J. E. Sniezek, and David J. Thurman. "Incidence of mild and moderate brain injury in the United States, 1991." *Brain Injury* 10.1 (1996): 47-54.

Tierney, Ryan Timothy, et al. "Gender differences in head-neck segment dynamic stabilization during head acceleration." *Medicine and science in sports and exercise* 37.2 (2005): 272-279.

Watson, Michael D. "Incidence of injuries in high school track and field athletes and its relation to performance ability." *The American journal of sports medicine* 15.3 (1987): 251-254.

Zuckerman, Scott L., et al. "Recovery from sports-related concussion: Days to return to neurocognitive baseline in adolescents versus young adults." *Surgical neurology international* 3 (2012).