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Presence and Characteristics of Axial Skeleton Fractures Experienced by Cheerleaders and Gymnasts from 2010-2019

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Presence and Characteristics of Axial Skeleton Fractures Experienced by Cheerleaders
and Gymnasts from 2010-2019

by

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ABSTRACT

Context: Cheerleading and gymnastics are sports containing dangerous skills that place athletes at risk of severe injuries, such as axial skeleton fractures. In addition, cheerleaders and gymnasts frequently have less access to on-site healthcare, such as athletic training services, which requires increased utilization of emergency departments.

Objective: To compare national estimates of axial skeleton fractures in cheerleading and gymnastics by injury characteristics over a 10-year period. **Design:** Descriptive Epidemiological. **Setting:** United States Emergency Department via the National Electronic Injury Surveillance System Database. **Participants:** Cheerleaders and gymnasts presenting to a sample of US hospitals. **Interventions:** Independent variables included body region fractured. **Main Outcomes:** The primary outcomes of this study included frequencies and distributions as well as Injury Proportion Ratios (IPR) comparing the prevalence of axial skeleton fracture characteristics in each sport. **Results:** An estimated total of 8,360 axial skeleton fractures occurred to cheerleaders and gymnasts nationally in a 10-year period (84.9% female; mean age=17.3±8.5). The most prevalent axial skeleton fractures in cheerleaders and gymnasts occurred to the face (n=4,183; 74.6%; n=1,492; 54.2%) and spine (n=1,334; 23.8%; n=1,212; 44.0%). Fractures to the upper trunk (IPR=0.43; 95% CI=0.33-0.53) and neck (IPR=0.33; 95% CI=0.25-0.41) were more prevalent in gymnasts whereas facial fractures were more prevalent in cheerleaders (IPR=1.38; 95% CI=1.05-1.70). **Conclusions:** Heightened awareness of injury types sustained by these athletes highlights the need for appropriate on-site healthcare providers, such as athletic trainers, who can work to optimize the

physical, emotional, and financial burden by referring patients through the proper channels and only when medically necessary.

Keywords: cheerleading, gymnastics, athletic training, medical care, fractures, axial skeleton

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LIST OF ABBREVIATIONS

AMA	Against Medical Advice
AT	Athletic Trainer
CI	Confidence Interval
CPSC	Consumer Product Safety Commission
C-spine	Cervical Spine
ECAC	Eastern College Athletic Conference
ED	Emergency Department
IPR	Injury Proportion Ratio
ISP	Injury Surveillance Program
MOI	Mechanism of Injury
NCAA	National Collegiate Athletic Association
NEISS	National Electronic Injury Surveillance System
NFL	National Football League
SEC	Southeastern Conference
SPSS	Statistical Package for the Social Sciences
UCLA	University of California, Los Angeles
UNC	University of North Carolina

CHAPTER I: INTRODUCTION

Competitive cheerleaders and gymnasts are at risk for many types of sports injuries, including axial skeleton injuries.^{1,2} The axial skeleton consists of the bones in the midline of the body: the bones in the head, face, and vertebral column. While axial skeleton fractures are not as common as appendicular skeleton fractures, they can be more severe.³ Previous studies have shown that a high-energy fall is the most common mechanism of injury (MOI) for vertebral fractures.⁴ Since falling from a cheer stunt or falling off of the balance beam is common in cheerleading and gymnastics, determining the rate of axial skeleton fractures by body region, severity, diagnosis type, and MOI is important. Additionally, exploring the potential significance of on-site medical care for these potentially dangerous sports is vital for successful patient care following axial skeleton fractures.

Athletic trainers (AT) are certified health care professionals who work in many different settings. Most commonly, these include high school, collegiate, and professional sports, military, and/or clinic-based settings. ATs provide medical care at practices and competitions, develop rehabilitation plans for injured athletes, and are trained in clinical decision making for emergency and non-emergency situations. ATs are not typically employed at recreational facilities, which is the most common setting where competitive cheerleading and gymnastic teams function.

Competitive cheerleaders and gymnasts require above average muscle strength, flexibility, balance, and coordination to execute skills safely. Competitive cheerleading involves a group of athletes who perform a routine with difficult skills such as jumps, tumbling, and stunts for a score. Competitive cheerleading is completely different than

sideline cheering at a football or basketball game; it is an intense sport that involves dangerous skills and significant person-to-person contact.

There are two types of competitive cheerleading teams: co-ed and all girls. The routines and stunts vary depending on the type and level (from miniature to international divisions) of the team. The skills progressively intensify as athletes move from beginner to advanced levels; every competitive cheerleading routine involves some form of jumps, tumbling, and stunts. Cheerleading involves a group of individuals in close contact, known as a team sport, whereas gymnastics is an individual sport contributing to overall team success. Competitive gymnastics is a men's and women's sport ranging from level one to level ten; most athletes advance to the collegiate or Olympic level after reaching level ten. The competitive events for women's gymnastics include the vault, uneven bars, balance beam, and floor while the events for men's gymnastics include the floor, pommel horse, still rings, vault, parallel bars, and horizontal bar. While there is no person-to-person contact within gymnastics, the nature of the events predisposes athletes to suffer from equipment or surface contact in which they fall from or contact a particular apparatus or onto the floor.

Research Questions

1. Which body regions are affected most often by axial skeleton fractures?
2. Who is affected most often by axial skeleton fractures?
3. How debilitating are axial skeleton fractures?
4. Which injuries could have been treated outside of the emergency department (ED)?

This bolstered the study by showing the importance of athletic training coverage to reduce athlete physical, mental, social, and financial burdens. These questions were essential in understanding axial skeleton fractures, which can further the knowledge related to these injuries and ultimately provide better care for cheerleaders and gymnasts.

Research Hypotheses

A hypothesis was formed that cervical spine fractures would be the most common due to the nature of advanced skills performed by cheerleaders and gymnasts.^{1,5} Also, it was assumed females will be affected most by these fractures since males do not dominate in either of these sports despite their presence in both.

Limitations

The data obtained for this study was secondary data. While axial skeleton fractures are severe, they are rare, and it is difficult to obtain adequate data locally. The Consumer Product Safety Commission (CPSC) maintains a National Electronic Injury Surveillance System (NEISS) that combines data from a sample of one-hundred hospitals in the United States to form nationwide estimates of the total number of product-related and recreational-related injuries treated in the emergency department. Acquiring data through the NEISS database strengthened the study, because the data obtained for axial skeleton fractures from 2010-2019 was able to be converted from 257 patients to 8,360 patients with these national estimates.

An additional limitation with the NEISS database includes being unable to distinguish between an acute and a chronic injury that reports to the emergency department. An acute injury happens suddenly, such as a nasal fracture, while a chronic

injury progressively worsens over a period of time. An example of a chronic injury that was possibly reported to the emergency department could have been a stress fracture of the vertebrae called a spondylolysis. While a diagnostic report is required to determine a stress fracture, an athletic trainer can diagnose these fractures and eliminate the need to refer through inappropriate channels, such as the emergency department. Athletic trainers can also provide preventative treatment so chronic injuries do not worsen and become emergent issues.

CHAPTER II: LITERATURE REVIEW

Introduction

The purpose of this project was two-fold: 1) to describe the presence of axial skeleton fractures by body region, severity, diagnosis type, mechanism of injury, and athlete profile (gender, age, race) in cheerleaders and gymnasts and 2) to explain the importance of athletic training coverage/medical care for these sports. Axial skeleton fractures consist of fractures to the head, face, neck (cervical spine), and back (thoracic and lumbar spine). Although potentially severe, there is a gap in the study of axial skeleton fractures in cheerleaders and gymnasts. In addition, cheerleading and gymnastics frequently have less on-site medical care, such as athletic training services.⁶ High school, collegiate, and professional-level sports are the most common settings in which athletic trainers work. However, much of cheerleading and gymnastics participation exists in recreational as opposed to school-based settings, which less frequently employ athletic trainers or other on-site medical providers. Understanding severe injuries suffered in this population is vital to advocate for appropriate medical care, preventing physical, mental, social, and financial hardship for athletes and their families.

National Electronic Injury Surveillance System for Data

The data collected for this research project is from the CPSC, which maintains the NEISS database. NEISS combines data from a sample of one-hundred hospitals in the United States to form nationwide estimates of the total number of product-related and recreational-related injuries treated in the ED across the entire United States. Fractures, while severe, are not as common in the axial skeleton when compared to the appendicular skeleton. Therefore, using a national database like NEISS allows more data to be

analyzed in a shorter period of time than collecting the data locally or even regionally. The information accessed for this study included patients who reported to the ED and were diagnosed with a fracture to the head, face, neck, or back while participating in cheerleading or gymnastics. The date of ED arrival, athlete profile, injury diagnosis, the outcome of the patient (ex: treated and released, admitted, referred, deceased, etc.), and a brief narrative about the visit were recorded in NEISS; the information provided in the public database did not identify any private or personal information.

Epidemiology of Axial Skeleton Fractures in Cheerleaders

Cheerleading is a competitive sport that has recently gained popularity because of its advanced skills. Today, cheerleading goes beyond the sideline of a sporting event to its own competitive sport season. While football is the most common sport to be associated with axial skeleton injuries, the risk of cervical spine fractures is also high in cheerleading, wrestling, and diving.⁷ The CPSC documented seventy-six cervical spine fractures in cheerleaders in the year 2000 alone.⁷

Boden et al.¹ performed a study to identify the risk factors of catastrophic injuries in cheerleaders. Coaches and athletic departments reported any catastrophic injuries that occurred during cheerleading participation; the results were recorded and analyzed for over twenty years. Injured athletes were contacted and asked to complete a survey to gain more information about their demographics and how the injury occurred. Twenty-nine injuries were collected over the twenty-year period with over half of them resulting in traumatic head injuries such as skull fractures (n=13) and cervical spine fractures (n=9), resulting in two fatalities.¹ Most of these injuries occurred during practice and the MOI

was direct trauma, which solidifies the importance of an athletic trainer's presence at cheerleading practice, even at recreational facilities.

One of the common skills during competitive cheerleading is a "stunt." A cheerleading stunt involves synchronous movement of bases and back spots to lift the flyer into the air and execute the skill. Although commonplace, while developing stunting skills, or trying new stunts, falls can occur. The University of North Carolina (UNC) at Chapel Hill studied forty cases of severe cheerleading injuries that occurred while falling from a stunt. Over half of these cases resulted in head injuries with five fatalities.⁶ The statistics on head injuries alone in cheerleading should raise concern for athletic trainers, especially since most injuries occur during practice rather than competition or events. If an athlete sustains an injury during practice, their coaches and parents are not qualified to determine the presence of injury and subsequent proper care for the athlete. Athletic trainers are trained to evaluate, manage, and treat injuries, which include but are not limited to, fractures, concussions, and/or other forms of head injuries.⁸

Epidemiology of Axial Skeleton Fractures in Gymnasts

The sport of gymnastics requires strength, flexibility, and endurance. Although gymnasts make the sport look easy with their elegant routines, gymnastics is a dangerous sport that can result in catastrophic injury. Several studies examined the physical demands, fracture rates, and the number of severe injuries in gymnasts.^{5,9,10} The physical demands placed on the bodies of male and female gymnasts put them at a high risk for axial skeleton injuries. They perform difficult skills that place a large amount of force on the axial skeleton. Kruse and Lemmen⁵ examined the physical demands through a biomechanical study that measured the amount of vertical force through gymnasts' feet

during take-off. The least amount of force recorded was triple the athlete's body weight.⁵ These results concluded the risk for spinal injury is increased when flipping, jumping, and landing on various surfaces, which are all commonplace in a gymnastics routine. In addition to forces sustained through their feet, male and female gymnasts perform events that require significant upper body strength, the uneven bars for females and the parallel bars for males. Bars are a dangerous event for spinal injuries due to the traction forces placed on the spine when swinging downwards, but impact forces can also occur to the upper extremity during release of the bars and re-grasp skills.

A study at the University of California, Los Angeles (UCLA) analyzed the history of fractures in Division I collegiate athletes from 1986 to 2000 using medical records.⁹ Men's and women's sports were studied in hopes to gain information about the type, location, and incidence rate of fractures. Sixteen different fracture locations were studied; fractures of the hand were determined to be the most common with facial being the fourth most common and spinal being the seventh most common location for fractures in collegiate sports. Basketball was shown to have the highest incidence rate for fractures in males while gymnastics had the highest incidence rate for fractures in females. During the study, it was determined that athletes who already sustained a fracture were more likely to have a recurring fracture.⁹ Determining which athletes are prone to certain fractures is important for athletic trainers, coaches, and even parents to be aware of during practice and competitions. It is also important for athletic trainers to get to know their athletes on a personal level; this can be beneficial in determining the severity of the injury. For example, an athlete who has a high pain tolerance and is in intense pain, may have a significant injury. Athletic trainers who are assigned to specific

sports can be more aware of their sports' fracture risk, which can help in determining what materials to have readily available at practice and competitions, as well as a rehabilitation plan for a strong recovery and optimal return to play.

In addition to the biomechanical risks of injury, the sport of gymnastics consists of difficult skills resulting in a greater chance for a surface contact injury (ex: hitting the floor).¹⁰ An epidemiologic study determined the prevalence of severe injuries in collegiate athletes. Severe injuries were defined as injuries resulting in at least twenty-one days of no participation in sport activity. The study consisted of twenty-five National Collegiate Athletic Association (NCAA) sports and the data collected was from athletic trainers reporting the injuries to the NCAA Injury Surveillance Program (ISP). Of the three thousand injuries reported from 2009-2015, gymnasts sustained the largest number of severe injuries out of all women's sports in the study.¹⁰

Risk Factors for Young Athletes

Many competitive gymnasts and cheerleaders participate in grueling training schedules at recreational facilities from a young age. Formalized competitions will occasionally have medical staff on standby in the event of an emergency, but most practice facilities lack on-site medical care. While athletic trainers are not typically employed in recreational sport settings, recreational and club-based athletes are also at risk of sustaining significant injuries. Although coaches and parents have the ability to remove an athlete from participation, they can only do so if they recognize something is wrong. Without the education to evaluate and manage injuries, many young athletes are at a disadvantage regarding health care. The dangers of not having appropriate medical providers could result in unnecessary referrals to the ED, resulting in a financial burden

on the patient and/or their parents. A trained healthcare professional can identify emergent situations and treat less severe injuries on-site or through other referral avenues; the financial burden and unnecessary referrals to the ED could be avoided or optimized by employment of an athletic trainer.

In addition to the environment in which young athletes participate, young athletes also have many physical characteristics that may increase their risk for injury. Proctor and Cantu² discussed the risk for youth injuries in gymnastics being second only to football. Research from the National Center for Catastrophic Sports Injury has shown the risk of head and spine injuries to increase with age, and gymnastics to be in the top four youth sports for head and neck injuries. The sport with highest risk is football followed equally by gymnastics, hockey, and wrestling.²

Research was conducted to examine injuries in sport and recreational activities in children aged one to eighteen. Information was gathered from the NEISS database from 2001 to 2008.¹¹ The goal of the study was to determine which sex was more likely to get injured and which age had the highest injury rate. Thirty-nine sports and recreational activities were examined. Basketball was the leading sport for youth injuries while playgrounds, bikes, and trampolines had the highest recreational injuries. Gymnastics and cheerleading were categorized together and were the tenth most common sport for youth injuries. Most sports injuries showed the highest peak risk during the teenage years; gymnastics and cheerleading injuries peaked at age fifteen. It was determined most factors for pediatric injuries were due to children having no fear and tending to be risk-takers.¹¹

The risk of head and spine injuries increases with age, and gymnastics and cheerleading being a high-risk sport for youth athletes, only emphasizes the importance of better understanding these injuries, such as axial skeleton fractures. Furthermore, the presence of athletic trainers at youth sports will help to improve injury management and care. The athletic training profession continues to grow and hopefully with more research, the field will further expand into youth and recreational sport coverage for high-risk sports such as gymnastics and cheerleading.

Purpose of Study

The purpose of this study was to identify the common types of axial skeleton fractures, body regions affected, and corresponding severities sustained by cheerleaders and gymnasts. By better understanding the injuries these athletes endure, there is heightened awareness of the need for appropriate on-site medical care, such as care provided by athletic trainers. The information gained from this study will highlight the need for current and future athletic trainers to start prioritizing medical care of competitive gymnastics and cheerleading in recreational, high school, and collegiate sports settings. This study contributes to the field of athletic training by identifying the descriptions of the common types of axial skeleton fractures and acknowledging the importance of athletic trainers in the gymnastics and cheerleading world.

CHAPTER III: METHODOLOGY

Secondary Data Analysis

Secondary data was used in this study because the injuries studied (axial skeletal fractures) are relatively rare. These injuries are serious and important, but not enough data could be obtained locally or in the study time frame. First, the injuries themselves are rare, meaning it would be impossible to gather a large amount of data across a single sport season. Second, there are not many competitive gymnastics and cheerleading teams within the local geographical area. Therefore, secondary data collection was the best choice of action for completing this study. Secondary data analysis involves using data that has already been collected to answer new research questions. The data collected for this study is from the NEISS public hospital database, which can be accessed through any computer with access to the internet. The process for obtaining data through NEISS is efficient because it is secondary data and does not require researchers to spend much time collecting data. By using the NEISS database, several years' worth of data can be analyzed with the ability to look at national estimates of these injuries across the United States. The database can also separate specific populations of interest. Given the unidentified nature of the data, using NEISS also allows researchers to bypass ethical review board approval making the research process extremely efficient.

The Public Hospital Database: NEISS

The CPSC maintains the NEISS database that combines data from a sample of one-hundred hospitals in the United States to form nationwide estimates of the total number of product-related and recreational-related injuries treated in the ED across the United States. The purpose of the NEISS database is to collect data on numerous product

and sports/recreational-related injuries of people throughout the United States for researchers to study. As part of the database, weighted estimates are provided to researchers for the estimation of nationwide cases based off the collected sample. This electronic database is helpful because it provides valuable and reliable data for researchers to conduct studies while also keeping private or personal information confidential. The NEISS query builder allows researchers to request specific information for their data and organizes the data into a Microsoft Excel spreadsheet that can be imported into any statistical software for analysis. Data provided include the date of the ED visit, subject age, sex, race, diagnosis, body part injured, disposition, location of the incident, and a brief narrative on subjective statements from the patient/physician.

Procedure for Obtaining Data

The data used for this study consisted of individuals participating in one of two sports: gymnastics or cheerleading. Any person, male or female, that reported to the ED from 2010-2019 because of a gymnastics or cheerleading injury and was diagnosed with an axial skeleton fracture was included in the dataset. Specific search terms used for the NEISS query builder included:

- a. Treatment Dates: 2010-2019
- b. Sports: Cheerleading, Gymnastics
- c. Sex: Male, Female
- d. Race: Unknown, White/Caucasian, African American, Asian, Other
- e. Age: All ages
- f. Body Parts: Head, Face, Neck, Upper Trunk, Lower Trunk
- g. Diagnosis: Fracture

- h. Disposition: Treated and Released, Treated and Transferred, Treated and Admitted, Left Against Medical Advice (AMA)
- i. Location: Not Recorded, Home, Other Public Property, School, Place of Recreation
- j. Type: Skull, Orbit, Nose, Maxilla, Jaw, Clavicle, Sternum, Rib, Vertebral, Non-Specific, Other
- k. MOI: Player to Player Contact, Equipment Contact, Surface Contact, Non-Contact, Unknown, Other

As a note, unknown for race and MOI meant it was not recorded in the patient's data; non-specific referred to any type of fracture that was not explicitly defined within the physician's notes; neck referred to the cervical spine, upper trunk the thoracic spine, and lower trunk the lumbar spine.

Procedure after Data is Obtained

After running the query from the NEISS database, a Microsoft Excel spreadsheet was exported. This spreadsheet incorporated all variables listed above and allowed the researchers to clean the data including verification that all injuries were from participation in gymnastics or cheerleading. Then, researchers used the Statistical Package for the Social Sciences (SPSS) software to generate estimates of axial skeleton fractures presenting to EDs nationally during the specified time period. The NEISS database assigns each case a statistical weight (based on the sample design) and provides a coefficient of variation. Those values are then used to create national estimates (summation of statistical weights) and their associated confidence intervals. National estimates are considered unstable if: 1) the estimate is less than 1,200; 2) the number of

cases is less than 20; 3) the coefficient of variation is more than 33 percent.¹³ National estimates were used throughout this study to describe the nature and relationships between age, gender, race, body region, diagnosis, and disposition on fracture diagnosis and sport. Descriptive statistics (means with standard deviations and frequencies with associated 95% confidence intervals) were used to establish a general understanding of the presence of axial skeleton fractures in gymnastics and cheerleading. Since national estimates incorporate a certain level of error, 95% confidence intervals were provided for all frequencies. In addition to descriptive statistics, injury proportion ratios (IPRs) and associated 95% confidence intervals (CI) were used to examine the differences in commonality of axial skeleton fractures by age, race, sport, body region, fracture type/location, and mechanism of injury.

Research Questions

- Which body regions are most affected by axial skeleton fractures?
- Who is affected most by axial skeleton fractures (age, gender race, sport etc.)?
- How debilitating are axial skeleton fractures?
- Which injuries could have been treated outside of the emergency department (ED)?

CHAPTER IV: RESULTS

There were a total of 257 cheerleaders and gymnasts who reported to the ED with an axial skeleton fracture during the 10-year study period (Table 1). Using the NEISS database standards,¹³ researchers calculated the national estimate of axial skeleton fractures in cheerleading and gymnastics from 2010-2019 to be 8,360 (95% CI: 6,394-10,326; Table 1). National estimates were used throughout the entire study. The majority of cheerleaders and gymnasts within this sample were aged 15-19 years old (n=3,752; 44.9%; 95% CI: 2,870-4,634) and white/Caucasian (n=4,398; 52.6%; 95% CI: 3,364-5432). Males do not dominate in either of these sports, as evidenced by the current sample (female: n=7,100; 84.9%; 95% CI: 5,430-8,770; Figure 1).

The actual number of axial skeleton fracture cases seen in cheerleaders was 150 with a national estimate of 5,608 (95% CI: 4,289-6,927). Cheerleaders aged 15-19 years old had the most axial skeleton fractures (n=2,874; 51.3%; 95% CI: 2,198-3,550). The majority of cheerleaders within this sample were white/Caucasian (n=2,957; 52.7%; 95% CI: 2,262-3,652) and female (n=5,320; 94.9%; 95% CI: 4,069-6,571).

The actual number of gymnasts who reported to the ED with axial skeleton fractures was 107 with a national estimate of 2,752 (95% CI: 2,105-3,399). The majority of gymnasts within this sample were aged 10-14 years old (n=870; 31.6%; 95% CI: 665-1,075), white/Caucasian (n=1,441; 52.4%; 95% CI: 1,102-1,780) and female (n=1,780; 64.7%; 95% CI: 1,361-2,199).

IPRs were used to examine the differences in commonality of axial skeleton fractures by sport (Table 2). Out of all age categories, gymnasts aged 5-9, 25-29 and >30-years-old were more likely to sustain an axial skeleton fracture than age-matched

cheerleaders (IPR=0.04, 95% CI: 0.03-0.04; IPR=0.61, 95% CI: 0.47-0.76; IPR=0.08, 95% CI: 0.06-0.10, respectively). Cheerleaders aged 15–19-years-old were more likely to sustain axial skeleton fractures than age-matched gymnasts (IPR=1.61, 95% CI: 1.23-1.99). All other age groups had comparable rates of axial skeleton fractures between cheerleading and gymnastics. In terms of racial differences, African American and Asian gymnasts were more likely to sustain axial skeleton fractures than race-matched cheerleaders (IPR=0.77; 95% CI: 0.59-0.96; IPR=0.09; 95% CI: 0.07-0.11, respectively). A racial categorization of “Other” sustaining axial skeleton fractures was more likely in cheerleading than gymnastics (IPR=1.32, 95% CI: 1.00-1.63). All other racial categories had comparable rates of axial skeleton fractures between cheerleading and gymnastics. Regarding gender, males were more likely to suffer an axial skeleton fracture in gymnastics (IPR=0.15, 95% CI: 0.11-0.18) and females more likely in cheerleading (IPR=1.47, 95% CI: 1.12-1.81).

Body Regions and Type of Fracture

Body regions and specific type of axial skeleton fractures were analyzed in this study. Body regions included the head, face, neck, upper trunk, and lower trunk. (Figure 2) Type of fracture suffered included skull, orbit, nose, maxilla, jaw, clavicle, sternum, rib, vertebral, non-specific, and other. (Figure 3) The most common body region fractured by these athletes consisted of fractures to the face (n=5,676; 67.9%; 95% CI: 4,341-7,011) with the most common type of fracture being a nasal fracture (n=4,460; 53.4%; 95% CI: 3,411-5,509). Fractures to the vertebrae were the second most common type of fracture regardless of body region (n=1,719; 20.6%; 95% CI: 1,315-2,123).

Cheerleaders suffered 4,183 facial fractures of which 3,700 were to the nose (face=74.6%, 95%CI: 3,199-5,167; nose=66.0%, 95%CI: 2,830-4,570). Gymnasts sustained 1,492 fractures to the face with 760 of these fractures occurring to the nose (face=54.2%; 95%CI: 1,141-1,843; nose=27.6%; 95%CI: 581-939). Given the multiple body regions that house vertebrae (upper trunk, lower trunk, and neck), the most common type of fracture suffered in gymnasts was vertebral (n=771; 28.0%; 95%CI: 590-952).

Gymnasts were more likely to suffer from an axial skeleton fracture to the upper trunk and neck (IPR=0.43, 95%CI: 0.33-0.53; IPR=0.33, 95%CI: 0.25-0.41, respectively) while cheerleaders were more likely to suffer from an axial skeleton fracture to the face (IPR=1.38, 95%CI: 1.05-1.70). Gymnasts in the study were shown to suffer from orbital (IPR=0.25, 95%CI: 0.19-0.31), rib (IPR=0.22, 95%CI: 0.17-0.27), vertebral (IPR=0.20, 95%CI: 0.15-0.25), maxilla (IPR=0.60, 95%CI: 0.46-0.75), jaw (IPR=0.30, 95%CI: 0.23-0.38) and non-specific fractures (IPR=0.54, 95%CI: 0.41-0.67) more so than cheerleaders. Cheerleaders were more likely to suffer from a nasal fracture than gymnasts (IPR=2.39, 95%CI: 1.83-2.95).

Mechanism and Location of Injury

Mechanism of Injury

Determining the MOI is important in diagnosing and treating an injury. The mechanisms in this study included player to player contact, equipment contact, surface contact, non-contact, unknown, and other. The national estimates recorded in the data show the most common MOI in cheerleaders and gymnasts combined was player to player contact (n=4,029; 48.2%; 95%CI: 3,081-4,977) followed by surface contact (n=2,533; 30.3%; 95%CI: 1,937-3,129).

The most common MOI recorded in cheerleading was player to player contact (n=3,748; 66.8%; 95%CI: 2,866-4,630). The most common MOI recorded in gymnastics was surface contact (n=1,293; 47.0%; 95%CI: 989-1,597) followed by equipment contact (n=482; 17.5%; 95%CI: 369-595).

Injuries from player-to-player contact and an unknown MOI were more likely in cheerleaders (IPR=6.55, 95%CI: 5.01-8.10; IPR=2.37, 95%CI: 1.81-2.93, respectively) while surface contact and non-contact injuries were more likely in gymnasts (IPR=0.47, 95%CI: 0.36-0.58; IPR=0.56, 95%CI: 0.43-0.69, respectively).

Location of Injury

The location of injury occurrence was also recorded and included injuries at home, school, a place of recreation, other public property, and unreported. School (n=2,569; 30.7%; 95%CI: 1,965-3,173) and a place of recreation (n=3,631; 43.4%; 95%CI: 2,777-4,485) are the two most common places cheerleaders and gymnasts' practice and compete, which translated to the most common places for injuries to occur as evidenced by the current sample.

The two most common locations cheerleaders suffered an axial skeleton fracture were at school and a place of recreation (n=2,212; 39.4%; 95%CI: 1,692-2,732; n=2,192; 39.1%; 95%CI: 1,676-2,708, respectively). The most common location gymnasts suffered an axial skeleton fracture was at a place of recreation (n=1,439; 52.3%; 95%CI: 1,101-1,777).

Gymnasts were more likely to sustain an axial skeleton fracture at home (IPR=0.08, 95%CI: 0.06-0.10), a public property (IPR=0.28, 95%CI: 0.21-0.35), and a place of recreation (IPR=0.75, 95%CI: 0.57-0.92) more so than cheerleaders. However,

cheerleaders were more likely to sustain a fracture to the axial skeleton at school (IPR=3.04, 95%CI: 2.33-3.76) or in an unreported location (IPR=1.57, 95%CI: 1.20-1.93).

Disposition

The disposition of the patients was recorded within the database and included being treated and released, treated and transferred, treated and admitted, or leaving against medical advice. The most common disposition recorded in cheerleading and gymnastics in general was treated and released (n=6,975; 83.4%; 95%CI: 5,334-8,616) as well as in each respective sport (cheerleading: n=4,992; 89.0%; 95%CI: 3,818-6,166) (gymnastics: n=1,983; 72.1%; 95%CI: 1,517-2,449). Dispositions of being treated and transferred or treated and admitted were more likely in gymnasts than in cheerleaders (IPR=0.15, 95%CI: 0.12-0.19; IPR=0.45, 95%CI: 0.34-0.55, respectively). All other dispositions had comparable rates in cheerleaders and gymnasts.

Table 1: Participant Demographics

Demographics	n	N	%	95%CI (lower level – upper level)
Sport				
Cheerleading	150	5,608	67.1	4,289 - 6,927
Gymnastics	107	2,752	32.9	2,105 - 3,399
Sex				
Female	220	7,100	84.9	5,430 - 8,770
Male	37	1,260	15.1	964 - 1,556
Age				
<5	1	5	0.1	4 - 6
5-9	15	307	3.7	235 - 379
10-14	105	3,005	35.9	2,298 - 3,712
15-19	106	3,752	44.9	2,870 – 4,634
20-24	14	503	6.0	385 - 621
25-29	6	252	3.0	193 - 311
≥30	10	536	6.4	410 - 662
Race				
Unknown	71	2,617	31.3	2,001 – 3,233
White/Caucasian	144	4,398	52.6	3,364 – 5,432
African American	23	590	7.1	451 - 729
Other	15	557	6.7	426 - 688
Asian	4	199	2.4	152 - 246

Table 2: Distributions of Axial Skeleton Fractures by Demographic Variables and Sport

	Cheerleading (N)	Gymnastics (N)	IPR (95%CI)
Sex			
Female	5,320	1780	1.47 (1.12 - 1.81) *
Male	288	972	0.15 (0.11 - 0.18) +
Age			
<5	0	5	0.0 (0.0 - 0.0)
5-9	21	286	0.04 (0.03 - 0.04) +
10-14	2,135	870	1.20 (0.92 - 1.49)
15-19	2,874	877	1.61 (1.23 - 1.99) *
20-24	361	142	1.25 (0.95 - 1.54) *
25-29	140	112	0.61 (0.47 - 0.76) +
≥30	77	460	0.08 (0.06 - 0.10) +
Race			
Unknown	1,811	806	1.10 (0.84 - 1.36)
White/Caucasian	2,957	1441	1.00 (0.77 - 1.24)
African American	361	229	0.77 (0.59 - 0.96) +
Other	448	167	1.32 (1.00 - 1.63) *
Asian	31	167	0.09 (0.07 - 0.11) +
Body Region			
Head	90	48	0.92 (0.70 - 1.14)
Face	4,183	1492	1.38 (1.05 - 1.70) *
Neck	227	339	0.33 (0.25 - 0.41) +
Upper Trunk	470	539	0.43 (0.33 - 0.53) +
Lower Trunk	637	334	0.94 (0.72 - 1.16)
Type			
Skull	105	48	1.07 (0.82 - 1.33)
Orbit	111	218	0.25 (0.19 - 0.31) +
Nose	3,700	760	2.34 (1.83 - 2.95) *
Maxilla	67	108	0.30 (0.23 - 0.38) +
Jaw	108	241	0.22 (0.17 - 0.27) +
Clavicle	62	0	0.0 (0.0 - 0.0)
Sternum	20	11	0.89 (0.68 - 1.10) +
Rib	102	251	0.20 (0.15 - 0.25) +
Vertebral	948	771	0.60 (0.46 - 0.75) +
Non-Specific	182	165	0.54 (0.41 - 0.67) +
Other	202	179	0.55 (0.42 - 0.68) +
Mechanism of Injury			
Player-to-player Contact	3,748	281	6.55 (5.01 - 8.08) *
Equipment Contact	0	482	0.0 (0.0 - 0.0)

Surface Contact	1,239	1293	0.47 (0.36 - 0.58) +
Non-Contact	196	171	0.56 (0.43 - 0.69) +
Unknown	425	88	2.37 (1.81 - 2.93) *
Other	0	437	0.0 (0.0 - 0.0)
Location			
Home	81	472	0.08 (0.06 - 0.10) +
School	2,212	357	3.04 (2.33 - 3.76) *
Other Public Property	92	161	0.28 (0.21 - 0.35) +
Place of Recreation	2,192	1439	0.75 (0.57 - .92) +
Not Recorded	1,030	323	1.57 (1.20 - 1.93) *
Disposition			
Treated and Released	4,992	1983	1.24 (0.94 - 1.53) *
Treated and Transferred	90	288	0.15 (0.12 - 0.19) +
Treated and Admitted	440	481	0.45 (0.34 - 0.55) +
Left AMA	86	0	0.0 (0.0 - 0.0)

*Denotes significance indicated by the 95% CI not crossing zero (cheerleaders more likely than gymnasts)

+Denotes significance indicated by the 95% CI not crossing one (gymnasts more likely than cheerleaders)

FIGURE 1: Relationship of Sex and Injury Occurrence by Sport

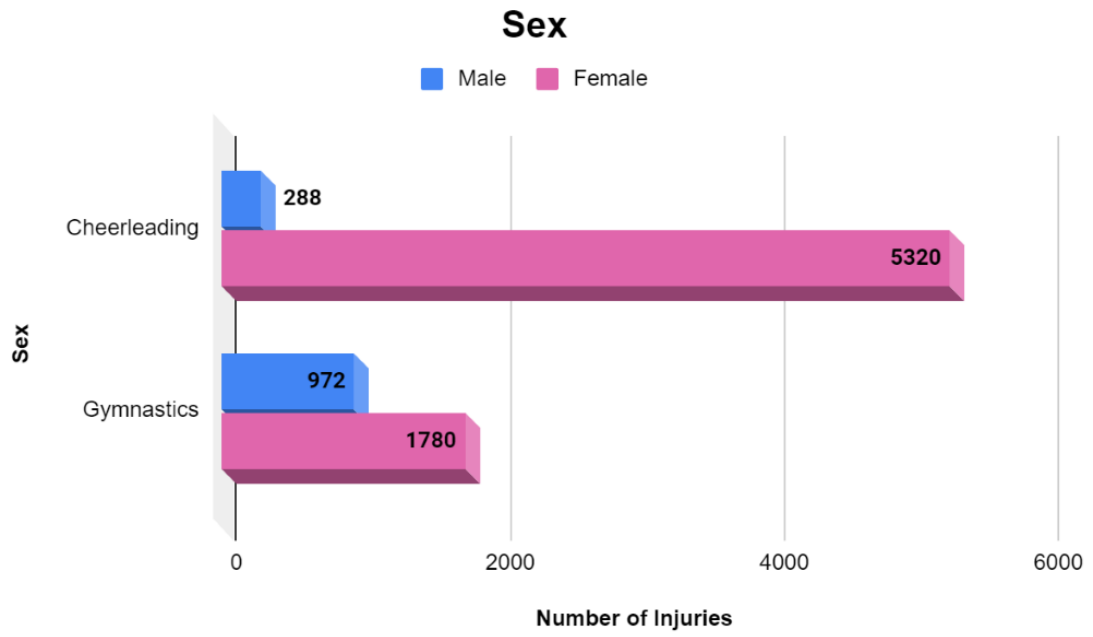


FIGURE 2: Distributions of Injuries to Specific Body Regions by Sport

Note: Spine includes upper trunk, lower trunk, and neck

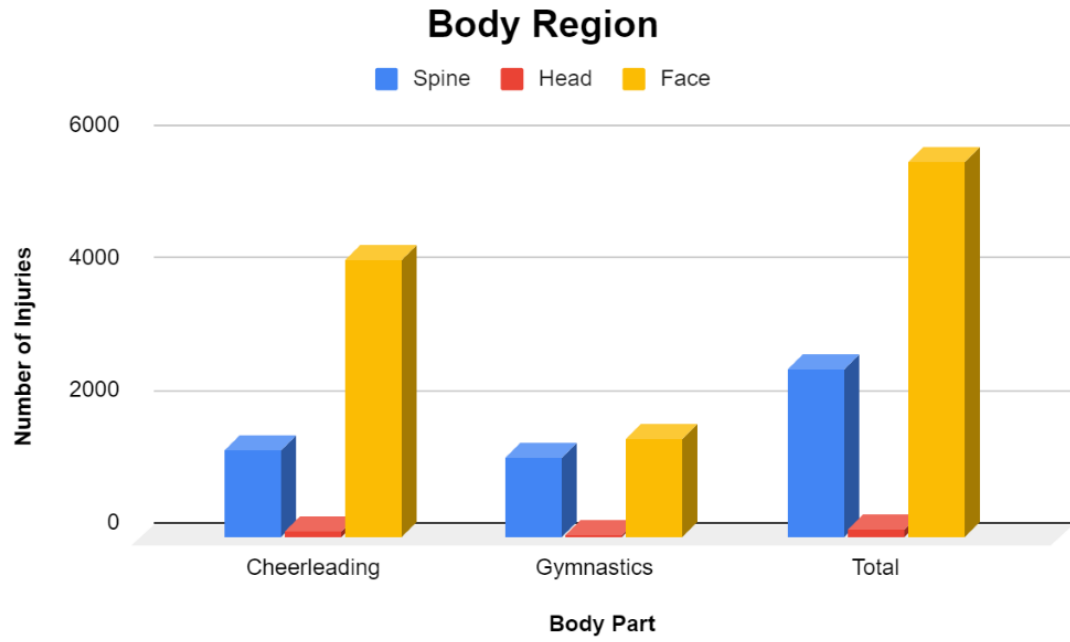
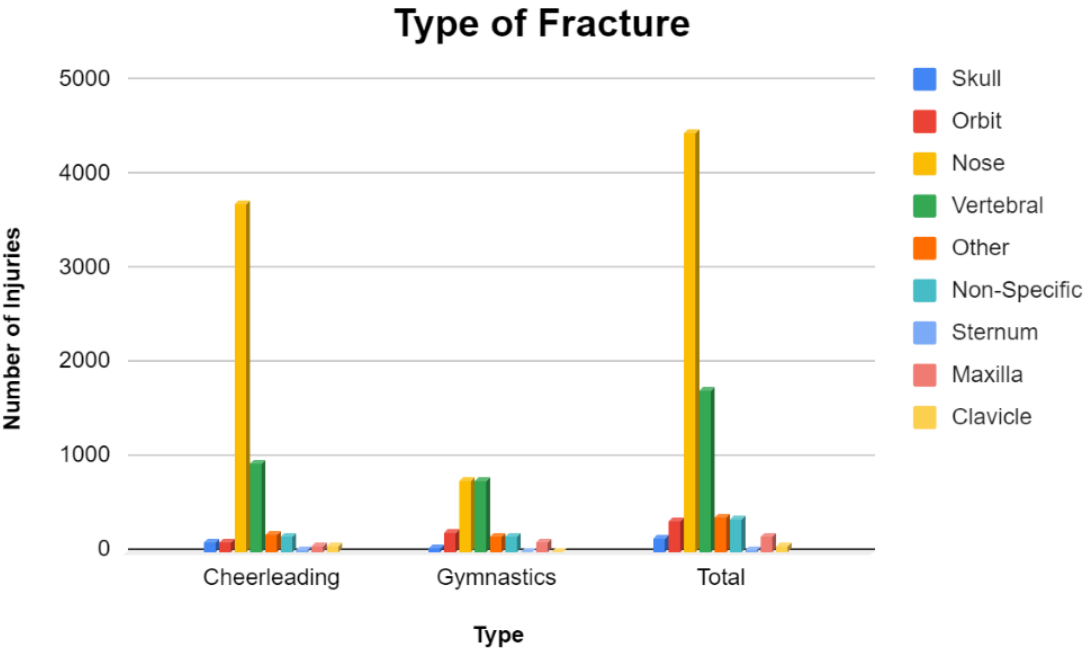


FIGURE 3: Type of Fracture Suffered by Sport



CHAPTER V: DISCUSSION AND CONCLUSION

Discussion

The objective of this study was to describe the epidemiology of axial skeleton fractures in cheerleading and gymnastics from 2010-2019. There were 257 actual cases reported to the ED; however, national estimates were used throughout this study (N=8360 cases). Most axial skeleton fractures occurred in females and were seen in individuals between the ages of 10 and 19, which are the typical demographic of sport participants. Axial skeleton fractures most commonly occurred to the face and spine with many of these fractures occurring to the nose and vertebrae.

Fractures to the axial skeleton can be detrimental and even life threatening, which reiterates the need for medical care during practices and competitions for cheerleaders and gymnasts at all facilities. A significant amount of these athletes train in recreational facilities, a place where athletic trainers are not commonly employed.¹⁴ The two most common locations cheerleaders suffered an axial skeleton fracture were at school and a place of recreation. The most common location gymnasts suffered an axial skeleton fracture was at a place of recreation. These statistics point out the significance of athletic training coverage for these sports at recreational facilities.

Studies have highlighted the severity of injuries within these sports. Currie et al.¹⁵ studied the presence of cheerleading injuries in high schools in the United States and pointed out the increase in difficulty and athleticism in the sport of cheerleading; the results showed the number of cheerleading injuries to be low compared to other high school sports, but the severity of the injuries was much greater. Similarly to the current study, head and face injuries were the most common types of injuries seen; concussions

resulted in the most significant injury sustained.¹⁵ Kruse and Lemmen⁵ studied the biomechanical forces and stress placed on gymnasts' bodies through 52 gymnasts with complaints of back pain. Almost half of these gymnasts were shown to have a spinal injury, like a spondylosis, which is a form of axial skeleton fracture observed within the current study.⁵ These studies in conjunction with the current findings reiterate the importance of medical care for these athletes. ATs are certified healthcare professionals who are qualified in treating sports injuries, especially head injuries like concussions, cervical spine injuries and facial fractures.¹⁶

Cheerleading

There were 150 cheerleaders (5,608 estimated nationally) that reported to the ED and were diagnosed with an axial skeleton fracture. Nearly all axial skeleton fractures sustained by cheerleaders in this study were treated and released from the ED the same day. If these athletes had access to an athletic trainer, many of these injuries could have been handled at the training facility, which could significantly reduce the financial burden placed on these athletes and their families.

Player to player contact was the most common MOI and nasal fractures consisted of a large majority of injuries sustained. It is rare for a nasal fracture to warrant a visit to the ED, but any force that is strong enough to fracture a facial bone could potentially cause a concussion or brain injury, which emphasizes the importance of athletic training coverage. Athletic trainers are knowledgeable in how to properly treat epistaxis (nosebleed), identify a fracture, and recognize, diagnose, and treat concussion-related symptoms.

Studies have shown that stunts are one of the most common mechanisms associated with injuries in cheerleading.¹⁷ An article titled, *Catastrophic Cheerleading Injuries*¹, explains that basket tosses, and pyramids are common stunts that result in injury. Another study included 29 cases reporting to the National Center for Catastrophic Sports Injury Research, which included 13 skull fractures and 8 cervical fractures, two of which were fatal. The most common mechanism of injury seen in this study included direct trauma with the ground, typically associated with falling.¹ The difficult skills performed and high risk of falls for this sport should concern healthcare professionals and spark interest in medical care for competitive cheerleaders.

Cheerleading is a sport that is frequently given less prioritization when it comes to medical care. Coaches are typically the ones on-site that may provide immediate care for injuries of all types. Due to the lack of medical care provided, coaches and cheerleaders need to be educated on common injuries and what warrants a visit to the ED. Educating these coaches and athletes, as well as providing proper medical care, will help reduce the financial burden on these individuals. Additionally, going to the hospital is extremely stressful and taxing on all aspects of a patient including familial obligation, physical injury, and psychological health. Having on-site medical care could not only improve financial burden sustained by athletes and their families, but also the physical, mental, and social burden of better managing a stressful situation.

Considering the desired improvement of medical care for cheerleading, current levels of medical care were examined. Of the 34 NCAA schools that have competitive cheerleading teams, only two reported having an athletic trainer specifically assigned to the cheerleading team.¹⁸ If a cheerleader sustains an injury during practice, and there is

not an athletic trainer on staff, the coach typically provides the immediate care until an athletic trainer arrives to the scene. This could be detrimental to an athlete who sustains a severe head or neck injury, especially since new skills and stunts are performed for the first time during practice, not competition.¹⁷

In 2017, the Minnesota Vikings became one of just two National Football League (NFL) teams to have an athletic trainer specifically dedicated to providing care for cheerleaders at all practices, games and other performances.¹⁹ This is an issue considering the number of athletes that train at recreational facilities before competing at the collegiate or professional level. Additionally, professional organizations and NCAA institutions likely have more resources than high schools and recreational sports facilities. Given the majority of axial skeleton fractures, as identified through the current study, happen to adolescents in a place of recreation or school, it can be assumed that the level of available care is even less.

Gymnastics

There were 107 gymnasts (2752 nationally) that reported to the ED over the 10-year period and were diagnosed with an axial skeleton fracture. Surface contact was the most common MOI and vertebral fractures were the most common type of diagnosed fracture. Vertebral fractures can occur anywhere in the spine: neck, upper trunk, or lower trunk. These spinal body regions resulted in nearly half of all fractures sustained.

Back pain is the chief complaint in gymnasts, which is expected due to the constant twisting and axial loading during the landing of a skill.⁵ The risk of falling from an apparatus is high⁵ and proven to be true in this study since the most common MOI was surface contact. In an article titled, *Spine Injuries in the Sport of Gymnastics*,⁵ a study of

38 injured gymnasts was discussed where 35 of the gymnasts were shown to have a cervical spine (c-spine) injury. A c-spine injury is serious and proper care is vital to prevent further injury. Athletic trainers are well-trained in how to provide immediate care for an acute c-spine injury, as well as how to implement an emergency action plan in the case of a life- or limb- threatening injury.¹⁶

Medical care is typically provided for these athletes at competitions, but not at practices. Gymnasts compete with skills they have perfected and will only try new skills at practice, which is why that is the environment where they get injured the most.²⁰ Skills involve an enormous amount of hyperextension in the spine, rotational movements, and axial loading.⁵ Due to the intense amount of stress placed on these athletes bodies, spinal fractures such as spondylolysis and spondylolisthesis are not rare occurrences.⁵ Gymnasts would benefit greatly from an athletic trainer who could provide rehabilitation exercises as well as work with coaches to enforce and refine proper technique and form to prevent back injuries.

Gymnastics is a sport that requires athletes to be dedicated to training for many years. The majority of gymnasts begin training early in life at recreational facilities and continue their participation at recreational facilities as they climb to elite levels of participation. These athletes have limited access to medical care during practice, which may result in unnecessary visits to the ED. Over half of the gymnasts in this study were injured at a place of recreation. As of 2019, the U.S. Bureau of Labor Statistics, reported athletic trainers held 32,100 jobs.¹⁴ Of those, 36% were employed in educational services (i.e., middle schools, high schools and colleges) while only 6% were employed in recreational sports centers.¹⁴ These statistics are meant to highlight the lack of healthcare

providers within the recreational sport setting despite the high number of participants, advocating for improved medical care for these athletes.

Once again, the current level of medical care was examined for collegiate competitive gymnastics teams. Of the universities listed on the USA Gymnastics website with associated competitive gymnastics teams, all of the Southeastern Conference (SEC) gymnastics teams, except for one, have a full-time athletic trainer dedicated to gymnastics. However, only one of the thirteen Eastern College Athletic Conference (ECAC) schools have an athletic trainer solely committed to the gymnastics team while the other twelve teams share an athletic trainer with another sport. These statistics show that an athletic trainer providing care to gymnastics teams may have multiple priorities. As such, the athletic trainer may or may not cover every practice as well as travel to all competitions.²¹

The NCAA requires their schools to provide athletes with access to athletic trainers and other medical professionals, but most are not dedicated to gymnastics or cheerleading. Due to some of these collegiate schools not having athletic trainers that continuously cover gymnastics and cheerleading practices and competitions, athletes may feel as if they are a burden asking for treatment or evaluations of injuries. Also, if these NCAA athletes do not have athletic trainers solely assigned to their sports, the assumption can be made that high school and recreational sports have even less access to athletic trainers.

Conclusion

Axial skeleton fractures are rare in these sports; however, many of them are either serious and warrant further attention/referral or they are minor and can be treated by on-

site healthcare providers. The potential severity of these injuries emphasizes the importance of medical care not only at competitions, but practice as well. The issue lays in the minimal athletic training involvement in these sports currently.

Many of the injuries reported in this study, such as nasal fractures, could have been treated by an athletic trainer and an unnecessary trip to the ED could have been prevented. Additionally, athletic trainers can ease the burden on the EDs by removing individuals who do not require emergent treatment; therefore, athletic trainers can prevent overload of the healthcare system.

On another note, the more serious injuries, such as vertebral or skull fractures, could have also been handled more efficiently had an athletic trainer been on-site. If an injury occurs, the athletic trainer has many resources available for athletes and can refer the athlete to a specific physician or collaborate with advanced medical professionals, such as emergency medical services. This can eliminate athlete's parents from sending their child to a physician who is not qualified in that specific sport-related injury while also reducing the financial burden placed on these athletes and their families.

APPENDIX A: IRB APPROVAL LETTER



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March. 31, 2020

To Whom It May Concern,

Acting on behalf of The University of Southern Mississippi Institutional Review Board, in accordance with Federal Drug Administration regulations (21 CFR 26, 111), Department of Health and Human Services regulations (45 CFR Part 46), and university guidelines, I have reviewed the following project and have determined that review by USM's IRB is not necessary.

Principal Investigator: Jordan Trimm

Title: "Presence and Characteristics of Axial Skeleton Fractures Experienced by Cheerleaders and Gymnasts from 2010-2019."

Date Submitted: March 31, 2020

Formal IRB review is not required in this instance, as the project does not meet federal or institutional definitions of "human subjects research."

Sincerely,

A handwritten signature in black ink, appearing to read "Samuel V. Bruton".

Samuel V. Bruton

Director of the Office of Research Integrity

REFERENCES

1. Boden BP, Tacchetti R, Mueller FO. Catastrophic Cheerleading Injuries. *Am J Sports Med.* 2003;31(6):881-888. doi:10.1177/03635465030310062501
2. Proctor MR, Cantu RC. HEAD AND NECK INJURIES IN YOUNG ATHLETES. *Clin Sports Med.* 2000;19(4):693-715. doi:10.1016/S0278-5919(05)70233-7
3. Spine fracture, Spinal fractures, vertebral fractures, compression fractures Mayfield Brain & Spine Cincinnati, Ohio. Accessed October 15, 2020. <https://mayfieldclinic.com/pe-spinefract.htm>
4. Leucht P, Fischer K, Muhr G, Mueller EJ. Epidemiology of traumatic spine fractures. *Injury.* 2009;40(2):166-172. doi:10.1016/j.injury.2008.06.040
5. Kruse D, Lemmen B. Spine Injuries in the Sport of Gymnastics. *Curr Sports Med Rep.* 2009;8(1):20–28. doi:10.1249/JSR.0b013e3181967ca6
6. Implementing Athletic Trainers for the Management of Cheerleading Injuries: Journal of Physical Education, Recreation & Dance: Vol 84, No 1. Accessed March 11, 2020. https://shapeamerica.tandfonline.com/doi/full/10.1080/07303084.2013.744926?casa_token=tzP8JvjJQhQAAAAA%3AjP9lm1Khr8FTWBrUvucfD1TszbDPGcHbh0u3Ng5EQoMnUoDTtvKfQU6l73qmZWMGcr8fldtjQK4
7. Boden BP, Jarvis CG. Spinal Injuries in Sports. *Neurol Clin.* 2008;26(1):63-78. doi:10.1016/j.ncl.2007.12.005
8. Sample Job Descriptions. NATA. Published May 1, 2018. Accessed October 15, 2020. <https://www.nata.org/career-education/career-center/post-a-job/sample-job-descriptions>
9. Hame SL, LaFemina JM, McAllister DR, Schaadt GW, Dorey FJ. Fractures in the Collegiate Athlete. *Am J Sports Med.* 2004;32(2):446-451. doi:10.1177/0363546503261708
10. Kay MC, Register-Mihalik JK, Gray AD, Djoko A, Dompier TP, Kerr ZY. The Epidemiology of Severe Injuries Sustained by National Collegiate Athletic Association Student-Athletes, 2009–2010 Through 2014–2015. *J Athl Train.* 2017;52(2):117-128. doi:10.4085/1062-6050-52.1.01
11. Schwebel DC, Brezaussek CM. Child Development and Pediatric Sport and Recreational Injuries by Age. *J Athl Train.* 2014;49(6):780-785. doi:10.4085/1062-6050-49.3.41

12. Knowles SB, Kucera KL, Marshall SW. Commentary: The Injury Proportion Ratio: What's It All About? *J Athl Train*. 2010;45(5):475-477. doi:10.4085/1062-6050-45.5.475
13. Explanation Of NEISS Estimates Obtained Through The CPSC Website. CPSC.gov. Published April 5, 2018. Accessed March 15, 2021. <https://www.cpsc.gov/Research--Statistics/NEISS-Injury-Data/Explanation-Of-NEISS-Estimates-Obtained-Through-The-CPSC-Website>
14. Athletic Trainers : Occupational Outlook Handbook: : U.S. Bureau of Labor Statistics. Accessed February 20, 2021. <https://www.bls.gov/ooh/healthcare/athletic-trainers.htm#tab-3>
15. Currie DW, Fields SK, Patterson MJ, Comstock RD. Cheerleading Injuries in United States High Schools. *Pediatrics*. 2016;137(1). doi:10.1542/peds.2015-2447
16. Swartz EE, Boden BP, Courson RW, et al. National Athletic Trainers' Association Position Statement: Acute Management of the Cervical Spine–Injured Athlete. *J Athl Train*. 2009;44(3):306-331. doi:10.4085/1062-6050-44.3.306
17. Shields BJ, Fernandez SA, Smith GA. Epidemiology of Cheerleading Stunt-Related Injuries in the United States. *J Athl Train*. 2009;44(6):586-594. doi:10.4085/1062-6050-44.6.586
18. See the results for the 2019 UCA & UDA College Cheerleading & Dance Team National Championship varsity tv event on Varsity.com. Accessed February 20, 2021. <https://tv.varsity.com/results/6310360-2019-uca-uda-college-cheerleading-dance-team-national-championship/25520>
19. Vikings at Forefront of Athletic Training Care for Cheerleaders. Accessed February 20, 2021. <https://www.vikings.com/news/vikings-at-forefront-of-athletic-training-care-for-cheerleaders-20472822>
20. Caine DJ, Nassar L. Gymnastics Injuries. *Epidemiol Pediatr Sports Inj*. 2005;48:18-58. doi:10.1159/000084282
21. USA Gymnastics | Schools that Sponsor Women's Gymnastics. Accessed February 20, 2021. <https://usagym.org/pages/home/college/womeninfo.html>