Author: **Reardon, Chris, M**
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STUDENT: Chris Reardon

NAME:[redacted] **DATE: 05/06/2012**

ADVISER: (Committee Chair if MS Plan A or EdS Thesis or Field Project/Problem): Dr. Renee Chandler

[redacted] **DATE:** 05/11/2012

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Reardon, Chris, M. ***Injuries and Contributing Factors in High School Sports***

Abstract

Playing high school sports is very important in maintaining a healthy lifestyle, but it does come with the risk of injuries. Injuries to the lower extremities are very common in high school sports, with ankle sprains being the most common type. Concussions among high school athletes are very high especially in football, and the consistent rise each year with concussions is extremely worrying. The contributing factors to why players get injured can be classified as either intrinsic (personally-related) or extrinsic (environmentally-related). The most common intrinsic factors include inadequate rehabilitation, gender, and age. The most common extrinsic factors include injury rates in competition over practice, foul play, and the position they play in. Implementing injury prevention programs is of the utmost importance in youth sports. Current programs have being very successful in decreasing injury rates using a mixture of plyometric, strength training, conditioning, agility drills, balance training, and flexibility programs.

The Graduate School

University of Wisconsin-Stout

Menomonie, WI

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Table of Contents

Chapter I: Introduction

Participation in high school sports helps promote a physically active lifestyle, and with the increasing obesity crisis, it is crucial that we protect and encourage children's ability to be active while in school. However, playing sports does increase the risk of sport-related injuries. Comstock, Collins, and McIlvain (2012), found injury rates in the 2010-2011 school year at 1.97 per 1,000 athlete exposures. With both the short term and long term effects of injuries, it is important to implement prevention programs, which require information on injuries, and the risk associated with different aspects of each sport.

A great deal of research on sport injuries has been carried out, and a number of facts about their nature, causative mechanisms, and characteristics have been established. For example, in a study by Rechel, Yard, and Comstock (2008), most injuries affected the lower extremities at 57.2%, followed by the upper extremities at 21.5%, several other studies had similar percentages with injuries to the lower extremities in high school sports (Beachy, Akau, Martinson & Olderr, 1997; Rauh, Ji, Macera & Wiksten, 2007; Yard, Collins & Comstock, 2009). Rechel et al. (2008) found injuries in the lower extremities were most common for boys' and girls' soccer, with 75.7%, and 73.2% respectively.

Rechel et al. (2008) also confirmed that of the injuries suffered to the lower extremities, ankle was the most common site for injury with 22.7%, followed by head/face 12.3%, and thigh/upper leg eight percent. Kerr, Collins, Fields, and Comstock (2011) studied player to player contact injuries, and discovered similar results with ankle being the most common injured location at 21.9%, followed by head/face 18.9%, and knee 16.9%. Of these injuries, strains, sprains, and contusions typically made up over 60% of all injuries (Yard et al., 2009; Kerr et al., 2011; McHugh, Tyler, Tetro, Mullaney & Nicholas, 2006). Interestingly, Kerr et al. (2011) reported very high rates of sprains and strains in basketball with 49.3% (boys), and 45.2% (girls).

According to Sosin, Sniezek, and Thurman (1996), an estimated 300,000 sport-related traumatic brain injuries, predominantly concussions occurred annually in the United States. But in a more recent study by Lincoln, Caswell, Almquist, Dunn, Norris, and Hinton (2011), sport-related concussions reached an epidemic level of between 1.6 million to 3.8 million annually.

In fact, for young people ages 15-24 years, sports are second only to motor vehicle crashes as the leading cause of traumatic brain injury. Meehan, d'Hemecourt, Collins, and Comstock (2011) found that concussions accounted for nearly 15% of all sports-related injuries reported to athletic trainers, which resulted in a loss of at least one day of play. However, in an earlier study by Gessel, Fields, Collins, Dick, and Comstock (2007) they identified 8.9% of injuries were concussions, which shows a worrying increase.

Gessel et al. (2007) found that football players accounted for 40.5% of all concussions, followed by women's soccer at 21.5%, and boys' soccer with 15.4%. Meehan et al. (2011) also reported very high rates of concussion in football with 76.8 per 100,000 athletic exposures, followed by girls soccer at 33, and boys soccer at 19.2. It is not surprising that football players are at a greater risk of concussions with full speed collisions. Broglio, Sosnoff, Shin, He, Alcaraz, and Zimmerman (2009) stated that there are approximately 67,000 diagnosed concussions in high school football every year. Studies suggest that girls are more susceptible to concussion in sports like soccer (Gessel et al., 2008; Meehan et al., 2011), but in basketball boys are at a greater risk of concussion with 21.2 concussions per 100,000 athletic exposures with girls 18.6 (Meehan et al., 2011).

The risk of injury can be influenced by various factors. Murphy, Connolly, and Beynnon (2002) stated that these factors can be split into two categories; intrinsic (personal-related), and extrinsic (environmentally-related). Intrinsic factors include age, previous injury, inadequate rehabilitation, and psychological factors. Extrinsic factors include level of

play (competition or practice), position on field, equipment, playing conditions, and foul play.

The most common intrinsic factor to be identified in recent studies is previous injury and inadequate rehabilitation. In high school athletics out of the 2 million injuries sustained annually, 10% were recurrent injuries (Swenson, Yard & Field, 2009; Rauh et al., 2007). Ankle sprains were the most frequently diagnosed recurrent injury (Brooks, Schiff & Rivara, 2009; Swenson et al., 2009), but 45.5% of recurrent shoulder injuries required surgery (Swenson et al., 2009). Nelson, Collins, Yard, Fields, and Comstock (2007) reported in boys soccer, and basketball (boys and girls) 20% of recurrent ankle sprains were from the same season. According to Zemper (2003), football players who had previously sustained a concussion were five times as likely to sustain another concussion. In another concussion study by Schulz, Marshall, Mueller, Yang, Weaver, Kalsbeek, and Bowling (2004), they confirmed that the likelihood of sustaining a concussion for athletes who had sustained a previous concussion was found to double for athletes in sports other than football.

Another intrinsic factor which has been heavily researched is the effect that gender has on injuries. Although there seem to be contradictory results, Powell and Barber-Foss (2000) reported no difference in the risk of injury in male and female basketball. They did however find that male soccer players were at a higher risk of injury than female soccer players. Emery, Meeuwisse, and Hartmann (2005) reported no difference in male and female soccer players in Canadian high school sports. Powell and Barber-Foss (2000) did however find that female basketball and soccer players were at a higher risk of sustaining knee injuries.

The most frequent extrinsic factor in current research relates to injuries sustained in competition over practice. Comstock, Collins, and McIlvain (2012) discovered an overall injury rate (competition and practice) of 2.44 injuries per 1,000 athletic exposures. Football

had the highest rate of injury with an overall rate of 4.36 injuries per 1,000 athletic exposures, with a significantly higher rate in competition than practice, 12.09 and 2.54 respectively. Other notable rates were; boys soccer 2.43, girls soccer 2.36, girls basketball 2.01, boys basketball 1.89. In all of these sports higher rates of injury occurred in competition over practice, which is supported by other studies (Messina, Farney & DeLee, 1999; Turbeville, Cowan, Owen, Asal & Anderson, 2003; Emery et al., 2005). It comes as no surprise that higher rates of injuries occur in competition, due to players being more aggressive, and taking more risks, which in turn increases the potential risk for injuries.

Another extrinsic factor is foul play, which was studied by Collins, Fields, and Comstock (2007). Although each sport has set rules to promote fair play and protect athletes, they still get exposed to inadvertent illegal activity and intentional acts of foul play. They stated that 6.4% of all high school sports-related injuries were related to illegal activity, with the highest proportion in girls basketball (14.0%), girls soccer (11.9%), and boys soccer (11.4%). The greatest proportion of injuries related to illegal activity were to the head/face (32.3%).

Consequently, to understand fully the risk and contributing factors of injury to which a player is exposed to during sport, it is necessary to analyse the actions made in the game and to relate these actions to the risk they may possess, and the subsequent injuries that may result. With this information prevention programs in youth sport have being implemented world-wide with a lot of success in decreasing sport injuries. Programs which incorporated a mixture of plyometrics, strength, conditioning, agility drills, balance, and flexibility were found to be the most successful (Soligard, Myklebust, Steffen, Holme, Silvers, Bizzini, Junge, Dvorak, Bahr & Anderson, 2008; Mandelbaum, Silvers, Watanabe, Knarr, Thmoas, Grffin, Kirkendall & Garrett, 2005; Junge, Rosch, Peterson, Graf-Baumann & Dvorak, 2002; Emery, Rose, McAllister & Meeuwisse, 2007).

Statement of Problem

According to the National Federation of State High School Associations (2010), based on the figures from all 50 states who are members of the National Federation of State High School Associations (NFHS), participation for the 2008-09 school year set an all-time high of 7,536,753. The survey also found that 55.2% of the students enrolled in high school participate in athletics - a slight increase from the previous year of 54.8%.

Nelson et al. (2007) suggested that athletics play an important role in an adolescent's adoption of a healthy lifestyle. Benefits include physical fitness, weight management, improved self-esteem, increased strength, endurance and flexibility. However, participation in any sport carries inherent risk of injuries. High school athletics accounts for an estimated 2 million injuries, 500,000 doctor visits, and 30,000 hospitalizations annually (Powell & Barber-Foss, 1999). The Center for Disease Control and Prevention (2006) confirmed a lower amount at 1.4 million injuries during the 2005-2006 school year, with more than 80% being new injuries.

When an athlete gets injured, there are both the short-term effects like pain and hospitalization, and the long term more severe effects. These long term effects were studied by Roos (1998), who found that soccer players who had knee and ankle injuries in their playing careers would be at high risk of joint problems in later life, but even uninjured soccer players were at a higher risk of developing arthritis than the normal population. Considering the number of active high school athletes Nation-wide, the socio-economic and financial consequences of injuries are of such high proportion that prevention programs are urgently required.

Statement of Purpose

The purpose of this literature review is to investigate sports injuries at the high school level, examining the contributing factors to why players get injured. The investigation will

also assess the effectiveness of current prevention programs. The review will focus on five high school sports; football, boys and girls soccer, boys and girls basketball. A comprehensive literature review was conducted during the Spring 2012 semester.

Research Questions

The following research questions will be addressed while reviewing literature related to injuries in high school sports.

1. What is the most frequent area injured?
2. What are the most common intrinsic risk factors (personally-related)?
3. What are the most common extrinsic risk factors (environmentally-related)?
4. How effective are current injury prevention programs?

Definitions of Terms

The following terms listed are definitions that are essential to fully understand this study. The terms are listed in alphabetical order.

Anterior cruciate ligament - A ligament in the knee that crosses from the underside of the femur (thigh bone) to the top of the tibia (bigger bone in the lower leg) (MedicineNet, 2011).

Athletic exposure - One athlete participating in one athletic practice or competition (Swenson, Yard, Fields & Comstock, 2009).

Center for Disease Control and Prevention (CDC) - A federal agency under the Department of Health and Human Services, which works to protect public health and safety by providing information to enhance health decisions (Center for Disease Control and Prevention, 2012).

Concussion - Mild traumatic brain injury, or concussion, can be defined as a short-lived loss of brain function due to head trauma that resolves spontaneously. With

concussion, function may be interrupted but there is no structural damage to the brain (MedicineNet, 2000).

Contusion - Another name for a bruise when blood vessels are damaged or broken as a result of a blow to the skin (MedicineNet, 2008).

Epidemiology - The science concerned with the study of the factors determining and influencing the frequency and distribution of disease, injury, and other health related events and their causes in a defined human population (Medical Dictionary, 2011).

High School Reporting Information Online (RIO) - This is the internet-based data collection tool used in the National High School Sports-Related Injury Surveillance Study (Center for Injury Research and Policy, 2011).

Inadequate rehabilitation - Tendency to under-treat an injury or the resumption of activity too early (Reilly & Williams, 2003).

Lower extremity - The hip, thigh, leg, ankle, or foot (Medical Dictionary, 2008).

National Federation of State High School Association (NFHS) - Is the body that writes the rules of competition for most high school sports and activities in the United States (National Federation of State High School Association, 2010).

Strain - A strain is an injury to a muscle or tendon in which the muscle fibers tear as a result of over stretching. Strains are also colloquially known as pulled muscles (MedicineNet, 1998).

Sprain - An injury to a ligament that results from overuse or trauma. Sprains occurs when there is a stretch or tear in one or more ligaments, the slightly elastic bands of tissue that keep the bones in place while permitting movement at a joint (MedicineNet, 1998).

Assumptions and Limitations

It is assumed that the information, discussion, and conclusions presented on high sport injuries and prevention methods are based on valid and reliable research, published

from professional sources. The current review of the literature is limited to the databases searched, and from which mainstream recourses were available. While comprehensive, this review is limited in its scope to the available data sources of the time.

Chapter II: Literature Review

Introduction

This chapter will examine sport-related injuries, and the contributing factors. The opening theme will focus on injury location, diagnosis, mechanism, and severity. The next part will discuss the contributing factors, looking at the intrinsic factors; previous injury, sex, and age. This will be followed by the extrinsic factors; level of play (competition and practice), foul play, and player position. The chapter will conclude by comparing current studies where intervention programs have been implemented.

Injuries

According to the National Federation of State High School Associations (2010), participation for the 2008-2009 school year set an all-time high of 7,536,753 across the United States. The survey found that 55.2% of the students enrolled in high school participate in athletics - a slight increase from the previous year of 54.8%. High school sports play an important role in athletes adopting and maintaining a healthy lifestyle. Although playing sport comes with risks, the benefits far outweigh these risk, for example, physical fitness, weight management, improved self-esteem, increased strength, endurance, and flexibility. Too often injury prevention is overlooked because sport-related injuries are viewed as unavoidable. This however is not the case, and by applying evidence-based prevention interventions sport-related injuries can be decreased.

Centers for Disease Control and Prevention (2006) stated an estimated 1.4 million injuries occurred during the 2005-2006 school year at a rate of 2.44 injuries per 1,000 athletic exposures. This rate is slowly dropping with the most recent study by Comstock, Collins, and McIlvain (2012) showing a rate of 1.97 injuries per 1,000 athletic exposures. These statistics can be confidentially compared because the same data collection method was used, which is the High School Reporting Information Online system (RIO). According to the

Center for Injury Research and Policy (2012), RIO is the internet based data collection tool used in the National High School Sports-Related Injury Surveillance Study. The system has been in place since the 2005/2006 academic year and is maintained annually. It captures athletic exposure, injuries, and injury event, which is completed online weekly by the schools certified athletic trainer. The system covers the following sports:

- Boys - Baseball, basketball, cheerleading, football, ice hockey, lacrosse, soccer, swimming and diving, track and field, volleyball, wrestling.
- Girls - Basketball, cheerleading, field hockey, gymnastics, lacrosse, softball, soccer, swimming and diving, track and field, volleyball.

The Injury Cost Model of U.S. Consumers Product Safety Commission (2006) revealed that injuries in the top five female and male school sports cost an estimated $588 million dollars in direct expenses, and $6.6 billion dollars in indirect expenses. With such high costs, injury rates among high school athletes should be reduced to the lowest possible level without discouraging them from engaging in this important form of physical activity.

Location and Diagnosis. Due to the physical demands of sport, it comes as no surprise that the majority of injuries occur in the lower extremities with constant twisting, turning, jumping, landing, and changing direction (Beachy et al., 1997; Ingram, Fields, Yard & Comstock, 2008). Rechel et al. (2008), found that 57.2% of injuries were to the lower extremities, followed by upper extremities 21.5%, and then head/face 14.6%. They reported that injuries to the lower extremities were most common in boys' and girls' soccer, 75.7% and 73.2% respectively. They discovered the ankle was the most common injury site with 22.7%, followed by head/face 12.3%, and then thigh/upper leg eight percent. Emery, Meeuwisse, and McAllister (2006) identified similar results with ankle at 20%, knee 19%, and head/face 14%. Rechel et al. (2008) pointed out that most injuries incurred by athletes were strains/sprains at 52.1%, followed by contusions 12.3%, fractures 9.8%, and

concussions 9.1%. Girls' basketball had the highest percent of strains/sprains which accounted for 62.5% of all injuries.

Ankle injuries were studied by Nelson et al. (2007), who identified ankle injury rates at 5.23 injuries per 10,000 athletic exposures. Ankle injuries were most commonly ligament sprains with incomplete tears (83.4%), followed by fractures (5.2%), ligament sprains with a complete tear (four percent), and contusions (two percent). Out of the nine sports studied, football had the highest number of ankle sprains (24.1%), then girls' soccer (17.9%), and boys' soccer (15.7%). This high percentage for football may be explained because they have the most players in their team, but in terms of rates per 10,000 athletic exposures, boys' basketball was the highest with 7.74, followed by girls' basketball 6.93, and football 6.52. The study's aim was to present ankle injury data from a nationally representative sample of US high schools by sport, sex, and exposure type. A direct comparison on ankle injuries across sports, and between sexes can be made from this study because the same definition of injury, units of exposure, and reporting times were used.

The study did have limitations, for schools to be eligible they had to have a certified athletic trainer, which means results cannot be generalized to all schools in the Nation. However, with highly qualified trainers better results are collected with more accuracy, and better treatment can be given to athletes. They also suggested that because of socio-economic differences between schools with and without athletic trainers, potential risk factors could also be present, such as field conditions or quality of equipment. Finally, because the study was only done over a single season they were unable to track individual athletes across several seasons to capture recurrent ankle injuries.

Ingram et al. (2008) did a similar study to Nelson et al. (2007), but investigated knee injuries at the high school level. They used nine high school sport teams; football, soccer (girls and boys), volleyball, basketball (girls and boys), wrestling, baseball and softball.

They collected the data using the High School Sport-Related Injury Surveillance System, High School RIO. The data was collected over 2 academic years, 2005-2006 and 2006-2007. The overall knee injury rate was 3.89 per 10,000 athletic exposures. They found that the knee was the second most frequently injured body part accounting for 15.2%, only behind ankle at 20.9%. Football had the highest knee injury rate of 6.91 per 10,000 athletic exposures, followed by girls' soccer and girls' basketball, 5.08 and 3.80 respectively.

However, the knee was responsible for 44.6% of all surgeries, which was a lot more than any other body part, with shoulder next at 8.8%. Ingram et al. (2008) confirmed that incomplete ligament tears made up 32% of all knee injuries, with contusions 15.2%, complete ligament tears 13.2%, torn cartilage eight percent, fractures/dislocations 5.8%, muscle tears 5.6%, tendentious 4.2%, inflammation two percent, and hyper-extension 1.3%. Moller, Weidenhielm, and Werner (2009) stated on average 11.5 years after anterior cruciate ligament reconstruction, 14-27% of the patients suffered severe loss of function and declared that they had to drastically modify their lifestyle. Ingram et al. (2008) suggested that knee injuries have decreased over the past decade which can be attributed to new injury prevention methods or improvements in diagnosis and treatment.

The study did have some limitations, for schools to be eligible they had to have a certified athletic trainer, which means results cannot be generalised to all schools in the Nation. However, with highly qualified trainers better results would be collected with more accuracy, and better treatment for players. Also, only injuries brought to the trainer's attention that kept the player out for the next competition or practice were noted. Despite these limitations, this is the only study that can nationally represent information on knee injuries on high school athletes.

Sport-related concussions have become a Nation-wide issue in high school sports with a consistent rise over the last five years. Gessel et al. (2007) found 8.9% of injuries were

concussions, but in a more recent study by Meehan et al. (2011), they suggested it had increased to 15%. They confirmed that this rise may be due to the increased attention focused on concussions, leading medical professions to over-diagnose a sport-related concussion. Lincoln et al. (2011) estimated that concussions had reached an epidemic level of between 1.6 million to 3.8 million annually. In fact, for young people ages 15-24 years, sports are second only to motor vehicle crashes as the leading cause of traumatic brain injury. These high concussion rates are very concerning according to Broglio, Macciocchi, and Ferrara (2007) because initially the athlete's cognitive function is temporally diminished. They suggest that another major concern is athletes returning to action too soon which can lead to second impact syndrome. Cantu (2007) argued that athletes who have had several concussions or multiple blows to the head are at risk of the longer terms more severe effects like dementia and chronic traumatic encephalopathy.

According to Meehan et al. (2011), 90% of facial injuries were concussions, followed by lacerations and contusions, 3.8% and 2.8% respectively. They found that 11.4% were recurrent concussions, which was a similar finding to Gessel et al. (2007) at 16.8%. Of recurrent concussions, Meehan et al. (2011) stated that 37% happened within the same season. They stated that football had an alarming rate of concussion with 76.8 concussions per 10,000 athletic exposures. Other sports worth noting were: girls' soccer 33, boys' basketball 21.2, boys' soccer 19.2 and girls' basketball 18.6. Boden, Tacchetti, Cantu, Knowles, and Mueller (2007) found that 39% of high school and collegiate football players during the period of 1989 to 2002 who suffered a catastrophic head injury (death, non-fatal but causing permanent neurologic functional disability, and serious injury but leaving no permanent functional disability) were still playing with neurologic symptom at the time of the catastrophic event.

The purpose of the study by Meehan et al. (2011) was to describe the medical providers and medical studies used when assessing sport-related concussions at high school over the 2009/2010 academic year. They found that during high school sports an athletic trainer was usually onsite to deal with the concussion. They argued that approximately 60% of the concussions were assessed by a primary care physician as opposed to a sports medicine specialist. This limits the results because they may not have the understanding of current concussion management practices. The study used high school RIO to collect results, so only schools with a certified athletic trainer could take part in the study, which means results cannot be generalized across the Nation. Although this may be a limitation, it does improve accuracy of results with a trainer inputting data as opposed to a coach who may lack medical knowledge. A final limitation to the study is that concussions can be very difficult to diagnose as there is no visible structural damage, therefore athletes may have not reported a concussion because they did not know they had one.

Injury mechanism. As high school players mature their strength and muscle mass increases and this consequently impacts how hard they challenge their opponents. According to Borowski, Yard, Fields, and Comstock (2008), player to player contact is a key mechanism of injuries to the knee, ankle, foot, head, and is the main cause of concussions. Every sport has different rules which allow different kinds of contact, for example in soccer, Wong & Hong (2005) stated that in competition tackling is used to get possession of the ball, and the lower extremity is often injured during tackling as players cannot respond quickly enough to get their body out of the way to avoid such raid and unpredictable movement.

Football on the other hand is a full contact sport, and although they wear protective equipment, when a player is running at full speed and gets tackled to the ground, player to player contact injuries are inevitable. For this reason player to player contact injuries are responsible for between 55% to 78% of all football injuries (Shankar, Fields, Collins, Dick &

Comstock, 2007; Kerr, Collins, Fields, & Comstock, 2011). According to Rechel, Collins, and Comstock (2011) the most common mechanisms for injuries in football were; being tackled (23.7%), tackling (20.9%), blocking (13%), and being blocked (12.2%). The most common specific activities were offensive running plays (28.7%), defensive running plays (21.9%), and offensive passing plays (11.5%).

Kerr et al. (2011) did a study to investigate the epidemiology of player to player contact injuries in nine high school sports across the Nation from 2005-2009. They used the high school RIO system to collect their results to calculate rates, describe patterns, and evaluate potential risk factors for player to player contact injuries. In their study they identified 46.4% of all injuries were due to player to player contact with a rate of 11.6 per 10,000 athletic exposures. Emery et al. (2006), found a slightly lower percentage of player to player contact injuries at 28.5% in their study of high school sport injuries in Canada.

Kerr et al. (2011) confirmed that football accounted for 53.5% of all the player to player contact injuries, followed by girls' soccer 12.6%, and boys' soccer 11.8%. Player to player contact injuries accounted for 87.8% of all concussions in football with tackling, and being tackled being the most common mechanism. In soccer (boys and girls), and basketball (boys and girls) ankle/foot injuries were the most common location for injuries from player to player contact. In basketball ankle/foot injuries were commonly from jumping and landing (boys 42.6% and girls 30%), and rebounding (boys 50.5% and girls 36.3%). Ingram et al. (2008) found in their study of knee injuries, player to player contact was the most common mechanism for knee injuries (52.0%), followed by no contact/overuse (25.4%), contact with the playing surface (15.4%), and contact with a playing apparatus (2.9%).

This study by Kerr et al. (2011) did have limitations; to be eligible for the study the school needed it to have a certified athletic trainer, so results from the study cannot be generalized across the Nation. By using certified athletic trainers it ensures accurate results

are collected so better more reliable results can be analyzed. They also used athletic exposures to calculate rates with one athlete exposure being a single athlete participation in one practice or competition. Expecting a trainer to note every minute of every practice and competition for each athlete is unrealistic and very time consuming.

Injury Severity. It is very important when comparing studies that data on injuries is consistent throughout. Many studies define an injury as a condition meeting the following 3 criteria: (1) occurred as a result of participation in an organized high school practice or competition, (2) required medical attention by an athletic trainer or physician, and (3) resulted in restriction of the student-athlete's participation for one day or more beyond the day of injury (Rechel et al., 2008; Nelson et al., 2007; Gessel et al., 2007, Meehan et al., 2011; Ingram et al., 2008; Kerr et al., 2011). According to Powell and Barber-Foss (2000), the severity of an injury is based on calendar days lost; minor injury fewer than eight days, moderate injury 8 to 21 days lost, or major more than 21 days lost.

Rechel et al. (2008) suggested that 52.5% of all injuries sustained were classed as minor, 30.3% moderate, 6.8% major, and 10.4% of the injuries resulted in the player's season or career ending. Nelson et al. (2007) discovered similar figures with their study on ankle injuries, with 51.7% classed as minor, 33.9% moderate, and 10.5% major. Interestingly, Ingram et al. (2008), confirmed in their study of knee injuries that when a player injured this location, major injuries accounted for a staggering 30.3%, with minor at 43.1%, and moderate 26.6%. They also discovered that 44.6% of all surgeries recorded were to the knee, which shows how vulnerable the knee is during sport. Rechel et al. (2011) studied sport-related injuries at high school which required surgery; they found that 48% of injuries resulted in medical disqualification for the season, 20.2% greater than 22 days, 12.8% 8 to 21 days, and 7.6% fewer than 8 days.

When results are gathered on concussions a different scale of severity is used in terms of days lost; 1-2 days, 3-6 days, 7-9 days, 10-21 days, greater than 22 days, end of season, and end of career (Meehan et al., 2011; Gessel et al., 2007). In their study of concussions Meehan et al. (2011) discovered the following concussion results; 1-2 days (4.7%), 3-6 days (20.7%), 7-9 days (30%), 10-21 days (34.5%), greater than 22 days (4.5%), end of season (5.4%), and end of career (0.3%). Gessel et al. (2007) identified similar results with 50% of athletes returning to action in 9 days or less. Interestingly, Broshek, Kaushik, Freeman, Erlanger, Webbe, and Barth (2005) suggested that female athletes were more likely than male athletes to have symptoms that persisted longer than seven days. This adds to previous literature that suggests more significant symptoms and poorer neuropsychological assessments in female athletes after sustaining sport-related concussions.

Contributing Factors

In a study by Murphy, Connolly, and Beynnon (2002) they make a distinction between so-called intrinsic (person-related), and extrinsic (environment-related) risk factors. The intrinsic risk factors are related to the individual biological or psychosocial characteristics of a person, such as age, sex, previous injuries and adequacy of rehabilitation, aerobic fitness, body size, limb dominance, flexibility, limb girth, muscle strength, imbalance and reaction time, postural stability, anatomical alignment, and foot morphology. Extrinsic risk factors relate to environmental variables such as the level of play (competition and practice), exercise load (amount of competition and practice), position played, equipment, playing field conditions, rules, and foul play. Both intrinsic and extrinsic factors can partially influence each other and are therefore not independent of each other.

Intrinsic Factors. Previous injury and inadequate rehabilitation are the most important and well established intrinsic risk factors. Approximately 10% of injuries are recurrent injuries, with these injuries tending to be more severe (Swenson, Yard, Fields &

Comstock, 2009; Rauh, Macera, Ji & Wikesten, 2007). Swenson et al. (2009) looked at recurrent injury patterns in high school sport from 2005 to 2008 using the high school RIO system to collect their results. They found recurrent injuries made up 10.5% of all injuries, with a rate of 2.57 per 10,000 athletic exposures. In their study of recurrent injuries, the most common location was ankle (34.9%), knee (16.8%), head/face (12.1%), and shoulder (12%). They suggested that recurrent injuries tended to be more severe with athletes ending their participation that season (recurrent injury ending season 2.4%, new injury ending season 0.7%).

Swenson et al. (2009) stated that football had the highest rate of recurrent injuries at 4.36 per 10,000 athletic exposures, they also had the highest rates of concussion. According to Lincoln, Caswell, Almquist, Dunn, Norris, and Hilton (2011), 16.8% of high school athletes who suffered a concussion had previously suffered a sport-related concussion either that season or in the previous season. Their study covered an 11 year period from 1997 to 2008 in one of the largest suburban school districts. Meehan et al. (2011) reported a much higher rate of recurrent concussions; in their study 37% of concussions were recurrent from that season. They concluded that once an athlete had suffered an initial concussion, his or her chances of a second concussion were 3 to 6 times greater than an athlete who had never sustained a concussion.

Although Swenson et al. (2009) did the largest and most recent epidemiological analysis of recurrent injuries among high school athletes, their study did have some limitations. The study only used schools that had a certified athletic trainer, which did restrict the population, but this did increase the accuracy of results collected. They also used athletic exposure as a unit rather than rates by minutes or hours of competition and practice. To ask the athletic trainer to document every minute of every competition and practice each athlete took part in is both time consuming and unrealistic.

Another intrinsic factor which is heavily researched is gender, focusing on the injury patterns between boys and girls. Although there seem to be contradictory results, Powell and Barber-Foss (2000) reported no difference in the risk of injury in male and female basketball. But they did find that male soccer players were at a higher risk of injury than female soccer players. However, Emery, Meeuwisse, and Hartmann (2005) confirmed no difference in male and female soccer players in their study of high school sport injuries in Canada.

Ingram et al. (2008) reported that gender differences in their study existed with regards to; rates of knee injuries, rates of major knee injuries, injury severity, and injury mechanism. Although boys had a higher rate of knee injuries with 4.29 knee injuries per 10,000 athletic exposures, to girls 3.11. They stated that girls had a higher rate of major knee injuries, which was supported by Mountcastle, Posner, Kragh, and Taylor (2007), and Powell and Barber-Foss (2000), who studied anterior cruciate ligament injuries and sex-related injury patterns respectively. Ingram et al. (2008) found girls were twice as likely to require surgery for knee injuries as boys. In soccer and basketball they stated that girls were twice as likely to incur non-contact knee injuries. These high rates of major knee injuries were studied by Hewett (2000), who concluded that structural and neuromuscular differences existed between genders which could be the reason for such high rates.

Girls are more likely to sustain a concussion in soccer and basketball according to Gessel et al. (2007). Meehan et al. (2011) supported this by reporting that girls' soccer had a higher rate of concussions compared to boys with 33 per 10,000 athletic exposures to boys 19.2, which was a similar finding to Powell and Barber-Foss (2000). However, Meehan et al. (2000) concluded that boys' basketball had a higher rate of concussion with 21.2 concussions per 10,000 athletic exposures compared to 18.6 for girls. Barnes, Cooper, Kirkcndall, McDormott, Jordan, and Garretl (1998) suggested that the higher rate of concussions in girls' soccer may be due to smaller head to ball ratio or weaker necks. Vertinsky (1994) suggested

that cultural explanations may also play a part in high female concussion rates. Female athletes in today's society are protected, and can be seen as weaker, which may lead to coaches, athletic trainers, and parents to take brain injuries more seriously. Another possible explanation according to Gessel et al. (2007), is that boys may be more reluctant to report a concussion because they will be pulled from practice or competition.

The final intrinsic factor which will be addressed is age, where there is a general consensus for older athletes with more experience are at greater risk of injury than younger, less experienced athletes. Turbeville, Cowan, Owen, Asal, and Anderson (2003) did a study looking at the epidemiological characteristics of, and risk factors for injury in high school football players. Their study was a two year investigation using high school football players in Oklahoma City, Oklahoma school district. They reported that older players with more experience were at significantly higher risk of injury, Ramirez, Schaffer, Shen, Kashani, and Kraus (2006) also confirmed this in their study of footballers in California. Both of these studies stated that older players are generally more aggressive so they put themselves at greater risk of injury than less aggressive younger players. Interestingly, Emery, Meeuwisse, and Hartmann (2005) studied adolescent soccer players, and found at the elite level the injury risk at under 14 was the greatest, followed by under 16, and then under 18 had the lowest risk of injury. Schulz, Marshall, Mueller, Yang, Weaver, Kalsbeek, and Bowling (2004) reported that concussion in ninth grade were considerably lower than any of the other grades. With such high recurrent concussion rates (Lincoln et al., 2011; Meehan et al., 2011) Schulz et al. (2004) argued that this low rate in ninth grade may be due to athletes not having any previous history of concussions.

Extrinsic Factors. The most discussed extrinsic factor is injuries patterns in competition over practice. Rechel et al. (2008) did a study to compare competition and practice injury rates in nine high school sports; football, soccer (boys and girls), basketball

(boys and girls), wrestling, baseball, volleyball, and softball. The study was conducted over the 2005-2006 school year, and used 100 high schools Nation-wide, using the high school RIO system to collect their results. The main finding of their study was that injury rates were higher in competition, with 4.63 injuries per 1,000 athletic exposures, compared to 1.69 in practice. Higher injury rates in competition were found in basketball (Emery et al., 2005), football (Ramirez et al., 2006), and soccer (Emery et al., 2005).

According to Rechel et al. (2008), football had the highest rates of injuries in practice with 2.4 injuries per 1,000 athletic exposures, followed by wrestling 2.04, and boys' soccer 1.58. Football also had a much higher injury rate in competition compared to any other sport, with 12.09 injuries per 1,000 athletic exposures, girls' soccer followed at 5.21, and then boys' soccer at 4.22. In their study of ankle injuries Nelson et al. (2007) reported an alarming rate of ankle injuries in competition over practice, with 18.4 ankle injuries per 10,000 athletic exposures in competition, and 3.72 in practice. Girls' soccer also had high rates of ankle injuries with 13.36 per 10,000 athletic exposures in competition compared to 3.26 in practice. Overall in their study they found that players were three times more likely to sustain an ankle injury in competition compared to practice, which was a similar finding to Rechel et al. (2008) of 2.73, which included all injury locations.

Powell and Barber-Foss (1999), and Ingram et al. (2008) confirmed that knee injuries were higher in competition than practice, with knee injuries three times more likely to occur in competition than in practice. Ingram et al. (2008) stated that of major knee injuries, 67.7 % were sustained during competition, which is not unexpected due to the higher intensity and likelihood of players taking risks. They found in football 3.74 knee injuries per 10,000 athletic exposures in practice, and an exceptionally high 21.7 knee injuries per 10,000 athletic exposures during competition. Girls' soccer had a high rate of knee injuries in competition with 11.74 per 10,000 athletic exposures compared to 2.24 in practice. In boys' soccer, and

basketball (boys and girls) athletes were 3-5 times more likely to sustain a knee injury in competition over practice.

Rechel et al. (2008) suggested that a larger proportion of competition injuries were season ending or required surgery. Mueller (2001) argued that the majority of catastrophic head injuries among football players occurred during competition. This higher proportion of severe injuries in football competitions was due to increased aggressiveness and physical contact according to Mueller (2001). He also stated that this heightened intensity may foster a greater number of high speed collisions which results in more severe head injuries, compared to practice sessions where it is a more controlled environment.

Rechel et al. (2008) completed a very comprehensive study, which analyzed data on competition and practice injuries in high school. Their study was the largest of its kind but it did come with some limitations. To be eligible the school had to have a certified athletic trainer on staff, which ruled out many schools but did ensure quality and accurate results. The high school RIO system was in its first year of operation, and a small number of injuries in certain stratifications prevented some findings being statistically significant. Finally, their definition of athletic exposure was participation in one competition or practice, which was less precise than actual minutes/hours played. It is not logistically possible for the trainer to note each minute of every competition and practice each athlete takes part in.

Another interesting extrinsic factor is foul play. Prior research in this area is limited, but Collins et al. (2012) did a study to compare sport and gender differences, and the proportion of injuries related to illegal activity. Their study used nine high school sports; football, baseball, wrestling, basketball (boys and girls), soccer (boys and girls), volleyball, and softball. Data was collected using the high school RIO system over two academic years from 2005-2007 using 100 high school Nation-wide.

They found an injury rate of 0.24 injuries per 1,000 athletic exposures were related to an action which was deemed foul play. Overall, 6.4% of all injuries were from foul play, which was a similar finding to Cromwell, Walsh, and Gormley (2000) who stated six percent of soccer injuries were classed as foul play. In a study of ankle injuries Nelson et al. (2007), confirmed 5.3% of ankle injuries where due to foul play. Ingram et al. (2008) suggested 5.7% of knee injuries were because of foul play, and of the knee injuries resulting in surgery, foul play accounted for 20%. Collins et al. (2012) insisted that girls' basketball had the highest percentage of injuries due to foul play at 14%, girls soccer followed at 11.9%, boys' soccer 11.4%, and boys basketball 10.3%.

According to Chomiak, Junge, Peterson, and Dvorak (2000) and Collins et al. (2012), almost one third of injuries that related to illegal activity were to the head/face. With the dangers associated with head injuries, Collins et al. (2012) argued that reducing the number of injuries attributed to illegal activity among high school athletes can specifically reduce the number of concussions. This is particularly important given the long-term effects of concussions (Cantu, 2007). Collins et al. (2007) suggested a possible limitation for this study is athletes self-reporting illegal activity, and not having the ability to differentiate between unintentional activity and intentional foul play. Another limitation of this study is the use of high school RIO because only schools with a certified athletic trainer could take part in the study so results cannot be generalized Nation-wide. But having certified athletic trainers inputting data far outweighs this limitation with accurate and consistent results. Finally, athletic exposure was used as opposed to minutes/hours played because asking the athletic trainer to note every minute of every practice and competition for each athlete is far too time consuming. Despite these limitations this study is the most up-to-date and comprehensive study of foul play across the Nation.

Player position is an extrinsic factor which was researched by Comstock, Collins, and MeIlvain (2012); they confirmed that linebackers accounted 43% of injuries in competition and 42% in practice. This position was also found to be at the highest risk in a study by Turbeville et al. (2003) and Ramirez et al. (2006). Tubeville et al. (2003) reported that linebackers sustained higher rates of knee injuries and season ending injuries. According Bradley, Honkamp, Jost, West, Norwig, and, Kaplan (2008) possible reasons for such high injury rates with linebackers can be explained by specific mechanisms such as "chop blocks," and "cut blocks." Comstock et al. (2012) also suggested that running backs were at a higher risk of injury with 18% in competition, and 16% in practice. Bradley et al. (2008) stated that running backs have additional injury risks because they are consistently getting tackled at full speed by more than one defensive player during a game.

Comstock et al. (2012) studied soccer for girls and boys, and found similar injury risks for all outfield positions (defenders, midfielders, and forwards), however, injury risk for goalkeepers was much less at only eight percent. In basketball they identified point guards at the highest risk of injury with 48% in competition, and 50% in practice. Forwards made up 36% of injuries in competition, and 38% in practice. Center was the position with the lowest risk at 16% in competition and practice.

Prevention Programs

Sustaining injuries in sport comes with; (a) short term effects, like pain and hospitalization, (b) long term more severe effects (Moller, Weidenhielm & Werner, 2009; Roos, 1998; Cantu, 2007), and (c) high medical costs (Injury Cost Model of U.S. Consumers Product Safety Commission, 2006), so implementing prevention programs is of paramount importance. Soligard, Myklebust, Steffen, Holme, Silvers, Bizzini, Junge, Dvorak, Bahr, and Anderson (2008) did a study to examine the effect of a comprehensive 20 minute warm-up program designed to reduce the risk of injuries in female youth soccer players aged 13-17.

The investigation took place in Norway using an intervention group, and a control group of soccer players. They found that that the overall risk of injuries was decreased, as well as lowering the risk with more severe injuries, and overuse injuries. They noted that a comprehensive warm-up designed to improve strength, awareness, and neuromuscular control can prevent injuries in young female soccer players. They identified the risk of injury can be reduced by approximately one third, and the risk of severe injuries by as much as a half. They concluded that educating coaches in the area is vital, as many coaches consider injuries an issue they cannot have an impact on. It was also reported that injury prevention seems to have a low priority on teams' seasonal plans. This study did come with a few limitations, firstly the study was done over one season, and secondly, coaches were in charge of recording injury information which can decrease accuracy of injury diagnosis.

Mandelbaum, Silvers, Watanabe, Knarr, Thmoas, Grffin, Kirkendall, and Garrett (2005) examined the use of a neuromuscular and proprioceptive performance programs in decreasing the incidence of anterior cruciate ligament injury. The study was done over a two year period using female soccer players aged 14 -18. The controlled group did their traditional warm-up, and the intervention groups did activities which consisted of; educating the players, stretching, strengthening, plyometrics, and sports specific agility drills. In season one there was an 88% decrease in anterior cruciate ligament injuries in the enrolled group compared to the controlled group, and in season two there was a 74% decrease. With such high rates of anterior cruciate ligament injuries among female athletes (Mountcastle et al., 2007; Powell & Barber-Foss, 2000; Ingram et al., 2008), implementing neuromuscular training programs is essential to maintain healthy female athletes.

Male soccer players aged 14-19 were studied by Junge, Rosch, Peterson, Graf-Baumann, and Dvorak (2002) in Norway over a two year period. Their study looked to improve warm-ups, cool-downs, taping of unstable ankles, and making sure players got

adequate rehabilitation. They reported lower rates of injury to low-skilled players in the intervention group, with 6.95 injuries per 1,000 hours, compared to the low-skilled control group at 11.1 injuries per 1,000 hours. There was no difference in injury rates with high-skilled players. The study did not give an accurate measure towards the overall picture of injury prevention, as it lacks the consideration towards amount of practices, number of competitions, time schedules, players' equipment and playing surface, which is clearly a bias. They defined the emphasis of the intervention as the amount and quality of training and the physical performance of the players which was good but not measurable. This was enforced via the coaches from training courses that they had to take part in prior to the study beginning. Although there was only one prevention group, both groups received pre-study assessments and individual players were instructed on how to improve individual weaknesses. This could be considered as prevention, given that prevention in this study was defined as improving the player's physical performance.

Emery, Rose, McAllister, and Meeuwisse (2007) looked at the effectiveness of a sport-specific balance program in reducing injury in adolescent basketball (boys and girls). They used twenty-five high schools in Calgary and the surrounding area. Both groups were taught a standardized warm-up, but the intervention group was taught an additional part to the warm-up and they were also given a wobble board to use at home. They concluded that the program decreased injuries among the intervention group, in lower extremity, and especially in ankle sprains. A major limitation to this study was placing such a large portion on home intervention (the wobble board), since the quality of execution cannot be easily verified. McGuine and Keene (2006) reported similar results with balance training and injury risk on ankle sprains in boys and girls, basketball and soccer. In their study they incorporated a five week balance program into their season and found ankle sprains in the intervention group

were significantly lower, with 1.13 ankle sprains per 1,000 athletic exposures, and 1.87 ankle sprains per athletic exposures in the controlled group.

By implementing prevention programs into sport-specific practices, injury rates can be decreased (Soligard et al., 2008; Mandelbaum et al., 2005; Emery et al., 2007; McGuine & Keene, 2006). It appears that to create a successful program, the following components must be incorporated; plyometrics (Soligard et al., 2008; Mandelbaum et al., 2005), strength (Soligard et al., 2008; Junge et al., 2002; Mandelbaum et al., 2005), conditioning (Junge et al., 2002), agility drills (Soligard et al., 2008; Mandelbaum et al., 2005), balance and body control (Emery et al., 2007; McGuine & Keene, 2006), and flexibility (Mandelbaum et al., 2005). According to Frisch, Croisier, Urhausen, Seil, and Theisen (2009) the frequency and duration of prevention sessions seems to be a key aspect, with the most successful programs having a high initial stage, for example, performing the exercises every day during the warm-up, and then maintaining throughout the season. They also stress that incorporating prevention programs into pre-season will also decrease injury rates throughout the season. They conclude by stressing how necessary it is to educate parents, players, trainers, and coaches in prevention curricula.

Literature Review Conclusion

After reviewing the literature it is clear that injuries in high school sports need to be closely monitored. The three most concerning areas that were found:

- Concussions rates, in particular concussions due to foul play.
- Football injury rates in competition.
- Serious knee injuries to girls.

Chapter III: Summary and Recommendations

This chapter will summarize all the literature that was reviewed and directly answer the researched questions that were initially stated. The chapter will conclude with recommendations for future research in the area of injuries in high school sports.

Summary

The following research questions were stated in chapter I and were then answered throughout the literature review. The questions are focused on the incidence of sport injuries in high school sports, considering the factors why players get injured, and then what action has being taken to decrease injuries in youth sports.

1. What is the most frequent area injured?

Injuries to the lower extremities are the most common location for injuries in high school sports (Beachy et al., 1997; Ingram et al., 2008; Rechel et al., 2008). Approximately 20% of all injuries were to the ankle, with knee and head/face following (Rechel et al., 2008; Emery et al., 2006). The majority of injuries were strains/sprains which made up over 50% (Nelson et al., 2007; Rechel et al., 2008). Basketball for boys and girls had the highest rates of ankle sprains (Nelson et al., 2007), and football had the highest rates of knee sprains (Ingram et al., 2008). Concussions made up 90% of all injuries to the face/head (Meehan et al., 2011), and with a consistent annual rise in concussions from 8.9% in 2006 (Gessel et al., 2007) to 15% in 2010 (Meehan et al., 2011) they have reached an epidemic level.

2. What are the most common intrinsic risk factors (personally-related)?

Previous injury and inadequate rehabilitation was the most researched intrinsic factor. In two studies approximately 10% of injuries were recurrent (Swenson et al., 2009; Rauh et al., 2007). Ankle sprains were the most common recurrent injury followed by the knee, and recurrent injuries tended to be more severe (Swenson et al., 2009). Meehan et al. (2011)

found 37% of concussions were recurrent from that season, a figure much higher than a previous study by Lincoln et al. (2011) who found 16.8%.

Injury patterns with gender have produced indifferent results. Powell and Barber-Foss (2000) found male soccer players were at a greater risk of injury than females, but Emery et al. (2005) found no difference amongst soccer players. Girls were at a greater risk of serious knee injuries, and knee injuries that required surgery (Ingram et al., 2008; Mountcastle et al., 2007; Powell & Barber-Foss, 2000). These high rates of major knee injuries can be explained by structural and neuromuscular differences between genders (Hewett, 2000). Girls are at a greater risk of sustaining concussions. However, Barnes et al. (1998) suggested that this may be due to weaker necks, and Vertinsky (1994) stated that girls were protected more in society and can be seen as weaker.

In football, older more experienced players have being reported to be at a greater risk of injury (Turbeville et al., 2003; Ramirez et al., 2006). These studies concluded that these higher rates may be due to more experienced players are more aggressive so put themselves at greater risk. However, Emery et al. (2005) found under 14 male soccer players at the elite level were at a greater risk of injury than under 16, and under 18 players.

3. What are the most common extrinsic risk factors (environmentally-related)?

The most researched extrinsic factor is comparing competition injuries against practice injuries. Several studies reported that players were more likely to get injured in competition over practice (Rechel et al., 2008; Emery et al., 2005; Ramirez et al., 2006). Players were 3 or more times as likely to get injured in competition over practice in soccer and basketball, and 6 times more likely in football (Rechel et al., 2008). Competition injuries tend to be more severe, with knee injuries 3-5 times more likely in competition, and the majority of catastrophic head injuries in football are in competition.

Foul play is considered an extrinsic factor which should be monitored closely because six percent of injuries are due to foul play (Collins et al., 2012; Cromwell et al., 2000). One third of injuries that resulted from foul play were to the head/face (Collins et al., 2012; Chomiak et al., 2000). With such high rates of concussions it was stated by Collins et al. (2012) that by decreasing foul play in sport it would dramatically reduce the number of concussions.

Player position can have an impact on the risk of injury (Comstock et al., 2012; Turbeville et al., 2003; Ramirez et al., 2006). In football, linebackers and running backs were at the greatest risk of injuries (Turbeville et al., 2003; Bradley et al., 2000), in soccer no difference was reported, and in basketball points guards were at the highest risk of injury (Comstock et al., 2012).

4. How effective are current injury prevention programs?

Current prevention programs have been very successful (Soligard et al., 2008; Mandelbaum et al., 2005; Junge et al., 2002; Emery et al., 2007). Soligard et al. (2008) set up a prevention program for youth female soccer players. They designed a 20-minute warm-up which increased strength, awareness, and neuromuscular control, and they concluded that the overall risk of injury, severe injury, and overuse injury was decreased by more than a third. Mandelbaum et al. (2005) created a neuromuscular and proprioceptive performance program to decrease anterior cruciate ligament injury. They reported an 88% decrease in season one, and a 74% decrease in season two. Emery et al. (2007) did a study for high school basketball, and found that by using balance training, injuries to the lower extremities, especially the ankle could be decreased.

The most successful programs are started in pre-season with a high initial stage, performing the exercises daily in the warm-up, and then maintaining throughout the season (Frisch et al., 2009). The key aspects of a good injury prevention program are a mixture of;

plyometrics, strength, conditioning, agility drills, balance, and flexibility (Soligard et al., 2008; Mandelbaum et al., 2005; Junge et al., 2002; Emery et al., 2007).

Recommendations

The high rate of serious knee injuries to girls is well-publicized (Mountcastle et al., 2007; Powell & Barber-Foss, 2000; Ingram et al., 2008). With the both the short-term and long-term effects of serious knee injuries like an anterior cruciate ligament rupture, it is very important to reduce these high rates. More research is needed to understand the physiology of girls, and educate girls, coaches and parents about the high risk of serious knee injuries. Ankle sprains are a very common injury in sports but have been widely researched over the last decade and a significant decrease has being reported of 86%. If the current medical theory behind anterior cruciate ligament injuries can be put into practice with prevention programs from an early age then rates can be decreased. The current increase of anterior cruciate ligament injuries (an increase of 172% in the last 15 years) is unacceptable, and with the medical theory and education these rates can be decreased.

Decreasing the number of injuries in football competitions is an area which needs to be examined. Football players were twice as likely to get injured during competition than any other sport, and with the high rates of football concussions and recurrent concussions research into injury prevention is very important. Research looking at equipment, or rule changes so that blows to the head are not as prevalent should be assessed. The long term effects of constant blows to head are far too severe for this issue to be looked over because "it is part of the game." A teenager losing his life playing high school football, or later in life suffering serious brain problems is a story too familiar in today's society, which is why serious measures need to be taken now.

Overall, high school sports are a wonderful opportunity for adolescents to be physically active, and learn lifelong skills such as leadership and teamwork. Although

playing sport comes with the risk of injury, it is well-publicized how well student-athletes do on their academics compared to the non-athlete. In order to reduce the risks of injury, coaches should be educated about sport injuries, and understand the physical demands of their sport, as well as being aware of prevention methods to minimize the risk.

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