January 2012

An Epidemiological Study Of Collegiate Women's Basketball Injuries

Alexandria Fern Pulvermacher

AN EPIDEMIOLOGICAL STUDY OF COLLEGIATE WOMEN’S BASKETBALL INJURIES

by

Alexandria Fern Pulvermacher
Bachelor of Science, University of Wisconsin Oshkosh, 2010

A Thesis

Submitted to the Graduate Faculty

of the

University of North Dakota

in partial fulfillment of the requirements

for the degree of

Master of Science

Grand Forks, North Dakota
August
2012

This thesis, submitted by Alexandria Pulvermacher in partial fulfillment of the requirements for the Degree of Master of Science from the University of North Dakota, has been read by the Faculty Advisory Committee under whom the work has been done, and is hereby approved.

Dr. Dennis Caine

Dr. Brett Goodwin

Dr. Mark Romanick

This thesis is being submitted by the appointed advisory committee as having met all of the requirements of the Graduate School at the University of North Dakota and is hereby approved.

Dr. Wayne Swisher
Dean of the Graduate School

July 13, 2012

Title	An Epidemiological Study of Collegiate Women's Basketball Injuries
Department	Kinesiology
Degree	Master of Science

Alexandria F. Pulvermacher
July 13, 2012

TABLE OF CONTENTS

LIST OF FIGURES

Figure Page

LIST OF TABLES

ACKNOWLEDGEMENTS

I wish to express a sincere thank you and appreciation to a number of people for their contributions during my time in the Graduate School at the University of North Dakota. First, a special thank you to Dr. Dennis Caine for serving as my advisor and spending endless hours reviewing multiple drafts of my thesis paper. Thank you to my other committee members, Dr. Brett Goodwin and Dr. Mark Romanick, for their input throughout the process of completing my thesis. A special thanks to Dr. Goodwin for taking the time to run my risk factor analysis.

I would also like to thank my family for their loving support throughout my lifetime. I would not be where I am today if it wasn't for their support and kick in the butt when it was most needed. Lastly, I would like to thank my fiancé, Eric Sand, for his support in the last couple of years. I wouldn't have been able to do this without him.

ABSTRACT

Objective: To study the nature and incidence rate of injuries that affect a NCAA division I Midwestern women's collegiate basketball team and to examine the relationship between injury rates and specific risk factors.

Background: Collegiate women's basketball has grown in popularity. Along with this increased popularity basketball has become more of a contact game. There has been limited research investigating the incidence and distribution of injuries affecting women's basketball players. Additionally, there has been a lack of consistency in research methods, and minimal analytical research examining risk factors.

Method: This 2-year study was both retrospective and prospective cohort in design. Institutional Review Board (IRB) approval was obtained from the University of North Dakota (UND). Women's basketball players from UND were invited to participate in this study. Baseline data were collected through UND's pre-participation physical examinations and demographic/medical history questionnaires. Each participant was tested on the Biodex Stability System to calculate their balance and postural sway scores. The basketball players were followed throughout their regular season and queried on all injuries sustained the year prior. All injuries were documented that were presented to the athletic trainer/principal investigator. Additionally, exposure to all practice, weightlifting, and competition was recorded in terms of minutes, hours, and Athletic Exposures (AEs).

Once the season was over, descriptive analyses were run to determine the nature and incidence and distribution of injury. Due to multiple injuries in some players, Poisson regression models were fitted using generalized estimating equations to estimate incidence rate ratios (IRR) and to test risk factors. Unadjusted rates were estimated from Poisson regressions with each of the following risk factors: stability, previous injury last year, previous injury ever, event, and position. For adjusted rate ratios a multiple-Poisson regression with all risk factors was used.

Results: Twelve of 15 participants sustained 35 injuries in the 2011-2012 season. During the 2010-2011 season, 11 of 15 participants accumulated a total of 27 injuries. During the 2011-12 season, overall injury rates were 0.19 per 1000 minutes, 11.25 per 1000 hours, and 13.29 per 1000 athletic exposures (AE). During the 2010-11 season overall injury rates were 14.34 per 1000 hours and 16.76 per 1000 AE. The majority of injuries sustained involved the ankle (23%), followed by the knee (17%) in the 2011-12 season. In the 2010-11 season the majority of the injuries sustained were to the lower extremity (63%), with the ankle being injured most frequently (22%). Injury rates for both seasons were greatest in competition: 63.99 per 1000 hours (2011-12) and 117.19 per 1000 hours (2010-11).

In the unadjusted Poisson regression analysis of injuries per 1000 hours exposure the following risk factors resulted in a significant effect: previous injury last year, previous injury ever, event (weight lifting) and position (center, forward). However, in the multiple-Poisson regression only event (weight-lifting) resulted in a significant effect.

In the unadjusted Poisson regression analysis per 1000 AEs only previous injury ever and event (center position) achieved significance as risk factors. In the multiple-Poisson regression none of the risk factors reached a significant effect.

Conclusion: Injury rates reported in this study are mostly higher than those reported by previous research, perhaps due to the more liberal definition of injury and precise documentation of individual exposures. Information on the distribution of injuries is more detailed in the type of injury, anatomical location of injury, who gets injured, and when injury occurs than previous studies. Risk factor analysis indicated that history of previous injury, weight lifting sessions, and basketball position played may be risk factors for injury in collegiate women's basketball. However, confirmation of these factors awaits longitudinal studies with multiple teams. Preventative programs need to be developed for players with a previous history of injuries to eliminate the risk of injury again.

CHAPTER I

INTRODUCTION

Basketball was invented in 1891 by James Naismith, a physical education teacher who had recognized the need for an indoor sport during the cold winter months (McKay & Cook, 2010). Since 1891, basketball has grown in popularity throughout the world. The International Basketball Federation is comprised of 213 countries and reported, in 2007, that 450 million people played basketball worldwide (International Basketball Federation, 1996). Men's basketball was played for the first time at the Berlin Olympic Games on August 1, 1936, and in 1976, women's basketball joined the Olympic program (McKay & Cook, 2010).

The National Collegiate Athletic Association (NCAA) was comprised of 705 schools and 9,624 athletes participating in women's basketball during the 1981-82 season. By 2008-2009, the number of schools participating had increased to 1,056, totaling 15,381 participants (National Collegiate Athletic Association, 2009). This increase (59.8%) in number of teams has been seen throughout all three NCAA divisions (National Collegiate Athletic Association, 2009). According to ncaa.org, in the 2010-2011 season there were a total of 1,069 participating schools (National Collegiate Athletic Association, 2011). Along with the increased participation in recent years, there has also been a change in the level of contact. The nature of the game has changed dramatically over the years, evolving from a game of finesse to a collision sport to its current designation as a high-risk contact sport (Starkey, 2000).

Against a background of the increased participation and more aggressive nature of women's basketball, concerns have been raised regarding the increased number of injuries (Zvijac & Thompson, 1996). However, injury studies that have been conducted suffer from the following methodological short-comings:

- The use of retrospective data collection which depends on the memory recall of the participants (Agel et al., 2007; Sallis et al., 2001; Arendt & Dick, 1995). Retrospectively collected data may miss minor injuries, thus resulting in lower overall injury rates.
- Data sources in past research vary and range from self-report forms, athletic trainers, physicians, coaches, injury registries, and injury surveillance systems, making it difficult to compare results across studies.
- Study populations have been diverse in nature with regards to level of competition, age, gender, and demographical location, making it difficult to compare results across studies.
- Measurement biases associated with self-reporting of injuries and coaching staff reporting injuries, which is common in the research.
- Participants being selected non-randomly or arising from convenience samples in many studies.
- Injury definitions were inconsistent across studies, making it difficult to compare results across studies.
- Many studies lack precise measurement of exposure to the risk of injury. For example, many studies report injury rates that are calculated based upon group estimations of hours or athlete-exposures.

There are multiple possible underlying factors that can lead to injuries in women's basketball, especially lower extremity injuries. An important modifiable risk factor may be neuromuscular control (Hewett, Myer, & Ford, 2006). Rozzi, Lephart, Gear, and Fu (1999) demonstrated that female athletes participating in collegiate basketball possess excessive knee joint laxity and proprioceptive deficits as measured by the Biodex Stability System that may predispose them to ligament injuries. Researchers analyzing balance as a risk factor for ankle injuries in high school basketball players report that compilation balance scores for subjects who sustained ankle sprains were significantly higher than the scores for subjects who didn't sustain an ankle injury (McGuine, Greene, Best, & Leverson, 2000). Subjects with high-sway scores (poor balance) sustained more ankle injuries than subjects with low-sway scores (good balance), who may be protected from ankle injuries (McGuine et al., 2000).

In summary, collegiate women's basketball has grown in popularity in recent years and has become more of a contact game. There has been epidemiological research on injury in women's basketball; however, there has been a lack of consistency. The lack of consistency has occurred with how injuries were reported, how data were collected, the types of populations studied, types of injury definitions used, and how exposure data were collected. There is also a need for more studies to address the abnormalities in balance/postural sway in the collegiate women's basketball population to help determine if poor balance and postural sway are possible risk factors for injury. All of these inconsistencies and lack of studies examining balance and postural sway within the collegiate women's basketball population have resulted in a gap in research that this study plans to address.

Statement of the Problem

The purpose of this study is to determine the incidence and distribution of injuries affecting NCAA Division I Women's Basketball Players. Additionally, this study explores the nature of the relationship between injury and the following potential risk factors: abnormal postural sway/balance and history of injury. Other risk factors of interest include position played and event at time of injury.

Significance of Problem

The results of epidemiological studies of injury affecting collegiate women's basketball athletes are difficult to compare due to inconsistency in definition of injury, approach to calculation of incidence rates, differences in reporting injuries, and different demographic locations. This study will provide a current accounting of the incidence and distribution of injuries that affect NCAA Division I collegiate women's basketball players. The measure of incidence will be based on a prospective accounting of individual exposure to risk of injury.

Limited research has addressed the role of previous injury as a risk factor for new injury among female collegiate basketball players. Another potential risk factor may be lack of balance/postural sway of the athletes. There has been little research done in the collegiate women's basketball population studying the athletes' balance and postural sway. It is also of interest to determine the role of position played and event in the etiology of injury. The results of this study will contribute to the research that describes the nature and incidence of injuries in collegiate women's basketball players and on possible risk factors related to injury.

Limitations

The sample is considered a convenience sample because participants were limited to the women's basketball players at a Midwestern university who were available to participate, accessible to the researcher, and were division I collegiate athletes. This sample is not necessarily an accurate representation of all competitive collegiate athletes in terms of age, experience, injury history, and so forth. Another limitation is the sample size and duration of the study. Research on the epidemiology of sports injury should ideally follow multiple teams over the course of several seasons to ensure the stability of the data and provide more power for statistical analyses.

CHAPTER II

LITERATURE REVIEW

Introduction

During the past three decades the NCAA has experienced a 150% increase in the number of women's basketball participating schools, and a 160% increase in the number of women's basketball players (National Collegiate Athletic Association, 2011). The increased participation and contact used in the game of basketball indicates that the sport can no longer be perceived to be a safe, non- contact sport (Cumps, Verhagen, & Meeusen, 2007). Basketball was once known as a finesse and non- contact sport, but has evolved into a contact sport where there is concern regarding increased risk and severity of injury (Starkey, 2000). The purpose of this chapter is to provide a review of the literature on the epidemiology of injury in collegiate women's basketball players. This review will identify any gaps in literature with the purpose of suggesting possible directions for further research.

Computer searches were executed using the Pubmed, Sports Discus, Google scholar, and CINAHL search engines. The following search terms were used: “women,” “basketball,” “collegiate,” “college,” “injury epidemiology,” “injuries,” and “adult.” The ancestry method was also used by searching the reference lists for relevant articles. The searches were limited to information from the last 15 years, although relevant articles prior to that time frame were also used. The searches were also limited to research that related to adult female basketball and published in the English language. Most studies retrieved were observational, including cohort and cross-sectional studies, as well as case reports and case series. Previous review articles were also scanned for relevant information.

Who Is Affected by Injury?

Overall Injury Rates

Table 1 summarizes studies which have reported injury rates affecting adult-aged female basketball players. A review of this table shows whether the studies were retrospective or prospective in nature, the length of the studies, whether the sample studied consisted of female collegiate, adult, or WNBA athletes, along with exposure-based injury rates, and whether the injuries included a time loss definition. Adult athletes were considered to be recreational adult players or other countries' professional teams.

Table 1. Overall Injury Rates in Female Adult Basketball Population

Study	Design	Duration	Sample	# of Injuries	Per 1,000 Hr	Per 1,000 AE
Agel et al. (2007)	R	16 years	College	2,468		7.68[a] game 3.99[a] practice
Arendt & Dick (1995)	R	5 years	College	3,305	5.16[a]	
Cumps et al. (2007)	P	1 season	Adult	98	13.9[a]	
Deitch et al. (2006)	R	6 seasons	WNBA	1,570		24.9[b]
McKay et al. (2001)	P	17 months	Adult	127	23.0[b] elite 25.7[b] rec	23.0[b] elite 17.2[b] rec

AE= athlete exposure; P= prospective; R= retrospective; [a] Any reported injury. [b] Time loss from reported injury. WNBA= Women's National Basketball Association.

As shown in Table 1, there have been five epidemiological studies of injuries affecting adult female basketball players, including one which reported results from the NCAA injury surveillance system. These studies occurred between 1980-2004 and included 3 retrospective and 2 prospective designs. These 5 studies ranged in duration from 1 season to 16 years. The subjects included were all females and classified as adult, college, or WNBA players. Injury rates ranged from 5.16 to 25.7 injuries per 1000 hours and 3.99 to 24.9 injuries per 1000 athlete exposures. With the exception of Cumps et al. (2007), the exposure used to determine injury rates in these studies were estimated and therefore lacked in precision. In the Cumps et al. (2007) study, athletic trainers and athletic training students recorded exposure times prospectively for each event.

Another two studies not included in Table 1 due to their method of reported injuries rates were by Sallis, Jones, Sunshine, Smith, and Simon (2001) and Lanese, Strauss, Leizman, & Rotondi (1990) also involved adult female basketball players. The research study done by Sallis et al. (2001) took place for 15 years between 1980-1995 and reported injury rates of college women in seven different sports, including basketball. The study reported injury rates by number of injuries per 100 participant-years. Female basketball players had an injury rate of 112.04/100 participant-years (Sallis et al., 2001). Lanese et al. (1990) performed their research for 1 year on college female basketball players. Nineteen injuries occurred resulting in an injury rate of 4.8 injuries per 100 person-hours. These rates provide only clinical incidence and do not account for varying exposure among participants to risk of injury.

Player Position

Research is inconclusive regarding whether a particular position in women's basketball is associated with an increased risk of injury. Meeuwisse, Sellmer, & Hagel (2003) reported that collegiate male basketball forwards had the lowest injury rate followed by guards, and that centers have the highest rate of injury to the lower extremities. Kostopoulos and Dimitrios (2010) found that male basketball guards to be at a higher risk of injury, especially more serious injuries due to all the agile movements required of their position as compared to other positions. In one study, small female basketball forwards had the lowest rate of ankle injuries (0.25 per 1000 hours of exposure) as compared to centers who were characterized by the highest rate of ankle injuries (5.26 per 1000 hours of exposure) (Kofotolis & Kellis, 2007). In one study, centers in women's basketball were found to have a greater incidence of anterior knee pain compared to other positions (Cumps et al., 2007).

Where Does Injury Occur?

Anatomical Location

The sport of basketball includes a lot of jumping, sprinting, and change in direction movements. For this reason, lower extremity injuries are common. Table 2 shows the percent distribution of injuries by major body parts for the female adult basketball population. Perusal of the data in Table 2 reveals that in all studies the lower extremity is characterized by the highest percentage of injuries ranging from 46.8% to 60.8% of all injuries, followed by the upper extremity which ranged from 14.1% and 23.2% of all injuries. Head and neck injuries were third most common, ranging from 9.3% to 23.7%.

Agel et al. (2007) found that more than 60% of all game and practice injuries occurred in the lower extremity. Approximately 15% of all game injuries involved the head and neck and another 14% involved the upper extremity (Agel et al., 2007). When comparing the WNBA and NBA, injuries to the lower extremity were also the most commonly injured body area (65%) (Deitch, Starkey, Walters, & Moseley, 2006).

Table 2. A Percent Summary of Injury by Anatomical location

Study	Head/Neck %	Spine/Pelvis %	Upper Limb %	Lower Limb %	Other %
Agel et al. (2007)	14.7	7.4	14.1	60.8	3.0
Deitch et al. (2006)	15.4	6.1	19.2	58.7	0.5
McKay et al. (2001)	23.7	6.3	23.2	46.8	
Stergioulas et al. (2007)	9.3	16.3	19.3	50.4	4.7

Environmental Location

Location on the court.

Injuries during the game of basketball take place all over the court. The "lane" has been found to host most injuries and the greatest number of severe injuries in women's basketball (Agel et al., 2007). The lane is what leads the athletes to the basket, and because their goal is to score the most points there is a lot of time that is spent within the lane (Agel et al., 2007). Kofotolis & Kellis (2007) report that 56.3% of ankle sprains occurred in the key area. The key area includes the lane along with the area inside of the 3 point line (Kofotolis & Kellis, 2007).

Competition versus training.

The injury rate in games was almost two times higher than in practices (7.68 versus 3.99 injuries per 1000 athlete exposures) among NCAA players (Agel et al., 2007). An explanation for this increased injury rate could be the greater intensity levels associated with competition as compared to practice (Agel et al., 2007). Deitch et al. (2006) reported that WNBA players were injured more frequently during practice as compared with games; however, more time is generally spent in practice than games.

When looking at ankle sprains, more specifically, the rate of injury was significantly higher in games than in practice sessions (Kofotolis & Kellis, 2007).

When Does Injury Occur?

Injury Onset

Few studies differentiate between acute and overuse injuries. The few studies that reported this distinction indicated that overuse injuries account for 12.8% to 37.7% of all injuries (Cumps et al., 2007; Deitch et al., 2006). This distinction is important since overuse and acute injuries may relate differently to injury risk factors (Deitch et al., 2006).

Chronometry

Injuries appear to occur with greater frequency at the NCAA Division I collegiate level compared with other divisions (Agel et al., 2007). Injuries also appear to occur with greater frequency during the second half of practices or games (Agel et al., 2007). Some possible reasons outlined for the increase of injuries during the second half of a basketball game is that cardiovascular and/or muscular fatigue may begin to affect the athletes' performance and mechanics, along with an increased intensity of play during the second half games (Stergioulas et al., 2007).

Preseason practice injury rates were more than twice as high as regular season practice injury rates across the three NCAA women's basketball divisions (6.75 vs. 2.84 injuries per 1000 athlete exposures) (Agel et al., 2007). During the preseason, de-conditioning from the off-season, increased intensity as players try to earn starting positions, and early season fatigue are all possible factors associated with the increased risk of injury (Agel et al., 2007). Regular season game injury rates were also significantly higher than post season injury rates (7.74 vs. 5.52 injuries per 1000 A-Es) (Agel et al., 2007). This increase in injury rates suggests that players might be more prone to injury earlier in the season, but there could also be a selection bias if those teams whose athletes are injured earlier in the season don't make it to postseason play due to injuries (Agel et al., 2007). When comparing the WNBA and NBA game injury rates, the WNBA were higher (24.9 vs. 19.3 per 1000 athlete exposures) (Deitch et al., 2006). Ankle sprains have also been found to occur at a significantly higher rate during games than during training sessions; and at an increased incidence while playing offense rather than defense (Cumps et al., 2007). In one study, 53.2% of ankle injuries occurred during the first two months of the season (Stergioulas et al., 2007).

What Is the Outcome?

Injury Type

Table 3 gives a summary of frequency and rates for common location-by-type injuries for female basketball athletes. As indicated in Table 3, few studies provide information on the distribution of injury by type. In general, ankle sprains are the most common injury ranging between 17.3% and 24.6%, followed by ligament tears of the knee ranging between 1.6% and 15.9% across studies.

Table 3. Frequency and Rates for Common Location-By-Type Injuries for Female Basketball Athletes

		Ankle Ligament Sprain		Knee Internal Derangement		Knee		Patella or Patellar Tendon		Upper-Leg Contusion		Lower Back Strain		Nose-Fracture		Head-Concussion	
		%	Per 1,000 AEs	%	Per 1,000 AEs	%	Per 1,000 AEs	%	Per 1000 AEs	%	Per 1000 AEs	%	Per 1000 AEs	%	Per 1000 AEs	%	Per 1000 AEs
Agel et al.[a]	2005				0.20-0.37												
Agel et al.[a]	2007	24.6	1.9	15.9	1.2			2.4	0.2	1.7	0.1	1.3	0.1	1.7	0.1	6.5	0.5
Arendt & Dick[a]	1995			5.7	0.29												
Beynnon et al.[a]	2005		1.9/PD														
Deitch et al.[b]	2006	17.3	4.3	1.6	0.4	22.5	4.4	4.7	1.2	2.6	0.7	2.8	0.7	1	0.3	2.4	0.6
Kofotolis&Kellis[b]	2007		1.12/Hr														
Mihata et al.[b]	2006			5.2	0.28												
Mountcastle et al.[a]	2007				0.39												
Trojian& Collins[b]	2006				0.45C 0.07AA												
Vauhnik et al.[b]	2011				0.037/Hr												

AE= athlete exposures; Hr= rate per 1,000 playing hours; RR= risk ratio; C= caucasian; AA= African American. [a] Any reported injury. [b] Time loss from any reportable injury.

Two studies in Table 3 found that ankle ligament sprains were the most common injury. When comparing the WNBA and NBA lateral ankle sprains were the most common specific diagnosis in both leagues (13% WNBA and 7% NBA) (Deitch, et al., 2006). Most studies in table 3 found that knee ligament tears were the second most common injury, especially injury to the ACL. When comparing male and female college basketball players, females have a higher rate of ACL injury than males (Mihata, Beutler & Boden, 2006). Arendt and Dick (1995) studied male and female soccer and basketball players and found an increased risk of ACL injuries to the females in both sports. Mountcastle, Posner, Kragh, & Taylor (2007) suggest that female basketball players are far more at risk for ACL injuries than their male counterparts.

Differences in ACL injury rates are only found in participants of specific sports as compared to the general college aged student population (Mountcastle et al., 2007). Another study reported that ACL rates in women's collegiate basketball was 0.28 per 1000 athlete exposures and the rates didn't decline at all throughout the 15 year study period (Mihata et al., 2006). For women's collegiate lacrosse, soccer, and basketball, ACL rates per 1000 athlete exposures were 0.18, 0.32, and 0.28 respectively (Mihata et al., 2006). A study looking at sportswomen in Slovenia found that basketball players had a higher ACL injury rate than team handball and volleyball players (0.090, 0.047, 0.019 respectively) (Vauhnik et al., 2011).

There has been an increase in number of stress fractures seen in female basketball players as well. Agel et al. (2007) found that women's collegiate basketball players commonly suffer from lower extremity stress fractures. The stress fracture injury rate increased from 0.10 per 1000 A-Es in 1988-89 to 0.19 per 1000 A-Es in 2003-04, which was a significant increase over time (Agel et al., 2007). The researchers believe that women's basketball players suffer from stress fractures due to the intensity and length of the season, with possibly too short of an offseason (Agel et al., 2007). The most common sites for stress fractures in women's collegiate basketball players are the foot (50%) and lower leg (39%) (Agel et al., 2007).

Another area of concern for female basketball players is head and neck injuries, especially as they relate to concussions. Concussion injury rate appears to have risen over the years for many different studies, but this could actually be due to the increased awareness of concussions versus the actual occurrence (Agel et al., 2007).

Time Loss

Time loss from injury is often viewed as an index of injury severity. There is considerable variation in the description of a time loss and severity of injury in basketball studies. Some researchers defined time loss through surgeries that were performed and others used days or weeks of time loss before returning to play (Agel et al., 2007; Arendt & Dick, 1995; Cumps et al., 2007; Deitch et al., 2006). One study considered "severe" injuries to be a result of a loss of participation for 7 or more days beyond injury (Agel et al., 2007). When looking at the ankle, a sprain was the most common injury that caused athletes to lose fewer than 7 sessions, and Achilles tendonitis was the most common injury which caused athletes to lose more than 7 sessions (Kofotolis & Kellis, 2007). Acute injuries of the knee resulted in the highest playing absence for basketball players in one study (Cumps et al., 2007).

Clinical Outcome

Recurrent injuries to the lower extremity are common in collegiate female basketball players. Agel et al. (2007) reported that 25% of all stress fractures were classified as recurrent injuries. Among NCAA women, players with a history of ankle injury were almost 5 times as likely to sustain another injury compared to those without previous history (Agel et al., 2007). Another study looking at ankle sprains found that 52.9% of the ankle sprains were re-injuries as opposed to new injuries (Cumps et al., 2007).

The National Center for Catastrophic Sport Injury Research (NCCSI) (2010) defines catastrophic injuries as those that result in brain/spinal cord injury or skull/spinal fracture. These catastrophic injuries are further sub-classified as fatalities, non-fatal (permanent severe functional disability), and serious (no permanent functional disability but severe injury). The NCCSI (2010) also classifies catastrophic injuries as direct (injuries which resulted directly from participation in the skills of the sport) or indirect injuries (caused by systemic failure as a result of exertion while participating in the sport or by a complication which was secondary to a non-fatal injury). The NCCSI (2010) reports that in collegiate women's basketball there have been no direct catastrophic injuries; however, they report a rate of 1.39 per 100,000 participants for indirect fatalities and 0.28 per 100,000 participants for serious injuries.

What Are the Risk Factors?

Intrinsic Factors

Gender

One study reported a significantly higher proportion of female ACL injuries versus males (24.4% vs. 10.5%) in basketball (Iwamoto, Takeda, Sato, & Matsumoto, 2008). White, Lee, Cutuk, Hargens & Pedowitz (2003) conducted a study which compared male and female collegiate basketball players on EMG strength and power readings of the quadriceps and hamstrings. The study showed that females had a significantly greater quadriceps co-activation ratio than the males for the knee flexion exercises. This increased quadriceps co-activation in females could increase the anterior tibial translation on the ACL during dynamic activities which puts the ACL at a higher risk of injury (White et al., 2003).

Dragoo et al. (2011) reported that Division 1 female athletes with ACL tears had a higher serum relaxin concentration (SRC) than the athletes without an ACL tear. The researchers also discovered that the athletes with an SRC greater than 6.0 pg/ml had over 4 times greater risk of ACL tear (Dragoo et al., 2011). Researchers explain that there is a long-term exposure effect and that athletes with higher levels of SRC experience increased activation of relaxin receptors on the ACL over time, which can ultimately lead to decreased ligament integrity and increased risk of ACL tear compared to those with no chronic exposure to relaxin (Dragoo et al., 2011). Female collegiate basketball players were also at a 25% increased risk of sustaining a grade I ankle sprain when compared to male collegiate basketball players (Kofotolis & Kellis, 2007).

Conditioning level.

De-conditioned athletes from the offseason may be at increased risk of injury earlier in the preseason and season from the increased intensity of training and practices while players are trying to earn starting positions (Agel et al., 2007). During the off-season some players may train on their own and this uncontrolled training environment (making their own decisions on surface, intensity, frequency, etc) may also lead to the increased risk of injuries in the preseason, especially stress fractures with the increase of intensity (Agel et al., 2007).

Strength differences in the lower extremity may also be a risk factor. Researchers evaluating overuse knee injuries among female athletes found that a decreased hamstring muscle endurance and strength relative to the quadriceps endurance and strength can be a predisposing risk factor to traumatic knee injuries (Devan, Pescatello, Faghri & Anderson, 2004).

Previous injury.

There is a paucity of research designed to test previous injury as a risk factor for new injury in women's basketball. In one study, ankle sprains accounted for most acute injuries and 52.9% of those who sustained an ankle sprain reported to have a previous history of ankle sprains (Cumps et al., 2007). Kofotolis and Kellis (2007) examined ankle injuries with a subject pool that consisted of 67.6% women with a history of previous ankle injury. Of these players, 17.4% sustained a new injury. Of the women who had no previous history of injuries, 12.5% sustained an ankle injury (Kofotolis & Kellis, 2007). A study involving recreational and elite basketball competitors reported that players with a history of ankle injury were almost five times (OR = 4.94) more likely to sustain an ankle injury (McKay et al., 2001).

Neuromuscular control.

There are multiple possible underlying factors that can lead to ACL injuries, but one of the most important may be neuromuscular control (Hewett et al., 2006). Neuromuscular control is considered to be a modifiable risk factor (Hewett et al., 2006). Using the Biodex Stability System, Rozzi et al. (1999) demonstrated that female athletes participating in collegiate basketball possess excessive knee joint laxity and proprioceptive deficits that may predispose them to ligament injuries. The excessive joint laxity of women appears to contribute to diminished joint proprioception, making their knees less sensitive to potentially damaging forces and possibly increasing risk for injury (Rozzi et al., 1999).

Webster and Gribble (2010) reported that collegiate female athletes participating in basketball, volleyball, and soccer who were approximately 2.5 years post ACL reconstruction (ACLR) demonstrated greater dynamic postural-control deficits as compared to their teammates. These deficits were determined by measuring the time to stabilization following a jump landing. The ACLR group took 2.01 ± 0.15 seconds to stabilize as compared to the control group 1.90 ± 0.07 seconds (Webster & Gribble, 2010). This result was associated with a large effect size and a 95% confidence interval that did not cross zero (Webster & Gribble, 2010). Another study looking at landing tasks found that elite women's basketball players showed significant asymmetry in their knee valgus angles while performing a bilateral jump landing as compared to volleyball players (Herrington, 2011). This study suggests that improper landing mechanics in basketball athletes may increase their risk for injury.

Researchers investigating balance as a risk factor for ankle injuries in high school basketball players found that the compilation of balance scores for subjects who sustained ankle sprains were significantly higher than the scores for subjects who didn't sustain an ankle injury (McGuine et al., 2000). The researchers pointed out that subjects with high-sway scores (poor balance) are predisposed to sustain more ankle injuries and subjects with low-sway scores (good balance) may be protected from ankle injuries (McGuine et al., 2000). Leanderson, Wykman, and Eriksson (1993) demonstrated that differences in postural sway between male adult basketball players who had injured an ankle compared to players with no history of previous ankle sprain. Even though the study found differences, the number of uninjured players was too low to allow statistical analysis of these postural sway differences (Leanderson et al., 1993).

A few studies have measured balance in female collegiate basketball players, but none of these tested balance as a possible risk factor (Sabin et al., 2010; Bressel et al., 2007). One study used the Star Excursion Balance Test (SEBT) and found that basketball players had a reduced reach score compared to a control group and an unstable surface SEBT was more complicated for the basketball athletes (Sabin, Ebersole, Martindale, Price, & Broglio, 2010). Bressel, Joshua, Kras, & Heath (2007) reported that female collegiate basketball players displayed inferior static balance compared to gymnasts and an inferior dynamic balance compared to soccer players with the use of both the Balance Error Scoring System (BESS) and the Star Excursion Balance Test (SEBT).

Race/ethnicity.

Trojian and Collins (2006) collected data to determine the difference in rate of ACL tears within the female professional basketball player population. The ACL tear rate for White European American players was 0.45 per 1000 athletic exposures, whereas for non-White European American players (African American, Hispanic, and Asian players) the rate was 0.07 (Trojian & Collins, 2006). White European American female basketball players were more than 6 times likely to tear their ACL than all the other ethnic groups combined (Trojian & Collins, 2006). Since the Trojian and Collins study (2006) was retrospective in design the researchers were unable to obtain all possible risk factors and therefore couldn't determine if proposed risk factors were different in each racial group. The researchers could only speculate that the difference between the two groups arose from differences in the intercondylar shelf angles (Trojian & Collins, 2006).

Extrinsic Factors

Playing position.

Meeuwisse et al. (2003) showed that centers had a significantly higher injury rate for the knee, ankle, and foot (rate ratio 13.0 (CI, 5.57-30.62), 4.5 (CI, 1.77-11.45), and 10.0 (CI, 3.06-32.65) respectively) as compared to other basketball positions on the court, especially forwards who had the lowest rate. This study was done looking at men's intercollegiate basketball players, but assumably can be applied to the female population as well.

Shoes.

McKay et al. (2001) found that basketball players wearing a more expensive shoe with air cells in the heel were 4.3 times more likely to injure their ankle than those wearing less expensive shoes (odds ratio 4.34, 95% CI 1.51-12.40). The researchers stated that it may be hypothesized that air cells located in the heels of basketball shoes decrease rear foot stability, which may increase the risk of injury, but further research is needed to explore this hypothesis (McKay et al., 2001).

Level of competition.

Injury rates differ by competition level within the collegiate setting. In collegiate basketball Division I players game injury rates (8.85 per 1000 AEs) were higher than Division II (7.43 per 1000 AEs, p=.01) and Division III players (6.62 per 1000 AEs, p< .01) (Agel et al., 2007). As the level of competition increases from scholastic to collegiate basketball so does the relative risk of suffering an ankle injury (Hosea et al., 2000; Kofotolis & Kellis, 2007). Waterman et al. (2011) determined that intercollegiate athletes, when compared with intramural athletes, (including basketball athletes) had significantly higher syndesmotic ankle sprain incidence rate ratios (IRRs) per 1000 person-years (20.95; 95% CI: 8.95-59.05) and per 100 000 athlete-exposures (2.41; 95% CI: 1.03-5.65). In this study, intercollegiate athletes, had a sevenfold increased incidence of medial ankle sprain (7.42 per 1000 person-years (95% CI: 3.12-17.64) compared to intramural athletes (Waterman et al., 2011).

What Are the Inciting Events?

There are three primary mechanisms for injury: player contact, other contact (balls, standards, floor, etc), and no contact (Agel et al., 2007). Most injuries occurring in NCAA women's basketball games were due to player contact (46%) (Agel et al., 2007). However, the majority of practice injuries did not involve contact (47%) (Agel et al., 2007). The majority of severe knee injuries (at least 10 consecutive days of restricted or loss of participation) were due to noncontact mechanisms, whereas most severe ankle ligament sprains were associated with player contact (Agel et al., 2007). Concussions were due mostly to contact injuries and accounted for 3.4% of all severe game injuries (Agel et al., 2007). Cumps et al. (2007) found that a contact mechanism is the major cause of acute injuries (69.2%) for both men and women's basketball study participants.

ACL injuries accounted for 8% of game injuries in women's collegiate basketball players (Agel et al., 2007). In games, 64% of injuries were associated with noncontact mechanisms, 27% from contact, and 8% from other non-player contact (Agel et al., 2007).

Most ankle sprains in professional basketball players were caused by a contact mechanism (Kofotolis & Kellis, 2007). Player contact accounted for 78.3% of contact ankle sprains and 56.3% of all ankle sprains (Kofotolis & Kellis, 2007). Of the noncontact ankle sprains, 77.7% occurred during landing or with a twisting and turning movement (Kofotolis & Kellis, 2007). Kofotolis and Kellis (2007) found that 45% of the ankle injuries in their study occurred when the participants landed on another player's foot or on the court surface.

Figure 1 provides a graphic representation of game and practice injury mechanisms for NCAA women's intercollegiate basketball players from the 1988-1989 season through the 2003-2004 season (Agel et al., 2007). The "other contact" variable is looking at when the athlete came in contact with items such as balls, standards, or the floor. Injury mechanisms were unavailable for only 1% of game injuries and 4% of practice injuries in the NCAA injury surveillance study (Agel et al., 2007).

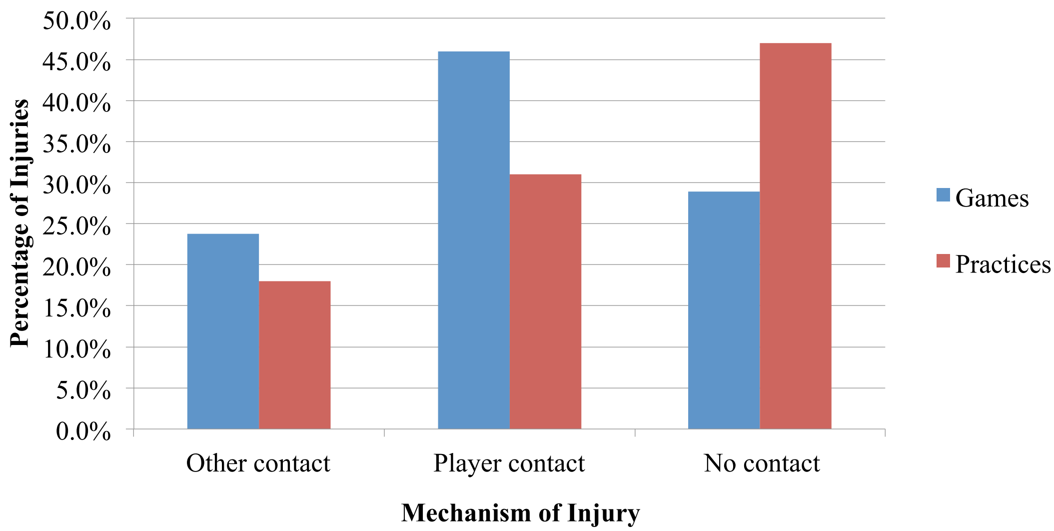

Figure 1. Game and practice injury mechanisms (Agel et al., 2007)

Injury Prevention

Table 4 gives a summary of studies that have tested measures to prevent injury in women's basketball. As the table shows, the studies examined proprioceptive/balance programs, a landing program, and also the use of ankle braces. All of the interventions resulted in a positive effect.

Table 4. Summary of injury prevention in the basketball population.

Study	Design	Sample	Sample Size	Intervention	Outcome
Eils, et al. (2010)	P; RCT	M/F Ages: 14-43	232	Multistation proprioceptive exercise program	Ankle inj. Sig. ↓ by 35%
Herrington (2010)	P	F adult Ages: 18-22	15	4 week jump training program	Distance jumped ↑ 73.6%, drop jump knee valgus angle ↓ (R 12.3°, L 9.8°), jump shot knee valgus angle ↓ (R 4.3°, L 4.5°)
Kofotolis& Kellis (2007)	P; Cohort	F Greek Pro	204	Documented use of ankle braces	Ankle Injuries: 9.82% wore brace, 22.9% didn't wear brace

Table 4. Cont.

Study	Design	Sample	Sample Size	Intervention	Outcome
McGuine et al. (2011)	P; RCT	M/F high school	1460	Lace-up ankle braces worn for one basketball season	Rate of ankle inj. (per 1000 basketball exposures): braced= 0.47 and control= 1.41
McGuine& Keene (2006)	R; RCT	M/F high school soccer &bball	765	5-phase balance training program	Balance training ↓ rate of ankle sprains by 38%
Paterno et al. (2004)	Pretest/ posttest design	F high school sports	41	6 week neuromuscular training program	Significant ↑ in single limb stability (P=.004) & anterior posterior stability (P=.001)

P= prospective; R= retrospective; RCT= randomized control trial; F= female; M=male

Further Research

Descriptive Research

There is a lack of descriptive epidemiologic research of injuries affecting the collegiate female population of basketball players. Much of the research reported on women's basketball has been retrospective in nature which relies on adequacy of records and is subject to recall bias. Also, there is a need for a more consistent definition of injury to be used with a time loss factor added to this definition. Previous research has estimated exposure time for the participants which lacks precision. Once research accurately collects exposure time of participants, a more reliable form of injury rates can be reported. Another consideration that should be examined further is the position that the athlete is playing when injuries occur. This could help determine if certain positions are at increased risk of injury.

Very little past research has actually differentiated between acute and overuse injuries. Knowledge of the relative frequency of acute vs. overuse injuries would help with analytical research as well and for testing risk factors. There have been few studies that actually provide information on the distribution of injuries by type. Also, there is a large variation in the description of time loss and injury severity throughout the research, which makes comparing studies difficult.

Analytical Research

More research needs to be done looking at the adult female population who participate in basketball, including the collegiate settings, to determine risk factors and possible injury prevention options (Hammig, Yang & Bensema, 2007). One possible risk factor is previous injury. However, few basketball studies have tested this risk factor. A detailed medical history would be beneficial in collegiate women's basketball population to help determine if previous history of injury is a risk factor for new or recurring injuries. Future research should be multi-directional in design so that it has a retrospective aspect to collect a detailed injury history and then data could be collected prospectively on injuries and exposure time. When collecting data on injuries, researchers should differentiate between acute and overuse injuries because these two different types of injuries could relate differently to risk factors.

Little research has been done studying whether or not the conditioning level of the basketball athlete could affect their risk of injury. Studies should try to determine if there are certain volumes of physical activity that can predispose an athlete to injury. If there is an amount of activity that is associated with an increased rate of injury, then guidelines could be put in place to help reduce these rates, especially chronic injuries (Gianoudis, Webster, & Cook, 2008).

Future studies should help us to further understand risk factors to try to prevent injuries from occurring. Some studies have measured balance in the women's basketball population, but haven't researched whether or not balance is actually a risk factor for injury. Studies should examine if neuromuscular control and balance training helps reduce the frequency of lower extremity injuries, especially ACL and ankle sprain injuries. A balance/postural sway test prior to season could be used to identify athletes who may be at increased risk of injuries and then preventative programs could be implemented for those that lack stability. Studies following up on female athletes' landing mechanics and muscle strength before their participation in sports are also recommended. This will help determine if serious knee injuries correlate with predisposing factors and if injury rates can be lowered with training.

Some extrinsic risk factors that should be further studied include player position and type of shoes worn. Little research has reported which basketball position is at greatest risk of injury. In fact, there are no analytical studies which provide this information for the collegiate women's basketball population. More research should also be done examining which type of shoes may be associated with a greater risk of injury (low top vs. high top, air cell vs. no air cell, etc).

CHAPTER III

METHOD

Participants

In this study all participants were women's NCAA intercollegiate basketball players from a Midwestern university. Informed consent was requested from each of the athletes. The athlete participants were also asked to give their written consent by signing a written consent form (see Appendix A). The written consent allowed the researcher to access information from subjects' medical files which are housed in the university's Sports Medicine department. This sample of participants is considered a convenience sample. The total number of participants was based on the number of female basketball players who agreed to participate in the study for the 2011-12 basketball season, and athletes who participated during the season of 2010-2011.

Study Design

This study used a multi-directional cohort design. The retrospective component is descriptive in nature and includes injuries which occurred during the 2010-11 season. The prospective component is both descriptive and analytical in nature and documents and analyzes injuries that occurred during the 2011-12 season. Medical and injury history, along with demographic information, were collected during baseline data collection on each of the participants prior to the onset of the 2011-12 season. Baseline data collection also included a balance and postural sway test for each participant using a Biodex Balance System. Injury surveillance was performed over the regular season and all injuries were recorded by means of direct interview using an injury report form. This included the documentation of both injury and exposure information. Once the season was over and injury surveillance completed, data were analyzed to determine the incidence and distribution of injury for both seasons. Additionally, selective risk factors were tested for predictability. A figure outlining the time for this study is provided below:

August	September	October-March	April-June
PPE Coach consent	Athlete consent Medical history form Baseline balance measure	Injury surveillance	Data analysis

Figure 2. Timeline for 2011-2012 season

Definitions

Injury

For the purposes of this study, a reportable injury is defined as one that occurred as a result of participation in intercollegiate basketball practice, training, or competition and met one or both of the following criteria (1) requires medical attention by the team certified athletic trainer or physician, and/or (2) results in restriction of participation or performance for one or more calendar days beyond the day of injury. Any dental injury occurring in an organized practice or game, regardless of time loss was also considered an injury (Dick, Agel, & Marshall, 2007). If an off day followed the day of injury, the athletic trainer assessed whether the injured athlete would have been able to participate.

Recurrent Injury

For the purpose of this study, a recurrent injury was defined as an injury of the same type and at the same site as the sustained injury and occurred after the player returned to full participation following the initial injury.

Exposure

A) A time exposure was defined as actual duration of activity in minutes and/or hours including practice, weight lifting, and competition

B) An athlete-exposure (A-E) was defined as one student-athlete participating in one practice, training, or competition in which she is exposed to the possibility of athletic injury, regardless of the time of that exposed participation (Dick et al., 2007).

Time Loss

Time loss was defined as the exact time, in days, between the original injury and the return to full participation in practice or competition. Time loss was categorized as follows: <1 day (minor), 1<7 days (mild), 7-21 days (moderate), and > 21 days (severe). The injuries that occurred in the "minor" category are injuries that were attended to by the athletic trainer, but the athlete was able to return to play or practice by the next exposure session.

Instruments

Pre-participation Examination

The pre-participation examination (PPE) was performed by the University of North Dakota's sports medicine staff and athletic training students. These forms can be found in Appendices C and D. Height was measured with a tape measure along the wall and weight was measured on a digital scale. Blood pressure was taken with a BP cuff and stethoscope. Vision was measured with the use of a vision chart. The flexibility measurements were measured with the use of a transparent plastic 12" goniometer. Use of a hydraulic hand dynamometer was used to determine grip strength.

Medical History Questionnaire

A copy of the medical history questionnaire is provided in Appendix E. This questionnaire was developed to query the athletes on injury history, particularly factors that might predispose to injury.

Injury Report Form

The injury report form (see Appendix F) is a modified version of the NCAA Injury Surveillance System injury report form (Dick et al., 2007). This modified version uses sections from the NCAA injury report form that identify the body part injured and also what type of injury has occurred. The injury report form provides information on the injury including the affected anatomical location, injury onset, injury mechanism, type of injury, timing of the injury, and time lost from the injury.

Exposure Report Form

The exposure report form is provided in Appendix G. This form was used every day that participants were exposed to risk of injury. The date was recorded along with the activity at time of injury whether it was weight lifting, practice, or competition.

Balance and Postural Sway Measurement

A baseline measurement for balance and postural sway was taken on each participant. This measurement required use of the Biodex Stability System Model 945-300 (Biodex Medical Systems; Shirley, New York).

Procedures

Pre-season

Approval of this study was obtained by the University of North Dakota Institutional Review Board. Consent to conduct the study was obtained from the women's basketball team head coach. Consent for participation was requested from each individual player. Each participant was asked to sign a consent form and Health Insurance Portability and Accountability Act (HIPAA) form which are found in Appendices A and B, respectively. These forms outlined the requirements of the study and also gave permission for the researcher to access participants' medical records and publish the information. All subjects' names were withheld from any published information.

Baseline data on each of the participants were collected during the pre-participation exams that were performed by personnel of the UND Sports Medicine department. All athletes filled out a short medical history questionnaire that included questions such as: Have you been previously hospitalized? Have you had surgery for any reason? Do you have asthma? Have you fainted or almost fainted during exercise/activity? Have you ever had a concussion or any other brain injury? Following completion of the medical history, study participants were given a series of tests/measurements that included: height, weight, BP, pulse, vision, flexibility, and strength. The flexibility measurements included ankle dorsiflexion, hip and hamstring range of motion, and quadriceps range of motion. The flexibility portion also included three different tests that tested range of motion: supine passive trunk rotation, Thomas test, and Obers test. The Thomas test examines hip and quadriceps range of motion, while

Obers test examines tightness of the iliotibial band. Strength tests that were performed were manual muscle tests of shoulder abduction, shoulder external rotation, supraspinatus, ilispoas, hamstrings, ankle eversion, and grip strength was also measured.

Whether the athlete was a first year or a returning player affected the extent of the PPE. First year athletes were required to take a more extensive PPE. All athletes were required to see a primary care sports medicine physician at the Grand Forks Family Medical Residency who looked over the PPE and performed additional tests before deciding if the athlete was able to participate in intercollegiate basketball. All of the physician notes were documented on the PPE forms.

Next, the researcher met with each individual athlete to oversee completion of the medical history questionnaire (Appendix E). The researcher remained present while the participants filled out the medical history questionnaire to ensure the form was completed correctly. The medical history questionnaire form asks questions related to the athletes' basketball experience and experience in other sports. It also includes a detailed series of questions designed to provide an in-depth description of the athlete's injury history. Another series of questions also queried the athlete about ankle supports, knee supports, type of shoes worn, and menstruation cycle status.

The balance and postural sway measurement was also taken during the preseason. This measurement was taken in the athletic training facility on the Biodex Balance System. The athlete stood barefoot on the platform while testing one foot at a time. The foot was placed in the center of the platform and the opposite leg not being tested was kept at 0° of hip flexion and about 90° of knee flexion. Their hands were placed on their hips. The participants were given 1 practice round for each foot for 20 seconds at level 4.

Then they completed 5 trials that lasted 20 seconds each at level 4. Their balance scores were recorded and an average balance index was calculated.

In-Season

An injury report form was developed (Appendix F) to record all injuries that took place during the competitive season. This form is a modification of the form used by the NCAA Injury Surveillance System. A summary of information that was collected in the injury report form is included below:

- Age
- Athletes position played
- Type of supports used: ankle, knee, orthotics
- Type of shoe worn
- Date of injury onset
- Date of return to full participation
- When injury occurred: practice, competition, weightlifting
- Timing of injury: first half, second half, other
- Location injury occurred: lane, key area, other
- Chronic or acute
- Type of mechanism: contact, non-contact, other and then specify
- Did the injury occur: with a specific skill, a foul called, while playing offense/defense
- Is this a recurrence of a previous injury, if so, when did athlete return to play

The injury report form not only gave a good background of the athlete and the injury, it also discussed what the injury was. Next there were a series of questions outlining the injury itself. Questions included:

- Body part injured
- Primary type of injury
- Does in the injury require surgery, if so, describe the surgery
- Best assessment procedure for the injury
- Progression of return to play (with dates)

Injury information was documented daily as needed by the athletic trainer for the women's basketball team. Any pain or injury that was reported by the athlete to the athletic trainer requiring attention was documented. The athletic trainer/principal investigator continued to follow up with injured athletes daily and documented their progress until their return to full participation. Once the injured athlete returned to full participation the injury report was filed.

Exposure time was also recorded by the athletic trainer on a daily basis, including each weight lifting, practice and game session. This weekly log recorded minutes and/or hours of participation for each of the athletes. The researcher recorded the time practice and lifting sessions began and then recorded their end time. The table was also filled out for games and each of the individual athletes' exposure times was recorded. In the column titled "missing-reason" the researcher recorded why the athlete wasn't there, such as: injury, illness, exam, etc. This information was used to determine the individual and total time that athletes were exposed to risk of injury.

During games, the number of minutes per player was collected from the official website of UND athletics, www.fightingsioux.com. On the website, the official game statistics were posted and included total minutes each player played for each game and also a season total of minutes played in competition.

Data Analysis

At the conclusion of the regular competitive season, all descriptive data were compiled and entered into an Excel spreadsheet.

Descriptive Data Analysis

Injury rate was calculated by dividing the total number of injuries sustained collectively by the total number of hours and/or minutes exposed collectively, then multiplying this number by 1000. This approach yields an injury rate per 1000 hours exposure and an injury rate per 1000 minutes exposure. The injury rate was calculated for competition, practice, weight lifting, and total exposure. A comparison was made between competition, practice, and weight lifting to determine if a player was more at risk for injury during a specific type of play. Injury rates were also calculated for each position. A comparison was made between centers, forwards, and guards to determine which position was more at risk for injury. In addition to injury rates, the distribution (e.g. anatomical location, injury type, injury severity) of injury was calculated. The number, percentage, and rate of injuries were determined with simple mathematical calculations.

In order to compare results with previous NCAA injury reports, collective injury rates were also calculated with reference to 1000 Athletic-Exposures (AEs). One AE is one athlete participating in one practice or competition.

Risk Factor Analysis

Due to multiple injuries in some players, Poisson regression models were fitted using generalized estimating equations (GEE) (Hanley, Negassa, Edwardes, & Forrester, 2003). The basketball players' individual injury rates were used as outcome variables. Predictor variables included stability, previous injury history (last year), previous injury history (ever), event, and player position. Each of these predictors were entered separately in an unadjusted model to estimate injury rate ratios (IRR's) for each risk factor. Unadjusted rate ratios (and associated confidence intervals) were estimated with each risk factor. For adjusted rate ratios, a multiple-Poisson regression was used using the following five risk factors: stability, previous injury history in the last year, previous injury history at any point, type of event (practice, weight lifting, competition), and player position.

The Poisson regression procedures in statistical package R (v. 2.14.1) was used to compute the IRR's in both the unadjusted and adjusted analysis (R Development Core Team, 2011).

CHAPTER IV

RESULTS

Demographic Information

Baseline data collection began on October 1, 2011, prior to the first regular season practice of the season. All 15 athletes for the 2011-12 basketball season agreed to participate in this study and completed an injury history questionnaire, along with signing the informed consent and HIPAA forms. All athletes participating in the 2011-12 season also granted access to their injury data from the 2010-11 season.

During the 2010-11 season, there were a total of 15 participants including 10 players who participated with UND women's program during both the 2010-11 and 2011-12 seasons. All 15 participants signed the informed consent and HIPAA forms. During the 2010-11 season, there were also 10 returning players and 5 newcomers. Table 5 gives a summary of the study participants each season.

Table 5. Summary of Study's Participants

Year	Total #	# of Returners	# of Newcomers
2011-2012	15	10	5
2010-2011	15	10	5

Table 6 summarizes the 2011-12 participants' demographic information including their age, height, and weight measurements.

Table 6. 2011-12 Participants Anthropometric Data

Variable	Mean	Range	Standard Deviation
Age (years)	19.13	18-21	1.02
Height (inches)	69.67	65-76.5	3.33
Weight (pounds)	160.53	132-259	29.99

Frequency and Incidence of Injury

During the 2011-12 season, 12 of 15 players were injured and accumulated a total of 35 injuries. Table 7 provides a summary of injuries sustained during the 2011-12 season. As shown in Table 7, 3 players remained uninjured throughout the season, 9 players incurred from 1-3 injuries, and 3 players reported from 4-6 injuries.

Table 7. Number of Injuries Per Number of Players During 2011-12 Season

# of injuries	0	1	2	3	4	5	6
# of players	3	3	1	5	1	1	1

The exposure and injury rate data for the 2011-2012 season are summarized in Table 8. The overall injury rates were 11.25 injuries per 1000 hrs and 13.29 injuries/1000 AE's.

Table 8. Total Team Exposures and Injury Rates for 2011-2012 Season (n = 15 players)

Training Type	# of injuries	Total Minutes	Total Hours	Total AEs	IR/1000 Mins	IR/1000 Hrs	IR/1000 AE's
Game	7	6563	109.39	364	1.07	63.99	19.23
Practice	24	161350	2689.17	1761	0.15	8.92	13.63
Weight lifting	4	18675	311.23	509	0.21	12.85	7.86
Total	35	186588	3109.79	2634	0.19	11.25	13.29

Along with the current season, the participants past history was accessed by the primary investigator and the health records were reviewed to find out how many injuries occurred during the previous season for each participant. During the 2010-11 season, 11 of 15 participants were injured and accumulated a total of 27 injuries. The exposure and injury rate data for the 2010-11 season are summarized in Table 9. The hours of practice and weight lifting exposure were estimated using the schedule from the previous season that were available to the athletic trainer, and the game exposures were accessed on the University's athletics website, fightingsioux.com. During the 2010-11 season the overall injury rates were 14.34 injuries per 1000 hrs and 16.76 injuries per 1000 AE's.

Table 9. Total Team Exposures and Injury Rates for 2010-2011 Season (n = 15 players)

Training Type	# of injuries	Total Minutes	Total Hours	Total AEs	IR/1000 Mins	IR/1000 Hrs	IR/1000 AE's
Game	9	4608	76.8	258	1.95	117.19	34.88
Practice	13	N/A	1611	1068	N/A	8.07	12.17
Weight lifting	5	N/A	195	285	N/A	25.64	17.54
Total	27	N/A	1882.8	1611	N/A	14.34	16.76

Who is Affected

Tables 10 and 11 show the injury rates by position for both the 2011-12 and 2010-11 seasons respectively. During the 2011-12 season (Table 10) guards received the greatest number of injuries. However, when injury rates were calculated the centers had the highest rate of injuries followed by forwards, then guards.

Table 10. Injury Rates by Playing Position for 2011-2012 Season

Who	# of injuries	Total Minutes	Total Hours	Total AEs	IR/1000 Mins	IR/1000 Hrs	IR/1000 AE's
Guards	16	112574	1876.21	1579	0.14	8.53	10.13
Forwards	10	48104	801.75	682	0.21	12.47	14.66
Centers	9	25910	431.83	373	0.35	20.84	24.13

For the 2010-11 season estimated injury rates were calculated for hours exposure and athlete-exposures. Perusal of Table 11 (2010-11) reveals that the forwards incurred the most injuries, followed by guards, then centers. The injury rates were also greatest for forwards, followed by centers, then guards.

Table 11. Injury Rates by Playing Position for 2010-2011 Season

Who	# of injuries	Total Hours	Total AEs	IR/1000 Hrs	IR/1000 AE's
Guards	10	1282.2	1090	7.80	9.17
Forwards	12	826.33	711	14.52	16.88
Centers	5	392.47	321	12.74	15.58

Where

Anatomical Location

Table 12 displays the distribution of injury by anatomical location for both the 2011-12 and 2010-11 seasons. In the 2011-12 season, 63% of injuries that occurred involved the lower extremities. The most frequent injury site was the ankle followed by the knee and foot. In the 2010-11 season, 63% of the injuries sustained also involved the lower extremity with the ankle again being the most frequent injury site followed by the hip/groin, hand/fingers, upper leg, and knee/patella (11.11% each).

Table 12. Anatomical Location of Injuries for 2011-2012 and 2010-2011 Seasons

	2011-2012 Season		2010-2011 Season	
Location	# of Injuries	% of Injuries	# of Injuries	% of Injuries
Head	1	2.86	1	3.70
Face	2	5.71	2	7.41
Shoulder	2	5.71	1	3.70
Elbow/Upper arm	1	2.86	1	3.70
Hand/Fingers	5	14.29	3	11.11
Back/Sacrum	2	5.71	2	7.41
Hip/Groin	1	2.86	3	11.11
Upper leg	1	2.86	3	11.11
Knee/Patella	6	17.14	3	11.11
Ankle	8	22.86	6	22.22
Foot	6	17.14	2	7.41
Total	35	100	27	99.99

Environmental Location

Injuries occurred in practice, competition and during weight training. Tables 8 and 9 show injury rates for each training session in minutes, hours and athlete exposures for the two seasons. The injury rates for the 2011-2012 season (table 8) were highest in games (63.99 per 1000 hours; 19.23 per 1000 AEs) followed by either weight lifting or practice depending on how rates were calculated. Table 9 shows that for the 2010-2011 season injury rates were also highest during competition, followed by weight lifting and then practice whether calculated per 1000 hours or per 1000 AEs.

Another way to classify where injuries occur is by their location on the court. Of the 35 injuries reported in the 2011-2012 season 13 (37%) of the injuries occurred within the lane, 1 (3%) injury occurred in the key area, while 9 (26%) other injuries occurred in other locations of the court. There were 12 (34%) injuries where court location was unknown due to pain gradually occurring over a period of time.

When

Injury onset refers to whether an injury was acute or overuse. Of the 35 injuries reported in the 2011-2012 season 21 (60%) were acute and 14 (40%) were overuse. Another way to classify when an injury occurred is by the part of a practice or game when it occurred. During the 2011-2012 season, the timing of injury was unknown in 15 of the 35 injuries. Of the known, 11 injuries occurred during the second half of practice and 6 injuries occurred during the second half of competition.

Injury Outcome

Type.

Table 13 shows the percent distribution of injury by injury type that occurred during the 2011-2012 and 2010-2011 seasons. Non-specific pain included any type of soreness, or pain in an area that was described, but wasn't assessed as anything more than pain (e.g., metatarsalgia and patellofemoral pain syndrome). The inflammation row includes any injuries that were characterized by inflammation (e.g., tendonitis, synovitis, fasciitis). In the 2011-2012 season the most frequent injury type was ligament sprain (31.4%), followed by pain (20%). The 2010-2011 season's most frequent injury type was muscle/tendon strain (25.93%) followed by sprains and inflammation (22.22% each).

Table 13. Descriptive Statistics on Injury Types in 2011-2012 and 2010-2011 Seasons

	2011-2012 Season		2010-2011 Season	
Injury Type	# of Injuries	% of Injuries	# of Injuries	% of Injuries
Concussion	1	2.86	1	3.70
Fracture	1	2.86	0	0
Contusion	6	17.14	3	11.11
Torn Cartilage	1	2.86	0	0
Sprain	11	31.43	6	22.22
Strain	3	8.57	7	25.93
Inflammation	5	14.29	6	22.22
Pain	7	20	0	0
Herniation	0	0	1	3.70
Dislocation	0	0	1	3.70
Laceration	0	0	2	7.41
Total	35	100.01	27	99.99

Time loss.

For this study, time loss was defined as the exact time, in days, between the original injury and return to full participation in practice or competition. Time loss was categorized as followed: <1 day (minor), 1-6 days (mild), 7-21 days (moderate), and > 21 days (severe). Injuries that occurred in the "minor" category were injuries attended to by the athletic trainer, but the athlete was able to return to play or practice by the next exposure session. Table 14 shows a percent comparison of time loss associated with each of the categories in both the 2011-2012 and 2010-2011 seasons. As shown in Table 14 the majority of injuries sustained during both years were considered minor.

Table 14. Time Loss due to Injury in 2011-2012 and 2010-2011 Seasons

	2011-2012 Season		2010-2011 Season	
Time Loss	Number	Percent	Number	Percent
<1 day	28	80	20	74.07
1-6 days	5	14.29	5	18.52
7-21 days	1	2.86	1	3.70
>21 days	1	2.86	1	3.70
Total	35	100.01	27	99.99

This time loss definition only included the time of injury during the in season. There were other injuries, time loss, and surgery that occurred outside of the regular season; however, these were not included in this report.

Clinical Outcome

Recurrent injuries.

Out of the 35 injuries sustained in 2011-2012 season, 13 (37%) were recurrent injuries. Four of these injuries (31%) were recurrent ankle sprains. Other injuries included in the recurrent category were 2 low back strains, 2 shoulder tendonitis, 2 knee tendonitis, 1 thumb sprain, 1 torn knee cartilage, and 1 knee contusion.

Surgical injuries.

In 2011-2012 there was one surgical injury case that occurred during the season, but didn’t require surgery until the post season. The knee meniscus tear injury was a recurrent injury from the previous season which was surgically repaired in the summer of 2011. During the 2011-2012 season the same athlete reinjured her meniscus, but was able to conservatively treat the injury until the season was over. This athlete had a menisectomy in the post-season.

There were also a few surgical cases that occurred around the 2010-2011 season. An ACL injury that occurred during the preseason of 2010-2011 caused the athlete to have surgery to repair her ACL. This surgery was her third ACL repair and the athlete decided to end her career after this injury. She didn't return to participation during the 2010-2011 regular season, but was still on the team's roster.

During the 2010-2011 season one athlete had a minidiscetomy due to herniation and was able to return to play later in the season, but at the end of season she required a second surgery to repair another herniated disc. This was a career ending condition for that participant.

Inciting Events

Injuries were categorized as contact, non contact, or an unknown mechanism. In the 2011-2012 season 17 (49%) injuries were due to contact, 11 (31%) injuries were non-contact, and the remaining 7 (20%) injuries had an unknown mechanism.

Risk Factor Analysis

Risk factors of interest in this study included average balance/stability, previous history of the same injury to the same location last year, previous history of injury to the same location ever, activity at time of injury (practice, competition, weight lifting) and player position at time of injury (guard, center, forward). Each of these predictors were entered separately into the Poisson regression model to estimate unadjusted IRR's. For adjusted rate ratios a multiple-Poisson regression was used. The Poisson regression model was fitted using general estimating equations to estimate incidence rate ratios (Hanley et al., 2003). Any risk factor that had a p-value of $< .05$ was considered statistically significant.

Table 15 shows both the unadjusted and adjusted results of the Poisson regression and identifies the injury rate ratio (IRR) per 1000 hours training for each risk factor.

Unadjusted results indicate significant results for previous history last year (IRR 2.71; 95% CI = 0.28; 5.15; p = 0.0234), previous history ever (IRR 3.16; 95% CI = 0.64, 5.68; p = 0.0109), for weight lifting (relative to practice) (IRR 4.13; 95% CI = 1.94, 6.32; p = 0.0001), and for the center (IRR 4.34; 95% CI = 1.18, 7.43; p = 0.0052) and forward (IRR 7.83; 95% CI = 4.8, 10.86; p < 0.0001) positions with the guard position used as a referent. However, only weight-lifting remained significant in the adjusted analyses (IRR 4.51; 95% CI = 2.10, 6.92; p = 0.0001).

Table 15. Risk Factor Analysis of Injury Rate Ratios (IRRs) per 1000 Hours

	Unadjusted			Adjusted		
Risk Factor	IRR	95% CI	P value	IRR	95% CI	P value
Stability Average	-1.25	-4.12, 1.61	0.3741	-3.33	-12.67, 6.01	0.4685
Prev. History Last Year			0.0234			0.5965
No	Referent			Referent		
Yes	2.71	0.28,5.15		-1.61	-7.79, 4.57	
Prev. History Ever			0.0109			0.2779
No	Referent			Referent		
Yes	3.16	0.64, 5.68		3.06	-2.67, 8.80	
Event						
Practice	Referent			Referent		
Competition	2.01	-0.60, 4.61	0.1170	-0.84	-7.06, 5.38	0.7840
Weights	4.13	1.94, 6.32	0.0001	4.51	2.10, 6.92	0.0001
Position						
Guard	Referent			Referent		
Center	4.30	1.18, 7.43	0.0052	5.82	-0.55, 12.18	0.0632
Forward	7.83	4.80, 10.86	<0.0001	12.91	-2.11, 27.92	0.0806

Table 16 shows both the unadjusted and adjusted results of the Poisson regression and identifies the injury rate ratio (IRR) per 1000 AE's. A review of this table shows that the univariate analyses resulted in a significant effect for only two variables: previous history ever (IRR 0.81; 95% CI: 0.01, 1.60; p = 0.0386) and the center position (IRR 1.20; CI: 0.64, 1.76; p < 0.0001) when guard was used as a referent. None of the variables remained significant in the multivariate analyses.

Table 16. Risk Factor Analysis of Injury Rate Ratios (IRRs) per 1000 AEs

	Unadjusted			Adjusted		
Risk Factor	IRR	95% CI	P value	IRR	95% CI	P value
Stability Average	-0.58	-1.47, 0.31	0.1870	-2.09	-6.04, 1.87	0.2831
Prev. History Last Year			0.2659			0.2824
No	Referent			Referent		
Yes	0.59	-0.49, 1.69		1.03	-0.92, 2.99	
Prev. History Ever			0.0386			0.2413
No	Referent			Referent		
Yes	0.81	0.01, 1.60		1.11	-0.81, 3.04	
Event						
Practice	Referent			Referent		
Competition	-0.47	-1.26, 0.32	0.2249	0.96	-1.57, 3.50	0.4399
Weights	-0.35	-1.13, 0.44	0.3726	0.47	-2.36, 3.30	0.7344
Position						
Guard	Referent			Referent		
Center	1.20	0.64, 1.76	<0.0001	0.96	-1.01, 2.92	0.3227
Forward	1.06	-1.16, 3.28	0.3321	4.64	-5.14, 14.41	0.3348

A follow up analysis was done examining whether or not stability was a significant risk factor for lower extremity injuries alone. For this analysis an unadjusted simple Poisson regression was performed using the matched stability against only lower limb injuries. Matched stability simply means if the injury took place on the right side the stability for the right leg was used and vice versa for the left side. The injury rate ratio was determined for both 1000 hours exposure and 1000 athlete exposures. The IRR per 1000 hours was statistically significant, 1.00 (95% CI: 0.10, 1.90; p-value 0.0211) and the IRR per 1000 AEs was not statistically significant, -0.17 (9% CI: -0.70, 0.35; p-value 0.4857).

CHAPTER V

DISCUSSION

Descriptive Analysis

Incidence of Injury

Table 17 shows a comparison of injury rates between this study and previously published studies involving adult female basketball injuries. Injury rates for this study were reported for both the 2010-11 and 2011-12 seasons. When combining both seasons the total number of injuries becomes 62, injury rate per 1000 hours 12.42, and injury rate per 1000 AEs 14.61. This study is the first study of injuries affecting collegiate female basketball players to report injury rates with reference to both 1000 hours and athlete exposures. Additionally, our rates were reported on the basis of actual time exposed rather than estimated time exposed which helps to assure the precision of the rates reported.

As shown in Table 17, only two other studies used a college female population and only one of these studies (Arendt & Dick, 1995) reported an overall injury rate. However, Arendt & Dick's (1995) injury definition required at least one day of time loss to be included in their results. The current study's injury rates were higher than that reported by Arendt & Dick (1995), perhaps in part due to the differences in definition of injury. The difference could also reflect the fact that the study and had both a retrospective and prospective component as compared to Arendt & Dick (1995) study which was retrospective in nature. The higher injury rates might also reflect the more precise approach of the current study to recording injuries and the use of actual time exposed.

Table 17. Overall Injury Rates in Female Adult Basketball Population

Study	Design	Duration	Sample	# of Injuries	Per 1,000 Hr	Per 1,000 AE
Agel et al. (2007)	R	16 years	College	2,468		7.68[a] game 3.99[a] practice
Arendt & Dick (1995)	R	5 years	College	3,305	5.16[a]	
Cumps et al. (2007)	P	1 season	Adult	98	13.9[a]	
Deitch et al. (2006)	R	6 seasons	WNBA	1,570		24.9[b]
McKay et al. (2001)	P	17 months	Adult	127	23.0[b] elite 25.7[b] rec	23.0[b] elite 17.2[b] rec
THIS STUDY	R	2010-11 season	College	35	14.34	13.29
THIS STUDY	P	2011-12 season	College	27	11.25	16.76

AE= athlete exposure; P= prospective; R= retrospective; [a] Any reported injury. [b] Time loss from reported injury. WNBA= Women's National Basketball Association.

Who is Affected

In this study, the centers and forwards had the highest rates of injury in both years, followed by guards. These results are in contrast to Kostopoulos and Dimitrios (2010) who reported that basketball guards are at the highest risk of injury. However, Kostopoulos and Dimitrios (2010) used a time loss injury definition which may cause the difference seen in injury rates. One other possible reason for guards to have the lowest injury rate in this study could be their experience and age level. Centers and forwards also tend to play more of the game within the lane and closer to the lane than do guards. This may expose them to more contact from other players.

Where Injury Occurs

Anatomical location.

Table 18 shows the percent comparison by anatomical location for previous published studies and this study. Like the other studies in this table, the current study identified the lower extremity as the most common anatomical location for injuries (63% during 2011-12 and 62.9% during 2010-11). This finding is not unexpected given the jumping, sprinting, and agile movements that are required in basketball. This results in an increased amount of loading on the lower extremity muscles and joints.

This study found that the upper extremity was the second most common anatomical location for injuries which was similar to the results reported by Deitch et al. (2006) and Stergioulas et al. (2007). The main reason for the upper extremity to be the second most common location for injury in this study is due primarily to the finger sprains that occurred.

In the current study, there is a relatively low percent of head and neck injuries compared to the previous studies. It is unknown why the frequency of head and neck injuries in this study is low compared to previous studies.

Table 18. A Percent Summary of Injury by Anatomical location

Study	Head/Neck %	Spine/Pelvis %	Upper Limb %	Lower Limb %	Other %
Agel et al. (2007)	14.7	7.4	14.1	60.8	3.0
Deitch et al. (2006)	15.4	6.1	19.2	58.7	0.5
McKay et al. (2001)	23.7	6.3	23.2	46.8	
Stergioulas et al. (2007)	9.3	16.3	19.3	50.4	4.7
THIS STUDY 2010-11	3.7	7.4	18.5	63.0	7.4
THIS STUDY 2011-12	2.9	5.7	22.9	62.9	5.7

Environmental location.

Location on the court.

Few previous studies examined where the injuries take place on the court. Two studies report that the lane and key areas were host to most injuries (Agel et al., 2007 and Kofotolis & Kellis, 2007). In this study, 37% of the injuries sustained in the 2011-2012 season occurred within the lane. Another 3% of injuries occurred in the key area (which includes the lane and inside the 3 point line) and 26% occurred somewhere else on the court. The location of the remaining 34% of injuries was unknown. The findings from the current study support the conclusion by Agel et al. (2007) that more injuries occur in the lane. This finding could be due to the amount of time (i.e., exposure to risk of injury) spent within the lane since there's a need to score the most points and the lane leads the athletes right to the basket.

Competition versus training.

This study's results showed that injury rates for games were much higher in both the 2010-11 and 2011-12 seasons than weight lifting and practice. The results indicated much higher injury rates for games than did Agel et al. (2007) which could be due to the differences in injury definitions, as Agel et al. (2007) required a time loss for the injury to be included in the results. It is likely as Agel et al. (2007) suggest that a reason for increased injury rates in competition could be due to the increased intensity levels during a game as compared to practices.

The second highest injury rate when reported per 1000 hours was weight lifting for both seasons (2010-11 & 2011-12). Previous studies haven't reported injuries that occur solely from weight lifting. Since this current study is first to report injury rates for weight lifting it can only be speculated why injury rates were so high during this activity. It could be that improper technique and form were being used. Another thought is that the weight lifting sessions during the season take place after practice sessions which typically lasted between 1.5-2 hours. Injury may relate to fatigue from practice.

When Does Injury Occur

Injury onset.

Two previous studies have differentiated between acute and overuse injuries (Cumps et al., 2007; Deitch et al., 2006). These studies reported that overuse injuries accounted for 12.8% (Cumps et al., 2007) and 37.7% (Deitch et al., 2006) of all injuries, respectively. The current study found that in the 2011-12 season 21 of the 35 injuries reported (60%) were acute and 14 injuries (40%) were overuse. This distinction between overuse and acute injuries is important and should be considered in future research studies since the impact of risk factors may vary according to injury onset.

Chronometry.

Another way to classify when an injury occurs is during time of a practice or game. Few studies have distinguished when the injury actually occurred during an activity. Agel et al. (2007) reported that injuries occurred with greater frequency during the second half of practices or games. This study found that the timing of injury was unknown in 15 of 35 injuries (43%), but 11 practice injuries were during the second half along with 6 injuries during competition. Stergioulas et al. (2007) explains that a possible reason for the increase of injuries during the second half of competition could be due to muscular fatigue, which begins to affect the athletes' performance and mechanics.

An increase in injuries during the second half of basketball practice is likely due to increase intensity of play towards the end of practice. Typically, practices started out with drills working on mechanics and running through plays, but the second half includes more intense drills and scrimmaging. The combination of both increased intensity at the end of practice and possible fatigue at that time may predispose the athlete to an increased risk of injury.

What is the Outcome

Injury type.

Table 19 compares the distribution of injury rates by injury type with previous research. Perusal of table 19 summarizes injury rates for different locations and types of injuries. The current study appears to have higher injury rates per 1000 AEs for ankle ligament sprains, and patella/patellar ligament injuries compared with previous studies. This could be due to the precise measure of exposure time and also the current study's lack of a time loss factor within the injury definition.

This study found that the most frequent injury type in 2011-12 season was a ligament sprain. Of the 11 sprains, 7 were to the ankle, and 2 to both the thumb and fingers. Deitch et al. (2006) also reported that lateral ankle sprains were the most common injury in both the NBA and WNBA. The second most frequent injury for the 2011-12 season found in this study was pain. This pain category included: metatarsalgia and patellofemoral pain syndrome. There were 5 cases of metatarsalgia reported during the 2011-12 season, all of which were new injuries. The possible explanation for the foot pain may be type of shoe. Four of the five athletes who experienced foot pain wore the team basketball shoe, which did not provide good support or stability. The one athlete who had foot pain, but didn't wear the team shoe had recently purchased new orthotics and basketball shoes, and didn't gradually adjust her feet into their new surroundings. This may have caused her foot pain. There was also one foot fracture reported during the 2011-12 season. The athlete did not have a previous history of foot problems and it is believed that the type of team basketball shoe she was wearing could have precipitated the fracture.

During the data collection period of this study no ACL injuries occurred; although one athlete who was a part of the team in 2010-11 season wasn't able to participate and her career ended after going through her third ACL reconstruction in the preseason of the 2010-11 season. Unfortunately, an ACL prevention program was not implemented for the 2011-12 basketball team.

During the injury surveillance period for the prospective study, only one fracture was reported. No other fractures or stress fractures were observed, but there is a previous history of stress fractures reported for some of the participants.

Another area of concern for female basketball players has been head injuries, mainly concussions. Agel et al. (2007) reported that concussion injury rates have risen over the years. The current study reported only 2 concussions, with one occurring in each of the 2010-11 and 2011-12 seasons.

Time loss.

For this study, time loss was defined as the exact time, in days, between the original injury and the return to full participation in practice or competition. The most common time loss for this study was <1 day which were considered minor injuries. These were only injuries that occurred during the in season. There were other injuries with greater time loss that occurred outside of the in season and were not included in these data. It is hard to compare this study's results with others due to the variety of time loss definitions. Some researchers defined time loss through surgeries that were performed and others used days or weeks of time loss before returning to play (Agel et al., 2007; Arendt & Dick, 1995; Cumps et al., 2007; Deitch et al., 2006).

Table 19. Frequency and Rates for Common Location-By-Type Injuries for Female Basketball Athletes

		Ankle Ligament Sprain		Knee Internal Derangement		Knee		Patella or Patellar Tendon		Upper-Leg Contusion		Lower Back Strain		Nose-Fracture		Head-Concussion	
		%	Per 1,000 AEs	%	Per 1,000 AEs	%	Per 1,000 AEs	%	Per 1000 AEs	%	Per 1000 AEs	%	Per 1000 AEs	%	Per 1000 AEs	%	Per 1000 AEs
Agel et al.[a]	2005				0.20-0.37												
Agel et al.[a]	2007	24.6	1.9	15.9	1.2			2.4	0.2	1.7	0.1	1.3	0.1	1.7	0.1	6.5	0.5
Arendt & Dick[a]	1995			5.7	0.29												
Beynnon et al.[a]	2005		1.9/PD														
Deitch et al.[b]	2006	17.3	4.3	1.6	0.4	22.5	4.4	4.7	1.2	2.6	0.7	2.8	0.7	1	0.3	2.4	0.6
Kofotolis&Kellis[b]	2007		1.12/Hr														
Mihata et al.[b]	2006			5.2	0.28												
Mountcastle et al.[a]	2007				0.39												
Trojian& Collins[b]	2006				0.45C 0.07AA												
Vauhnik et al.[b]	2011				0.037/Hr												
This Study [a]	10-11	14.8	2.5	0	0	3.7	0.6	7.4	1.2	0	0	3.7	0.6	0	0	3.7	0.6
This Study [a]	11-12	20	2.66	0	0	2.9	0.4	14.3	1.9	2.9	0.4	5.7	0.8	0	0	2.9	0.4

AE= athlete exposures; Hr= rate per 1,000 playing hours; RR= risk ratio; C= caucasian; AA= African American. [a] Any reported injury. [b] Time loss from any reportable injury

Clinical outcome.

Recurrent injuries.

Thirteen (37%) of the injuries sustained during the 2011-12 season were recurrent injuries. Four of the seven ankle sprains that occurred during this season were classified as recurrent injuries (57%). This finding is similar to Cumps et al. (2007) who found that 52.9% of the ankle sprains were re-injuries. These findings suggest that implementation of preventative programs should be considered especially with athletes who have a previous history of ankle sprains. In conjunction with a preventative program, ankle braces or tape jobs could be utilized to help support the ankle during activities. Other injuries reported in the current study that were considered recurrent injuries were 2 low back strains, 2 shoulder tendonitis, 2 knee tendonitis, 1 thumb sprain, 1 torn knee cartilage, and 1 knee contusion.

Inciting events.

In the present study, injuries were categorized as contact, non contact, or an unknown mechanism. During the 2011-2012 season almost half of the (49%) injuries were due to contact. During that same season 11 (31%) injuries had a non contact mechanism, and the remaining 7 (20%) injuries had an unknown mechanism. The seven ankle sprains reported in 2011-12 were categorized as 3 due to contact, 3 non contact mechanisms, and 1 unknown cause. Kofotolis & Kellis (2007) stated that most ankle sprains in professional basketball were due to contact, and more specifically player contact. More studies need to collect data on whether or not the injury sustained was due to contact or no contact. The different mechanisms of injury can be caused by different risk factors. Knowledge of what mechanism caused injury will help determine the different possible risk factors.

Risk Factor Analysis

The risk factor analysis for this study used Poisson regression models that were fitted using general estimating equations. The results of simple Poisson regression for individual injury rates per 1000 hours of exposure showed that previous history within the last year, previous history ever, weight lifting, center position, and forward position all were significant risk factors. However, only weight lifting remained significant in the adjusted analyses.

The finding of weight lifting being a significant risk factor is different than the descriptive results of this study which found that competition had the highest rate of injuries. A possible reason that weight lifting remained significant in the multivariate risk factor analysis is that the athletes that got hurt during weight lifting had also suffered other injuries throughout the season; which causes the Poisson regression to be fitting to a high rate of injury for just a few individuals (only 4). The four injuries were also reoccurring injuries that the athletes had experienced the pain previously. The injuries that presented during a weight lifting session could have originated during previous activities such as practice or competition and not solely due to the weight lifting activity. So, the risk factor stating that while weight lifting the athlete is 4x more likely to be injured is correct, but may not be trustworthy due to the details of this dataset.

Results of the Poisson regression that determined injury rate ratio per 1000 AE's found that previous history ever to that location and the center position were both significant in the univariate analysis. However, these variables did not remain significant in the multivariate analyses. A larger sample size and extended period of injury surveillance would likely have resulted in more significant outcomes. Also, the results suggest that many of the factors are correlated and linked, making it harder to disentangle them. This study should therefore be viewed as a preliminary work in the important search for injury predictors.

To date, there have only been three studies that analyzed previous history of injury as a risk factor for ankle injuries in basketball (Kofotolis & Kellis, 2007; Cumps et al., 2007; McKay et al., 2001) and none of them were studying collegiate women's basketball players. The current study is the first to look at previous history within the last year and ever as being a risk factor for injury in the collegiate women's basketball population. This study is also the first to report injuries occurring during weight lifting sessions, and found that athletes are at a greater risk of injury during their weight lifting sessions as compared to practicing sessions. Few studies have looked at basketball positions as being a risk factor for injury and those that have provided inconclusive results (Meeuwisse et al., 2003; Kostopoulos & Dimitrios, 2010). Our study found that playing at the center and forward positions as compared to the guard position was associated with an increased risk of injury.

A follow up analysis was also performed to determine whether or not stability was a significant risk factor for lower extremity injuries alone. An unadjusted simple Poisson regression was performed with matched stability and found that IRR per 1000 hours was statistically significant, but was not significant per 1000 AEs. This indicates that for every level of stability the subjects were less likely to sustain an injury to the lower extremity. This would suggest that female collegiate basketball athletes should partake in a stability and proprioceptive program to help reduce the number of lower extremity injuries. More studies need to exam what types of balance programs would best benefit the female basketball athlete.

Study Limitations

Limiting factors for this study included a small sample size and relatively short period of injury surveillance. The use of only one Division I basketball team limits the number of participants and is not necessarily representative of the injury picture in all NCAA women's basketball team. The study was also limited to a relatively short time frame, i.e., one basketball season. A multi-year study involving multiple teams is required to ensure greater stability of data.

Suggestions for Further Research

There is a lack of descriptive epidemiologic research of injuries affecting the collegiate female basketball population. Most of the research reported on women's basketball has been retrospective in nature. Therefore, future research in this population should include:

- Additional prospective cohort studies that follow a large sample of women's collegiate basketball players forward over longer periods of time to record injuries as they occur.
- Studies that involve a larger number of teams and participants
- A more consistent definition of injury to be used with a time loss factor added to the injury definition. Rates could be reported for all injuries as well as for time loss injuries.

- An accurate collection of exposure time of participants on a day to day basis, collected in minutes, hours, and athlete exposures.
- Differentiating between acute and overuse injuries.
- Collect and report information on the distribution of injuries by type.
- Examining possible intrinsic risk factors such as: history of previous injury, athletes conditioning level, neuromuscular control and balance training, landing mechanics, muscular strength deficits.
- Examining possible extrinsic risk factors such as: basketball position being played, type of shoes, ankle supports.
- Studies researching possible prevention programs such as: balance and stability, proprioceptive, landing mechanics, and jumping mechanics.

Conclusion

For years, injuries have been affecting women's collegiate basketball players' ability to perform to their utmost capabilities. There has been research done to determine where and when injuries occur, but more in depth studies are needed to identify modifiable risk factors and viable preventative measures. This study was designed to add to the current literature and analyzed whether player position, previous history of injury, stability, and event were related to increased risk of injury. Of these, centers, forwards, previous history last year, previous history ever, and weight lifting were all found to be significant risk factors for injury in univariate analyses. However, only weight lifting remained a significant risk factor in the multivariate analyses.

Another main contribution of this study was to provide an in-depth and precise descriptive analysis of injuries affecting NCAA Division I women's basketball athletes.

The determination of injury rates was based on a precise recording of exposure time for each individual basketball player during practice, weight lifting, and competition. This study also broke down larger injury categories to more specific injury locations and injury types. This study also reported injury rates per 1000 minutes, 1000 hours, and 1000 AEs which helps to bridge a gap in previous literature. However, further research is still needed to examine collegiate women's basketball injuries and associated risk factors to help reduce incidence rates.

APPENDICES

Appendix A

Informed Consent

Title: An Epidemiological Study of Injury Affecting Female Intercollegiate Basketball Players

Principal Investigator: Alexandria Pulvermacher, Graduate Student, Department of Physical Education, Exercise Science, & Wellness, University of North Dakota, (920) 229-9913, alexandria.pulvermacher@und.edu. Student's Advisor; Dr. Dennis Caine, University of North Dakota, (701) 777-4041

Invitation to Participate: You are invited to participate in a research study on injuries affecting the University of North Dakota women's basketball players during the 2010-2011 and 2011-2012 seasons.

Statement of Research: A person who is to participate in the research must give her informed consent to such participation. This consent must be based on an understanding of the nature and risks of the research. This document provides information that is important for this understanding. Research projects include only participants who choose to take part. Please take your time in making your decision as to whether you wish to participate. If you have any questions at any time, please ask.

Purpose of Research: The purpose of this research study is to determine the nature and rate of injuries that affect collegiate women's basketball athletes throughout the regular season and to determine the relationship between injuries and the following risk factors: previous years of competitive basketball, injury history, and balance ability as measured by the Biodex Stability System. This research is important in addressing some gaps that are present in research for collegiate women's basketball players including the lack of definition of injury, exposure, injury rates, and identification of potential injury risk factors.

Length of the Study: Your participation in the study will last for the entire 2011-2012 regular season of collegiate basketball. You will set up a time with the researcher where you will fill out your paperwork and perform your baseline balance measurement during the pre-season, but otherwise the rest of the data collection will be done by the researcher. If you participated during the 2010-2011 season, but not currently you will be asked permission to grant access to your medical records for the 2010-2011 season.

What Will Happen During This Study: For the first part of the study you will be asked to complete a medical history questionnaire that asks about injuries that you may have sustained previously as a result in participating in basketball or any other sport. This questionnaire will take between 10 to 20 minutes to complete. You will also be asked to perform a balance test on the Biodex Stability System which is located in the Betty Engelstad Sioux Center athletic training room. This test will take about 10 minutes to complete.

The second part of the study will involve observing and recording any injuries that you sustain during the 2011-12 basketball season. The researcher will be keeping track of your injuries and also your exposure time in regards to training minutes in practices, weight lifting, and games.

Risks of the Study: This study is intended to observe and record any pain or injuries that occur during the season. The only foreseeable risk to participation would be mild ankle discomfort after completion of the balance test on the Biodex Balance System.

Benefits of the Study: You may not benefit personally from being in this study. However, we hope that, in the future, other people might benefit from this study because it will give both coaches and players in-depth data on the types of injuries, the nature and incidence of injuries, and risk factors that may increase their risk of injury.

Confidentiality: All of your data and information obtained through forms will remain confidential. In addition, you will not be identified in any reports about this study that might be published. All data will be retained for a period of 3 years following completion of this study in a locked container in the PXW office. Any information that is obtained in connection with this study that can be identified with you will remain confidential and will be disclosed only with your written permission.

Voluntary Participation: Your decision whether or not to participate is completely voluntary and no penalties will result from refusal to participate. Your decision whether or not to participate will not affect your current or future relations with the University of North Dakota. If you decide to participate, you are free to discontinue participation at any time without it being held against you. To discontinue participation, inform the researcher in writing (Alexandria.pulvermacher@und.edu) that you do not wish to continue with this project.

Contacts and Questions: The researcher conducting this study is Alexandria Pulvermacher, a UND graduate student in the Physical Education, Exercise Science, and Wellness department. You may ask any questions that you have now. If you later have questions, concerns, or complaints about the research please contact Alexandria Pulvermacher at (920) 229-9913. You may also contact my thesis advisor, Dr. Dennis Caine, at (701) 777-4041.

If you have questions regarding your rights as a research participant, or if you have any concerns or complains about the research, you may contact the University of North Dakota Institutional Review Board at (701) 777-4279. Please call this number if you cannot reach research staff, or you wish to talk with someone else.

Agreement: Your signature indicates that this research study has been explained to you, that your questions have been answered, and that you agree to take part in this study. You will receive a copy of this form.

Participant' Name: ____

______________________________ ______________________

Signature of Participant Date

______________________________ ______________________

Signature of Principal Investigator Date

Appendix B

Health Insurance Portability and Accountability Act

HIPAA[1] AUTHORIZATION TO USE AND DISCLOSE INDIVIDUAL HEALTH INFORMATION FOR RESEARCH PURPOSES

1. Purpose. As a research participant, I authorize Alexandria Pulvermacher and her thesis advisor, Dr. Caine, to use and disclose my individual health information for the purpose of conducting the research project entitled An Epidemiological Study of Injury Affecting Female Intercollegiate Basketball Players.

2. Individual Health Information to be Used or Disclosed. My individual health information that may be used or disclosed to conduct this research includes: medical information (physical exams, results from diagnostic testing, MD notes, procedures, and previous history) that pertains to injuries that are either sustained as a result of participating in basketball or injuries and conditions that restrict or hinder my ability to participate fully in basketball practices or competitions.

3. Parties Who May Disclose My Individual Health Information. The researcher and the researcher's advisor may obtain my individual health information from medical files contained in the UND Athletic Training Room, Grand Forks Family Medical Residency, other previous clinics/hospitals where I have had treatment at the discretion of myself, and from hospitals, clinics, health care providers and health plans that provide my health care during the study.

4. Parties Who May Receive or Use My Individual Health Information. The individual health information disclosed by parties listed in item 3 and information disclosed by me during the course of the research may be received and used by Alexandria Pulvermacher and the researcher's advisor.

5. Right to Refuse to Sign this Authorization. I do not have to sign this Authorization. If I decide not to sign the Authorization, I may not be allowed to participate in this study. However, my decision not to sign this authorization will not affect any other treatment, payment, or enrollment in health plans or eligibility for benefits.

6. Right to Revoke. I can change my mind and withdraw this authorization at any time by sending a written notice to Alexandria Pulvermacher at alexandria.pulvermacher@und.edu to inform the researcher of my decision. If I withdraw this authorization, the researcher may only use and disclose the protected health information already collected for this research study. No

[1]HIPAA is the Health Insurance Portability and Accountability Act of 1996, a federal law related to privacy of health information.

further health information about me will be collected by or disclosed to the researcher for this study.

7. Potential for Re-disclosure. My individual health information disclosed under this authorization will not be subject to re-disclosure outside of the research study.

This authorization does not have an expiration date.

I am the research participant or personal representative authorized to act on behalf of the participant.

I have read this information, and I will receive a copy of this authorization form after it is signed.

______________________________ ______________________________

Signature of research participant or research participant's personal representative — Date

______________________________ ______________________________

Printed name of research participant or research participant's personal representative — Description of personal representative's authority to act on behalf of the research participant

Appendix C

Pre-Participation Exam

UND Division of Sports Medicine
Pre-Participation Exam

Student's Full Name (Print)_________________________________ Sport(s)________________
Last First M.I.

Student's Home Address____
Street City State Zip

Student's Local Address____
Street City State Zip

Birthdate_____/______/______ Gender___________ Home Phone(_____)___________________

Local Phone(_____)___________________ Cell Phone(_____)______________________

HISTORY

Explain all "Yes" answers below. Yes No

1. Do you wear glasses or contacts or protective eyewear?..
2. Have you been previously hospitalized for any reason? (If yes explain) ………….....................
3. Have you had surgery for any reason? (If yes, explain) ………………………………………...
4. Have you lost or had serious impairment of an eye, lung, kidney, testicle or other organ?
   (If yes, explain) …………………………………………………………………………………
5. Do you have asthma or other breathing problems?..
6. Have you ever fainted or almost fainted during exercise?...
7. Have you ever had a concussion or other head injury?..
8. Have you ever lost consciousness during athletic activity (If yes, explain)……………………
9. Have you experienced any heat related illnesses (muscle cramps, dizziness etc)?.....................
10. Have you ever experienced any cardiac symptoms (high blood pressure, murmur etc)?..........
11. Has anyone in your family died of heart related problems or a sudden death before age 50?...
12. Have you ever sprained/strained, dislocated, fractured, broken or had repeated swelling or
    other injuries of any bones or joints? (if yes, explain)……………………..………………..
13. Have you had any other medical problems (infectious mononucleosis, diabetes etc)?..............
14. Are you currently taking medication for ADHD?...
15. List all **current** muscle, joint, bone injuries.____
____
16. List all medications/supplements/vitamins you are currently taking.___________________________
____
17. List all known allergies. ____
____

Explain "YES" answers:____
____
____

To the best of my knowledge, the above information is correct.

Signature ____ Date ________________________

PHYSICAL EXAM

PRE-PHYSICAL SCREENING

Date:________________

Vision Corrected? ☐	R L B		
Vitals			Int.
Height (in.)			
Weight (lbs.)			
BP (b/min)			
Pulse (resting)			
MMT (0-5 Scale)	Right	Left	
Shoulder Abduction			
Shoulder Ext Rotation			
Supraspinatus (Empty Can)			
Iliospoas (hip flexors)			
Hamstrings (sitting)			
Ankle Eversion			
Grip Strength (dynamometer)			
Flexibility (degrees)			
Ankle Dorsiflexion			
Hips/Hams (90/90)			
Quads (prone)			
Supine Passive Trunk Rotation			
Thomas Test (+ or -)			
Ober's Test (+ or -)			

Orthopedic Screening

Ankle	**Right**	**Left**
Ant. Drawer	+ -	+ -
Talar Tilt	+ -	+ -
Knee	**Right**	**Left**
Valgus Stress (MCL)	+ -	+ -
Varus Stress (LCL)	+ -	+ -
Ant. Drawer Test (ACL)	+ -	+ -
Lachman's (ACL)	+ -	+ -
Shoulder	**Right**	**Left**
ROM: Scratch Test		
Apprehension Test	+ -	+ -
AC Distraction	+ -	+ -
Impingement Test(Hawkins)	+ -	+ -
Low Back		
Active Extension/Flexion		

Medical Screening

	Normal		**Abnormal**
Ears			
Eyes			
Nose			
Heart			
If Murmor:	**Yes**	**No**	
Diastolic			
Holosystolic			
Precordial thrill			
Abnormality split P2			
Systolic click			
Valsalva			
Additional sound			
Lungs			
Hernia			
Abdomen			
Testes			

Comments:________________________________
____
____
____

Clearance:

Approved for participation in Athletics at UND

Disqualified for participation in Athletics at UND

Approved **pending** further evaluation /rehabilitation by Sports Medicine Staff

Approved **pending** further evaluation by Team Physician

Physician________________________________ Date

Certified Athletic Trainer____________________ Date

Athletic Training Student____________________ Date

Appendix D

Pre-Participation Update

UND Division of Sports Medicine
Pre-Participation Update

Student's Full Name (Print)___________________________________ Sport(s)____________________
Last First M.I.

Birthdate_____/______/______ Gender___________ Home Phone(_____)_________________________

Local Phone(_____)____________________ Cell Phone(_____)_________________________

HISTORY Yes No

1. Have you been hospitalized within the past year? (If yes explain)…………..................................
2. Have you had surgery within the past year? (If yes explain) …………………………………….
3. Have you experienced a concussion within the past year? (If yes, explain) ……………………..
4. Have you experienced any cardiac symptoms within the past year (high BP, murmur)? (If yes, explain) …………………………………………………………
5. Has anyone in your family died of heart related problems or sudden death within the past year?
6. Were you held back from competition/practices due to an illness/injury? (if yes, explain)……..
7. Are you currently taking medication for ADHD?...
8. Have you been diagnosed with any medical condition within the past year (asthma, thyroid, anemia, pregnancy, etc)? (if yes, explain)……………………………………...

Explain "YES" answers:____

9. List all current muscle, joint, bone injuries. ____

10. List all medications/supplements/vitamins you are currently taking.___________________________

11. List all known allergies.____

To the best of my knowledge, the above information is correct.

Signature ______________________________________ Date _______________________

Vitals (To be completed by ATS) ATS____________________ Date_____________

Height (in.)		Weight (lbs)		BP		Pulse (b/min)	

Records Review (To be completed by ATS)
List all injuries and dates that the athlete has sustained: ____
____
____
____

Orthopedic Screening: (On bottom of sheet) To be completed by Physician if needed.

Clearance: Approved for participation in Athletics at UND

Disqualified for participation in Athletics at UND

Approved ***Pending*** further evaluation /rehabilitation by Sports Medicine Staff

Approved **pending** further evaluation by Team Physician

Physician____ **Date**____________________________________
Certified Athletic Trainer__________________________ **Athletic Training Student**__________________
Date Date

Orthopedic Screening
(If Applicable)

Ankle	**Right**	**Left**
Ant. Drawer	+ -	+ -
Talar Tilt	+ -	+ -
Swelling (yes/no)		
Knee	**Right**	**Left**
Valgus Stress (MCL)	+ -	+ -
Varus Stress (LCL)	+ -	+ -
Ant. Drawer Test (ACL)	+ -	+ -
Lachman's (ACL)	+ -	+ -
Shoulder	**Right**	**Left**
ROM: Scratch Test		
Apprehension Test	+ -	+ -
AC Distraction	+ -	+ -
Impingement Test (Hawkins)	+ -	+ -
Low Back		
Active Extension/Flexion		

Comments:______________________
____
____
____
____
____
____
____

____
Physician's Signature Date

Appendix E

Medical History Questionnaire

Subject #: ______________________ Age: _______ Year: _____________

1. At what age did you start playing basketball? ______________________________
2. How long have you been playing basketball competitively? __________________
3. What other sports have you participated in? _______________________________
   ____
4. What age range did you participate in these sports (start date-end date)? ________
   ____
5. How long did you compete in these other sports? ___________________________
   ____

Injury Definition: An injury is pain or discomfort caused by sport which causes an athlete to rest from practice/competition for at least one day, modify their activity level, or to seek medical attention from a physician, certified athletic trainer, chiropractor, or dentist.

If you answer "yes" to any question, please explain further in the space provided. Please include: type of injury, location of injury (anatomically & where), severity of injury (mild, severe, season ending), activity/move you were doing when injury occurred, length of time injury affected performance (time loss or modified activity time), and what type of treatment you received for this injury. If you have any

Please answer the following questions which relate to previous injuries you have had.

6. Have you experienced one or more injuries during practice or competitions?
   ____
   ____
   ____
   ____
   ____
   ____

7. Have you experienced any pain or discomfort from sport which "bothered you", but did not cause you to miss practice/competition or to seek medical attention?

____
____
____

8. Has any injury been so severe that you saw a physician or athletic trainer?

____
____
____

9. Have you injured your ankle or knee before? ______________________________

____
____

If you answered "Yes" to Question 9 please answer Questions 10-12. If you answered "No" please skip down to Question 13.

10. Were you wearing ankle tape, ankle braces, or nothing when this injury occurred? Why? On both ankles or which one? Type of ankle braces?

____
____
____

11. Were you wearing any type of brace/sleeve on your knee? Why? On both knees or which one? Type of knee brace/sleeve?

____
____
____

12. What type of shoe were you wearing at the time of the injury? (Brand, high top, low top, etc.)

____
____
____

13. Approximately when was your last growth spurt? __________________________

14. How many inches did you grow in your last growth spurt? ___________________

15. What is your menstrual cycle status? (Amenorrhea, Oligomenorrhea, Dysmenorrhea) Explain.

___

___

___

Appendix F

Injury Report Form

Subject #: ___________________ Age: _______ Year: __________ Date: ____________

Athlete's position: ___________________ Menstruation status: ______________________

Ankle support:_________ Knee support:_________ Orthotics:_________

Date of Injury Onset **Date of Return to full participation**

____/____/____ ____/____/____

Injury occurred in: Practice Competition Weight lifting Other?

Timing of injury: 1st half 2nd half Other: ____________

Injury location on court: Lane Key area Other: ____________

Is the injury: Overuse/Chronic Acute/Sudden Onset Other

Type of mechanism: Contact Non-contact Other: ____________

Specify MOI in detail: ____

____

Did injury occur with a specific skill, explain: __________________________________

____

Did a foul occur at the time of injury? Was it called? Explain: __________________

____

Did injury occur while on offense, defense, loose ball? __________________________

Has there been previous injury of same type and onset at the same location? (reoccurrence)

____

Date RTP from the previous injury? ____

Principal body part injured (for 1-10, complete Head-Injury Information; for 31 or 32, complete Knee-Injury Information):

(1) Head	(23) Spine
(2) Eye(s)	(24) Lower back
(3) Ear(s)	(25) Ribs
(4) Nose	(26) Sternum
(5) Face	(27) Stomach
(6) Chin	(28) Pelvis, hips, groin
(7) Jaw (TMJ)	(29) Buttocks
(8) Mouth	(30) Upper leg
(9) Teeth	(31) Knee
(10) Tongue	(32) Patella
(11) Neck	(33) Lower leg
(12) Shoulder	(34) Ankle
(13) Clavicle	(35) Heel/Achilles' tendon
(14) Scapula	(36) Foot
(15) Upper arm	(37) Toe(s)
(16) Elbow	(38) Spleen
(17) Forearm	(39) Kidney
(18) Wrist	(40) External genitalia
(19) Hand	(41) Coccyx
(20) Thumb	(42) Breast
(21) Finger(s)	(99) Other: ______
(22) Upper back	

HEAD INJURY

This student-athlete was diagnosed as having:
(1) 1° cerebral concussion. [No loss of consciousness, short post-traumatic amnesia (seconds up to two minutes).]
(2) 2° cerebral concussion. [Loss of consciousness (less than five minutes) and amnesia for up to 30 seconds].
(3) 3° cerebral concussion. [Loss of consciousness (more than five minutes) and extended amnesia.]
(4) No cerebral concussion
(5) Unknown

Was a mouthpiece (MP) worn?
(1) MP worn—dentist-fitted (3) MP not worn
(2) MP worn—self-fitted

Type eye injury:
(1) Orbital fracture (4) Soft tissue
(2) Cornea (99) Other: ______
(3) Ruptured globe

KNEE INJURY

Circle ALL knee structures injured:
(1) Collateral (5) Patella and/or patella tendon
(2) Anterior cruciate (6) None
(3) Posterior cruciate (99) Other: ______
(4) Torn cartilage (meniscus)

Primary type of injury (circle one):

(1) Abrasion	(16) Fracture
(2) Contusion	(17) Stress fracture
(3) Laceration	(18) Concussion
(4) Puncture wound	(19) Heat exhaustion
(5) Bursitis	(20) Heatstroke
(6) Tendinitis	(21) Burn
(7) Ligament sprain (incomplete tear)	(22) Inflammation
	(23) Infection
(8) Ligament sprain (complete tear)	(24) Hemorrhage
	(25) Internal injury (nonhemorrhage)
(9) Muscle-tendon strain (incomplete tear)	(26) Nerve injury
(10) Muscle-tendon strain (complete tear)	(27) Blisters
	(28) Boil(s)
(11) Torn cartilage	(29) Hernia
(12) Hyperextension	(30) Foreign object in body orifice
(13) AC separation	
(14) Dislocation (partial)	(31) Avulsion (tooth)
(15) Dislocation (complete)	(99) Other: ______

Did a laceration or wound that resulted in oozing or bleeding occur as a part of this injury?
(1) Yes (2) No

Did this injury require surgery?
(1) Yes, in-season (2) Yes, postseason (3) No

Describe the joint surgery:
(1) Arthrotomy (3) Operative arthroscopy
(2) Diagnostic arthroscopy (4) No joint surgery
(99) Other: ______

Injury assessment (best assessment procedure):
(1) Clinical exam by athletic trainer
(2) Clinical exam by M.D./D.D.S.
(3) X-ray
(4) MRI
(5) Other imagery technique
(6) Surgery
(7) Blood work/lab test
(99) Other: ______

Figure 3. Injury Report. (Dick et al., 2007).

More details on injury: ______________________________

____

____

More details on referrals, treatment, and results: ______________________________

____

____

____

Progression of return to play (with dates): ______________________________

____

____

Appendix G

Exposure Report Form

Date:		**Activity:**	
Start time:		**End time:**	
Total time:			

Subjects	**Start time**	**End time**	**Total time**	**Missing-Reason**

Notes/Comments: ____

____

REFERENCES

Agel, J., Arendt, E.A., & Bershadsky, B. (2005). Anterior cruciate ligament injury in national collegiate athletic association basketball and soccer: A 13-year review. *The American Journal of Sports Medicine, 33*(4), 524-531.

Agel, J., Olson, D. E., Dick, R., Arendt, E. A., Marshall, S. W., &Sikka, R. S. (2007). Descriptive epidemiology of collegiate women's basketball injuries: National collegiate athletic association injury surveillace system, 1988-1989 through 2003-2004. *Journal of Athletic Training*, *42*(2), 202-210.

Arendt, E. and Dick, R. (1995). Knee injury patterns among men and women in collegiate basketball and soccer. *The American Journal of Sports Medicine*, *23*(6), 694-701.

Beynnon, B. D., Vacek, P. M., Murphy, D., Alosa, D., &Paller, D. (2005). First-time inversion ankle ligament trauma: The effects of sex, level of competition, and sport on the incidence of injury. *The American Journal of Sports Medicine*, *33*(10), 1485-1491.

Bressel, E, Joshua, Y. C., Kras, J., & Heath, E. M. (2007). Comparison of static and dynamic balance in female collegiate soccer, basketball, and gymnastics athletes.*Journal of Athletic Training, 42*(1), 42-46.

Cumps, E., Verhagen, E., & Meeusen, R. (2007, February 28). Prospective epidemiological study of basketball injuries during one competitive season: Ankle sprains and overuse knee injuries. *Journal of Sports Science and Medicine*, *6*, 204-211.

Deitch, J. R., Starkey, C., Walters, S. L., & Moseley, J. B. (2006). Injury risk in professional basketball players: A comparison of women's national basketball association and national basketball association athletes. *The American Journal of Sports Medicine*, *34*(7), 1077-1083.

Devan, M. R., Pescatello, L. S., Faghri, P., & Anderson, J. (2004). A prospective study of overuse knee injuries among female athletes with muscle imbalances and structural abnormalities.*Journal of Athletic Training*, *39*(3), 263-267.

Dick, R., Agel, J., & Marshall, S. W. (2007). National collegiate athletic association injury surveillance system commentaries: Introduction and methods. *Journal of Athletic Training*, *42*(2), 173-182.

Dragoo, J.L., Castillo, T.N., Braun, H.J., Ridley, B.A., Kennedy, A.C., & Golish, R. (2011). Prospective correlation between serum relaxin concentration and anterior cruciate ligament tears among elite collegiate female athletes. *The American Journal of Sports Medicine,* 1-6.

Eils, E., Schroter, R., Schroder, M., Gerss, J., & Rosenbaum, D. (2010). Multistation proprioceptive exercise program prevents ankle injuries in basketball. *Medicine & Science in Sports & Exercise, 42*(11), 2098-2105.

Gianoudis, J., Webster, K. E., & Cook, J. (2008, March 1). Volume of physical activity and injury occurrence in young basketball players. *Journal of Sports Science and Medicine*, *7*, 139-143.

Hammig, B. J., Yang, H., & Bensema, B. (2007, November). Epidemiology of basketball injuries among adults presenting to ambulatory care settings in the United States. *Clinical Journal of Sports Medicine*, *17*(6), 446-451.

Hanley, J. A., Negassa, A., Edwardes, M. D., & Forrester, J. E. (2003). Statistical analysis of correlated data using generalized estimating equations: An orientation. *American Journal of Epidemiology, 157*(4), 364-375.

Herrington, L. (2010). The effects of 4 weeks of jump training on landing knee valgus and crossover hop performance in female basketball players. *Journal of Strength and Conditioning Research, 24*(12), 3427-3432.

Herrington, L. (2011). Knee valgus angle during landing tasks in female volleyball and basketball players. *Journal of Strength and Conditioning Research, 25*(1), 262-266.

Hewett, T. E., Myer, G. D., & Ford, K. R. (2006). Anterior cruciate ligament injuries in female athletes: Part 1, mechanisms and risk factors. *The American Journal of Sports Medicine*, *34*(2), 299-311.

Hosea, T.M., Carey, C.C., & Harrer, M.F. (2000). The gender issue: Epidemiology of ankle injuries in athletes who participate in basketball. *Clinical Orthopaedics and Related Research, 372*, 45-49.

International Basketball Federation (1996). Inside FIBA: We Are Basketball: Quick facts. Retrieved from http://www.fiba.com/pages/eng/fc/FIBA/quicFact/p/openNodeIDs/962/selNodeID/962/quicFacts.html

Iwamoto, J., Takeda, T., Sato, Y., & Matsumoto, H. (2008, August 8). Retrospective case evaluation of gender differences in sports injuries in a Japanese sports medicine clinic. *Gender Medicine*, *5*(4), 405-414.

Kofotolis, N. and Kellis, E. (2007). Ankle sprain injuries: A 2-year prospective cohort study in female Greek professional basketball players. *Journal of Athletic Training*, *42*(3), 388-394.

Kostopoulos, N., & Dimitrios, P. (2010). Injuries in basketball. *Biology of Exercise*, *6.1*, 47-55.

Lanese, R.R., Strauss, R. H., Leizman, D. J., & Rotondi, A.M. (1990) Injury and disability in matched men's and women's intercollegiate sports. *American Journal of Public Health, 80*(12), 1459-1462.

Leanderson, J., Wykman, A., & Eriksson, E. (1993). Ankle sprain and postural sway in basketball players. *Knee Surgery, Sports Traumatology, Arthroscopy, 1,* 203-205.

McGuine, T.A., Brooks, A., & Hetzel, S. (2011). The effect of lace-up ankle braces on injury rates in high school basketball players. *The American Journal of Sports Medicine, 39*(9), 1840-1848.

McGuine, T.A., Greene, J.J., Best, T., & Leverson, G. (2000). Balance as a predictor of ankle injuries in high school basketball players. *Clinical Journal of Sports Medicine, 10*, 239-244.

McGuine, T.A. and Keene, J.S. (2006). The effect of a balance training program on the risk of ankle sprains in high school athletes. *The American Journal of Sports Medicine, 34*(7), 1103-1111.

McKay, G. and Cook, J. (2010). Basketball. In D. J. Caine, P. A. Harmer, & M. A. Schiff (Eds.), *Epidemiology of Injury in Olympic Sports* (pp. 78-91). Chennai, India: Wiley-Blackwell.

McKay, G.D., Goldie, P.A., Payne, W.R., & Oakes, B.W. (2001). Ankle injuries in basketball: Injury rate and risk factors. *British Journal of Sports Medicine, 35*, 103-108.

McKay, G.D., Goldie, P.A., Payne, W.R., Oakes, B.W., & Watson, L.F. (2001). A prospective study of injuries in basketball: A total profile and comparison by gender and standard of competition. *Journal of Science and Medicine in Sport, 4*(2), 196-211.

Meeuwisse, W. H., Sellmer, R., & Hagel, B. E. (2003). Rates and risks of injury during intercollegiate basketball. *The American Journal of Sports Medicine*, *31*(3), 379-385.

Mihata, L. C., Beutler, A. I., & Boden, B. P. (2006). Comparing the incidence of anterior cruciate ligament injury in collegiate lacrosse, soccer, and basketball players: Implications for anterior cruciate ligament mechanism and prevention. *The American Journal of Sports Medicine*, *34*(6), 899-904.

Mountcastle, S. B., Posner, M., Kragh, J. F., & Taylor, D. C. (2007). Gender differences in anterior cruciate ligament injury vary with activity: Epidemiology of anterior cruciate ligament injuries in a young, athletic population. *The American Journal of Sports Medicine*, *35*(10), 1635-1642.

National Collegiate Basketball Association. (2009). 1981/82-2008/09 NCAA sports sponsorship and participation rates report [Data file]. Available from http://www.ncaa.org/wps/portal/ncaahome?WCM_GLOBAL_CONTEXT=/ncaa/NCAA/Research/Participation+and+Demographics/Sponsorship_Participation_Archive.html

National Collegiate Basketball Association. (2011). Composition & sport sponsorship of the NCAA [Data file]. Retrieved from http://www.ncaa.org/wps/portal/ncaahome?WCM_GLOBAL_CONTEXT=/ncaa/ncaa/about+the+ncaa/membership/membership_breakdown.html

National Center for Catastrophic Sport Injury Research (NCCSI). (2010). 2010 all sports tables [Data file]. Available from http://www.unc.edu/depts/nccsi/

Paterno, M.V., Myer, G.D., Ford, K.R., & Hewett, T.E. (2004). Neuromuscular training improves single-limb stability in young female athletes. *Journal of Orthopaedic& Sports Physical Therapy, 34*(6), 305-317.

R Development Core Team (2011). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.r-project.org/.

Rozzi, S.L., Lephart, S.M., Gear, W.S., & Fu, F.H. (1999). Knee joint laxity and neuromuscular characteristics of male and female soccer and basketball players. *The American Journal of Sports Medicine, 27*(3), 312-319.

Sabin, M.J., Ebersole, K.T., Martindale, A.R., Price, J.W., & Broglio, S.P. (2010). Balance performance in male and female collegiate basketball athletes: Influence of testing surface. *Journal of Strength and Conditioning, 24*(8), 2073-2078.

Sallis, R.E., Jones, K., Sunshine, S., Smith, G., & Simon, L. (2001). Comparing sports injuries in men and women. *International Journal of Sports Medicine, 22*, 420-423.

Starkey, C. (2000). Injuries and illnesses in the national basketball association: A 10-year perspective. *Journal of Athletic Training, 35*(2), 161-167.

Stergioulas, A., Tripolitsioti, A., Kostopoulos, N., Gavriilidis, A., Sotiropoulos, D., & Baltopoulos, P. (2007). Amateur basketball injuries. A prospective study among male and female athletes. *Biology of Exercise*, *3*, 35-46.

Trojian, T.H. and Collins, S. (2006). The anterior cruciate ligament tear rate varies by race in professional women's basketball. *The American Journal of Sports Medicine, 34*(6), 895-898.

University of North Dakota Athletics (2010).*North Dakota Women's Basketball Statistics* [Data file]. Retrieved from http://www.fightingsioux.com/ViewArticle.dbml?DB_OEM_ID=13500&ATCLID=776864

Vauhnik, R., Morrissey, M.C., Rutherford, O.M., Turk, Z., Pilih, I.A., & Perme, M.P. (2011). Rate and risk of anterior cruciate ligament injury among sportswomen in Slovenia. *Journal of Athletic Training, 46*(1), 92-98.

Waterman, B.R., Belmont, P.J. Jr., Cameron, K.L., Svoboda, S.J., Alitz, C.J., & Owens, B.D. (2011). Risk factors for syndesmotic and medial ankle sprain: Role of sex, sport, and level of competition. *The American Journal of Sports Medicine, 39*(5), 992-998.

Webster, K.A. and Gribble, P.A. (2010). Time to stabilization of anterior cruciate ligament-reconstructed versus healthy knees in national collegiate athletic association division I female athletes. *Journal of Athletic Training, 45*(6), 580-585.

White, K. K., Lee, S. S., Cutuk, A., Hargens, A. R., & Pedowitz, R. A. (2003). EMG power spectra of intercollegiate athletes and anterior cruciate ligament injury risk in females. *Medicine and Science in Sports and Exercise*, *35*(3), 371-376.

Zvijac, J. and Thompson, W. (1996). Basketball. In D. J. Caine, C. G. Caine, & K. J. Lindner (Eds.), *Epidemiology of Sports Injuries* (pp. 86-97). Champaign, IL: Human Kinetics Publishers, Inc.