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An Epidemiological Study Of Injury Affecting Ncaa Division I Women's Intercollegiate Soccer Players

Elizabeth Ostrowski

AN EPIDEMIOLOGICAL STUDY OF INJURY AFFECTING NCAA DIVISION I WOMEN'S INTERCOLLEGIATE SOCCER PLAYERS

by

Elizabeth M. Ostrowski, ATC, LAT, CSCS
Bachelor of Science, University of Wisconsin – Stevens Point, 2010

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This thesis, submitted by Elizabeth Ostrowski 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
Chairperson

Dr. Brett Goodwin

Dr. Mark Romanick

This Thesis meets the standards for appearance, conforms to the style and format requirements of the Graduate School of the University of North Dakota, and is hereby approved.

Wayne Swisher
Dean of the Graduate School

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ABSTRACT

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

Background: Minimal research has been conducted on women's collegiate soccer injuries and specifically on the relationship of injury to the hamstring to quadriceps ratio (HQR). Past research reports that the HQR may be a risk factor for injury but it has not been tested at speeds considered more functional for soccer. Lower body agility and skin folds have not been examined as risk factors for women's soccer injuries.

Methods: The study was both retrospective and prospective in design. Institutional Review Board (IRB) approval was obtained from at the University of North Dakota. Women's soccer players from the UND soccer team were invited to participate in this study. Once consent was obtained, baseline data were collected using medical and demographic history questionnaires. Each participant was tested on the Biodex System 2 Dynamometer to calculate the HQR, skinfold measurements were taken, and the Illinois agility test was administered. Afterwards, the soccer players were followed for an entire season. All injuries were reported and documented using a direct interview technique. Additionally, exposure to all training and competition was recorded by the researcher in terms of minutes, hours, and athletic-exposures. Once the season was over, descriptive and analytical data analyses were run to determine the nature and incidence of injury and the relation between individual incidence rates and selected risk factors.

Results: Of the 24 participants, 17 sustained a total of 28 injuries in the 2011 season. In the 2010 season, 18 of 24 participants accumulated a total of 46 injuries. During the 2011 season, overall injuries rates were 8.65 injuries per 1000 hours, 0.14 injuries per 1000 minutes, and 14.43 injuries per 1000 athletic exposures (AE). During the 2010 season the overall injury rate was 14.07 injuries per 1000 hours and 24.02 injuries per 1000 AE. The majority of the injuries involved the knee (21%), followed by the ankle (17.9%) in 2011 and the same was true for the 2010 season with the knee at 19.6% and the ankle at 17.4%. Of the total injuries in 2011, 35% were strains and the second highest were sprains at 21.4%. During the 2010 season, strains occurred most often (39.1%) followed by sprains (30.4%). Most of the injuries (85.7%) resulted in less than 8 days time loss in 2011 and it was close to the same in 2010 at 87%. Risk factor analysis was attempted using Poisson regression, but unsuccessful due to unstable data, due most likely to small sample size and unwieldy data.

Conclusion: Injury rates reported in this study are similar to those reported by previous research involving collegiate female soccer players, with the exception of the game rates from the 2010 season. Information on the distribution of injuries is more

detailed in the type of injury, anatomical location of injury and clinical outcomes of injury in this study than in previous studies. All of the injury rates are reported in hours, athletic exposures and in minutes in order to make this study comparable to all the previous researchers who reported only one type of rate. This study also reports the cost of medical services provided for the injuries.

CHAPTER 1

INTRODUCTION

Soccer (football) is the world's most popular sport.[1] People around the world have been playing soccer-like games for over 2000 years.[1] Most people play soccer for recreational entertainment and the majority of players are children and youth.[1] In the United States almost 18 million people are registered to play soccer each year.[1] Out of all those players the National Collegiate Athletic Association (NCAA) reported having 23,357 women's collegiate soccer players registered for the 2009 season.[2] As evidenced by the numbers of players registered with NCAA, soccer is the most popular competitive sport for collegiate women.[2] Although there are many health benefits associated with participation in this sport, there is also risk of injury. Soccer is reported to have one of the highest rates of injuries in women sports.[3-5]

The sequence of injury prevention has been described by van Mechelen et et al[6] and conveys the importance of data collection to illuminate the incidence and severity of injury (step 1) and the analysis of possible risk factors (step 2). Next, research creates a prevention strategy to reduce the injury burden (step 3). Finally, research evaluates the effectiveness of the implemented prevention strategy by re-examining the extent of injury (step 4).

The literature on the epidemiology of injury in women's soccer is characterized by multiple studies that provide descriptive and analytical data on injury.[5,7-17] However, there remains a gap in research at the collegiate level.

There has not been a research study that distinguishes injury incidence for weight training, which is mandatory at a collegiate level. Weight training has been considered an integral part of training at the collegiate level. It is assumed that as the athlete gets stronger and quicker they will be better players and have a lower risk of injury. Faigenbaum and Westcott[18] reported that weight training in youth athletes has helped the athletes to better sustain the forces of athletic participation. This ideal has been carried into the collegiate setting and is common practice among universities.

Also, previous studies have not tested agility score as a possible predictor of injury. A specific part of the weight training portion at a university includes sprinting and agility drills. There have been studies that show agility and plyometric training programs can help prevent ACL tears.[19-20] These studies failed to report initial agility scores or what tests they used to measure agility and cutting ability.

Research that has been conducted on women's collegiate soccer injuries is characterized by several methodological short-comings, as follows:

- The use of retrospective data collection which depends on memory recall. It has been shown that retrospectively collected data tend to miss minor injuries, thereby resulting in lower overall injury rates.[21]

- Data sources varied from self-report forms, athletic trainers and therapists, physicians, and injury registries.
- Populations were diverse with regard to age, gender, training routines, and level of competition.
- Inconsistent injury definitions across studies. and
- Denominator data used to calculate injury rates are not consistent across studies, thus limiting the comparability of rates across studies.

These shortcomes impact differentially the data used to calculate injuries rates. Therefore accurate comparability across studies is compromised. For example, studies of collegiate female players, in particular, report rates relative to athletic-exposures only and therefore lack precision in calculations related to the incidence and distribution of injury and analysis of related risk factors.[5] Knowing what kinds of injuries are occurring, what risk factors for injury are involved, who is getting injured, and where and when they are getting injured is important so the coach, strength coach or certified athletic trainer can test and implement an injury prevention program for women's soccer teams in the future (i.e., steps 3 and 4).

Significance of the Problem

There is only one epidemiological study that has reported incidence rates of injuries in female collegiate soccer players. Dick et al[5] report that their early data sources in the NCAA Injury Surveillance System varied from self-report forms, athletic trainers and therapists, physicians, and injury registries. The new injury surveillance system used by the NCAA is now set up to accept data collected and reported in the same units of measure and with the same injury definitions from specifically athletic trainers so these data are considered reliable. Dick et al[5] still used the older data in their 15 year NCAA study which may make the results little less reliable. This study also did not investigate possible risk factors for injury.[5] Risk factors for injury are important to identify as a basis for the conceptualization and implementation of prevention programs.

Starkey et al [22] reported the hamstring to quadriceps ratio (HQR) is a known risk factor for injury if the ratio excedes 50 to 60%. At this time, only one study has investigated this ratio as a risk factor in female collegiate soccer athletes; however, it did not take into account previous injury history.[23] Additionally, the study that investigated the HQR in collegiate female athletes was conducted on Division III athletes, used a concentric HQR, and only tested at one speed of 60°/s.[23] Their suggestions for further research stated using different test speeds and using the eccentric to concentric HQR (also known as the Functional Ratio of HQ) which is more functional for a soccer player.[23] This study will address the problem by using different test speeds and not using the Functional Ratio because the Functional Ratio may cause more soreness that could lead to injury. There remains some controversy regarding whether the HQR may be a risk factor for injury.[23]

Skinfold measures have not been used in previous studies due to the time constraints of having to test every participant. If a study has analyzed body composition as a risk factor, it used BMI.[24] BMI is not as accurate in measuring body composition as a skinfold measure. It is thought that a higher BMI is considered a risk factor for injury but this measure may not accurately describe body composition. This study used skin fold measures to test for possible risk factors.

Lower body agility scores have not been looked at as risk factors for injury. It is known that integrating agility, plyometric, and balance exercises into a training program can help prevent ACL injuries.[19-20] However, agility scores have not been used as a bases for testing injury risk.

Leg dominance is important when examining a soccer athlete. It is thought that a player will lead more often with the dominant leg which could put it at greater risk for injury. One study found no difference between leg dominance; however, the data were only reported as injury rates and not analyze using risk factor analysis.[24] This study attempts to run a risk factor analysis to identify whether leg dominance is a risk factor for injury.

Injury history was analyzed as a risk factor for injury by one study.[24] There was not enough data to clearly define if there was a correlation between previous injury history and injuries sustained during the season. This study reports recurrent injuries based on injury history.

Descriptive statistics concerning playing position and injury rates have been reported by two studies.[24] Both studies found forwards to have a higher rate of injury but a risk factor analysis was not performed.[24] A risk factor analysis was attempted in this study to find out if player position associated with an increased risk of injury.

Statement of the Problem

This study includes both a prospective and retrospective component. An attempt was made to determine incidence of injury, where injury occurs, when injury occurs, and injury outcomes. In addition to injury rates reported with reference to athletic-exposures (AE's), rates are reported as a function of player exposure time (e.g., games and practice). This study investigated risk factors that may relate to injuries that are happening at the collegiate level. In addition to hamstring to quadriceps strength ratio (HQR), risk factors that were investigated include skinfold measurements, lower body agility, leg dominance, and playing position. An HQR was determined for each leg and can be compared bilaterally to find out if there is not only an imbalance within the leg but between the legs.

Limitations

The sample is considered a convenience sample because participants were limited to the soccer players at a Midwestern college 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, etc. Another limitation is the sample size and duration of the study. Research on the epidemiology of sports injury should follow multiple teams over the course of several seasons to ensure the reliability and stability of the data and provide more power for statistical analyses. In this study, the HQR is only being tested before the season starts. It is recognized that this ratio may change during the season, if only slightly.[23] For example, if a player sustains a hamstring injury, their ratio would change until fully rehabilitated.

CHAPTER II

LITERATURE REVIEW

People around the world have been playing soccer-like games for over 2000 years. In the United States, almost 18 million people are registered to play soccer each year.[1] Out of all those players the National Collegiate Athletic Association (NCAA) reported having 23,357 women's collegiate soccer players registered for the 2009 season.[2] Soccer is the most popular competitive sport for collegiate women.[2] Although there are many health benefits associated with participation in this sport, there is also risk of injury. Soccer is reported to have one of the highest rates of injuries in women sports.[3-5] Health care professionals are trying to take preventive measures against injury and studies that identify risk factors for injury will help prevent injuries.

Injuries in women's collegiate soccer have only been investigated in one study by Dick et al.[5]However, there is a gap in the college injury research on soccer reporting risk factors for injury. A review of literature was conducted to help identify the gaps in the research literature on the epidemiology of injury in women's soccer.

A search was conducted using the PubMed, SportDiscus, and Google Scholar search engines. The key words used were 'women's soccer,' 'injury epidemiology,' 'adult,' and 'collegiate.' This search yielded only one study specific to the collegiate setting. As a result, the search was expanded to include any elite and/or adult women's soccer studies. The ages of the participants needed to be at least 16 years of age and older. The ancestry approach was also used; that is, reference lists of articles retrieved were scanned to detect any additional, relevant articles. All articles that were used in this review were written within the past 15 years.

Who is Affected by Injury?

Table 1 provides a summary of the studies that provide injury rates in women's soccer.[5, 7-17] A review of this table reveals that with the exception of one study, Dick et al, the collegiate study, injury rates are reported as number of injuries per 1000 hours.[5] A range of 1.9 to 9.6 injuries per 1000 hours of overall play was reported.[5,7-17] However, meaningful comparison across studies is compromised due to varying definition of injury. Injuries have been defined with respect to both time loss and medical attention. The time loss injuries are classified on severity and some studies used minor (<7 days), moderate (7-30 days) and severe (>30 days)[7] whereas other studies have classified injuries as slight (0 days), minimal (1-3 days), mild (4-7 days), moderate (8-28 days) and severe (>28 days).[21] Table 1 shows that the risk of injury is greater during games than practice. Tournament play or championship games have a spike in injury rates compared to regular season play.[12] The incidence rate for injury during tournament games ranges from 36 to 67.4 injuries per 1000 hours of play, whereas all other games are between 12.6 to 23.6 injuries per 1000 hours of play.

There is limited research on position associated with injury. Two studies indicate that of the four positions on the soccer field, forwards typically sustain more injuries than any other position.[24-25]There was an injury rate of 49.3 injuries per 1000 playing hours for forwards in a study done by Tscholl et al.[25]The goalkeepers and defenders had the next highest rates at 46.9 and 46.4/1000 playing hours respectively.[25] Midfielders had the least at 34.6/1000 playing hours. There was no significant difference between injury rates related to player positions.[25]

Where Does Injury Occur?

Anatomical Location

A summary of the studies on anatomical location of injury in women's soccer is shown in Table 2.[5,7-17] The table shows the percent of injuries found at each anatomical location. About 70 percent of all injuries occurred in the lower extremities of women soccer players.[5,7-17] The head/neck is the second most injured anatomical region. Most of the head and neck injuries are concussions.[26-28] Overall, the body part most commonly injured was the ankle (9.3 to 28.4 percent) followed by the knee (6.2 to 31.8 percent).[5,7-17]

Table 1. Injury Rates in Women's Soccer. [5,7-17]

Study	Study Design (country, yr)	Population (age, level of play)	Sample Size	Injury Definition	Data-Collection Method	No. of Injuries	Game Incidendece Rate (95% CI) No. of injuries per 1000 hr or AEs	Practice Incidence Rate (95% CI) No. of injuries per 1000 hr or AEs	Total Incidence Rate (95% CI) No. of injuries per 1000 hr or AEs
Dick et al. (2007)	Descriptive (USA, 1998-2003)	Women's College (NCAA) 15 yr	20,447 Games and 54,750 Practices	Medical Attention and Time Loss	Injury Surveillance System (athletic trainers)	G= 5,373 P=5,836	16.44 (16.0-16.88) AEs	5.23 (5.09-5.36) AEs	
Faude et al. (2005)	Cohort (Germany, 2003-2004)	ages 17-27, elite, national league, 11 months	n=165	Time Loss	Injury Surveillance System (physician, physical therapist)	241	23.3	2.8	6.8
Giza et al. (2005)	Cohort (USA, 2001-2003)	Age not reported, elite, 2X5 months	n=202	Time Loss	Injury Surveillance System (physician)	173	12.6	1.2	1.9
Jacobson & Tenger (2007)	Cohort (Sweden, 2000)	Ages 16-36, permiere league, 10 months	n = 269	Time Loss	Interview by primary investigator weekly	237	13.9	2.7	4.6
Ostenberg & Roos (2000)	Cohort (Sweden, 1996)	ages 14-39, 7 months	n = 123	Time Loss	Injury Surveillance System (physical therapist)	65	14.3	3.7	6.6
Soderman et al. (2001)	Cohort (Sweden, 1998)	Ages 20-25, elite, 7 months	n = 146	Time Loss	Injury Surveillance System (physical therapist)	80	Acute 10.0	Acute 1.3	Acute 5.5

Table 1. Injury Rates in Women's Soccer Continued. [5,7-17]

Study	**Study Design (country, yr)**	**Population (age, level of play)**	**Sample Size**	**Injury Definition**	**Data-Collection Method**	**No. of Injuries**	**Game Incidendece Rate (95% CI) No. of injuries per 1000 hr or AEs**	**Practice Incidence Rate (95% CI) No. of injuries per 1000 hr or AEs**	**Total Incidence Rate (95% CI) No. of injuries per 1000 hr or AEs**
Jung & Dvorak (2007)	Cohort (International, 199-2006)	Tournament (7 international)	5742 player hrs	Medical Attention	Injury Surveillance (physician)	387	67.4 (60.7-74.1)		
Walden et al. (2007)	Cohort (Europe, 2004-2005)	WS Championship	n = 160	Medical Attention	Injury surveillance (physician)	17	36	2.5	
Hartmut et al. (2010)	Cohort (Germany)	Ages 16-35, elite, 1 yr.	n = 254	Time Loss	Injury Surveillance (physician)	246	18.5	1.4	3.3
Tegnander et al. (2008)	Cohort (Norway, 2001)	Ages 17-34, elite, 1 season	n = 181	Time Loss	Injury surveillance (physiotherapists)	189	Acute 23.6	Acute 3.1	
Hagglund et al. (2009)	Cohort (Swedish, 2005)	Ages 15-41, elite, 1 season	n = 228	Time Loss	Injury Surveillance (medical staff)	299	16.1	3.8	5.5
Jacobson & Tenger (2006)	Cohort (Swedish, 1998)	Ages 15-38, elite, 1 season	n = 253	Time Loss	Injury surveillance (trainer)	229	13.3	8.4	9.6

Environmental Location

There are few data reported on environmental location of injury in women's soccer. In one study, injuries occurred most often in the attacking one third of the field because the ball is most highly contested in this area.[26] The defenders and forwards play most intensely in this area and contact injuries occurred most often in this area of the field. The playing surface has not been connected to an increase of injury should a game or practice be played on either artificial turf or grass.[24-25]

When Does Injury Occur?

Injury Onset (acute/chronic)

A study of three top level women's soccer tournaments reported over 85% of all injuries were acute with only a few injuries resulted from overuse.[13]The chronic injuries were mainly considered to have an insidious onset which makes it more difficult to research to determine the cause.[13] Some of the studies didn't report the rate of chronic injuries because they are much less common compared to acute injuries.[11,15] Even though chronic injuries are not reported in most studies, they are very important for understanding long term outcomes. Additionally, injury risk factors may relate differently to acute and overuse injuries.

Table 2.Percent Distribution of Injury by Anatomical Location.[5,7-17]

Study	Study Design (country, yr)	Population (age, level of play)	Sample Size	Injury Definition	Head/Neck	Trunk/Back	Upper Extremity	Hip/Groin	Thigh	Knee	Lower Leg	Ankle	Foot	Other
Dick et al. (2007)	Descriptive (USA, 1998-2003)	Women's College (NCAA) 15 yr	20,447 Games and 54,750 Practices	Medical Attention and Time Loss	13.8/3.9	8.4/13.2	6.3/4.2	67.8/72 (all LE injuries)						3.7/6.7
Faude et al. (2005)	Cohort (Germany, 2003-2004)	ages 17-27, elite, national league, 11 months	n=165	Time Loss	6.6	7.5	5.3	6.2	18.3	18.7	8.2	17.8	11.2	
Giza et al. (2005)	Cohort (USA, 2001-2003)	Age not reported, elite, 2X5 months	n=202	Time Loss	10.4	12.8	7.5	5.5	6.9	31.8	6.5	9.3	9.3	
Jacobson & Tenger (2007)	Cohort (Sweden, 2000)	Ages 16-36, permiere league, 10 months	n = 269	Time Loss	4.7	12.7	0.34	4.8	11.4	15.3	12.2	28.4	10.5	
Ostenberg & Roos (2000)	Cohort (Sweden, 1996)	ages 14-39, 7 months	n = 123	Time Loss		10.8	7.7	17	26.2	6.2	10.8	12.3	9.2	
Soderman et al. (2001)	Cohort (Sweden, 1998)	Ages 20-25, elite, 7 months	n = 146	Time Loss	12 head	6.6	6.3	5.7	16.1	12.7	18.7	15.5	6.3	0.3

Table 2 continued. Percent Distribution of Injury by Anatomical Location.[5,7-17]

Study	Study Design (country, yr)	Population (age, level of play)	Sample Size	Injury Definition	Head/Neck	Trunk/Back	Upper Extremity	Hip/Groin	Thigh	Knee	Lower Leg	Ankle	Foot	Other
Jung & Dvorak (2007)	Cohort (International, 199-2006)	Tournament (7 international)	5742 player hrs	Medical Attention	18	9	8	3.1	12	11	11	24	3.1	
Walden et al. (2007)	Cohort (Europe, 2004-2005)	WS Championship	n = 160	Medical Attention	1.3	5	6.5	8.8	21.3	13.8	12.5	18.8	12.5	
Hartmut et al. (2010)	Cohort (Germany)	Ages 16-35, elite, 1 yr.	n = 254	Time Loss	7.1	7.8	2.4	1.7	12.9	31	9.4	22.1	4.6	
Tegnander et al. (2008)	Cohort (Norway, 2001)	Ages 17-34, elite, 1 season	n = 181	Time Loss	7.4	6.8	4.7	8.9	17.5	16.4	7.4	23.8	6.8	
Hagglund et al. (2009)	Cohort (Swedish, 2005)	Ages 15-41, elite, 1 season	n = 228	Time Loss	4	9	2	11	23	22	7	16	5	
Jacobson & Tenger (2006)	Cohort (Swedish, 1998)	Ages 15-38, elite, 1 season	n = 253	Time Loss	4	13	1	5	11	15	12	28	10	

Chronometry

Time of Season

Few studies report time of season when injury occurs. In one study, there was a higher rate of injuries in the preseason compared to the regular season and a lower rate of injuries in the post-season compared to the regular season.[5] There is some speculation that as the season progresses athletes may become more skilled and therefore have less injuries.[5] As mentioned previously, studies have shown that injury rates were much higher during games than in practices. [5,7-17.] In the European Championships there were also more contact injuries during game than in practice compared to non-contact injuries.[13]

Time of Game

In two studies, most contact injuries occured towards the end of each half and there was no significant difference between which half injuries occurred.[13,15] An explanation for the increase in injury at the end of each half may have been due to the fact that intensity of play is usually increased at this time because both teams are trying to score under pressure of running out of time. Fatigue may also be a factor. In one study, non-contact injuries were seen more often in the second half compared to contact injuries.[25] The increase in non-contact injuries during the second half may be attributed to more fatigue from playing most of the game.

What is the Outcome?

Type of Injury

A summary of studies reporting on percent distribution of injury type in women's soccer is shown in Table 3. There are five regions that injury types are classified into: head/neck, upper extremity, lower extremity, trunk/back and other/systems. Among collegiate women soccer players, 70% of injuries occurred in the lower extremity, and these were mainly ankle sprains, knee internal derangements, and contusions.[5] Sprains were the most common injury type occurring between 18.5 to 65.6 percent of the time.[7-12,14-17] Strains were the second most common injury accounting for 7 to 35.9 percent of injuries.[7-12,14-17] In one study, contusion to the head was the most common injury type followed by concussion.[26] Contusions were also mainly found in the thigh or lower leg.[7-12,14-17] The least common injury, noted in three studies, was dislocation with only a 0.8 to 2.1 percent chance of occurrence.[8,12,16]

Time Loss

Time loss categories have been used to indicate severity of injury. Most studies used a scale of minor injury equating to less than 8 days missed time, moderate injury between 8 and 28 days missed, and a severe injury was being out for 28 days or more.[5,12-13] In these studies the majority of injuries were minor.[5,12-13] Half of the injuries reported in the Tscholl study resulted in time loss.[25] Only a couple of injured athletes were out for more than 10 days.[25] The most common reason for this time loss was rupture of a ligament in the lower extremity with an ACL tear being the most common ligament being ruptured.[5,24-25]

Clinical Outcome

Even though there are few severe injuries in women's soccer there can be long-term issues associated with the injuries sustained while playing.[27] One of the common long-term issues comes from having sustained one or more concussions while playing.[26] Some of the long term effects include declines in memory and increased reaction time.[26]The knee and ankle joints are the most likely to develop osteoarthritis (OA) due to sprains of the ligaments in those joints.[7,19,29-32]One study done in Sweden looked at the prevalence of OA in female soccer athletes 12 years after they had sustained an ACL tear.[33] The study found that 51% of the women had radiographic knee OA and 75% of the participants had symptoms of OA.[33] Out of the players who had an ACL tear about 60% had reconstructive surgery but this had no significant effect on the likelihood of developing OA 12 years later.[33] Unfortunately, many of the studies didn't follow up with the subjects to look for the long term effects of being injured.

What are the Risk Factors?

Intrinsic Factors

There is a paucity of research on risk factors in women's soccer. Intrinsic factors include age, sex, body composition, physical fitness, and psychosocial factors. In one study of elite female soccer, players who were heavier had an increased risk for

Table 3. Percent Distribution of Injury by Injury Type. [7-12,14-17]

Study	Study Design (country, yr)	Population (age, level of play)	Sample Size	Injury Definition	Sprain	Strain	Contusion	Concussion	Fracture	Dislocation	Other
Faude et al. (2005)	Cohort (Germany, 2003-2004)	ages 17-27, elite, national league, 11 months	n=165	Time Loss	46.5	17.4	23.7		5.4		16.1
Giza et al. (2005)	Cohort (USA, 2001-2003)	Age not reported, elite, 2X5 months	n=202	Time Loss	19.1	30.7	16.2	2.9	11.6		
Jacobson & Tenger (2007)	Cohort (Sweden, 2000)	Ages 16-36, permiere league, 10 months	n = 269	Time Loss	24.5	28.7	8.4	3.8	1.3	0.8	1.7
Ostenberg & Roos (2000)	Cohort (Sweden, 1996)	ages 14-39, 7 months	n = 123	Time Loss	18.5	32.2	16.9		3.1		7.8

Table 3.T Percent Distribution of Injury by Injury Type Continued. [7-12,14-17]

Study	Study Design (country, yr)	Population (age, level of play)	Sample Size	Injury Definition	Sprain	Strain	Contusion	Concussion	Fracture	Dislocation	Other
Soderman et al. (2001)	Cohort (Sweden, 1998)	Ages 20-25, elite, 7 months	n = 146	Time Loss	65.6	16.4	18				
Jung & Dvorak (2007)	Cohort (International, 1999-2006)	Tournament (7 international)	5742 player hrs	Medical Attention	26	8	45	3.1	2.3	2.1	
Hartmut et al. (2010)	Cohort (Germany)	Ages 16-35, elite, 1 yr.	n = 254	Time Loss	35.4	10.8	15.8	5.3	5.8		3
Tegnander et al. (2008)	Cohort (Norway, 2001)	Ages 17-34, elite, 1 season	n = 181	Time Loss	31.2	35.9	7.4	3.7	5.2		5.2
Hagglund et al. (2009)	Cohort (Swedish, 2005)	Ages 15-41, elite, 1 season	n = 228	Time Loss	22	28	11	2	3	1	2
Jacobson & Tenger (2006)	Cohort (Swedish, 1998)	Ages 15-38, elite, 1 season	n = 253	Time Loss	28	7	18	3	2		41

non-contact injuries and taller players had an increased risk of injury in general.[24] In general, the more fit someone is, the less likely to get injured.[24] In one study, players with a previous history of injury did not show an increased risk of injury.[24] However, the athletes in this study had sufficient rehabilitation to the injured area which prevented re-injury.[24]The players dominant leg sustained significantly more injuries than a players non-dominant leg.[24] This finding may be due to the fact that the athlete will kick and lead into tackles more often with the dominant leg than the non-dominant leg. [24]

One study looked at the HQR as a possible risk factor for injury in both basketball and soccer.[23] The study found that the HQR may be a risk factor for non-contact knee injuries but the HQR was only tested at one speed which may skew the results.[23] Further research needs to be done to confirm this finding by testing other the HQR at different speeds.

Gender may also be a risk factor for injury. A few studies including women's lacrosse, basketball, and soccer have shown that females are at increased risk of ankle sprain and ACL injury compared to male athletes in the same sports.[19,24-25,29-32,34] Women tend to have high hip adduction which will cause higher knee abduction when landing from a jump which in turn can increase the risk of ACL injuries.[19,29] Female athletes also have narrower intercondylar notches inside the knee which can lead to ACL injuries.[30]

Extrinsic Factors

Extrinsic factors include coaching, rules, equipment, and environment. There is no difference in injury rates when playing on natural grass or artificial turf.[24-25,35-36] Many soccer players of both genders were sustaining lower leg injuries so the Federation International Football Association (FIFA) introduced shin guards to help prevent the injuries. However, since the rule of wearing shin guards was introduced the incidence of shin injury hasn't decreased.[5]Soccer shoes have been contested as a possible source of creating stress fractures in the lower leg.[37]So far there has been not enough research done on soccer shoes to implicate them in increasing risk for injury.[37]

What are the Inciting Events?

Most of the injuries that occur are due to contact. A study looking at women's top level soccer tournaments showed that 86% of the injuries resulted from player to player contact and only 14% were non-contact injuries.[25] Most of the contact injuries (sprains, concussions, fracture) were due to tackling followed by collisions with the ground or ball.[7-17] The injury types that were most common in non-contact events are ACL tears, hamstring strains, and ankle sprains.[5,7-27,29,29-32,34] Strains were most commonly caused by quick explosive movements and cutting.[7-17,35]

Injury Prevention

There is some research on the prevention of injuries in adult female soccer players.[33-34] This research has focused mainly on the prevention of ACL tears and ankle sprains. This research has shown that ACL and ankle proprioception prevention programs are effective in reducing the number of ACL tears or ankle sprains in female soccer players.[20,27] A randomized controlled trial with a large number of teams found that a neuromuscular and proprioceptive training program is effective in preventing ACL injuries in general.[20] There was a greater decrease in non-contact ACL injuries with this kind of program compared to contact ACL injuries.[20]Ankle braces have also been proven effective in preventing ankle injuries for women's soccer players who have injured their ankle previously.[5] The best way to prevent re-injury is a sufficient rehabilitation protocol which unfortunately is not always readily available.[5,7] Proprioceptive exercises and strength gains have been shown to be most effective in preventing injuries.[5,7,19,29-32,34] One of the injuries that a soccer-specific balance program has been proven to prevent is hamstring and back strains.[35] All of the proprioceptive programs were implemented for at least one entire season.[20,34-35,38]

Further Research

Many studies have commented on the limited amount of research done on women's soccer. There needs to be more research on women's soccer in order to understand if the same types of injuries are happening to both genders. It is known that a higher rate of ACL tears happen in women compared to men in soccer but this is the only injury comparison that has been done so far. Injury prevention research should target lower extremity injuries, mainly ankle and knee. More research should address prevention of overuse injuries. Overuse injuries are becoming more common in women's collegiate soccer.[39] A good way to help figure out preventative measures is to investigate injury mechanisms of the slide tackle and risk factors associated with injury.

The study conducted using the NCAA data was descriptive in nature and did not analyze risk factors.[5] The individual injury rates were never reported and injuries per hour of exposure were not used. There needs to be more detailed descriptive data on the exact injury rates using a prospective study to track even the most minor injuries. The injuries that are being reported also have not been described with injury history. The readers are unsure if the injuries reported are recurrent injuries due to an injury at the same site or if it is just an overuse chronic injury that developed over time. As discussed earlier, the HQR ratio has not been confirmed as a possible risk factor for injury in collegiate women's soccer. Long term follow-up studies of the athletes that were injured need to be performed to find out what are the long term effects of injuries. The full effects of how the athletes' lives are affected by their injuries in the long run is also unknown.

This study will address the gaps in descriptive data by looking at the participant's previous injury history and using a prospective cohort design to track exact minutes of exposure in multiple categories such as AEs, minutes and hours. Another category that has not been researched is the injury rates during weight lifting for collegiate female soccer players. Weight lifting is considered a mandatory practice at the collegiate level and therefore should be included in the regular training like practices and games. This study will track weight lifting injuries along with practice and game injuries to help expand the literature.

Finally, this study will address the gap in analytical data looking at possible risk factors. The HQR at 180 degrees per second has been suggested as a better functional speed but it has not been tested yet. This study will test the participants at that speed to see if the strength changes can cause injury. Along with testing strength, the participants' lower body agility will be assessed. There has not been a study testing to see if a person's agility is a possible risk factor for injury. Studies have not reported using skinfold measures to assess body composition and it's relation to risk of injury. Overall, this study will address these gaps in the research.

CHAPTER III

METHOD

Participants

All participants were female collegiate soccer players for the NCAA Division I Midwestern women's soccer team. This sample is considered a convenience sample. The number of participants was based on the number of members on the soccer team who agreed to participate in the study. Twenty four players were approached and asked to participate in this study.

Study Design

The study design is multi-directional in nature. A prospective cohort design over one season was used to study the incidence and distribution of injury, and to test possible risk factors. The retrospective aspect of the study was used to study retrospectively (by accessing medical records and interviewing athletes) the incidence and distribution of all injuries occurring in the previous year. Both prospective and retrospective aspects included access to player medical records. Risk factors studied in the prospective aspect of the study included the hamstring to quadriceps ratio at 180 degrees per second, lower body agility, skin fold measures, years playing the sport, year in college and playing position.

Baseline data, collected at the outset of the prospective study component, consisted of the following:

- Agility (time to complete the Illinois agility test)[40]
- Anthropometric (height, weight, skinfolds [triceps, thigh, suprailiac, and abdominal])
- Demographic (age, years in competitive soccer)
- Injury history (year prior, all years prior)
- Pre-participation Physical Examination
- Strength testing (hamstring/quadriceps ratio)

Once the season began, the participants were monitored forward in time for the duration of the regular soccer season to determine the incidence and distribution of injuries. Precise exposure data for each study participant (i.e., minutes and hours of training and competition) were collected as a basis for calculating incidence of injuries and as a basis for analyzing risk factors. Distribution of injury information was collected and reported as follows: anatomical location, environmental location, time of injury (in season and in game or practice), injury type, injury severity, and inciting events. Individual injury incidence data were used as a basis for testing risk factors.

Definitions

Injury

For the purposes of this study injury was defined as any physical complaint sustained by a player which results from a soccer match or soccer training, irrespective of the need for medical attention or time-loss from soccer activities.[21]

Recurrent injury

For the purposes of this study a recurrent injury was defined as an injury of the same type and at the same site as an index injury and which occurred after a player's return to full participation following the index injury. An index injury is a documented injury that has been sustained in previous training or match play.[21]

Injury severity

Injury severity was determined by the number of days that have elapsed from the date of injury to the date of the player's return to full participation in team training and availability for match selection. The initial date of injury is considered day "zero".[21] The injuries were grouped according to the severity based on this scale: slight (0 days); minimal (1-3 days); mild (4-7 days); moderate (8-28 days), severe (>28 days) and career ending injuries.[21]

Match exposure

A match exposure is defined as one game play between teams from different clubs. A game exposure is one player participating in one game. Match exposure is measured by counting the number of hours and minutes of play per player. Match exposures were recorded per participant and overall as follows: number of minutes played, and number of game exposures.[21]

Training exposure

A training exposure refers to team-based and individual physical activities under the control or guidance of the team's coaching or fitness staff that are aimed at maintaining or improving players' soccer skills or physical condition. Pre-match warm-up and post-match cool-down sessions are recorded as training exposure. Weight training is counted as a separate training session. Training exposures were calculated per participant and overall as follows: number of minutes played, and number of practice exposures. A practice exposure is one player participating in one practice.[21]

Instruments and Procedures

Instruments

Demographic (age, years in competitive soccer)

The players filled out a demographic questionnaire (see Appendix A), to help the researcher obtain an understanding of the player demographic characteristics. The question regarding the number of years in competitive soccer refers to the number of years the player has played on a travelling competitive soccer team. All of the questions were designed to help determine the caliber of player and may be used as possible predictor variables.

Pre-participation Physical Exam and Injury history (year prior, all years prior)

Injury history was collected on the pre-participation forms, Appendix B (pre-participation exam) and Appendix C (pre-participation update), used by the UND sports medicine staff. The pre-participation forms in Appendix B and C ask questions about previous injury history and all existing medical issues like asthma. The forms are similar except the returners form, Appendix C, is shorter and only asks for the last year's injury history instead of the player's lifetime history. It includes all previous injuries sustained within the past 4 years and any surgeries that the player may have ever had.

Strength testing (hamstring/quadriceps ratio)

All participants were tested at baseline for hamstring to quadriceps ratio on the Biodex Dynamometer prior to the beginning of the competitive season. The Biodex System 2 Dynamometer was used to test each participant's concentric hamstring to quadriceps ratio at two different rates. The two rates that were tested on the Biodex System 2 Dynamometer will be 60°/s and 180°/s. The hamstring to quadriceps ratio is traditionally computed by taking the maximal concentric knee flexion strength divided by the maximal concentric knee extension torque at the same angular velocity.[41] The ratio computed by the Biodex should show that both legs are within 10% strength of each other when compared bilaterally. The ratio should also show that each leg has the hamstrings at 50 to 60% strength compared to the quadriceps which is shown to be the best ratio for not incurring injury.[22] The ratio was recorded on the baseline information data sheet, Appendix D. A study investigated the reliability of the Biodex System 2 Dynamometer and found it to be reliable at all speeds when the participants are correctly positioned on the Biodex.[42]

Anthropometric (height, weight, skinfolds)

Each athlete had a set of four skinfold measures taken at the first testing session. This was to see what each player's body composition was at the start of season. The skinfold measures can be used in the risk factor analysis.[43] Jackson et al[43] found the triceps, thigh, abdominal and suprailiac skinfold measures to be the best predictors of body density. Height and weight were taken by one senior athletic training student assisting the principle investigator gather baseline data. Each participant took off their shoes and stood on a digital scale that reads out the weight of the participant. After the weight was recorded on the baseline data sheet (see Appendix D), the scale has a pull up measuring stick that was used to assess a person's height. The same athletic training student assessed everyone's height with their shoes off by using the scales measuring stick and reading off the height in inches. The height was recorded on the baseline data sheet in Appendix D. Only one measurement of height and weight was taken.

Illinois Agility Test

The Illinois Agility test was conducted in the Hyslop Multipurpose gym. The aim of the test is for each participant to run a weaving pattern around the cones in the fastest time possible without touching or knocking down the cones. Figure 1 shows the pattern. The normal time for a female between the ages of 16 and 19 should be 18 to 22 seconds to complete the test.[40]

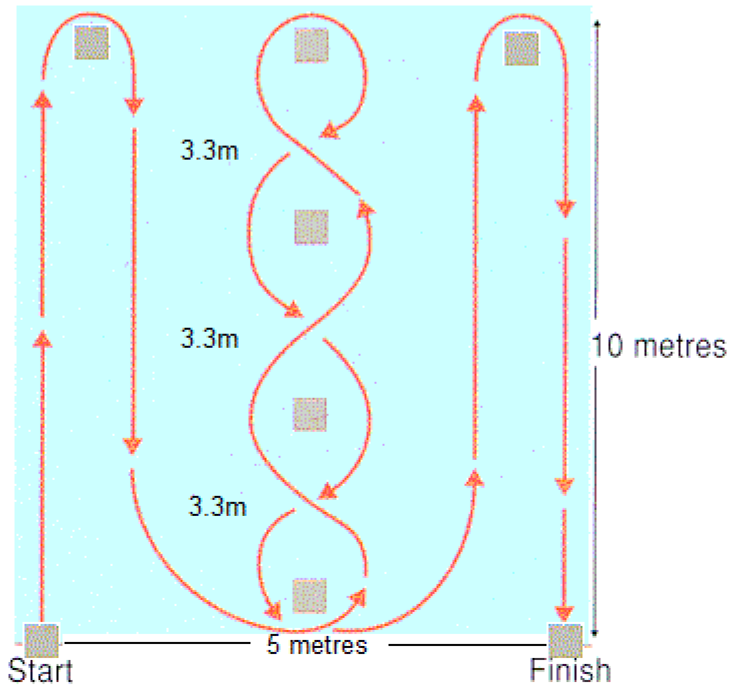

Figure 1. Illinois agility test.[40]

Procedures

Pre-Season

Approval to conduct this study was obtained from the University of North Dakota Institutional Review Board, project # 201107-011. Consent from the head coach was obtained to ask the players if they would like to participate. The head coach set up a meeting time on August 7th, 2011 to allow the principal investigator to inform the players about the study. Consent was obtained from each participant in writing, giving her approval to participate in the study and for access to her medical files from the athletic training room. Each participant signed a consent form, Appendix E, which outlines the study requirements and a Health Insurance Portability and Accountability

Act (HIPAA) form, Appendix F, which allowed the researcher to look into the participant's medical records in the UND athletic training room. The consent and HIPAA forms were signed at the meeting set up by the head coach on August 7th, 2011. Once consent was obtained the participants filled out a questionnaire, Appendix A, including demographic information such as age, gender, soccer experience, and past injury history at the first meeting. Each participant's information is only identifiable to the researcher. Each participant was randomly coded with a number to disguise the identity of each participant in the study.

The researcher set up times on August 15th, 2011 and August 16th, 2011 to meet with each individual participant to complete the tests and measurements, including Biodex testing, Illinois agility run, pre-season musculoskeletal assessment, and anthropometric measures (height, weight, skin fold). Each meeting was approximately 30 minutes in length. The participants were instructed to show up at the UND athletic training clinic in the Hyslop building wearing shorts, a t-shirt, and tennis shoes when they signed up for a time to meet with the researcher. The researcher took all of the skinfold measures using a slim guide skinfold caliper[44] following the protocol by Harrison et al from the Book, *Anthropometric Standardization Reference Manual*.[45] Three measurements were taken at each site and the mean was used to calculate the aggregate score. Height and weight were taken by a senior athletic training student who was assisting the researcher in the data collection process. Both were taken on a digital scale which has a pull up arm to measure height. The participant had their shoes off for testing weight and height following the protocol set by our team physician.

The principal researcher followed the Biodex Manual's instructions on proper positioning for the testing to ensure the reliability of the data.[46] The Biodex is located in the UND athletic training clinic and was calibrated according to the Biodex Manual. Due to the possibility of soreness as a result of the biodex testing, we did not want to create a possible injury for the athletes. Therefore the participants were not tested on the Biodex for the remainder of the study. This study was not looking for changes in HQR over the course of the study. This ratio was used to find imbalances that could be a risk factor for injury.

After the Biodex testing each athlete ran the Illinois agility test in the Hyslop Multipurpose gym. Each athlete was given 5 minutes to jog and perform a dynamic stretch before completing the test. The principal investigator administered the test and blew a whistle to sound the start of the test and start a stop watch at the same time. The test was completed when the participant crosses back over the finish line and the stop watch was stopped. Each participant had two attempts at the run. The best time was recorded on the baseline data sheet in Appendix D.

Pre-participation Examination

Before any soccer player was able to start playing, she was required to complete a pre-participation examination with the UND athletic training staff. The examination is a requirement for all UND athletes and is not specific to just this study. The team physician cleared the athlete to play or for the athlete to play with certain restrictions or conditions. The exam was shorter for returning players versus new players. The returning players had a shortened musculoskeletal assessment and a shorter physician section as well. The information from the pre-participation exams was used to assist in identifying any previous injuries that affected the soccer players. The height, weight and injury history was used from this examination to be recorded on the player's baseline data sheet found in Appendix D.

Competitive Season

Injury Surveillance

Injury Surveillance proceeded from August 7th, 2011 until November 8th, 2011 and was conducted by the principal investigator who is a certified athletic trainer. The principal investigator was present at each training session and game to monitor the participants and collect exposure and injury data. The pre-season was considered from August 7th until August 26th, the regular season began August 26th and lasted until October 27th, and the post season was October 28th through November 8th. An injury report form (Appendix G) was used to record all injuries that the soccer players occur throughout the course of the study. This form was created by a committee of soccer researchers who wanted to standardize research in the sport through the creation of a consensus statement.[21] The injury report form is intended to provide information on the anatomical location of the injury, injury onset, injury mechanism, type of injury, timing of injury, and time lost from injury. The injury type was recorded on the form according to the classifications specified in the consensus statement created by Fuller et al[21] which can be found in Tables 4 and 5.

Table 4. Categories for Classifying Injury Anatomical Location[21]

Main grouping	Category	Equivalent OSICS Body Area Character (Orchard, 1995)
Head and neck	Head/face	H
	Neck/cervical spine	N
Upper limbs	Shoulder/clavicula	S
	Upper arm	U
	Elbow	E
	Forearm	R
	Wrist	W
	Hand/finger/thumb	P
Trunk	Sternum/ribs/upper back	C, D
	Abdomen	O
	Lower back/pelvis/sacrum	B, L
Lower limbs	Hip/groin	G
	Thigh	T
	Knee	K
	Lower leg/Achilles tendon	Q, A
	Ankle	A
	Foot/toe	F

OSICS, Orchard Sports Injury Classification System.

Table 5. Categories for Classifying Injury Type[21]

Main grouping	Category	Equivalent OSICS Pathology Character (Orchard, 1995)
Fractures and bone stress	Fracture	F
	Other bone injuries	G, Q, S
Joint (non-bone) and ligament	Dislocation/subluxation	D, U
	Sprain/ligament injury	J, L
	Lesion of meniscus or cartilage	C
Muscle and tendon	Muscle rupture/tear/strain/cramps	M, Y
	Tendon injury/rupture/tendinosis/bursitis	T, R
Contusions	Haematoma/contusion/bruise	H
Laceration and skin lesion	Abrasion	K
	Laceration	K
Central/peripheral nervous system	Concussion (with or without loss of consciousness)	N
	Nerve injury	N
Other	Dental injuries	G
	Other injuries	

OSICS, Orchard Sports Injury Classification System.

Injury incidence information was obtained by the researcher on a daily basis since the researcher was the Certified Athletic Trainer for the UND women's soccer team. The direct observation and interview technique were used for recording and following up on all injuries. While at practice each day the researcher asked the participants about any current injuries and kept a record of the progress of past injuries. If any new injuries occurred, an injury report form was filled out on the date of injury.

Exposure Data

In addition to collecting information regarding injuries, the researcher also collected data on the players training and match time. The soccer players were observed at every game and practice by the researcher and an accurate time log was filled out for each player. The consensus statement[21] provided an exposure report form, Appendix H and I, which were used to record the exposure data. If the entire team was practicing, a team exposure form, Appendix H, was filled out recording the number of minutes the team practiced. If the practice started at 2pm and went until 5pm the time was recorded as 180 minutes. All portions of practice were considered part of the practice including water breaks. If a player came late to practice or if there was a player missing from practice then this individual's practice time was recorded on the Individual Exposure form, Appendix I, instead of using the team exposure form. The missing person had a time of 0 hours for the day. During match play the researcher used the official time log kept by the scorers at the match because they recorded the exact number of minutes that each player was on the field. Having the researcher record all playing times minimized possible errors that may occur if the participants filled out their own time logs. If the participants had done this on their own, they may have done it retrospectively and just averaged time instead of recording exact minutes of start and stop.

Data Analysis

At the conclusion of the regular competitive season, all descriptive data were compiled and entered into an Excel spread sheet. Thereafter, the data were exported to SPSS for analysis.

Descriptive Data Analysis

Individual and team injury rates were calculated. One injury rate was calculated by dividing the total number of injuries sustained collectively on the team by the total number of hours exposed collectively, then multiplying this number by 1000. This approach yielded an injury rate per 1000 hours exposure. Injury rates were also calculated by 1000 playing minutes and 1000 athletic exposures. The injury rates were calculated for the match exposure, practice exposure, weight training and total exposure in each type of rate (hours, minutes, AE). A comparison was made between match exposure injury rates, weight training rates, and practice exposure injury rates to determine if a player was more at risk for injury during a specific type of play. In addition to the injury rate, injury distribution (anatomical location, injury type, and injury severity) were calculated using SPSS. The frequencies and computer variable in SPSS were used to determine the number, percentage, and rate of injuries.

In order to compare with previous NCAA injury reports, collective injury rates were also calculated with reference to 1000 Athletic-Exposures (AEs).

Risk Factor Analysis

A Poisson regression model was attempted using generalized estimating equations (GEE) to estimate incidence rate ratios (IRR, 95% CI). The soccer players' individual injury rates were used as outcome variables. Predictor variables included years playing soccer, the Illinois agility test scores, skin fold aggregate scores, the H:Q ratios, and playing position.

CHAPTER IV

RESULTS

Demographic Information

Baseline data collection began on August 8, 2011, following the first practice of the season. All 24 of the athletes were interested in participating and completed a history questionnaire, along with signing the informed consent and HIPAA forms. Table 6 summarizes the participants' demographic information. Of the twenty four players who agreed to participate, 8 were freshman (33.3%), 8 sophomores (33.3%), 4 juniors (16.6%), and 4 were seniors (16.6%).

Additional demographic information obtained at baseline included the number of years competitive experience, age the participants started to play soccer, position played, and leg dominance. Twenty two out of the twenty four participants were right leg dominant, one was left leg dominant and one was ambidextrous.

Table 6. Participants Demographic and Anthropometric Data

Variable	**Mean**	**Range**	**Standard Deviation**
Age (years)	19.25	18-22	1.5
Height (inches)	65.75	62-69.5	2.4
Weight (lbs)	148.55	103.4-189.4	21.82
Age Started	5.54	4-10.0	1.64
Years Played	9.46	7-11.0	1.1

Frequency and Incidence of Injury

Seventeen of the 24 participants were injured during the season and those 17 players accumulated a total of 28 injuries. Only 8 participants (33.3%) were injury free for the entire season. The exposure and injury rate data are summarized in Table 7. The game injury rates were almost 3 times higher than practice injury rates when reporting in AE's.

The study was designed to count every minute of exposure to risk of injury including practice, weight training and game play which makes it possible to provide injury rates relative to minutes, hours, and athletic exposures. The overall injury rate was 0.14 injuries per 1000 minutes exposure.

Along with counting this season's injuries, the participants past history was accessed by the athletic trainer and the health records were reviewed to find out how many injuries happened the previous season for each person. Table 8 shows the injury rates for the previous season based on estimated hours of exposure and athletic exposures. The hours of exposure were estimated using the schedule from the previous season that the coach kept on record. The injury rates for the 2010 season were 2 times as high during this season compared to the 2011 season.

Table 7.Total Team Exposures and Injury Rates for 2011 Season.

Training Type	# of Injuries	Total Min	Total Hrs	Total AEs	IR/1000Min	IR/1000Hrs	IR/1000AE's
Game	10	18796	312.93	276	0.53	31.96	36.23
Practice	15	151673	2527.88	1207	0.1	5.93	12.43
Weight Training	3	23725	395.41	457	0.13	7.59	6.56
Total	28	194194	3236.22	1940	0.14	8.65	14.43

AEs = Athletic Exposures (One athlete playing in one game or one practice)

Table 8. Total Team Injury Rates for 2010 Season

Training Type	# of Injuries	Total Hrs	Total AEs	IR/1000Hrs	IR/1000 AEs
Game	21	320	300	65.62	70
Practice	22	2550	1230	8.63	17.88
Weight Training	3	400	457	7.5	6.56
Total	46	3270	1987	14.07	23.15

Who is Affected

Table 9 shows the injury rates by year in college and table 10 shows the injury rates by playing position for the 2011 season. Looking at the year in college (Table 9), the sophomores have the highest rate of injury at 15.15 injuries per 1000 hours and the juniors have the lowest rate of injury at 3.25 injuries per 1000 hours. The injury rates by position were not able to be calculated for the 2010 data due to not accurately being able to account for each individuals playing time. There may have been day's missed due to class or other issues that cannot be accounted for. Table 10 shows the midfielders have the highest rate of injury at 16.57 injuries per 1000 hours and the forwards had the lowest rate of injury at 4.69 injuries per 1000 hours.

Table 9. Injury Rates by Year in College for 2011.

Who	# of Injuries	Total Min	Total Hrs	Total AEs	IR/1000Min	IR/1000Hr	IR/1000AE
Senior	2	34001	566.69	328	0.06	3.53	6.1
Junior	2	36879	614.65	365	0.05	3.25	5.48
Sophomore	16	63347	1055.78	628	0.25	15.15	25.48
Freshman	8	59930	998.83	581	0.13	8.01	13.77

Table 10. Injury Rates By Playing Position for 2011.

Who	# of Injuries	Total Min	Total Hrs	Total AEs	IR/1000Min	IR/1000Hr	IR/1000AE
Forward	5	63961	1066.01	623	0.08	4.69	8.03
Midfielder	11	39837	663.95	400	0.28	16.57	27.5
Defender	8	65554	1092.57	649	0.12	7.32	12.33
Goalkeeper	4	24828	413.8	230	0.16	9.67	17.39

Where

Anatomical Location

Table 11 displays the data for anatomical location of injury for the 2011 and 2010 seasons. Of the 28 injuries in 2011, 19 (69%) were to the lower extremities. The most frequent injury site was the knee followed by the ankle. The knee and ankle injuries accounted for the majority (57.9%) of injuries to the lower extremities. The upper body accounted for 6 injuries (21.4%). The 2010 data are similar in overall distribution; however, there were twice as many injuries. The knee and ankle were also the most frequently injured anatomical locations in the 2010 season.

Table 11. Anatomical Location of Injuries for 2011 and 2010

	2011 Season		**2010 Season**	
Location	**# of Injuries**	**% of Injuries**	**# of Injuries**	**% of Injuries**
Head/Face	4	14.3	3	6.5
Neck	0	0	1	2.1
Shoulder/Clavicle	2	7.1	2	4.3
Abdomen	1	3.5	1	2.1
Back/Sacrum	2	7.1	3	6.5
Hip/Groin	3	10.7	6	13
Thigh	2	7.1	3	6.5
Knee	6	21.4	9	19.6
Lower Leg	1	3.5	5	10.9
Ankle	5	17.9	8	17.4
Foot/Toes	2	7.1	5	10.9
Total	**28**	**100**	**46**	**100**

Environmental Location

The injuries occurred in training, competition and during weight training. In 2011 there were a total of 15 injuries in practice (53.6%), 10 in games (35.7%), and 3 during weight training (10.7%). A player in 2011 was 5.89 times more likely to be injured in a game than in practice according to the injury rates per 1000 hours. Table 7 shows injury rates for each training session in minutes, hours and athletic exposures. Injury rates were greatest in competition followed by either practice or weight training depending on type of injury rate. In 2010 there were a total of 22 injuries in practice (47.8%), 21 in games (45.7%), and 3 during weight training (6.5%). Table 8 displays the injury rates for the 2010 season. The injury rates for 2010 were almost double compared to 2011. In 2011 there was a game injury rate of 31.96 injuries per 1000 hours and in 2010 there was a rate of 65.62 injuries per 1000 hours. The rate of injury was greatest for games, followed by practice then weight-training.

When

Injury onset refers to whether an injury was acute or overuse. Of the 28 injuries in 2011, only 3 (11%) were chronic in nature while the other 25 (89%) were acute. In 2010 the participants suffered 8 (17.4%) chronic injuries and 38 (82.6%) acute injuries. The chronic injuries during both seasons were recurrent muscles strains or patellar tendonitis.

Another way to classify when an injury occurred is time of season. Nine of the 28 injuries occurred during the preseason, 19 occurred during the regular season and there were no injuries during the 2011 post-season. The injuries during the preseason accounted for 31% of the total injuries, while the injuries during the regular season accounted for 69%. In 2010 there were more injuries occurring in the post-season. Thirteen occurred during preseason, 20 occurred during the regular season and thirteen occurred during the post season. Table 12 shows the injury rates based on time of season for the 2011 season. The injury rate during the regular season is the highest.

Table 12. Injury Rates by Time of Season.

Time of Season	# Injuries	# Minutes	# Hours	# AEs	IR/1000Min	IR/1000HRs	IR/1000AE
Preseason	9	71,791.00	1,196.52	553.00	0.13	7.52	16.27
Regular Season	19	110,284.00	1,838.07	1,206.00	0.17	10.34	15.75
Post Season	0	12,119.00	201.98	69.00	0.00	0.00	0.00
Totals	**28**	**194,194.00**	**3,236.57**	**1,828.00**	**0.14**	**8.65**	**15.32**

Injuries can also be defined by when during a practice or game did they occur. Most injuries occurred during the second half of the game or practice. For example, out of the 10 game injuries that occurred in the 2011 season, 3 (30%) occurred during the first half of a game and 7 (70%) happened during the second half of the game. During practice, 6 (40%) of 15 injuries occurred during the first half of practice, while 9(60%) of 15 injuries occurred during the second half of practice.

Injury Outcome

Type

Table 13 shows the descriptive statistics for type of injuries that occurred during the 2011 and 2010 seasons. In 2011, the most frequent injury was a muscle strain, accounting for 35.7 percent of the injuries followed by ligament sprains (21.4%). In 2010, strains were also most frequent (39.1%), followed by sprains (30.4%). Table 14 details the distribution of sprains and strains over both seasons. In both season the majority of sprains were to the ankle and knee. The strains in both seasons are more widely spread out but the hip and groin area had the most strains.

Table 13. Descriptive Statistics on Injury Types in 2011 and 2010 seasons

	2011		2010	
Injury Type	**# injured**	**% injured**	**# injured**	**% injured**
Concussion	2	7.1	3	6.5
Fracture	1	3.6	0	0
Bone Bruise	1	3.6	2	4.3
Meniscus Tear	3	10.7	2	4.3
Sprain	6	21.4	14	30.4
Strain	10	35.7	18	39.1
Tendonitis	1	3.6	1	2.2
Bruise	3	10.7	4	8.7
Laceration	1	3.6	0	0
Nerve Injury	0	0	1	2.2
Disk Herniation	0	0	1	2.2
Total	**28**	**100**	**46**	**100**

Table 14. Distribution of Sprains and Strains for 2011 and 2010.

	2011 Season Sprains		2010 Season Sprains		2011 Season Strains		2010 Season Strains	
Location	**# Inj.**	**% Inj.**	**# Inj.**	**% Inj.**	**# Inj.**	**% Inj.**	**# Inj.**	**% Inj.**
Neck			1	7.14			1	5.26
Shoulder/Clavicle	1	16.67					1	5.26
Back/Sacrum			1	7.14	2	20	2	10.53
Hip/Groin					3	30	6	31.57
Thigh					3	30	2	10.53
Knee	1	16.67	5	35.71			2	10.53
Lower Leg					1	10	2	10.53
Ankle	4	66.67	7	50			1	5.26
Foot/Toes					1	10	2	10.53
Total	**6**	**100**	**14**	**100**	**10**	**100**	**19**	**100**

Time Loss

For this study, time loss was calculated based on the number of practices that the player either missed completely or did not fully participate in because of an injury. Time loss was divided into three main categories: less than 8 days, 8-28 days, and more than 28 days. Table 15 shows a comparison of the time loss associated to injuries with the number of injuries and the percentage that it accounts for in both the 2011 and 2010 seasons. The most common time loss category in 2011 was less than 8 days which accounted for 24 injuries (86%). Of the 24 injuries, 20 (83%) did not result in any time loss. A further analysis shows that the most common injury locations for the time category of less than 8 days were to the knee followed by the hip/groin and ankle. A concussion, facial fracture and ligament sprain to the ankle accounted for the three injuries lasting 8 to 28 days. The time loss category longer than 28 days had one injury and it was a ligament sprain to the ankle.

In 2010 there were more injuries that lasted more than 28 days. However, most injuries were minor in nature, requiring less than 8 days recovery. There were 40(87%) injuries lasting less than 8 days. Thirty five of the 40 injuries in the less than 8 days category required no time loss. These injuries included contusions, minor sprains and strains that could be braced or taped and played through. The one injury lasting 25 days was a neck sprain. Four out of the 5 injuries lasting more than 28 days were surgical including two ACL repairs, a meniscus repair and an ankle surgery.

Table 15. Time Loss Due to Injury for 2011 and 2010

	2011		2010	
Time Loss	**Number**	**Percent**	**Number**	**Percent**
Less than 8 Days	24	85.7	40	87
8-28 Days	3	10.7	1	2.2
More than 28 Days	1	3.6	5	10.8
Total	**28**	**100**	**46**	**100**

Clinical Outcome

Recurrent Injuries

Out of the 28 injuries in 2011 there were 6(21%) recurrent injuries. Two injuries (33%) were concussion, 2(33%) were sprains to the ankle and knee, and 2(33%) were strains to the foot and thigh. In 2010 there were 10(22%) injuries that were recurrent injuries, including 4 sprains, 4 strains, 1 concussion, and 1 quad contusion. The locations for these injuries were more varied. The most occurred in the ankle with 3(30%). The knee and gastrocnemius came next with 2 injuries each. The other 3 injuries happened to the foot, head, and groin.

Surgical Injuries

In 2011, 4 injuries were considered surgical: the three meniscus tears and one ruptured ligament in the ankle. None of the athletes received surgery during the season because they were able to participate in the sport with minimal discomfort. All of these athletes indicated they would like to have surgery to repair the injuries when they are finished with their playing career. In 2010, there were 5 injuries that were considered surgical and 4 out of the 5 proceeded to surgery postseason. Two of the injuries (1 ACL and 1 ankle) needed to have two surgical procedures for a total of 6 surgeries for the season. All of the surgeries were performed on ankle or knee injuries.

Cost

The cost of health care has been on the rise in recent years. The principle researcher went to the local clinic billing department where the athletes receive all of their health care to find out the costs of each service provided. Table 16 shows the costs of medical services provided. In the 2011 and 2010 seasons there were a total of 29 doctor's visits. The team physician charges $158 dollars per visit which is a total of $4582 between the two seasons. An average doctor's examination is around $150 depending on the area according to the clinic this team receives all of it services. Specialists will charge more per visit than a general family physician. During the two seasons a total of 15 x-rays were taken at $40 each equaling $600 in x-ray costs. An x-ray can run between $40 to $80. The final images ordered were 6 MRIs and 2 CT scans over the two seasons. The average MRI costs $1350 - $1450 and a CT scan costs $1350 - $1600 depending on the area. The local hospital in this study charged $1350 for both an MRI and CT scan. The participants were billed $10,800 for the MRIs and CT scans.

Table 16. Cost of Injuries Over the 2010 and 2011 Seasons.

Type of Service	# of Services	Cost	Total
Physician Exam	29	$158	$4,582
X-ray	15	$40	$600
MRI	6	$1350-1450	$8,100
CT	2	$1350-1600	$2,700
Surgeries	6	$10,000-$12,000	$60,000
TOTALS	**58**	**-**	**$75,982**

In the 2010 season there were 6 surgeries, two ACL reconstructions, one meniscus repair, one shoulder labral repair and two Brostrom repairs. Each of these surgical procedures was between $10 to $12 thousand dollars. In the 2010 season the surgeries alone cost between $60 to $72 thousand dollars. The 24 participants in this study over the course of two seasons created medical costs between $75982 and $87982 without the addition of physical therapy costs. In the 2011 and 2010 seasons there were a total of 72 injuries which averages out to over $1000 per injury for the team.

Collegiate athletes rarely have to pay directly for the medical procedures required which can lead to ordering extra tests or imaging that may not be necessary. The university system absorbs those costs through the athletics program after insurance companies have paid their portion of the bill.

Risk Factor Analysis

Risk factors of interest in this study included the hamstring to quadriceps ratio (HQR), the Illinois agility test time, skinfolds, year in college, playing position and years played. A Poisson regression model was used to analyze the risk factors but the analyses were unable to produce reliable results due to small sample size and unwieldy data. The data are plotted below for each variable and discussed briefly.

HQR

Figure 2 shows the data set for the HQR at 180 degrees per second for the right leg. The data set looks the same when compared with the injury rates per minute.

The Illinois Agility Test

The Illinois agility test assesses level of lower body agility based on the time it takes to complete the run in seconds. This can be categorized into Poor (over 23 sec), Fair (23.0-21.8), Average (21.7-18.0), Good (17.9-17.0) and Excellent (under 17 sec). Out of the 24 participants, 8 (34.8%) completed it in the good category and 15 (65.2%) completed it in the average category. One participant was unable to complete the test due to ankle instability. Figure 3 shows a box graph of the injury rates related to their agility score.

Skinfolds

All of the participants had four skinfold measures taken (triceps, thigh, suprailiac, and abdominal) at the beginning of the season. A skinfold aggregate score was calculated for each participant and plotted with their individual injury rate score. The scores range widely and this may be due to the fact that each position on the field requires a little different body type to be played. The varying body type could contribute to the variant skin fold aggregates and the injury rates associated with it. Table 17 shows the results for the skin fold measures. Figure 4 shows a scatter plot of the data.

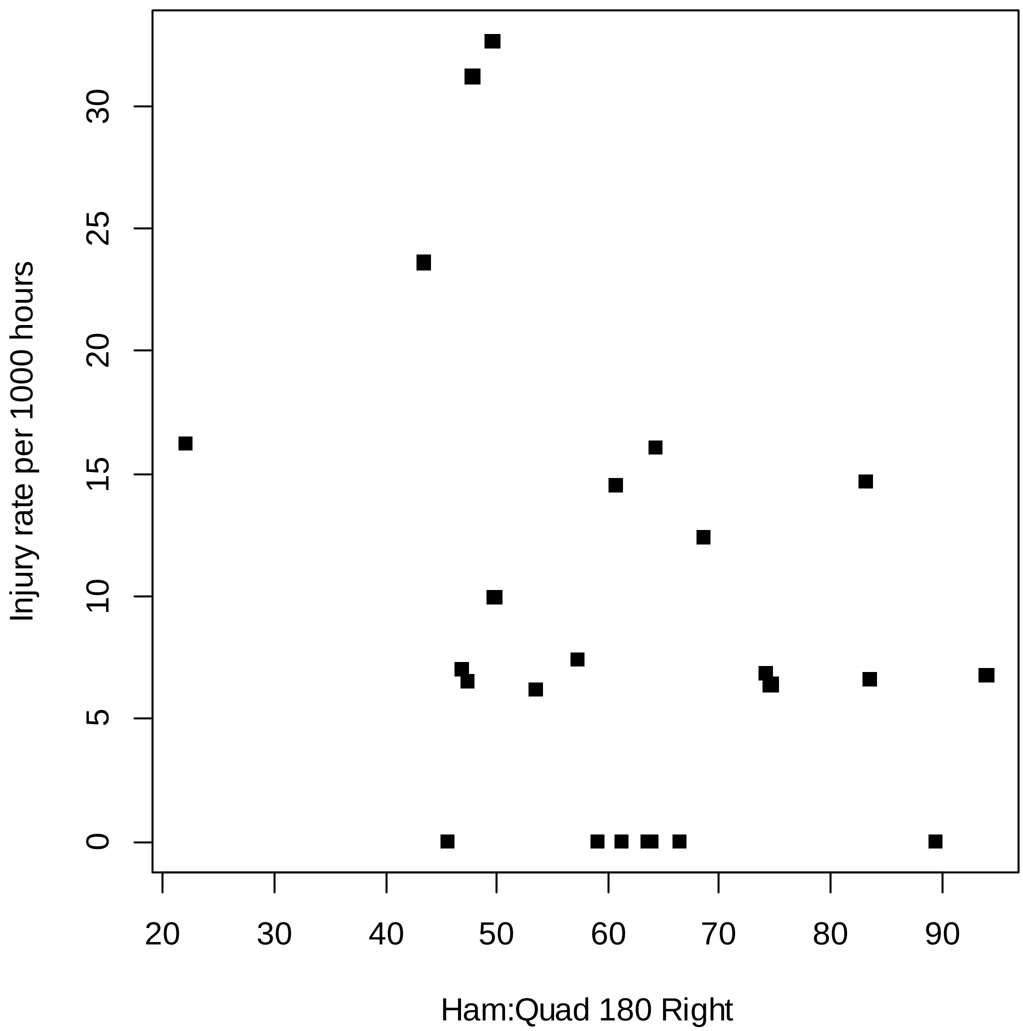

Figure 2. Data Plot of Individual Injury Rate per 1000 Hours and Right HQR at 180 Degrees per Second

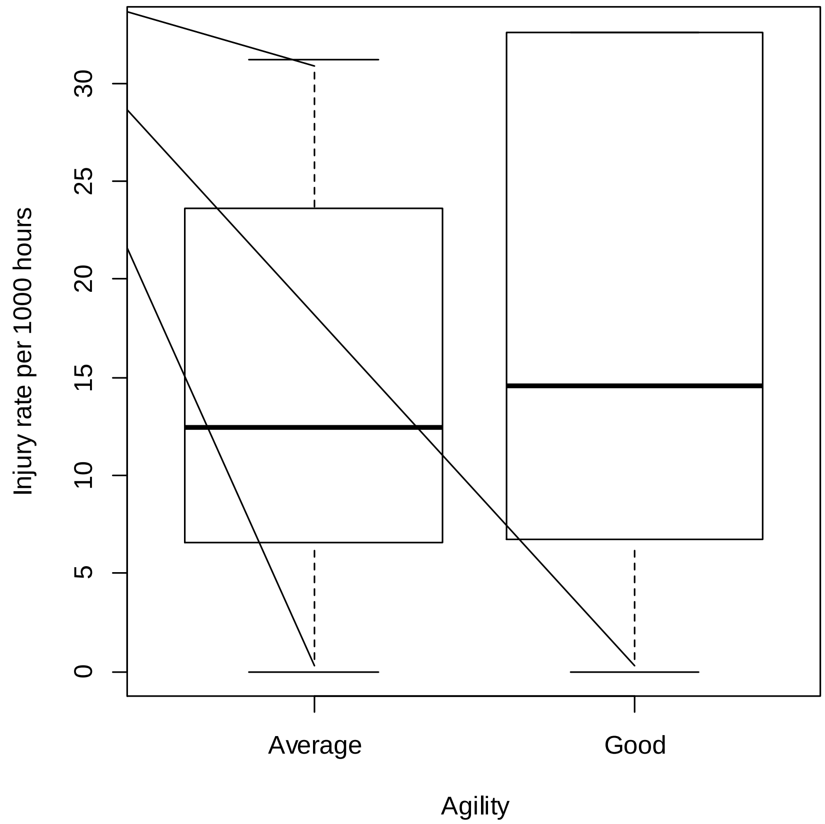

Figure 3. Injury Rates per 1000 Hrs Related to Agility Scores. Lines indicate median values, boxes indicate interquartile range and the whiskers indicate the range.

Table 17. Skinfold Results (mm)

Variable	Mean	Range	Standard Deviation
Tricep	17.25	10.0-25.0	4.33
Thigh	24.00	14.0-35.0	5.98
SuperIlliac	13.21	7.0-28.0	5.02
Abdominal	18.21	10.0-43.0	6.49
Aggregate	72.66	44.0-119.0	17.59

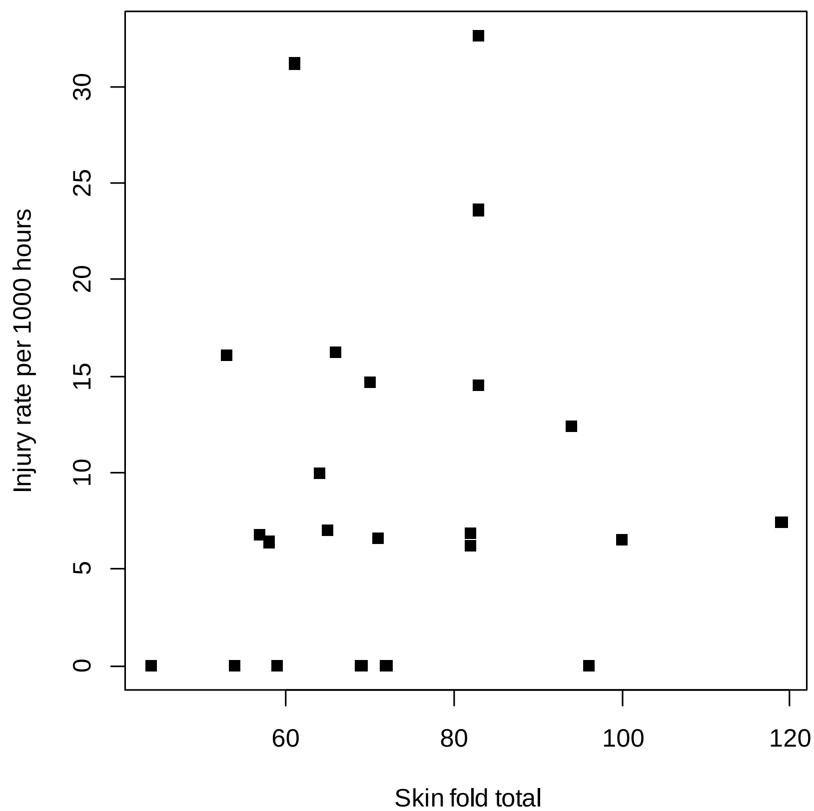

Figure 4. Skinfold Aggregate Related to the Injury Rate per 1000 Hours

Years Played

Figure 5 shows the years played compared to the injury rates for 1000 hours exposure in a scatter plot. There is no distinguishable pattern to this graph and the results are widely spread apart. The graphs for athletic exposures and injury rates per 1000 minutes are very similar to the graphs for injury rates per 1000 hours.

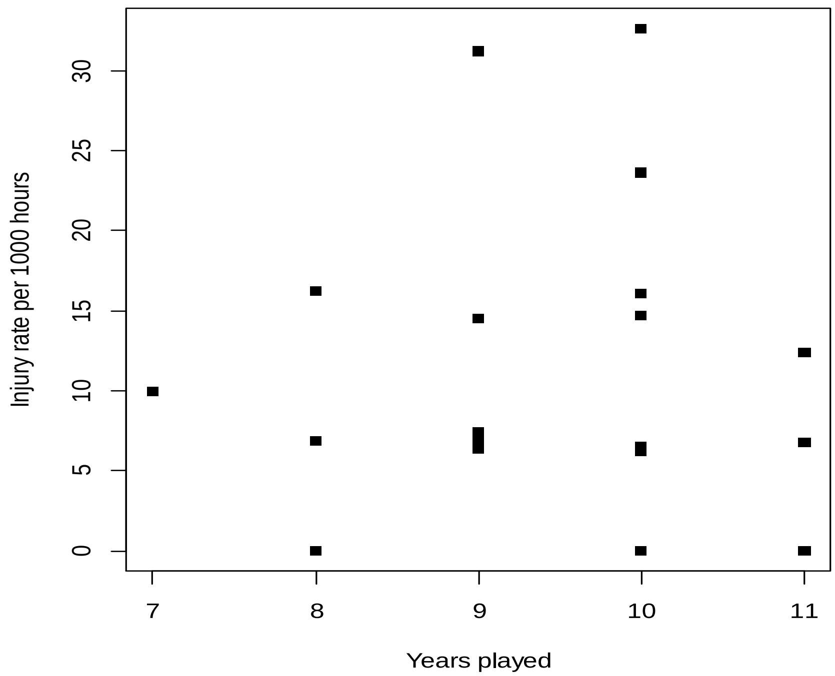

Figure 5. Years Played related to Injury Rates per 1000 Hours

Year in College

Figure 6 depicts a box plot based on the year in college compared to the injury rates per 1000 hours exposure. This figure shows that injury rates for sophomores and freshman were higher than those for juniors and seniors. The sophomores had the highest rate of injury on the graph.

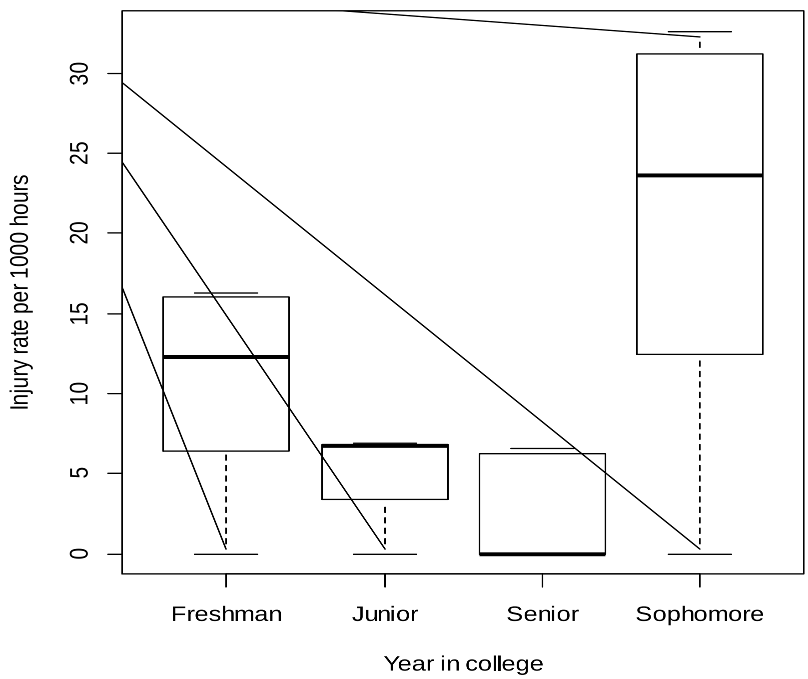

Figure 6. Year in College Compared to Injury Rate per 1000 Hours. Lines indicate median values, boxes indicate interquartile range and the whiskers indicate the range.

Player Position

Figure 7 shows a box plot of the player’s position in relation to the injury rates per 1000 hours exposure. Midfielders appear to have a higher risk of injury according to this graph but it was unable to be input into the Poisson regression. The other three positions on the field have around the same risk of injury. The graphs for rates per minute and athletic exposures look the same as the graph for injury rates per 1000 hours.

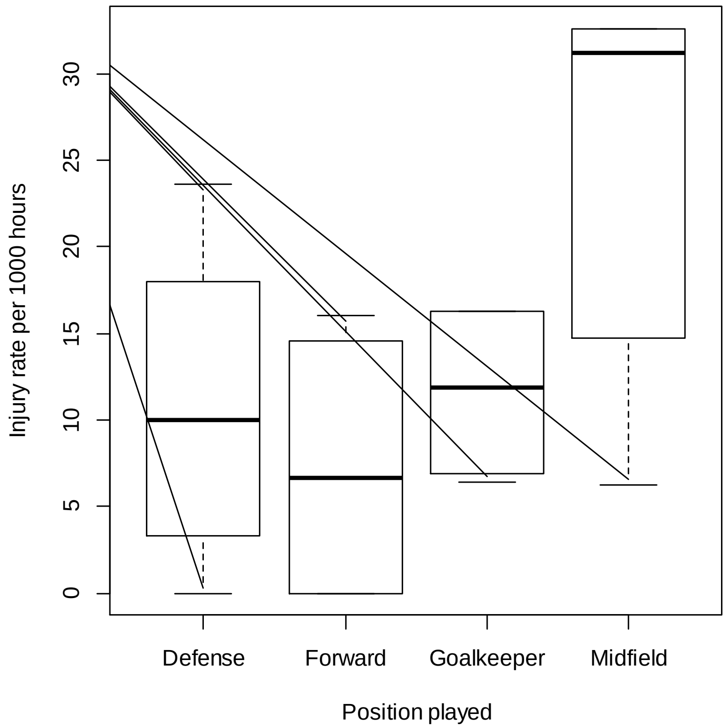

Figure 7. Player Position Compared to Injury Rates per 1000 Hours. Lines indicate median values, boxes indicate interquartile range and the whiskers indicate the range.

CHAPTER V

DISCUSSION

Descriptive Analysis

Injury Rate

Table 18 shows a comparison between this study and the previously published studies of women's soccer injuries. To date, there is only one published study that reported the rate of injuries per 1000 athletic exposures (AEs).[5] Dick et al[5], an NCAA study that reported 15 years of data collected by their injury surveillance system, reported an injury rate of 16.44 in games and a rate of 5.23 in practices. The injury surveillance system had certified athletic trainers, physical therapists, and doctors reporting data. The injury definition may be different than the present study's definition. The definition in this study includes everything even as small as a bruise whereas the NCAA study most likely did not include injuries that minor. This will cause the present study to have a slightly higher injury rate due to the very inclusive nature of injury definition used.[5] In this study there was a much higher incidence rate of 36.23 in games and 12.43 in practices during 2011.

The higher rate reported in this study may reflect the use of only a certified athletic trainer to collect the data and the prospective nature of this study. Athletic trainers will see more injuries than just a physician because the less severe injuries are not reported to a physician and the ATCs are onsite. The prospective nature of this study allows the researcher to count even the minor injuries in contrast to a retrospective study where the minor injuries are usually forgotten. The higher injury rate during the 2010 season might be due to having a larger freshman class and the freshman had incurred more injuries coming into the season than any other class. Another factor might be that the team had an extra game and practice in the post season creating a longer tournament play which resulted in injuries.

The present study is the first to provide a rate of injury relative to weight training, separating it from other practice. In this study there was a rate of 6.56 injuries per 1000 AE during the weight lifting portion of the participants training. The rest of the studies are not specifically collegiate but they are women of the same age range playing in elite leagues and their data is in the form of injury rates per 1000 hours.[7-17]

The participants in this study put in a cumulative total of 3236.56 hours of training which includes game, practice, and weight lifting minutes. This means there was an overall injury rate of 8.65 injuries per 1000 hours of exposure. The injury rates for previous studies range between 1.9 - 9.6 injuries per 1000 hours but the injury definitions for previous studies are not all the same.[5,7-17] Some use time loss and other studies use medical attention to define the injuries. The differences in injury rates could be due to who was reporting the data and the definitions used for the study.

Table 18. Comparison of Overall Injury Rates in Women's Soccer Ages 14-41.[5,7-17]

Study	Year	Study Design	Level	Sample Size	# Injuries	G Rate/1000 AEs	P Rate/ 1000 AEs	G Rate/ 1000 Hours	P Rate/ 1000 Hours	WT Rate/ 1000 Hours	T Rate/ 1000 Hours
Dick et al	2007	D	C	20,447 games and 54,750 practices	G= 5,373 P=5,836	16.44	5.23				
Faude et al	2005	C	E	n=165	241			23.3	2.8		6.8
Giza et al	2005	C	E	n=202	173			12	1.2		1.9
Jacobson & Tenger	2007	C	E	n=269	237			13.9	2.7		4.6
Ostenberg & Roos	2000	C	R	n=123	65			14.3	3.7		6.6
Soderman et al	2001	C	E	n=146	80			10*	1.3*		5.5*
Jung & Dvorak	2007	C	E	5742 player hrs	387			67.4			
Walden et al	2007	C	E	n=160	17			36	2.5		
Hartmut et al	2010	C	E	n=254	246			18.5	1.4		3.3
Tegnander et al	2008	C	E	n=181	189			23.6*	3.1*		
Hagglund et al	2009	C	E	n=228	299			16.1	3.8		5.5
Jacobson & Tenger	2006	C	E	n=253	229			13.3	8.4		9.6
THIS STUDY	2012	C	C	n=24	28	36.23	12.43	31.96	5.93	7.59	8.65

Study Design D= Descriptive C= Cohort
Level C= College E= Elite CL= Competitive League

*Denotes injury rates based on acute injuries only.

G= Game
P= Practice
WT= Weight Training
T=Total

Who is Affected

In this study the injury rate for midfielders was greatest which isn't congruent with previous studies. One previous study looked at playing position as a risk factor and found no statistical significance in playing position; the midfielders had the lowest rate of injury in the study.[25] The midfielders might have a higher rate of injury in the present study because they traverse the entire field during a game and usually are challenging the 50/50 balls more often which result in collisions with the opposing player. The midfielders might be fatiguing quicker than other positions due to the high volume of running up and down the field compared to the other positions.

This study also looked at injury rates relative to the player's year in college which has never been done before in a study. The sophomores had a higher rate of injury followed by the freshman. This might be explained by the sophomores not having as much training in the weight room and during practice at this level compared to the juniors and seniors. The higher intensity of training can cause an increase in injuries if the athletes are not used to the training. The NCAA study that reported on 15 years of data did not include data on rates of injury by year in college.[5]

Where Injury Occurs

Anatomical Location

Table 19 shows the percent of injuries occurring by anatomical location compared to the previous studies published. This study identified that the knee (21.4%) and ankle (17.9%) were associated with the highest proportion of injuries. Table 19 shows that 4 previous studies found the knee to have the highest rate of injury (range = 18.8-31.8), yet 6 other studies found the ankle had the highest rate of injury (range = 15.5-28.4), in contrast to this study. The biggest difference is the detail in which this study is able to report the injuries compared to the only other collegiate study done by Dick et al.[5] The collegiate study reported the injury location only as a total of lower extremity injuries instead of breaking it down into more specific body parts.[5] This study found the percent of lower extremity injuries was 67.7 percent compared to the only collegiate study of 67.8 percent for games and 72 percent for practices. The number of lower extremity injuries is very close to those in the NCAA study even with the large differences in number of participants.[5]

The higher rate of injuries at the knee and ankle is cause for concern. Many of these injuries are due to contact and during the pre-season the strength training program focuses on lower body strength. A proprioceptive and plyometric program should be instituted to help prevent these injuries.[6,19-20,31,38]

Environmental Location

This study is unique because it looks at environmental location with respect to where the players are training and playing. There has not been a study that looks at all components of a collegiate athlete's workout. No study has published the number of injuries that the athletes sustain during their weight lifting sessions in relation to their playing status. At the Division I level, weight lifting is a mandatory part of any athletes training regime and it can result in a substantial number of injuries. Three of the 28 (10.7%) injuries sustained this season were sustained in the weight room.

When Does Injury Occur

Injuries can occur in different times of the season and different times of a practice or game. This study found that most of the injuries (69%) occurred during the 2011 regular season. In contrast, during 2010 43% of the injuries occurred during the regular season. One study reported by the NCAA found the highest rate of injury occurred during the preseason, followed by the regular season, and the least amount occurring in the post season.[5] This study found the preseason to be second highest with the post season with the least in 2011.

Previous research has found a higher incidence of injury in the second half of a game compared to the first half of a game.[13,25] This study found the same results with 7 of the 10 game injuries occurring in the second half during 2011. Other studies have not published data on when injuries occur during time of practice. All research until this point has focused solely on the time of injury during a game. The implications of having more injuries happen in the second suggests fatigue as an etiological factor. The athletes will lose technique as they become tired and the reaction time can decrease putting them at risk for injury.

Injury Outcome

Injury Onset

Most of the studies have not looked at or tracked the number of chronic injuries. This study found that the majority of the injuries sustained in the season were acute injuries. Acute injuries accounted for 89% of the total injuries. That leaves a very small amount occurring chronically. One explanation for the high number of acute injuries could be the high amount of contact involved in the sport. Out of the 25 injuries that were acute in 2011, 12 were caused by collision with the ground, ball or other player.

Injury Types

In this study the most common injury type was strain (35.7%) followed by a sprain (21.4%). Perusal of Table 20 shows that the most common injury types in other studies varied somewhat. In five studies strain was most common (range = 28 – 35.9), yet in 4 other studies sprain was most common (range = 26 – 65.6). At a quick glance, the table has many open spaces. Previous studies used broader injury types instead of breaking it down into more specific injuries. The studies that report an “other” column may include some of the injuries this study reports like lacerations, tendonitis and meniscus tears. Faude et al[7] and Jacobson & Tenger [17] have large percentages in the other category of 16.1 and 41 respectively. Those are large percentages of unknown injury types. Only one category on the table is historically a chronic injury which is tendonitis. This study is the only one to report the injury type specifically to help show that chronic injuries do occur. Overall, the results of this study are similar to the other studies when comparing injury type.

Time Loss

Time loss associated with an injury can vary based on several different factors including severity of injury, the athlete’s compliance to treatment, the athlete’s perception of pain, and the overall healing process. Previous research has reported around half of all injuries result in time loss but very few result in more than 10 days of lost time.[5,24-25] The results of this study have been consistent with the finding that the majority of injuries required less than 8 days before return to full practice. In 2011, 85.7% of the injuries required less than 8 days and in 2010, 87% of the injuries were less than 8 days' time loss. Of 24 injuries in 2011, 20 (83%) did not result in any time loss. Thirty-five out of the 40 injuries in 2010 resulted in the less than 8 days category required no time loss. In this category, the most common anatomical location injured was the knee with 6 injuries and ankle with 3 injuries. A high number of injuries within this category may demonstrate the player's passion for the sport and the will to adhere to injury rehabilitation and persistence through minor discomfort. According to Tschollet al,[25] injuries lasting longer than 28 days were typically due to a ligament rupture, most commonly the ACL in the knee. In the 2011 season there were no injuries lasting longer than 28 days but in the 2010 season there were 5 injuries in this category. Of the 5 injuries, two were ruptured ACL's in the knee, two were ruptured ligaments in the ankle, and one was a shoulder surgery. The one injury in 2010 that fit into the 8 to 28 days category was a neck sprain and concussion that lasted 26 days. This study is congruent with other research in reporting severe injuries to be most commonly ligament ruptures. One reason ruptured ligaments take longer to heal is that the body's healing process time and the fact that many times there is a need for surgery to repair the ruptured ligament.

Table 19. Comparison of Percent Distribution of Injuries by Anatomical Location[5,7-17]

Study	Year	Study Design	Level	Sample Size	# Injuries	Head/ Neck	Trunk/ Back	Upper Extremity	Hip/ Groin	Thigh	Knee	Lower Leg	Ankle	Foot
Dick et al	2007	D	C	20,447 games and 54,750 practices	G= 5,373 P=5,836	13.8/3.9	8.4/13.2	6.3/4.2	All LE injuries 67.8/ 72					
Faude et al	2005	C	E	n=165	241	6.6	7.5	5.3	6.2	18.3	18.7	8.2	17.8	11.2
Giza et al	2005	C	E	n=202	173	10.4	12.8	7.5	5.5	6.9	31.8	6.5	9.3	9.3
Jacobson & Tenger	2007	C	E	n=269	237	4.7	12.7	0.34	4.8	11.4	15.3	12.2	28.4	10.5
Ostenberg & Roos	2000	C	R	n=123	65		10.8	7.7	17	26.2	6.2	10.8	12.3	9.2
Soderman et al	2001	C	E	n=146	80	12	6.6	6.3	5.7	16.1	12.7	18.7	15.5	6.3
Jung & Dvorak	2007	C	E	5742 player hrs	387	18	9	8	3.1	12	11	11	24	3.1
Walden et al	2007	C	E	n=160	17	1.3	5	6.5	8.8	21.3	13.8	12.5	18.8	12.5
Hartmut et al	2010	C	E	n=254	246	7.1	7.8	2.4	1.7	12.9	31	9.4	22.1	4.6
Tegnander et al	2008	C	E	n=181	189	7.4	6.8	4.7	8.9	17.5	16.4	7.4	23.8	6.8
Hagglund et al	2009	C	E	n=228	299	4	9	2	11	23	22	7	16	5
Jacobson & Tenger	2006	C	E	n=253	229	4	13	1	5	11	15	12	28	10
THIS STUDY	2012	C	C	n=24	28	14.3	10.6	7.1	10.7	7.1	21.4	3.5	17.9	7.1

Table 20. Comparison of Percent Distribution of Injuries by Injury Type[7-12,14-17]

Study	Year	Study Design	Level	Sample Size	# Injuries	Concussion	Fracture	Bone Bruise	Meniscus Tear	Sprain	Strain	Tendonitis	Bruise	Laceration	Dislocation	Other
Faude et al	2005	C	E	n=165	241		5.4			46.5	17.4		23.7			16.1
Giza et al	2005	C	E	n=202	173	2.9	11.6			19.1	30.7		16.2			
Jacobson & Tenger	2007	C	E	n=269	237	3.8	1.3			24.5	28.7		8.4		0.8	1.7
Ostenberg & Roos	2000	C	R	n=123	65		3.1			18.5	32.2		16.9			7.8
Soderman et al	2001	C	E	n=146	80					65.6	16.4		18			
Jung & Dvorak	2007	C	E	5742 player hrs	387	3.1	2.3			26	8		45		2.1	
Hartmut et al	2010	C	E	n=254	246	5.3	5.8			35.4	10.8		15.8			3
Tegnander et al	2008	C	E	n=181	189	3.7	5.2			31.2	35.9		7.4			5.2
Hagglund et al	2009	C	E	n=228	299	2	3			22	28		11		1	2
Jacobson & Tenger	2006	C	E	n=253	229	3	2			28	7		18			41
THIS STUDY	2012	C	C	n=24	28	7.1	3.6	3.6	10.7	21.4	35.7	3.6	10.7	3.6		

Recurrent Injury

Of the 6 recurrent injuries in 2011, 4 might have been preventable. The two concussions that happened were due to impact and these are almost impossible to prevent. The sprains and strains may have been preventable with more strength and conditioning drills like plyometric training and agility drills. The high impact of the sport and the nature of collisions places the athletes at a higher risk for recurrent injuries. In 2010 there were 10 recurrent injuries including: sprains, strains, contusion, and concussion. During this season most of the recurrent injuries were contact injuries that occurred to the same body part. Only one other study looked at recurrent injury and didn't define what was meant by recurrent injury.[24]

Cost

No other study has conducted an in-depth look at the cost of health care associated with women's collegiate soccer. This study found the average injury costs $1000 in health care services. Even though most injuries were minor and required only a few days time loss, at the collegiate level there is a lot of travelling. Many of the injuries were seen by physicians on the road to be sure the athlete was safe to travel in a plane or bus. All of the concussions were seen by a physician to be cleared to play again. This is the first study to report the costs of each medical procedure according to the local facilities and break down what each injury costs on average.

Risk Factor Analysis

The risk factor analysis for this study was done using a Poisson regression model. Unfortunately, the Poisson regression analyses were inconclusive. There may be a few reasons which explain the unsuccessful attempt at analysis using the Poisson regression model and general estimating equations. First, is the small sample size. Another possible issue is the large variability between subjects. Each position on the soccer field is associated with different physical and motor characteristics that are unique and that will create data that has a wider spectrum of diversity. The idea of using another regression model to try to fit the data was not possible due to the fact that other models don't take into account that one person may have more than one injury (a strength of a Poisson regression). With that in mind, the data were reported with graphs.

Study Limitations

This study was limited by the number of participants due to the nature of using a convenience sample. The use of only one Division I women's soccer team limited the variety of players in reference to body types.

Practical Suggestions

The high number of injuries occurring during the second half of games and practices suggests that the athletes are becoming fatigued and losing correct form. This also means they might be more reckless going into 50/50 balls causing higher impact collisions with an opposing player. Coaches should try to condition the athletes as much as possible to prevent this and recognized when the fatigue is occurring. Stop training when the athletes start to lose technique to help prevent injuries from occurring.

Strength coaches should work on exercises that are more endurance in nature and work on speed and agility. The injuries are occurring because the athletes start to collide and are unable to move out of the way in time or catch themselves before hitting the ground. Plyometric drills can help condition these athletes better.

Athletic trainers should pre-screen each athlete to find postural and strength issues that might contribute to the risk of injury. They should help teach the athletes with genu valgum (knock kneed), to land with their knees over their toes to prevent ACL tears and ankle sprains. Additionally, they should strengthen all of the supporting muscles and use proprioceptive training to help prevent knee and ankle injuries. Previous research has found proprioceptive training to be effective in preventing knee and ankle injuries.[6,19-20,31,38]

Suggestions for Future Research

This study is only the second study to look specifically at women's collegiate athletes only and it provided a more in depth in description of the incidence and distribution of injuries. Also this study is the first to publish the costs associated with the injuries seen at the collegiate level. This study attempted to look at lower body agility and the hamstring to quadriceps ratio at a more functional level as risk factors for injury but was unable to come up with enough data to run the Poisson regression. Both of these areas have not been researched at the collegiate level and have been minimally researched at the elite level. Therefore, future research in this area should include the following:

- Prospective cohort studies that follow multiple women's collegiate soccer teams forward in time over longer periods to record injuries as they occur.
- Ask the participants to rate injuries on a pain scale to help classify severity of injury.
- Run a power analysis to determine the number of participants necessary to be able to run more reliable statistics which will only be done by including multiple teams from different colleges in the study.

Conclusions

For years, injuries have been affecting women's soccer players' ability to perform at their best. There has been research to find out where and when injuries have been occurring but a more in depth look needs to be done to identify modifiable risk factors and viable preventative measures. This study was designed to add to the current literature on the possibility of the hamstring to quadriceps ratio, lower body agility scores and skin fold measures as risk factors for injury but was unfortunately unable to come up with reliable results.

The main contribution this study was to provide an in-depth and precise descriptive analysis of injuries affecting NCAA Div. I women's soccer players. Determination of injury rates was based upon a meticulous recording of exposure time for each individual soccer player. Also this study broke down the bigger injury categories into more specific injury locations, injury types, and it looked at the cost of injuries unlike any of the other studies. The gap was bridged between the studies that report in only injuries per hour or injuries per athletic exposures so comparisons can be made across studies. However, further research is still needed to examine women's collegiate soccer injuries and related risk factors more closely to hopefully reduce injury incidence rates.

Other researchers should also follow-up and collect more collegiate data. Other researchers are invited to pool their data with the data of this study to create a larger pool of participants. This could create more years' worth of data and a risk factor analysis might be able to be run if there were more data available.

APPENDICES

Appendix A

History Questionnaire

ID Number: __________________ Age:______________ Year: _____________

1. At what age did you start to play soccer? ______________________________________
2. How long have you played soccer competitively? _______________________________
3. What positions have you played?____
4. What position do you currently play? ____
5. Which leg is your dominant leg? □ Left □ Right □ Both
6. What year are you on the UND team? □Freshman □Sophomore □ Junior □Senior

Appendix B

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 (including medications/epi-pen).

Explain "YES" answers:

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

Signature ____ Date __________________________

Appendix C

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 (including medications/epi-pen).

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

Signature ____ Date ________________________

Appendix D

Baseline Data Form

Team code No.: ....

Player's code No.*	Playing position†	Age‡, years	Stature, cm	Body mass, kg	Dominant leg§, (L/R/B)	Agility Time	H:Q ratio 60°/s	H:Q ratio 180°/s

*Use additional sheets if required. †Goalkeeper, Defender, Midfielder, Forward. ‡Age as at the start of season/year/tournament. §Left, Right, Bilateral.

Appendix E

Informed Consent

Title: A Prospective Study of Injury Affecting NCAA Division I Women's Intercollegiate Soccer Players

Principal Investigator: Elizabeth Ostrowski, Graduate Student, Department of Physical Education, Exercise Science, & Wellness, University of North Dakota, 715-213-5055, elizabeth.ostrowski@und.nodak.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 the injuries affecting the University of North Dakota women's soccer players during the 2011 season.

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 your 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 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 Division I women's soccer players throughout a regular season and to determine the relationship between injuries and specific risk factors such as leg dominance, the hamstring to quadriceps strength ratio, number of years participation, and previous injury history. This research is important because to date there have only been a handful of studies that look at the injuries in Division I collegiate soccer players and the risk factor of the hamstring to quadriceps strength ratio.

Length of Study: Your participation in the study will last one complete regular season in 2011. You will be contacted by the researcher after each practice or match to discuss in private any pain or injuries that you have experienced during that practice or match. Depending on the extent of the pain and/or injuries, it may take anywhere from 5 to 30 minutes to complete. The study will end at the end of the 2011 regular season at the conference championship.

What Will Happen During This Study: For the first part of the study you will be asked to complete a questionnaire that asks about injuries that you may have sustained during the past 12 months as a result of participating in soccer practices or competitions. It will also ask about the number of years you have played soccer, what your leg dominance is, playing position and age. This questionnaire will take between 10 and 20 minutes to complete.

The second portion of the study will involve you coming into the UND athletic training room to have your hamstring to quadriceps ratio tested on the Biodex Dynamometer prior to the start of the season. You will set up a time with the principal investigator to come in for a 20 to 30 minute testing session. This will only be done once at the beginning of the season.

The third portion of the study will take place during the competitive season where the principal investigator will observe and record all playing time. The researcher will also ask at the end of each practice or match for you to talk about any injuries or pain that you may have experienced during play. The researcher will record all injuries on an injury report form that asks several questions about how the injury occurred.

Risks of the Study: You may become sore after testing your hamstring to quadriceps ratio. There will be a week's recovery time allowed for you before you start participating in practices to prevent any possible injury. This study is otherwise intended to just observe and record any pain or injuries that occur during the regular season.

Benefits of the Study: You may benefit personally from being in this study by finding out if your hamstring to quadriceps strength ratio is putting you at risk for injury. This information can then be used to adjust any strength and conditioning programs to help balance the ratio to a normal level. In the future other people may benefit from this study because it will give coaches, players, and athletic trainers in-depth data on the types of injuries, the nature and incidence of injuries, and the risk factors that may increase the players risk of injury.

Confidentiality: All your data and information obtained through forms will remain confidential. Your identity will be withheld from data files, sheets, and analyses through the use of a numeric coding system. 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 the completion of this study in a locked container in the PXW office. Any information that is obtained in connection with this study and 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, tell the researcher that you no longer wish to continue with this project.

Contacts or Questions: The researcher conducting this study is Elizabeth Ostrowski, a UND graduate student in the PXW department. You may ask any questions you have now. If you later have questions, concerns or complaints about the research please contact Elizabeth Ostrowski at 715-213-5055 or you may 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 complaints 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 to someone else.

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

Participant's Name:
____

____ _______________
Signature of Participant Date

____ _______________
Signature of Principal Investigator Date

Appendix F

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

1. Purpose. As a research participant, I authorize Elizabeth Ostrowski and the researcher's staff to use and disclose my individual health information for the purpose of conducting the research project entitled: A Prospective Study of Injury Affecting NCAA Division I Women's Intercollegiate Soccer 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 that pertains that are either sustained as a result of participating in soccer or injuries that restrict or hinder your ability to participate fully in soccer practices or competitions.

3. Parties Who May Disclose My Individual Health Information. The researcher and the researcher's staff may obtain my individual health information from medical files contained in the UND Athletic Training Room or from you, the participant, themselves.

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 Elizabeth Ostrowski and the researcher's staff.

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 or receive any research related treatment that is provided through the 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 Elizabeth Ostrowski at 1011 Campbell Drive, Grand Forks, ND 58203 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 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 may be subject to re-disclosure outside the research study and no longer

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

protected. For example, researchers in other studies could use my individual health information collected for this study without contacting me if they get approval from an Institutional Review Board (IRB) and agree to keep my information confidential.

7A. Also, there are other laws that may require my individual health information to be disclosed for public purposes. Examples include potential disclosures if required for mandated reporting of abuse or neglect, judicial proceedings, health oversight activities and public health measures.

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 G

Injury Report Form

(Team) Player-code:. . . . . Date:. . . . .

1A Date of injury: . . . . 1B Date of return to full participation: . . . .

2A Injured body part

☐ head/face ☐ shoulder/clavicula ☐ hip/groin
☐ neck/cervical spine ☐ upper arm ☐ thigh
☐ sternum/ribs/upper back ☐ elbow ☐ knee
☐ abdomen ☐ forearm ☐ lower leg/Achilles tendon
☐ low back/sacrum/pelvis ☐ wrist ☐ ankle
☐ hand/finger/thumb ☐ foot/toe

2B Side of body

☐ right ☐ left ☐ not applicable

3. Type of injury

☐ concussion (with or without haematoma/ contusion/loss of consciousness) ☐ lesion of meniscus or cartilage ☐ bruise
☐ fracture ☐ muscle rupture/strain/ tear/cramps ☐ abrasion
☐ other bone injury ☐ laceration
☐ dislocation/subluxation ☐ tendon injury/rupture/ tendinosis/ bursitis ☐ nerve injury
☐ sprain/ligament injury ☐ dental injury
☐ other injury (please specify):. . .

4. **Diagnosis** (text or Orchard code): . . . . .

. . . .

5. Has the player had a **previous injury** of the same type at the same site (i.e. this injury is a recurrence)?
☐ no ☐ yes
If **YES**, specify date of player's return to full participation from the previous injury:. . .

6. Was the injury caused by **overuse** or **trauma**?
☐ overuse ☐ trauma

7. **When** did the injury occur?
☐ training ☐ match

8. Was the injury caused by **contact or collision**?
☐ no ☐ yes, with another player
☐ yes, with the ball
☐ yes, with other object (specify) . . .

9. Did the **referee** indicate that the action leading to the injury was a **violation of the Laws**?
☐ no ☐ yes, free kick/penalty ☐ yes, yellow card ☐ yes, red card
If **YES**, was the referee's sanction against: ☐ injured player ☐ opponent,

Appendix H

Team Exposure Report Form

Exposure Report Form No.: . . . .
(for the documentation of team exposures)

Date	**Match/ Training**	**No. of players** (fully participating in training)	**Duration of training session** (minutes)

Appendix I

Individual Exposure Report Form

Exposure Report Form No.:. . . . . Team Code
(for the documentation of individual players' exposures)

Date										
Training/Match										
Player Code No.	**Report the duration of training and match play for each player (minutes)**									

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