2006

Prevalence of injuries in a selected cohort of high school football players in the city of Winnipeg

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Your file Votre référence
ISBN: 978-0-494-24056-4
Our file Notre référence
ISBN: 978-0-494-24056-4

Abstract

While many studies have been published documenting injuries in college aged and professional sports, there are few studies that describe the prevalence of injuries among high school athletes. As a first step to creating an injury prevention strategy for high school football, the following study describes the prevalence of injuries among high school aged players. The study included 464 high school football athletes aged 15-18 years. Injuries for the 2005 Winnipeg high school football season were recorded. Athletes were more often injured during practices. The lower body was defined as any structure below the waist. The leg was most often involved in an injury, followed by the torso, and the hand. Sprains/strains and contusions occurred more frequently than concussions and fractures. Defensive backs and linebackers displayed the greatest number of injuries for the defense compared with the running backs on offense. Injury surveillance in Winnipeg will provide comparison opportunities of injury data against established studies with similar cohorts. Injuries will occur within any physical activity (Backx et al, 1991). Therefore, implementation of injury surveillance measures will monitor the injury profile.

Acknowledgements

There have been many individuals that I wish to thank that have made meaningful contributions toward completion of my research. Dr. William Montelpare, my thesis supervisor, for his support, accessibility, and personal dedication throughout the research process. His feedback and guidance has facilitated many invaluable learning experiences. Dr. Jim McAuliffe, for contributing his time and expertise to enhance my academic foundation. Michel Johnson for his support during my thesis studies. I appreciate Dr. Brent Faught for his role as my external examiner. Many thanks are extended to Dr. Glen Bergeron for the opportunity to conduct football research and work along side of him during my research endeavor.

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Introduction

What is the prevalence of injuries in football? To answer this question, one must consider the separation of injuries across all levels of participation. Albright et al. (2004) have reported about injury patterns in big ten Conference football. Fewer studies have investigated the profile of injuries in high school players. Currently, Culpepper and Niemann (1983) published studies describing the epidemiological profile of injuries in American high school athletes.

It is not uncommon to observe injuries in sport participation. Since injuries will occur, it is important to monitor the proportions of such events to ensure coaches and administrators are using evidence-based best practices to reduce injury risk. Athletic injuries are influenced by a variety of extrinsic and intrinsic factors. Injury surveillance provides a quantifiable report of the nature and prevalence of athletic injuries and enables researchers to monitor and describe the injury profile. The implementation of injury surveillance measures is the first step in any injury prevention strategy.

Football is a collision sport that can present a wide range of injuries. The injury profile in football consists of a variety of prevalence, incidence, and severities of injuries (Meeuwisse et al., 2000; Albright et al., 2004). Studying high school football injuries in Canada is the initial investigation to providing valuable information about risks and behaviors in this sport.

Football Canada governs all amateur football (5-23 years old) under the same system of competition. The rules and regulations are identical throughout

Canada. The comparison between the American and Canadian game includes some subtle differences. The field of play in Canada is longer by 10 yards. The game involves one less down, one additional receiver and is shorter by 12 minutes (Football Canada, 2004). Research into the Canadian high school system would allow for comparative analysis under similar conditions. However, with regards to comparison to the U.S game, differences in data could be due to style of play, player profiles, different injury definitions, severity classifications and methodologies implemented.

What do we know about the epidemiology of football injuries? There are inconsistencies in the published literature about many of the characteristics of football injuries. For example, DaGiau, Dillman, and Milner (1980) reported a greater prevalence of injuries in practice, while Culpepper and Niemann (1983) reported a lower prevalence of injuries in practice. DaGiau et al. (1980) investigated the relationship between exposure time and injury in football and the trends associated with these relationships. DaGiau et al. indicated when comparing exposure during games and practices, it appears that players would be at greater risk during practice. Culpepper and Niemann's intent was to determine an injury profile of high school football in Birmingham and to determine the number and types of injury that occur. They measured the injury profile between the summer and fall session, indicating the number of game injuries is higher than practice injuries, considering the playing intensity.

Blyth and Mueller (1974) indicated that the majority of injured players (34.7%) sustained an injury that kept them out of action for at least seven days. Blyth and Mueller also found that only 18.1 % players missed an additional day of competition due to injury. It would appear that either an athlete is injured quite severely or barely at all. DeLee and Farney (1992) found an overall incident rate of 0.506 injuries per athlete, per year. However, if only severe injuries were considered, the incidence rate was 0.031 injuries per athlete, per year. Severe injuries were defined as those that required hospitalization or surgery. The differences in severity according to time loss, was influenced by the date of injury, possibly providing the player with additional rest between football sessions (Blyth & Mueller, 1974) or the definition of severity used in different research studies (DeLee & Farney, 1992).

Powell (1987) reported offensive linemen sustained 20% of injuries in the study while defensive linemen accounted for 19%. The prevalence of injuries among linemen could be due to the number of players on the field at one time. Culpepper and Niemann (1983) reported the percent of injuries as a function of the percent of injuries divided by the number of players at that position. They found that the chance of injury to a quarterback increases almost twofold during a game, possibly due to the difference in contact intensity a quarterback receives during games. Wide receivers are injured less frequently in games because they are not at risk as often as they are in practice (Culpepper & Niemann). Culpepper and Niemann identified injury types by position whereas Powell did not make that

association. However, while linemen sustained a high frequency of injuries, the skill positions (running back/quarterback) incurred more significant game related injuries (Powell).

Culpepper and Niemann (1983) reported a higher prevalence of injuries for sprains, contusions, and fractures, while Blyth and Mueller (1974) reported a higher prevalence of strains, lacerations and concussions. The differences between these two studies may be attributed to variation between definitions and classifications, rule changes, equipment changes, and differences in style of play (Culpepper & Niemann). Blyth and Mueller reported a higher prevalence of head and neck injuries and a lower prevalence of shoulder injuries than Culpepper and Niemann. The decline in head and neck injuries could be a result that "spear" tackling with the helmet is illegal. Shoulder injuries increase because the shoulder is now the initial contact area involved in tackling and blocking (Culpepper, 1983). As a result, the 1976 rule change prohibiting initial contact with the head demonstrated a dramatic decline in cervical spine injuries (Mueller, 2001).

The mechanism of significant injuries and sport characteristics associated with the injury profile provides an objective tool to assess reasonable risk (Buckley & Powell, 1982). Studies that identify populations at risk and the etiology of injury are fundamental to developing prevention strategies (Weaver, Mueller, Kalsbeek, & Bowling, 1999). In North America, the skills required to evaluate a sports injury are limited (Janda, 1997). It is not required that all teams have certified athletic therapists present at all practices and games. Many injuries

may occur but never reported. Beachy et al. (1997) found players may bring minor injuries to the attention of the trainers during practices and ignore similar injuries during competition. As a result, players may sustain an injury and continue to compete. Such behavior can exacerbate the injury and lead to long-term problems. The present study focused on the injury profile in high school football in Winnipeg. An understanding of the injury profile in football, may allow a shift of resources and philosophy toward a proactive and preventative approach.

Examination of risk factors associated with sustaining an athletic injury is important to understanding the characteristics of football injuries. When high school athletes had easy access to athletic trainers and athletic training facilities, recovery rates were swift and uneventful (Lackland, Akers, & Hirata, 1985). Adequate provision of first aid, estimation of severity of the initial injury, and rehabilitation are important elements in the prevention of re-injuries and sports damage. (Lysens, De Weerdt, & Nieuwboer, 1991). Research into sports provides data into the current injury landscape and reveals the adequacy of preventative measures (Cantu & Mueller, 1992).

Prevalence of Injuries in a Selected Cohort of High School Football Players in the City of Winnipeg

Introduction

Football is a collision sport that can present a wide range of injury profiles and often demonstrates different types and severity of injuries. High school and college catastrophic injuries may never be eliminated but with reliable methodology and comprehensive analysis, these severe injuries can be drastically reduced (Mueller, 2001). According to Backx, Beijer, Bol, & Erich. (1991), injury occurs most often during organized sport (62%), followed by physical education class (20%), and in non-organized or unsupervised sport (18%). Despite such risks, the health benefits of physical activity are well documented (Weir & Watson, 1996; Backx et al, 1991). Further, school sport is recognized as an important means of promoting physical activity in children (Department of National Heritage, 1995).

Glossary of Terms

Prevalence Rate – The number of events (instances of a given disease or other condition) in a given population at a designated time (Last, 2001).

Prevalence of Sports Injuries

Many published studies have documented injuries in college aged and professional sports. Studies that describe the prevalence of injuries focused on the American high school athletes. As a first step to creating an injury prevention

strategy for high school football, the following study describes the nature and prevalence of injuries among high school aged players. Earlier research by Culpepper and Niemann (1983) showed that among high school football players in Alabama, there were 661 (35.2%) game injuries compared with 1,216 (64.8%) injuries during practices. A 1986 nationwide study by Powell (1987) reported 61% of all injuries occurred during the regular season compared to 37% during preseason. In addition, seniors sustained the majority of football injuries (38%) compared with juniors (33%), sophomores (23%) or freshmen (6%). Quarterbacks and linebackers were significantly more injured during games whereas wide receivers sustained greater injuries during practices (Culpepper & Niemann, 1983). Several researchers showed that contusions (17.7%) and fractures (10.6%) (Blyth & Mueller, 1974) injuries were prevalent in football (Tuberville et al., 2003). Backx et al. (1991) reported that the older the athlete, the higher the rate of injury. Likewise, Lysens and coworkers (1989) found males with a high score of upper body strength, limb speed, and joint laxity predisposes athletes to acute injuries.

Buckley and Powell (1982) found that in college players, hip and leg injuries occurred every 13.5%. Albright et al. (1985) later found that sprains, strains, contusions, and concussions were the most prevalent type of injury in college football.

Rates and Proportions of Injury Profile

Although injuries are ubiquitous in all sports, it is imperative that the rates and proportions of such events are monitored and described using the most efficient, accurate, and relevant methodologies available. An analysis of high school football injuries will allow administrators to better understand potential risks related to participation. Injuries are the most prevalent in high school populations with less than 500 students (0.529). September was the most hazardous month for football injuries (36% injuries). Players between 180-190 pounds have the highest injury rate (0.645) (Blyth & Mueller, 1974).

Injury Surveillance

Cahill and Griffith (1979) have documented injuries in college sports. Comprehensive surveillance measures at the high school level could modify an injury profile making the sport safer. Studying high school injury characteristics provided an injury profile and trends in Winnipeg. The purpose of the present study was to provide a prospective review of football injuries among secondary school athletes in the City of Winnipeg during the 2005 season. There were 1,015 football players in the province of Manitoba in 2005 (Football Manitoba, 2005). Injury surveillance in Winnipeg will provide comparison opportunities of injury data against established studies in other jurisdictions.

Methodology

A cross sectional study design was used to provide information for a single season. The study intended to identify the risks of injury associated with secondary school athletes engaged in competitive football. The sample was comprised of players from twelve high schools, with athletic therapy student coverage, participating in the Winnipeg High School Football League. Three schools were out of province so student coverage was not an option while three additional schools did not utilize student services. The study included 464 male football athletes aged 15-18 years. Injuries were recorded throughout the 2005 season in Winnipeg using software designed to track injuries. High schools were given information regarding the purpose of the data collection and subsequent details of the research. A cover letter explaining the research study was provided to the coach. All athletes completed a letter of informed consent. The ethics committees at Lakehead University and the University of Winnipeg approved the present study. The appropriate officials within the Winnipeg School Division also approved the study.

Injury Data Collection

Presagia designed injury tracker during the mid 1990's. The data entry forms and injury fields were designed based on feedback from athletic therapists and clients. Injury tracker software was used on a personalized digitalized apparatus (PDA – Palm OS 4x) to collect information about football injuries.

Student therapists recorded pertinent injury data on the athletes during practices and games. The athlete's involvement in this study varied based on assessment complexity and individual student therapists. The goal was to collect information on athletic injuries sustained throughout the entire season for statistical analysis. The injury tracker software was downloaded from www.injurytracker.com. Information was downloaded weekly to a central database at the University of Winnipeg where a backup file was created and sent to a designated location at Lakehead University for integration into its injury software database. Information regarding an injury sustained during a game or practice was entered into the PDA by the student therapist, and subsequently downloaded for analysis to determine the injury profile for high school football.

An injury was defined as an episode that required medical attention in order for the athlete to continue or return to participation (Meeuwisse et al., 2000). An injured athlete approached the therapist for an injury assessment or first aid was provided if the situation warranted it.

Table 1: Collection of Injury Information

Patient History [height (m), weight (kg), age]	Jersey Number, Position, String
Playing Surface, Weather, Segment Acute v.s. Chronic	Body Part (anterior cruciate ligament, deltoid ligament)
Severity (degrees), Mechanism of Injury	Body Structure (ankle, knee)
Type of Footwear and Helmets	Injury symptoms and initial first aid

A physician was only available during games if advance medical assistance was required. If the severity of the injury warranted it, then the physician became the charge person in dealing with the injured athlete. The therapist assisted the physician with athlete care and then entered the athlete injury history into the PDA.

Data Classification

The following classification system was used in all data recording. Injuries to the thigh referred to muscle injuries of the upper leg, while the lower leg referred to injuries to the calf, knee, and ankle. The knee was indicated as the injured body part when no specific structure (ie. ACL) was involved. A collision was defined as a higher impact force whereby the injured player sustained an injury. A collision mechanism was selected for head trauma (concussions), contact with equipment (goal posts), or a player being blindsided. A direct contact mechanism was identified when an opposing player made contact in a normal sequence of events (tackling/blocking) causing injury.

To illustrate an accurate reflection of the association between a specific mechanism of injury and body segments, the body was divided into five main regions. The upper limb referred to the shoulder, arm, forearm, elbow, wrist, and hand. The head included the mouth, face, throat, and head while the torso involved the chest, back, and pelvis. The thigh region involved all the musculature found in the region, which involved the quadriceps, hamstrings, and adductors. The lower leg referred to the knee, shin, calf, ankle, and foot (Table 14).

The categories of injury types used in this study were comparable to those used in Powell's study (1987). General trauma involved contusions, lacerations, and abrasions. The category of sprains involved the broader inclusion of not only ligament injuries but joint related ones as well (bursitis, subluxations, dislocations, separations, and patella femoral syndrome). Strains referred to musculo-tendonis injuries, which included medial tibia stress syndrome, overuse, muscle spasms, and tendonitis. Neurotrauma injuries involved neuropraxia, burners, and concussions. Musculoskeletal injuries included inflammatory or irritable conditions (Figure 1).

Statistical Analysis

Frequency distributions of different injury variables were used to identify the number of items within each category to form the injury profile.

Injury rate = number of injured players/total number of players within each range

Comparison of Proportion:

$$Z = \frac{P1-P2}{\sqrt{\frac{P\,(Q)}{N}}}$$

P1 = proportion of Injured

P2 = proportion of Non Injured

N = number of players at season's end

$Q = 1-P_1$

Results

Our first step was to determine a first level analysis on injury variables. The team demographic, site, type, mechanism, activity, event segment, and player positions were examined based on frequency distributions. Comparative analysis included injury type and grade levels against reported frequencies in other populations. Injury rates were identified for height and weight levels demonstrating the number of players injured at those different values. The final level of analysis involved comparison association of injury variables.

Table 2: Distribution of Schedules and Players

ID CODE	# Games	# Practices	# Players Start	# Players End
T_1 - AA	10	44	55	53
T_2 - AA	8	41	34	33
T_3 - AA	9	30	42	42
T_4 - AA	9	25	34	33
T_5 – AA	10	42	39	39
TOTAL	46	182	204	200
T_6 - A	11	36	39	35
T_7 - A	9	6	37	27
T_8 - A	8	37	39	31
T_9 - A	9	35	45	44
T_{10} - A	11	48	35	33
T_{11} - A	11	39	42	41
T_{12} - A	10	40	53	53
TOTAL	69	281	290	264

A descriptive analyses of frequency of injuries by body part (Table 3) demonstrated that the lower leg was most often involved in an injury followed by

the torso, hand, and head. Overall, 216 injuries (40.3%) were sustained by the lower body compared with 140 injuries (26.2%) occurring to the upper body regions.

Table 3: Observed Frequencies of Injuries by Body Part

Body Part	**Frequency / 536**	**Percent /100**
Leg	128	23.9
Torso	90	16.8
Hand	57	10.6
Head	48	9.0
Arm	34	6.3
Thigh	33	6.2
Neck	32	6.0

The most prevalent type of injury (Table 4) was sprains and strains accounting for 199 injuries (37.1%) followed by contusions of different severities. Fractures only accounted for 19 injuries or 3.5% of the total injuries reported. The reported concussion rate in the present study was 35/536 (6.5%) for high school youth.

Table 4: Observed Distribution of Injury Type

Injury Type	**Frequency**	**Percent /100**
Sprain	122	22.8
Contusion	91	17.0
Strain	77	14.3
Concussion	35	6.5

Collisions were responsible for 58 or 10.8% of total injuries reported. A

collision mechanism was implicated as the cause of 9/35 (25.7%) concussions, 20/91 (22.0%) contusions, and 14/199 sprains/strains (7.0%) (Table 5).

Table 5: Distribution of Mechanism of Injuries

Mechanism of Injury	**Frequency/ 536**	**Percent / 100**
Direct Contact	126	23.5
Collision	58	10.8
Running	35	6.5
Unknown	34	6.3
Hyperextension	32	6.0
Inversion	28	5.2
Overuse	28	5.2

Blocking and tackling were the two most common activities associated with injuries (Table 6).

Table 6: Distribution of Injuries by Activity

Activity Type	**Frequency /536**	**Percent /100**
Blocking	144	26.9
Tackling	120	22.4
Running	61	11.4
Non Contact Drills	23	4.3

There were more practice related injuries (246) than game related injuries (216) (Table 7). The simplest explanation was that there were more practice events and therefore more participants at risk at each event.

Table 7: Distribution of Injuries by Football Segment

Segment	Frequency /536	Percent /100
Practice	246	45.9
First Quarter	26	4.9
Second Quarter	70	13.1
Third Quarter	66	12.3
Fourth Quarter	54	10.1

The results indicated that linemen (offensive/defensive) sustained 21.1% of injuries. In the Winnipeg High School Football League, there are 5 offensive and 5 defensive linemen on the field at any one time, contributing to a greater risk of injury for linemen. Overall, 245 injuries were sustained by defensive players compared with 218 occurring on the offensive side of the ball (Table 8).

Table 8: Profile of Football Injuries According to Position

Position	Frequency /536	Percent /100
Defensive Back	98	18.3
Running Back	86	16.0
Linebacker	82	15.3
Defensive Lineman	60	11.2
Offensive Lineman	53	9.9
Wide Receiver	52	9.7

Different football positions had a higher prevalence for certain types of injuries. Linemen (offensive/defensive) had the highest percentage of injuries for general trauma (25.2%), sprains (31.9%), strains (30.1%), and neurotrauma (40.0%). Running backs sustained more fractures (26.3%) while defensive backs had the greatest number of musculoskeletal injuries (34.8%). Overall, defensive positions were more likely to sustain an injury type with the exception of fractures.

Table 9 Comparison of Proportion by Injury Type

Injury Type	**Z score**	**Expected Proportion**[1]
Sprains	2.60	21.6%
Contusions	-3.50	26.6%
Strains	5.00	8.6%
Concussion	1.20	6.5%

The population observed in the present study for contusions and concussions were not significantly different than previous reported studies. However, the population observed for sprains and strains were significantly different ($p = 0.05$) than previous reported research.

[1] **(Hoffman, 1988)**

Table 10: Comparison of Injuries Among Grade Levels

Grade	Winnipeg Study (2005) Frequency	Percentage	Powell Study (1987) Percentage
9	73/536	13.6%	6%
10	114/536	21.3%	23%
11	174/536	32.5%	33%
12	173/536	32.3%	38%

A one sample X^2 for goodness of fit test was used to compare the injury rate across the four grade levels. The chi square (X^2) test results showed that there was significant difference from grade 9 to grade 12 for the number of injuries reported ($x^2 = 52.24$; $df = 3$; $p < 0.06$).

Table 11: Proportion of Injured Athletes Among Grade Levels

Grade	Frequency	Rate
9	35/70	0.500
10	71/130	0.546
11	97/148	0.655
12	89/134	0.664

There was a different proportion of injured athletes by grade levels (Table 11). 50% of players who were categorized as grade 9 players reported an injury compared with 54.6% of grade 10 players. Among the senior players, 65% and 66% of grade 11 and 12 athletes respectively sustained an injury.

Table 12: Rates and Number of Injuries According to a Player's Height

Height (m)	Injured	Non Injured	Total	Injury Rate
1.55 – 1.59	4	3	7	0.571
1.60 – 1.64	4	5	9	0.444
1.65 – 1.69	37	12	49	0.755
1.70 – 1.74	78	36	114	0.684
1.75 – 1.79	60	57	215	0.280
1.80 – 1.83	47	41	88	0.534
1.85 – 1.88	98	26	124	0.790
1.90 – 1.93	37	9	46	0.804
1.96 – 1.98	3	0	3	1.000
2.01 – 2.03	0	0	0	0.000
2.06 – 2.08	1	1	2	0.500
Missing	3	8	11	X
Total	536	198	723	0.741

The rate of injury increased with a player's height (Table 12). Injuries were likely to occur if a player was between 1.85 and 1.98 meters based on actual reported injuries.

Table 13: Rates and Number of Injuries According to a Player's Weight

Weight (kg)	Injured	Non Injured	Total	Rate
43.1	0	1	1	0.000
47.6-56.7	11	13	24	0.458
57.2-66.2	57	35	92	0.620
66.7-75.8	113	48	161	0.702
76.2-85.3	147	35	182	0.786
85.7-94.8	81	22	103	0.786
95.3-104.3	51	24	75	0.680
104.8-113.9	41	5	46	0.890
114.3-123.4	10	4	14	0.714
123.8-132.9	15	2	17	0.882
133.4-142.4	7	0	7	1.000
142.9	0	1	1	0.000
Missing	3	8	11	X
Total:	536	198	723	0.741

*** Unknowns deleted from population.

There appeared to be a relationship between weight and injury (Table 13). Since generally as a player's weight increased, the risk of injury also increased.

Table 14: Association Between Mechanism of Injury and Body Segment

	Upper Limb (140)	Head (82)	Torso (97)	Thigh (33)	Lower Leg (183)
Mechanism					
Catching	12 (8.6%)				
Collision	9 (6.4%)	15 (18.3%)	21 (21.6%)		12 (6.6%)
Direct Contact	48 (34.3%)	28 (34.1%)	23 (23.7%)	8 (24.2%)	27 (14.8%)
Hyper - Extension	14 (10%)	5 (6.1%)			8 (4.4%)
Hyper-flex		7 (8.6%)	2 (2.0%)		
Stretching			6 (6.2%)	3 (9.1%)	
Running				11 (33.3%)	16 (8.7%)
Overuse					23 (12.6%)
Inversion					28 (15.3%)

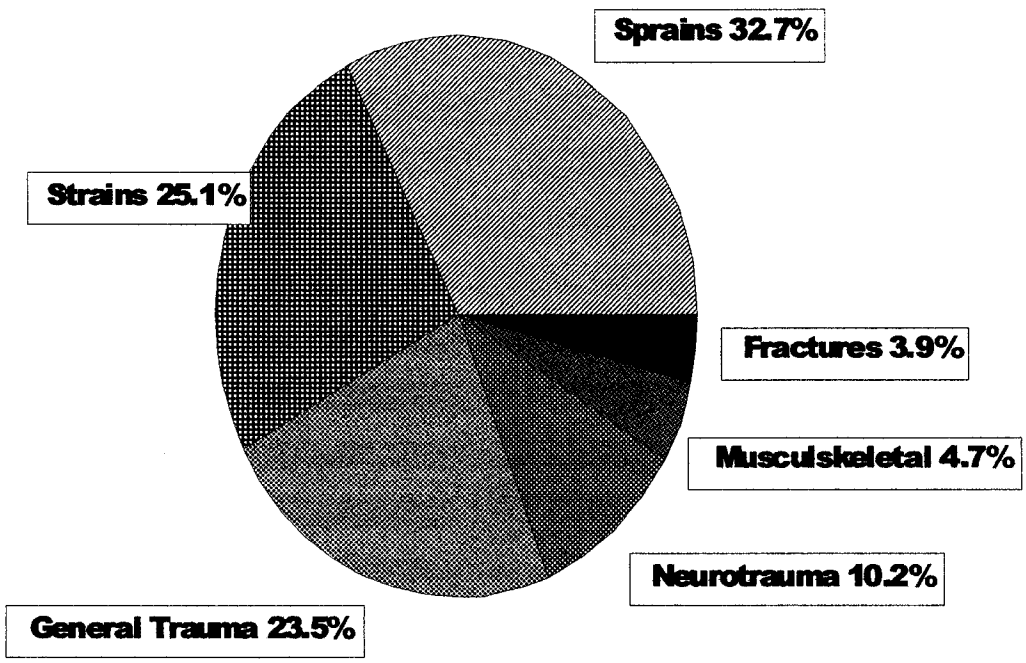

Figure 1. Types of Injuries Sustained in High School Football

Table 15: Type of Injuries by Mechanism of Injuries

	General Trauma (115)	Sprains (160)	Strains (123)	Fractures (19)	Neurotrauma (50)	MK (23)
Mechanism						
Collision	24 (20.9%)	8 (5%)	9 (7.3%)		9 (18.0%)	3 (13.0%)
Direct Contact	43 (37.4%)	28 (17.5%)	16 (13.0%)	4 (21.1%)	25 (50.0%)	3 (13.0%)
Scraped	10 (8.7%)					
Hyper-Ext.		13 (8.1%)	8 (6.5%)			
Inversion		25 (15.6%)				
Overuse			12 (9.8%)			5(21.7%)
Running			23 (18.7%)	2(10.5%)		
Catching				2 (10.5%)		
Compression				3 (15.85)		
Head BBButting						
Pile On				2 (10.5%)		
Head Butt					4 (8.0%)	
Side Flexion					3 (6.0%)	
Stretching					3 (6.0%)	

Discussion

The present study was an epidemiological surveillance of football injuries over a single season in twelve high schools in Winnipeg. The primary direction of this research was to provide a prevalent perspective into different injury variables associated with football. Injuries are inherent in a contact sport (Culpepper & Niemann, 1983). There were a different proportion of injuries throughout the grade levels. Overall, only 61.5% of athletes sustained at least one injury. As such, not every player has an identical risk of injury. Furthermore, injury rates may vary depending if players sustained multiple injuries or the scope of the injury definition. Additionally, the monitoring and detailed analysis could reduce the number and severity of football injuries (Culpepper & Niemann).

As shown in Table 6, 246 (45.9%) of 536 injuries occurred in practices compared with 216 (40.4%) injuries sustained during games. The number of game related injuries is similar (43%) to research by Prager et al. (1989). On the other hand, Llackland (1982) reported 62.5% of injuries occurred in games. A higher injury rate may indicate that players may bring minor injuries to the attention of trainers during practices and ignore similar injuries during competition (Beachy et al, 1997).

In addition, the present study found 18% of injuries occurred in the first half compared with 22.4% during the second half of competition. An alternative explanation for the observation of a greater frequency of injuries during the second half of a game may be the increase in fatigue of a player (Blyth &

Mueller, 1974). Additionally, if the athlete is not focused on the task at hand, he may be more likely to sustain an injury (Gunnoe, Horodyski, Tennant, & Murphy, 2001).

Injuries were found to be more prevalent among football linesmen collectively. Offensive and defensive linesmen are typically heavier, less mobile; less conditioned, and engaged in every play leaving them exposed to a high injury risk (Pincivero & Bompa, 1997). Furthermore, linesmen usually have a higher percentage of body fat, which has been associated with a reduction in speed, power, and endurance and may hinder performance (Pincivero & Bompa). Culpepper and Niemann (1983) found defensively, that defensive backs and linebackers sustained the greatest number of injuries, which was similar to the present study. Blyth and Mueller (1974) concluded that this scenario is likely due to the complexity of defensive formations.

Older players had a higher prevalence of injury. The significance of injuries among the older athletes could illustrate repetitive habits where huge implications with players of mass, speed, or skill differences exists. The instruction of proper fundamentals and conditioning would help decrease injuries among senior players.

The frequency of injuries to the upper limb was not surprising, considering hands and fingers were minimally protected while the shoulder was the initial contact point during tackling and blocking. Injuries to the upper body are likely to

occur from direct contact with helmet, grasping an opponent's jersey, blocking or tackling (Mueller, Zemper, & Peters, 1996).

The knee is a vulnerable joint and was reported often as a body part injured in the present study. The knee can be stressed into awkward and unusual positions, and is usually the result of direct contact from other players (Blyth & Mueller, 1974). In addition, most ankle injuries involved an inversion mechanism resulting in damage to the lateral ligaments causing ankle instability (Rishel, Wilson, & Brodell, 1989). Proper strengthening to the muscles of the upper leg and ankle may prevent knee and ankle injuries (Backx et al, 1991).

The prevalence of the three most commonly occurring types of injuries in the game of football is sprains (ligaments), strains (muscle), and contusions. This result was fairly consistent with previous reported studies (Mueller, Zemper, & Peters, 1996). Sprains and strains were both significant injuries that occurred in this study. Strain injuries could be a result of inadequate conditioning (Culpepper & Niemann, 1983). Concussions exist in football due to the collision nature of the sport. Concussions in the present study occurred 6.5% of total injuries sustained (35/536). Concussions were also present as the main head trauma injury in earlier studies (Blyth & Mueller, 1974; Hoffman & Lyman, 1988). The enforcement of concussion protocol (McCrory et al., 2005) should help minimize the chances of subsequent concussions protecting the player's welfare.

The prevalence of sports injuries was highlighted in high school football in Winnipeg. The recording of minor injuries, such as sprains, lacerations, and

contusions may be statistically important but increases the injury rate and provides ammunition for alarmists who would like to see high school tackle football abolished (Olson, 1979). The involvement of certified athletic therapists would have enhanced the data collection process. Student therapists also had limited prior experience using the injury tracker on the PDA, and with any technological software, problems can arise. Back up injury journals protected against frozen computer screens or the use of the reset function to restore normal palm pilot function. The monitoring of sports injuries highlighted the current injury scene in hopes of decreasing future injuries. Sport injuries may never be completely eliminated. However, collection of injury data provides an understanding into the landscape of injuries. Further research measuring player exposure and injuries as a result of specific time loss will put an injury rate into the proper context.

According to DaGiau et al. (1980), there is an inverse relationship between exposure time and injury in football especially in game situations. Cahill and Griffith (1979) reported the injury rate in relation to exposure time to demonstrate risk of injury. This approach was not used in the present study because of the limitation of data collection personnel. In the present study, it would be necessary to recruit an exposure coordinator to determine the actual number of minutes a player was at risk for injury. As exposure time increases, the number of injuries decreases (DaGiau et al.), potentially leaving the fourth quarter

the safest for competition. Further, as reported by Prager et al. (1989) football players in high school play both offense and defense positions within a game.

A measure of exposure by calculating the number of players by number of games and practices to obtain denominator data would reflect a more accurate injury rate, as it would focus on actual participation (Meeuwisse et al, 2000). Comprehensive surveillance measures may be useful in identifying high-risk situations likely to cause an injury. However, it may be cost prohibitive to have an exposure coordinator to concentrate on actual playing time.

Football is one of the most popular sports in the United States and is associated with a substantial number of injuries occurring as a result of participation (Culpepper & Niemann, 1983). There is no national database for tracking high school football athletes in Canada. The results of the present study provided an initial description of the profile of football injuries in an urban secondary school cohort in Canada. There has been limited research focusing on the Canadian high school athlete. The present study demonstrated that injuries of various types, mechanisms, positions, segments, and player profiles were inevitable in this collision sport. Risks are associated with any sport participation. The implementation of injury surveillance measures will allow the monitoring of the injury profile and may facilitate discussions on an injury prevention strategy.

Conclusion

The measure of exposure would provide the proper context for injury rates in sport. Risk may vary with position played, actual rather than average time played, or intensity of activity during practice and games (Llndenfeld, Noyes, & Marshall, 1988). It was reasonable to conclude that injuries are a product of high school football, but this study highlighted the prevalence of injuries that all stakeholders should be aware.

The present study included a broad definition of injury. Thus, any injury that was brought to the attention of the student therapist was recorded as an incident. However, examination of proportion of injuries by grade level highlighted that while injuries happened not every player was involved. Future studies that differentiate between injuries based on severity would present different injury rates based on the seriousness of injuries occurred (DeLee & Farney, 1992).

The use of a personalized digitized apparatus (PDA) with injury tracker allowed the tracking of sports injuries on site. This study provided a valuable injury profile using current technology. The critical element with any technological method was to maintain data accuracy and minimize potential setbacks.

In conclusion, the present study identified an injury profile and highlighted a need for further research into the Canadian high school scene for comparative purposes. In addition, without any long-term surveillance in high

schools, the monitoring of injuries cannot occur and appropriate preventative strategies would not be in place to benefit the athlete. Today's youth should actively engage in high school sports for health benefits. It is true with any sport, risks are inherent and injuries are likely to occur. Injury surveillance will allow the identification of possible anomalies, trends, or effective strategies aimed at reducing sports injuries.

After Thoughts

We recommend that these preventative measures be discussed in developing a high school prevention strategy.

1. Pre-Season Medical Examination - A comprehensive medical history prior to athlete participation will detect any preexisting medical abnormalities and provide baseline information about the health of the player (Abenour & Weir, 1986).

2. Yearly Conditioning - A mandatory football specific conditioning and training program should be aimed at improving muscular and ligament imbalances and weaknesses; coordination and timing; flexibility, mobility and cardiovascular and endurance capacities (Lysens et al, 1989).

3. Public Health Education and Intervention - Parents and sport personnel should understand both risks associated with sport but also the nature of injuries and different strategies to reduce injuries.

4. Medical Integration Network - The involvement of certified athletic therapists involved during the football season to monitor an athlete's progress and training, provide appropriate rehabilitation and an accurate assessment in a timely manner. Proper medical supervision during all facets of competition will ensure that activities are performed under safe conditions (Lackland, Akers, & Hirata, 1982).

5. Long term injury surveillance – The monitoring of athletes during their tenure of sport involvement. This longitudinal scope of tracking would allow sport personnel to highlight long term trends and identify repetitive injuries posing long term risks or residual effects.

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