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Injury Patterns in Selected High School Sports: A Review of the 1995–1997 Seasons

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Objective: To characterize the risk of injury associated with 10 popular high school sports by comparing the relative frequency of injury and selected injury rates among sports, as well as the participation conditions within each sport.

Design and Setting: A cohort observational study of high school athletes using a surveillance protocol whereby certified athletic trainers recorded data during the 1995–1997 academic years.

Subjects: Players listed on the school's varsity team rosters for football, wrestling, baseball, field hockey, softball, girls' volleyball, boys' or girls' basketball, and boys' or girls' soccer.

Measurements: Injuries and opportunities for injury (exposures) were recorded daily. The definition of reportable injury used in the study required that certified athletic trainers evaluate the injured players and subsequently restrict them from participation.

Results: Football had the highest injury rate per 1000 athlete-exposures at 8.1, and volleyball had the lowest rate at 1.7. Only boys' (59.3%) and girls' (57.0%) soccer showed a larger proportion of reported injuries for games than practices, while volleyball was the only sport to demonstrate a higher injury rate per 1000 athlete-exposures for practices than for games. More than 73% of the injuries restricted players for fewer than 8 days. The proportion of knee injuries was highest for girls' soccer (19.4%) and lowest for baseball (10.5%). Among the studied sports, sprains and strains accounted for more than 50% of the injuries, except in field hockey (45.7%). Of the injuries requiring surgery, 60.3% were to the knee.

Conclusions: An inherent risk of injury is associated with participation in high school sports based on the nature of the game and the activities of the players. Therefore, injury prevention programs should be in place for both practices and games. Preventing reinjury through daily injury management is a critical component of an injury prevention program. Although sports injuries cannot be entirely eliminated, consistent and professional evaluation of yearly injury patterns can provide focus for the development and evaluation of injury prevention strategies.

Key Words: injuries, risk, surveillance, epidemiology

It has been estimated that more than 6 million high school youth from approximately 20 000 high schools participate in local sports programs each year. This population of young athletes accounts for more than 2 million injuries, 500 000 doctor visits, and 30 000 hospitalizations.[1] Many of the more significant sport-related injuries may lead to long-term physical impairment.[2] The sports of football and basketball (boys' and girls') are the most popular and are played in more than 13 000 and 16 000 schools, respectively.[1]

Sports injuries are not generally the result of a single causative variable but are associated with various risk factors interacting at a given time.[2–5] Associations between variables may exist and can be identified, but the relationships are not necessarily cause-effect in nature.[6]

The existing data regarding the type, nature, and frequency of high school sports injuries demonstrate that specific injury patterns occur in different sports.[7] Each sport has its characteristic injury profile and degree of risk, and the injuries vary widely among sports.[8] Football players commonly incur knee injuries, while wrestlers are often affected by shoulder problems.[9] Each sport, in combination with environmental factors such as player position, activity at the time of injury, playing surface, and protective equipment, produces a specific injury pattern.[7,10] One of the most important challenges for the sports medicine community is to be able to differentiate the impact of the variables among the different sports.

In 1974, a multisite and multilevel injury surveillance system was designed and implemented as the National Athletic Injury/Illness Reporting System (NAIRS). NAIRS used a cohort observational design to record the variety of injuries associated with specific sports at the high school and college levels.[11] NAIRS' strengths included a multidisciplinary design team, daily documentation of injuries and exposures, consistent data forms, specific definitions of reportable injury, and the NATA-certified athletic trainer as a data recorder. The NAIRS basic design was included in the development of the injury surveillance programs in the National Football League, the National Hockey League, the National Collegiate Athletic Association, and the National Athletic Trainers' Association (NATA) project in the mid 1980s.[10]

The NAIRS data identified specific risk factors that affect the injury patterns in selected sports. For example, player position and player activity at the time of injury in college football is associated with the risk of knee injury and concussions.[12,13] NAIRS data were used to establish the concept that the number of injuries occurring in practice is higher than that occurring in games, yet

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the relative risk of sustaining an injury in a game is 7 to 10 times greater than in a practice.[14–16] Whiteside[17] used the NAIRS data to report the difference in incidence rates for men's and women's sports at the college level.

In 1985, the NATA commissioned a study of the frequency, severity, and type of injuries associated with selected high school sports. The study monitored high school football, boys' and girls' basketball, and wrestling in 150 schools for 3 years. The project used the strengths of the NAIRS experience and the professional preparation of the certified athletic trainer as its field data recorder.[10,18] The experiences of the 1985 NATA study were incorporated into the design and operation of the current NATA injury surveillance project.

Our purpose was to describe the injury patterns in 10 high school sports and identify the injury risk as measured by the observed injury patterns. The significance of the study resides in the integration of the injury patterns with the nature of the sport and the activities of the players. This method provides a solid foundation for the continual evaluation of an injury prevention program at the high school level.

METHODS

Subjects

Subjects were high school athletes on the varsity sports rosters for any one of the following sports: football, wrestling, baseball, field hockey, softball, girls' volleyball, boys' or girls' basketball, or boys' or girls' soccer. No effort was made to manipulate or control the athlete's participation in any sport.

Instruments

The athletic trainers used a surveillance protocol to report daily participation and injuries within their sports program. The exposure data included the type of session and the number of participants for each day. When a reportable injury occurred (Table 1), the following types of data were recorded: date of injury, date of return, clinical impression, extremity, time of injury, action taken, type of management, nature of injury, player position, player activity, team activity, and playing surface. The injuries were identified according to a detailed clinical impression code that allowed for accurate description of the injury, eg, third-degree sprain of the anterior cruciate ligament. Injury data were linked directly to the player data that included height, weight, and age. Two data-recording procedures were used: (1) a customized version of the Sports Injury Monitoring System (SIMS) (Med Sports Systems, Iowa City, IA) for those athletic trainers with computer capability; and (2) a parallel system of paper forms for those athletic trainers without computer capability. T1

Procedures

School selection. More than 300 certified athletic trainers volunteered to participate in the project during the study

Table 1. Operational Definitions Used in the NATA Injury Surveillance Study

Term	Definition
Reportable injury	Any injury that causes cessation of participation in the current game or practice and prevents the player's return to that session.
	Any injury that causes cessation of a player's customary participation on the day following the day of onset.
	Any fracture that occurs, even though the athlete does not miss any regularly scheduled session.
	Any dental injury, including fillings, luxations, and fractures.
	Any mild brain injury that requires cessation of a player's participation for observation before returning, either in the current session or the next session.
Athlete	A player is considered to be eligible as a participant if he or she is a member of the varsity roster and capable of participating without any activity restrictions.
Return to participation	A player is fully returned when he or she is available and has been medically cleared for such participation.
Exposure	An exposure (an opportunity for injury) is considered a coach-directed session that involves physical activity.
Body category	Head/neck/spine: includes injuries to the skull and spinal column.
	Face/scalp: includes injuries about the head that are not included in the Head/neck/spine group.
	Shoulder/arm: includes injuries to the shoulder, clavicle, axilla, and upper arm.
	Forearm/wrist/hand: includes injuries from the elbow through the fingers.
	Trunk: includes injuries to the internal organs and muscles of the chest/back.
	Hip/thigh/leg: includes injuries to the hip, thigh, and lower leg.
	Knee: includes injuries about the knee and to the menisci and patella.
	Ankle/foot: includes injuries about the ankle and foot area.
	Other: systemic sport-related illnesses, eg, heat illness and skin conditions.
Type of injury	General trauma: contusions, wounds, cramps, and acute inflammations.
	Neurotrauma: includes the nervous system, eg, mild traumatic brain injury.
	Sprains: injuries to the connective ligamentous structures about the joint.
	Strains: includes injuries to the muscle-tendon complex.
	Fractures: includes all types of fractures and stress fractures.
	Musculoskeletal conditions: includes conditions that affect the musculoskeletal system, eg, inflammations, tumors, etc.
	General stress: includes sport-related medical conditions, eg, heat illness and skin conditions.

period. From this group, 246 athletic trainers were selected because they (1) worked directly with high school sports programs on a daily basis, (2) fell within a geographic distribution among the 50 states, and (3) fit a broad representation from different size schools (Figure 1). These procedures created a stratified cluster sample representing high schools with small, medium, and large student enrollments (Figure 2). Each certified athletic trainer was required to obtain written permission to participate from his or her school's athletic director and to submit the approval to our research office before submitting data. Because not all schools offered all 10 sports, the number of team-seasons (1 team in 1 season) for each sport varies. Only the data related to the varsity sport teams were included in the study.

Sample size. Within this group of athletic trainers and their athletic programs, our goal was to monitor 100 team-seasons for each of the 10 sports for each of the study years. We continually replaced athletic trainers who dropped out with recorders from similar-sized school programs and regional locations in an attempt to maintain sample consistency. We accumulated data for nearly 3200 team-seasons and more than 75 000 player-seasons (1 person on 1 team in 1 season), 4.4 million athlete-exposures (sum of the number of the players' participations in each session), and 23 500 reportable injuries (Table 2).

Surveillance protocol. Before the project began, we distributed operational definitions and reporting requirements to all participants in the form of a user's manual. As part of the instructional protocol, we created a videotape to provide the athletic trainers with a visual tool for orientation to the injury-recording software. The central data collection office maintained a 24-hour/7-day toll-free number for recorder support. The athletic trainers transferred their recorded information, either electronically or by mail, to the central office monthly. The project staff monitored all incoming data, and recorders were contacted regarding any areas identified as needing clarification. Data summary tables and project newsletters were distributed to all participating athletic trainers each month. As new athletic trainers joined the study, we worked with them to ensure a smooth transition into recording the system requirements.

Study definitions. One of the critical elements in conducting a large data-collection project is the operational definition that is used to identify reportable events. The key definitions we used (Table 1) are similar to those used in the NATA study in the 1980s, as well as other current injury surveillance programs.[10,14,16]

Categories. Severity categories were created based on calendar days lost due to injury and grouped as minor (<8 days lost), moderate (8 to 21 days lost), and major (>21 days lost). Reported injuries were identified as new injuries or reinjuries. Athlete-exposures, or opportunities for injury, were calculated by aggregating the number of participants for each game or practice. Only those persons who played in the game accumulated game exposures. Individuals who dressed for games but did not play were not counted as exposures.

Coding. The project employed an extensive coding structure that provided an accurate description of each injury. These

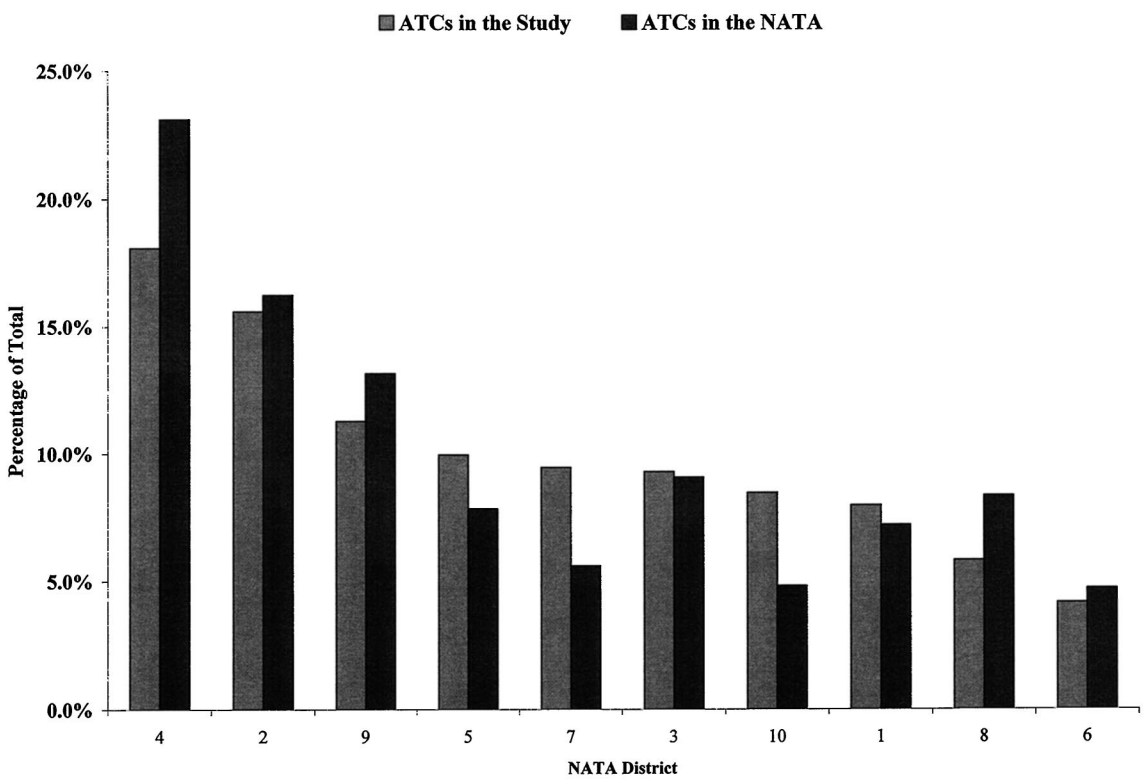

Figure 1. Certified athletic trainers participating in the study and membership by NATA district.

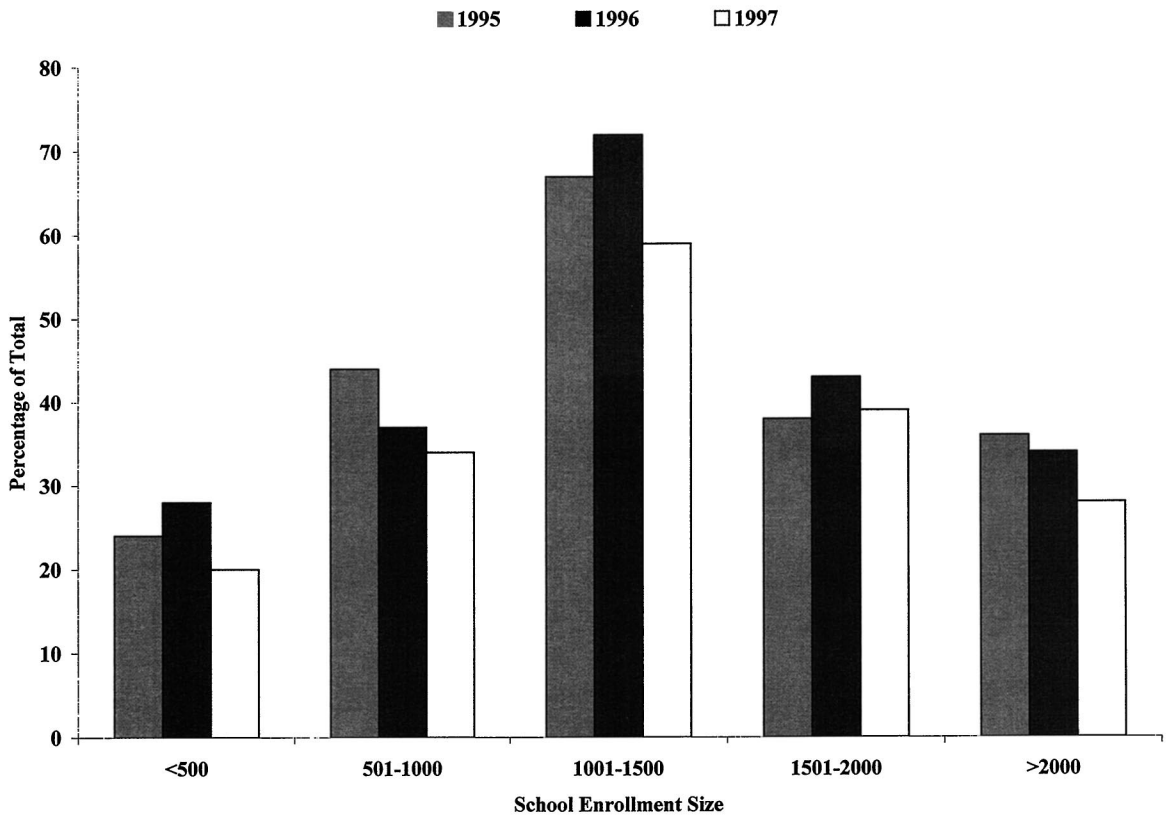

Figure 2. Study participation by school enrollment size.

Table 2. Team-Seasons, Player-Seasons, and Athlete-Exposures for Selected High School Sports

	Boys' Sports					Girls' Sports				
	Baseball	Basketball	Football	Soccer	Wrestling	Basketball	Field Hockey	Softball	Soccer	Volleyball
Team-seasons	324	406	400	315	328	395	128	311	292	296
Player-seasons	6502	6831	21 122	7539	8117	6083	2805	5435	6642	4222
Athlete-exposures	311 295	444 338	1 300 446	385 443	522 608	394 143	138 073	258 754	335 512	359 547

detailed clinical impressions, recorded by the athletic trainers, were recoded into categories to provide a basic comparative description. These categories were designed to provide perspective on the data and can be used to group data for more in-depth analysis.

Data Analysis

The data presented in this paper represent the findings based on the aggregate data for the 3 study years. The injury patterns among the selected sports were compared using specific incidence rates as follows: case rate/100 players = number of injuries/total number of players; player rate/100 players = number of players sustaining at least 1 injury/total number of players. The case rate per 100 players is different from the player rate per 100 players in that it includes multiple injuries to the same players. A case rate per 1000 athlete-exposures is used to describe specific conditions where not all players are participating, eg, games and practices.

The incidence density ratio (IDR) is calculated as follows: IDR = game injury rate/practice injury rate. An IDR of 1 indicates no difference in the injury rates. An IDR greater than 1 indicates that the games have the higher injury rates, and an IDR less than 1 indicates higher injury rates in practice.

Using the case rates per 100 players for the 3 data years, the individual seasons were statistically tested to determine whether the year of recording showed variation in the injury rates, ie, a test for heterogeneity within the database.[19] The wrestling, boys' and girls' basketball, girls' soccer, softball, baseball, field hockey, and volleyball data represent homogeneous populations. The football ($\chi^2 = 29.3$, $P < .001$) and boys' soccer ($\chi^2 = 12.7$, $P < .01$) data represent heterogeneous populations. This finding results from the influence of the 1995 season. The data for the 1996 and 1997 seasons are homogeneous. If the injury data are partitioned to include fractures, dental and brain injuries, and injuries with >1 day lost, all sports are homogeneous over the 3 seasons. The variation lies in the reporting of injuries from practice condi-

tions and from minimal time lost to participation and is important for the analysis of specific and detailed injury patterns for these 2 sports. In a general discussion of injury patterns among the 10 sports, however, these variations have little impact on the data analysis.

The description of the injury patterns among the different sports focused on the proportion of the reportable injuries that were included in specific categories. Our study included data for the different body categories, types of injuries, severity, new injury versus reinjury, and surgeries.

RESULTS

We collected data from 3195 team-seasons and 75 298 player-seasons among the 10 study sports. During the study, 23 566 reportable injuries occurred, and an average of 6000 people were injured at least once each year (Table 2). Among the study sports, the girls' teams accounted for 44.5% of the exposures. The data included in this review reflect injuries and exposure for practices and games that adhere to the established definitions for reporting displayed in Table 1.

Football had the highest player rate per 100 players, case rate per 100 players, and case rate per 1000 athlete-exposures. Baseball had the lowest player rate per 100 players, and volleyball had the lowest case rate per 1000 athlete-exposures (Table 3). The risk of injury differed according to whether the player was participating in a practice session or in a game/competition. An average of 55.5% of the reported injuries occurred in practice sessions, with a range of 68.8% in volleyball to 40.7% in boys' soccer (Table 4). When the injury rates per 1000 athlete-exposures and session were compared, the IDR for 9 sports showed a higher injury rate per 1000 athlete-exposures for game conditions (range, 1.5 to 5.0). Volleyball was the exception and showed an injury rate for practice 2.3 (IDR = 0.4) times greater than for games.

The lower extremity area (hip/thigh/leg, knee, and ankle/foot) showed a higher percentage of injuries within the reported cases (mean = 59.9%) than the upper extremity (mean = 20.8%), except in the case of wrestling (22.2% versus 32.3%) (Table 5). Hip/thigh/leg injury percentages were similar for field hockey (21.8%) and boys' (28.0%) and girls' (25.8%) soccer, whereas ankle/foot injuries were highest in boys' (39.3%) and girls' (36.4%) basketball and boys' (33.5%) and girls' (33.5%) soccer. Football accounted for more head/neck/spine injuries (13.3%) than any other sport (range, 1.9% to 9.5%).

The largest proportion of injuries in the fracture category came from boys' baseball (8.8%), basketball (8.6%), and soccer (8.5%) and softball (8.4%) (Table 6). For both boys' (44.8%) and girls' (45.2%) basketball, sprains were the most frequent type of injury, accounting for the largest proportion of reported injuries for baseball (31.2%) and softball (32.2%).

Among the 10 study sports, an average of 73.5% (range, 67.3% in wrestling to 79.6% in field hockey) of the reportable injuries resulted in a time loss from participation of fewer than

Table 3. Reportable Injuries, Injured Players, and Injury Rates for Selected High School Sports

	Boys' Sports					Girls' Sports				
	Baseball	Basketball	Football	Soccer	Wrestling	Basketball	Field Hockey	Softball	Soccer	Volleyball
Reportable injuries	861	1933	10557	1765	2910	1748	510	910	1771	601
Injured players	765	1538	7310	1521	2166	1399	442	785	1442	628
Player rate/100 players	11.8	22.5	34.6	20.2	26.7	23.0	15.8	14.4	25.6	14.9
Case rate/100 players	13.2	28.3	50.0	23.4	35.9	28.7	18.2	16.7	31.4	14.2
Case rate/1000 athlete-exposures	2.8	4.8	8.1	4.6	5.6	4.4	3.7	3.5	5.3	1.7

Table 4. Percentages of Reported Injuries and Injury Rates by Type of Session for Selected High School Sports

	Boys' Sports					Girls' Sports				
	Baseball	Basketball	Football	Soccer	Wrestling	Basketball	Field Hockey	Softball	Soccer	Volleyball
Practice										
Percentages of injuries	49.4	58.0	56.4	40.7	67.0	53.2	63.5	56.0	42.3	68.8
Case rate/1000 athlete-exposures	1.8	3.4	5.3	2.5	4.8	3.2	3.2	2.7	3.1	2.8
Game										
Percentage of injuries	50.6	42.0	43.6	59.3	33.0	46.8	36.5	44.0	57.0	31.2
Case rate/1000 athlete-exposures	5.6	7.1	26.4	10.2	8.2	7.9	4.9	5.9	11.4	1.2
Incidence density ratio	3.1	2.1	5.0	4.1	1.7	2.5	1.5	2.2	3.7	0.4
Standard deviation	0.20	0.09	0.08	0.17	0.06	00.11	0.14	0.14	0.16	0.18

Table 5. Percentages of Reported Injuries by Body Category for Selected High School Sports

	Boys' Sports					Girls' Sports				
	Baseball	Basketball	Football	Soccer	Wrestling	Basketball	Field Hockey	Softball	Soccer	Volleyball
Head/neck/spine	1.9	3.3	13.3	4.1	9.5	4.3	3.1	3.2	4.9	2.9
Face/scalp	8.9	10.0	2.2	4.6	7.0	6.7	13.5	8.0	4.8	1.6
Shoulder/arm	19.7	2.4	12.0	2.4	18.4	2.4	3.1	16.3	1.9	9.4
Forearm/wrist/hand	24.6	11.4	14.2	5.8	14.2	10.3	12.7	22.9	4.5	11.4
Trunk	7.2	7.7	8.6	6.5	11.9	6.4	4.9	5.5	4.5	11.4
Hip/thigh/leg	14.5	14.4	16.7	28.0	5.4	16.8	21.8	18.0	25.8	9.6
Knee	10.5	11.1	15.1	15.1	14.8	15.7	13.7	10.8	19.4	11.1
Ankle/foot	12.5	39.3	15.9	33.5	7.0	36.4	23.3	14.8	33.5	41.8
Other	0.1	0.4	2.0	0.2	11.7	1.1	3.3	0.5	0.7	0.4

Table 6. Percentage of Reported Injuries by Type of Injury

	Boys' Sports					Girls' Sports				
	Baseball	Basketball	Football	Soccer	Wrestling	Basketball	Field Hockey	Softball	Soccer	Volleyball
General trauma	30.7	24.8	25.2	29.9	20.7	20.3	36.9	27.6	24.9	11.7
Sprains	20.6	44.8	31.7	32.4	28.6	45.2	25.5	23.8	38.7	51.5
Strains	31.2	15.1	21.0	22.8	23.2	17.7	20.2	32.2	22.4	26.4
Fractures	8.8	8.6	7.5	8.5	6.3	6.8	5.9	8.4	5.8	3.7
Musculoskeletal	6.6	2.2	1.8	1.8	2.6	4.0	4.1	3.8	2.3	4.1
Neurotrauma	1.7	2.8	10.3	3.9	5.7	3.6	3.1	3.2	4.6	1.3
General stress	0.3	1.4	2.4	0.7	13.0	2.1	4.1	1.0	1.2	1.3

Table 7. Percentages of Reported Injuries by Severity Category

	Boys' Sports					Girls' Sports				
	Baseball	Basketball	Football	Soccer	Wrestling	Basketball	Field Hockey	Softball	Soccer	Volleyball
Minor	69.0	75.5	72.5	74.6	67.4	72.1	79.6	77.1	72.5	75.0
Moderate	18.5	14.5	16.3	15.0	17.8	15.4	13.3	15.1	15.4	17.1
Major	12.5	9.9	11.2	10.4	14.8	12.4	7.1	7.8	12.1	7.8

8 days. The highest proportion of injuries for which a player missed more than 7 days was in baseball (31.0%) and wrestling (32.6%), with the lowest proportions for field hockey (20.4%) and softball (22.9%) (Table 7). T7

Among the 10 study sports, only about 10% of the reported injuries were identified as reinjuries (Table 8). The proportion of injuries that were reported as a reinjury was lowest for boys' soccer (8.4%) and highest for girls' basketball (13.6%). T8

During the study years, 608 (2.6%) of the reportable cases were identified as having had surgery as a result of the initial injury (Table 9). The girls' sports accounted for 180 (29.6%) of the reported surgeries. The largest proportion of surgeries reported among the 10 sports was for girls' basketball (4.0%), and the lowest proportion was for field hockey (1.2%). Within the surgical cases, there were 369 (60.3%) knee surgeries. Four of the 5 girls' teams had a higher proportion of knee surgeries than any of the boys' sports. T9

DISCUSSION

The information on high school sports injuries included in the NATA database was recorded and reported by certified athletic trainers who volunteered to participate in the study. Their daily presence at the high school allowed the accumulation of a great deal of information regarding the exposure (opportunities for injury), the nature of the injury, and the sport-related circumstances at the time of injury. The system provided data regarding the frequency patterns for the injuries that were recognized early and managed with little time lost from participation. An evaluation of an injury prevention program would include comparisons of these minimal time-loss injury patterns with the patterns for the more serious injuries. The data in this study reflect the injury patterns associated with school programs that have placed injury prevention as a high priority by employing the services of a certified athletic trainer.

Table 8. Percentages of Reported New Injuries and Reinjuries for Selected High School Sports

	Boys' Sports					Girls' Sports				
	Baseball	Basketball	Football	Soccer	Wrestling	Basketball	Field Hockey	Softball	Soccer	Volleyball
New injury	89.1	89.7	90.0	91.6	89.6	86.4	89.4	90.3	89.6	89.4
Reinjury	10.9	10.4	10.0	8.4	10.5	13.6	10.5	9.7	10.5	10.5

Table 9. Reported Surgeries and Knee Surgeries for Selected High School Sports

	Boys' Sports					Girls' Sports				
	Baseball	Basketball	Football	Soccer	Wrestling	Basketball	Field Hockey	Softball	Soccer	Volleyball
Surgeries	30	50	256	35	57	70	6	20	69	15
Percentage of reported cases	3.5	2.6	2.4	2.0	2.0	4.0	1.2	2.2	3.9	2.5
Knee surgeries	13	22	152	18	30	52	6	8	58	10
Percentage of surgeries	43.3	44.0	59.4	51.4	52.6	74.3	100.0	40.0	84.1	66.7

The NATA conducted a study from 1986 through 1988 that examined the injury patterns for school programs for football, boys' and girls' basketball, and wrestling.[9,20] We compared these injury proportions with the proportions and variables presented in our study. For example, an examination of the severity categories between the study done in the 1980s and our study shows very similar proportions for minor, moderate, and major injuries for football and boys' and girls' basketball. The wrestling data showed a similar proportion of moderate injuries, with fewer minor injuries (72.3% to 67.4%) and more major injuries (11.5% to 14.8%) in our study. Among the 4 sports, very similar proportions of cases resulted in surgery in the 2 studies. The 4 sports showed a consistently higher proportion of injuries in the head/neck/spine category in both studies. In addition, a comparison between the 2 decades shows an increase in the proportion of injuries in the neurotrauma category. When considered together, these increases may be attributable to a heightened awareness of concussion among members of the sports medicine community.

In many cases, high school sports programs represent the first opportunity of the young athlete to play a specific sport. High school practice sessions are the prime classroom for teaching the skills of the game to the otherwise unskilled player. Often this means that practices must simulate game conditions in order to prepare the players for competition. In addition, there are always many more practices than games. The data from the NATA study in the 1980s and from our study show that more than half of the injuries occurred under practice conditions. When the 2 studies are compared, there were fewer practice-related injuries in our study for football (60% to 57.4%) and girls' basketball (59% to 53.4%) and no difference for boys' basketball and wrestling. The injury rates per 1000 athlete-exposures in our study support the concept that the risk of injury for most sports is higher in a game than in a practice. The exception to this trend is volleyball, where the injury rate per 1000 athlete-exposures was 2.3 times higher in practice than in games. The higher frequency of injury during practices is related to the high number of practice sessions, and, therefore, a large amount of exposure. On a practical basis, this relationship implies the need for a strong program of early recognition and management of practice-related injuries. Managing the practice injury may keep the player from becoming a game-injury statistic.

The idea of injury prevention is to reduce the frequency of injury. Regardless of the strength of the injury prevention program, there will always be injuries in sports, and those injured players will most likely return to participation. Injury prevention programs must focus on the issues of reinjury and acute injury.[2] The care and rehabilitation of the initial injury constitutes an important aspect of injury prevention, ie, minimizing the risk of reinjury. It is interesting to note that, among the sports in our study, 10% (range, 8.4% to 13.9%) of the reported cases were identified as reinjuries. These reinjuries reflect multiple injuries to the same area for the same player. When the reinjury proportions in our study are compared with the data from the NATA study in the 1980s, boys' basketball shows a drop (15.5% to 8.4%) compared with the earlier study.[9,20] The other sports show no difference in the reinjury proportion. The consistency of the reinjury proportion for the 2 studies may be an indicator of a positive influence that the certified athletic trainer has on the reinjury pattern.

There has been a great deal of discussion regarding the comparisons of the incidence of knee injuries that occur in boys' and girls' sports.[21,22] From our data, it is clear that girls' basketball and girls' soccer players sustained a higher proportion of knee injuries than their male counterparts. We found the frequency of knee surgery for girls' basketball to be about 1 case per 8 team-seasons, and for girls' soccer, about 1 case per 5 team-seasons. The boys' basketball and boys' soccer players demonstrated about 1 case for 18 team-seasons and 1 case for 18 team-seasons, respectively. This finding is consistent with the current belief that girls are at a higher risk for knee surgery

in basketball and soccer than boys. Baseball and softball showed a lower incidence of knee surgery than basketball and soccer. The sex differences seen in basketball and soccer do not exist when we compare baseball (1 in 25 team-seasons) and softball (1 in 39 team-seasons). Knee surgery is more likely in baseball players than in softball players. The sex differences for knee surgery are probably related to an interaction between sport and sex. Future projects will focus on the in-depth examination of this question.

CONCLUSIONS

Our data stimulate questions and discussion regarding programs to reduce the number of injuries to high school athletes and establish 4 important points:

1. Each sport has an inherent risk of injury based on the nature of the game and the activities of the players.
2. Injury prevention programs should be in place for practice sessions as well as games.
3. The prevention of reinjury through daily injury management is a critical component of an injury prevention program.
4. Sex differences in knee surgery patterns are specific to the sport being considered.

While not all sports injuries can be eliminated, consistent and professional evaluation of the yearly injury patterns can help to focus the task of developing and evaluating injury prevention strategies. The best way to minimize the risk of injury in the young athlete is to provide participation opportunities that are under the blanket of a well-designed and operational injury prevention program.

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