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original research

The National Athletic Treatment, Injury and Outcomes Network (NATION): Methods of the Surveillance Program, 2011–2012 Through 2013–2014

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Context: Previous epidemiologic researchers have examined time-loss (TL) injuries in high school student-athletes, but little is known about the frequency of non–time-loss (NTL) injuries in these athletes.

Objective: To describe the methods of the National Athletic Treatment, Injury and Outcomes Network (NATION) Surveillance Program and provide descriptive epidemiology of TL and NTL injuries across athletes in 27 high school sports.

Design: Descriptive epidemiology study.

Setting: Aggregate injury and exposure data collected from 147 high schools in 26 states.

Patients or Other Participants: High school student-athletes participating in 13 boys' sports and 14 girls' sports during the 2011–2012 through 2013–2014 academic years.

Main Outcome Measure(s): Athletic trainers documented injuries and exposures using commercially available injury-tracking software packages. Standard injury-tracking software was modified by the software vendors to conform to the surveillance needs of this project. The modified software exported a set of common data elements, stripped of personally identifiable information, to a centralized automated verification and validation system before they were included in the centralized research database. Dependent measures were injury and exposure frequencies and injury rates with 95% confidence intervals stratified by sport, sex, and injury type (TL or NTL).

Results: Over the 3-year period, a total of 2337 team seasons across 27 sports resulted in 47 014 injuries and 5 146 355 athlete-exposures. The NTL injuries accounted for 38 765 (82.45%) and TL injuries for 8249 (17.55%) of the total.

Conclusions: The NTL injuries accounted for a substantial amount of the total number of injuries sustained by high school student-athletes. This project demonstrates the feasibility of creating large-scale injury surveillance systems using commercially available injury-tracking software.

Key Words: incidence, injury epidemiology, injury surveillance, sport

Key Points

- Among high school student-athletes, non–time-loss injuries predominated over time-loss injuries.
- Surveillance data that are limited to time-loss injuries will substantially underestimate the number of injuries managed by athletic trainers in this setting.
- The routine capture of both time-loss and non–time-loss injuries in high school athletes is feasible via extraction of common data elements from commercially available injury-tracking software.

The National Federation of State High School Associations reported that more than 7.7 million adolescents participate in US high school athletics annually.[1] In the last decade, the absolute number of participants in high school sports has increased 15%,[1] which is greater than the 5% increase in high school student enrollment during the same time.[2] Personal health and socialization benefits are widely considered to result from participation in high school sports. However, concerns are increasing about student-athlete health and safety, particularly as related to the long-term health implications of concussions and overuse injuries.[3–5]

Many injury-surveillance programs report only *time-loss (TL) injuries*, which are defined as those injuries that restrict the student-athlete's participation for at least 24 hours beyond the day of injury.[6–8] In addition, dental injuries, fractures, and concussions are generally included in the capture of injury data, regardless of TL. This may lead to an underrepresentation of injuries with no TL, such as tendinitis and other overuse injuries. Furthermore, such data may underrepresent the total benefit of the clinical services provided by athletic trainers (ATs) in high school athletic training rooms, particularly for acute injuries that may not restrict participation beyond the day of injury but may require costly diagnostic or therapeutic interventions.

The restricted definition of *injury* to only those with TL is a long-standing limitation in sports injury epidemiology. The use of the TL definition dates back to the 1970s and the earliest injury-surveillance system, the National Athletic Injury Reporting System (NAIRS) project.[9] The NAIRS project was among the first to rely on ATs to document and report injuries and exposures. Generally, ATs had to document each injury twice: once for their medical recordkeeping and a second time to report the injury to

NAIRS. This double reporting added a respondent burden to ATs' daily duties. Furthermore, at the time, no personal computers were in athletic training rooms; medical records were paper based, and research data from these reporting forms were converted to electronic databases for analysis. The burden of data collection for both the ATs and investigators was substantial, and as a result, the original NAIRS injury definition was a compromise between the burden required by participation in the NAIRS project and the need to document the burden of injury.[9]

The operational definition of *injury* used in most surveillance systems is largely unchanged since the days of NAIRS. During the 1980s and 1990s, injury documentation entered the digital era with the use of locally installed and online electronic health record applications.[7] Injury-surveillance experts have sought to leverage these technological innovations.[6,8] However, despite such innovations, most injury-surveillance efforts continue to collect only TL injuries. As a result, the evolution of the operational definition of *injury* has been limited. Typically cited reasons for restricting data collection to only those injuries with TL include minimizing the reporting burden for ATs, lessening the work responsibilities of ATs in daily clinical practice, and limiting reporting to injuries of significant medical concern (ie, TL injuries).[9] The reporting burden associated with non–time-loss (NTL) injuries has remained a major concern for standalone surveillance systems (ie, surveillance systems whose information technology architecture does not allow them to use the detailed information recorded by ATs as part of the electronic health records).

As a result, there is a paucity of literature reporting NTL injuries, particularly in high school athletes. For most of the past decade, much of our injury-surveillance data for high school sports have come from the National High School Sports-Related Injury Surveillance System (High School Reporting Information Online [RIO]; Nationwide Children's Hospital, Columbus, OH).[10–13] High School RIO is an Internet-based sports injury-surveillance system. However, High School RIO does not capture NTL injuries other than fractures, concussions, heat-related injuries or illnesses, and dental injuries.

Partly in response to concerns about the underrepresentation of NTL injuries in national injury-surveillance systems, the National Athletic Treatment, Injury and Outcomes Network (NATION) project was launched. The purpose of this article is 2-fold: (1) to describe the methods of the NATION Surveillance Program (SP) and (2) to document the descriptive epidemiology of the TL and NTL injuries reported to NATION in 31 high school sports, using data collected from 147 high schools across 26 states.

METHODS

The NATION-SP is an injury-surveillance program that aims to provide a comprehensive examination of injuries, including both TL and NTL injuries, sustained by student-athletes who receive services from ATs working in the high school setting. Between the 2011–2012 and 2013–2014 school years, the NATION-SP captured data for 27 high school sports in 147 high schools across 26 states. An additional 4 sports (boys' ice hockey, water polo, and volleyball and girls' water polo) were included in the program but provided only a single season of data each and were therefore not included in this report. The methods of NATION-SP are very similar to those of the National Collegiate Athletic Association (NCAA) Injury Surveillance Program (ISP).[14] However, a companion project, the NATION Outcomes Project, provides cost-benefit analyses and quantifies patient-reported health outcomes for a small subset of the injuries reported to NATION-SP.

Participating Schools

The NATION-SP uses a convenience sample of high schools via a rolling recruitment model, and enrollment grows year by year. High schools were recruited in various manners. First, over the course of the study period, staff of the Datalys Center continuously searched the Internet state by state for high school Web sites that had AT contact information. From this search, we contacted 4572 ATs by phone or e-mail (or both). Of these, 914 responded and 78 agreed to participate. The remaining ATs were not interested, could not obtain approval from their high school to participate, or believed they were not available on a sufficiently regular basis at their high school to warrant participation. In addition, Datalys Center staff marketed NATION at the NATA Annual Meeting and Clinical Symposia. The Datalys Center Web site, word of mouth, and software applications certified to export data to NATION (eg, Athletic Trainer System [ATS], Keffer Development Services, LLC, Grove City, PA, and Sports Injury Monitoring System [SIMS], FlanTech, Inc, Iowa City) also helped to promote NATION.

In year 1 (2011–2012), 47 schools contributed 579 team seasons across 27 sports. In year 2 (2012–2013), 68 schools provided 762 team seasons across 27 sports. In year 3 (2013–2014), 147 schools contributed 985 team seasons across 27 sports. In year 2 (2012–2013), 33 (70.2%) of the 47 schools in year 1 (2011–2012) provided data. And in year 3 (2013–2014), 47 (69.1%) of the 68 schools in year 2 (2012–2013) provided data. Thirty schools provided data across all 3 years. Data were collected for sports during preseason, regular season, and postseason practices and competitions. In addition, data were recorded for all off-season practices or competitions. Overall, boys' sports contributed 1185 team seasons across 13 sports, and girls' sports contributed 1141 team seasons across 14 sports (Table 1).

Injury Definitions

Injuries that are reported in the NATION-SP must have been evaluated or treated (or both) by an AT, physician, or other health care professional. A *TL injury* required the student-athlete to be restricted from participation for at least 24 hours past the day of injury. The TL injuries also included all fractures, concussions, and dental injuries, regardless of TL.[6–8,15,16] An *NTL injury* was any injury (other than fractures, concussions, and dental injuries) that was evaluated or treated (or both) by an AT, physician, or other health care professional but did not result in restriction from participation beyond 1 day.[15,16] Both TL and NTL injuries must have occurred during an organized practice or competition for a school-sponsored sport.

Table 1. Teams Studied by Sport and Academic Year: National Athletic Treatment, Injury and Outcomes Network (NATION) Surveillance Program, 2011–2012 Through 2013–2014

	Boys				Girls			
Sport	2011–2012	2012–2013	2013–2014	Total	2011–2012	2012–2013	2013–2014	Total
Baseball	31	41	48	120	NA	NA	NA	NA
Basketball	28	45	71	144	24	46	73	143
Crew	7	4	2	13	6	7	4	17
Cross-country	24	38	63	125	23	39	60	122
Field hockey	NA	NA	NA	NA	23	24	28	75
Football	25	50	88	163	NA	NA	NA	NA
Golf	12	24	26	62	7	14	18	39
Gymnastics	NA	NA	NA	NA	21	19	12	52
Indoor track	23	22	17	62	24	21	17	62
Lacrosse	24	20	17	61	23	18	16	57
Outdoor track	26	34	45	105	24	34	45	103
Soccer	24	28	50	102	23	30	48	101
Softball	NA	NA	NA	NA	30	39	49	118
Swimming and diving	18	21	17	56	20	19	16	55
Tennis	19	19	17	55	19	14	26	59
Volleyball	NA	NA	NA	NA	24	46	73	143
Wrestling	24	40	59	123	NA	NA	NA	NA
Total	285	386	520	1191	291	371	488	1146

Abbreviation: NA, not available.

Athlete-Exposure Definition

An *athlete-exposure* (AE) was defined as 1 student-athlete participating in 1 high school-sanctioned practice or competition in which he or she was exposed to the possibility of athletic injury, regardless of the time associated with that participation.[7] Only athletes with actual playing time in a competition were included in competition exposures.

Common Data Elements

Similar to the NCAA ISP,[14] an innovation of the NATION program is that it uses a common data element (CDE) export standard to gather data from a variety of different injury-documentation applications. The CDE export standard allows ATs to document injuries as they normally would as part of their clinical practice. There is no independent reporting portal for injury surveillance. Rather, reporting of injuries to the surveillance program is integrated into the AT's injury-tracking software. Currently, 3 software applications are certified to export data to NATION: the ATS, Injury Surveillance Tool (IST; Datalys Center, Indianapolis, IN), and SIMS. Before export, data are stripped of identifying information, tagged with a random 16-digit alphanumeric code, and encrypted.

Advantages and Disadvantages of the Common Data Elements Strategy

The CDE strategy has advantages relative to a single dedicated data-entry portal. First, it allows ATs to focus on entering injuries into their own injury-documentation application without considering which injuries should be included or excluded from the study. Because the data-collection process is part of the ATs' own documentation of injuries as athletes present, we can minimize ATs' concerns about forgetting to enter the data in a timely manner. Second, the CDEs allow ATs to select the injury-documentation application they prefer to use. Third, data are exported to servers frequently (ie, typically every night or whenever the application is closed by the AT). We do not have data that verify a smaller time lag between the injury event and report filing compared with other injury-surveillance systems. However, the frequent data exports allow NATION data quality-control staff to work with ATs to correct errant data with less risk of memory decay.

Although this approach does significantly reduce the burden of reporting injuries, ATs are still asked to provide exposure data, which is generally not recorded as part of their normal clinical practice. In addition, each application is slightly different in terms of how many additional variables must be specifically entered by the AT versus those that are easily mapped during the certification process. For example, if an application has a free text field for a required variable, the vendor would have to create a categorical option coded to the CDEs required of that variable. The frequency of export or submission of data also varies slightly among vendors.

Overview of Quality Control

This process of verification and review by the NATION data quality-control staff is an essential component in the quality-control process. Before data enter the research database, they are checked for accuracy and completeness through a series of automated and manual range and consistency checks implemented by the verification engine and NATION data quality-control staff. The staff is employed by the Datalys Center and is thoroughly trained to manage incoming data. The staff also has years of experience working with incoming data from the NCAA ISP.[14]

Data are checked throughout the sport season to provide the AT the opportunity to make corrections before memory decay occurs. The verification engine performs the automated process of flagging missing or errant values, and the NATION data quality-control staff is notified about the failed or partial submission. The staff then contacts the AT for assistance in correcting the errors. Because the staff

reviews submission logs on a daily basis, most ATs are contacted within 24 hours. The amount of time it takes to rectify an error varies by the response time of the AT who submitted the data. In the rare case that an AT is nonresponsive, errant data are coded as *missing*.

Quality Control: Exposure Counts

Exposure data were considered valid if values per exposure were not zero or missing. Unacceptable exposure data (1.6% of all exposure data) were replaced with mean imputation values. These mean values were estimated from all valid AE data from the same year, school, sport, and exposure type (ie, practice, competition). For example, if AE data were missing for a school football team practice, the mean value computed from all other AE data for football practices from that school occurring that same year would be assigned.

Quality Control: Injury Data

All injury-data submissions were considered final 30 days after the final postseason competition. If the AT modified these records beyond that date, the modifications were not included in the research datasets. Each injury event was given a unique identifying injury-event number. Data quality-control staff assessed injury events with multiple injuries reported (less than 1.0% of all reported injury events). These injuries were retained in the dataset if each had a separate specific injury definition (eg, an anterior cruciate ligament sprain) or different body parts affected (eg, ankle and knee injuries occurring in the same injury event). Otherwise, duplicate injuries were removed. After the injury-event record was cleaned of duplicate data, its recorded date and season were compared with the date and season of the associated exposure record. If discrepancies existed between the records, the exposure record was considered correct and the date and season associated with the injury-event record were changed.

Quality Control: Time Loss

Reported TL injuries lasting more than 1 week were reviewed individually to ensure the data appeared valid based on the information provided. For example, an anterior cruciate ligament sprain may require 6 months to 1 year of rehabilitation. However, a contusion would likely not require as much recovery time. If there was a negative TL value for an injury, the return date was evaluated and an assessment was made as to whether the return date could be logically changed based on the month and day entered (eg, an AT may have accidentally imputed the incorrect year). If there was no consensus on an appropriate date between quality-control staff and the participating AT, the return date was set to missing.

Quality Control: Qualifying Criteria for Inclusion

At the completion of the sport season, NATION data quality-control staff further review the data from each team to determine if they qualify for inclusion in the reportable dataset. To qualify, the AT for the team must report at least 80% of the expected exposures (practices and competitions) for a particular sport. In addition, the number of injuries reported must fall within 1 standard deviation of the expected frequencies (as calculated from the sample by sport). Each of the 31 sports included in NATION has a different number of competitions and different expected injury rates. For example, it is unrealistic to assume a football team would have no injuries during a season. Therefore, if an AT reports only exposures but no injuries, that team's exposures would not be included in the reportable data. To include only a team's exposures would deflate the injury rate calculated from all included teams' data. Including only injuries would inflate the injury rate.

Statistical Analyses

Data were analyzed using SAS-Enterprise Guide software (version 4.3; SAS Institute Inc, Cary, NC). Injury rates (IRs) per 1000 AEs were defined as

$$\mathrm{IR} = \sum \text{injuries} \Big/ \sum \text{AEs} * 1000,$$

where $\sum$ injuries is the sum of all injuries and $\sum$ AEs is the sum of all athlete-exposures.[17] The quotient is multiplied by 1000, and all IRs are reported with 95% confidence intervals (CIs). The SP portion of the NATION project was reviewed by the Western Institutional Review Board (Puyallup, WA) and determined to be exempt from human subjects protections review.

RESULTS

Over the 3-year period (2011–2014), a total of 2337 team seasons across 27 sports were responsible for 47 014 injuries and 5 146 355 AEs. A total of 38 765 (83.63%) NTL injuries and 8249 (17.55%) TL injuries were reported. The 13 boys' sports contributed 31 728 injuries (67.49%) and 3 233 840 AEs (62.84%; Table 2). The 14 girls' sports contributed 15 286 injuries (32.51%) and 1 912 515 AEs (37.16%; Table 3). Among boys' sports, football accounted for the most team seasons (143), injuries (16 931), and AEs (1 107 485). Among girls' sports, basketball contributed the most team seasons (143) and injuries (2409), but volleyball contributed the most AEs (296 446).

All 27 sports reported NTL injuries (Tables 2 and 3). However, less than 10 total TL injuries were reported in boys' and girls' crew, boys' and girls' golf, and boys' tennis. Boys' crew, boys' golf, and girls' golf did not report any TL injuries at all. Among boys' sports, the proportion of NTL injuries reported ranged from 78.1% in football to 100.0% in both golf and crew. Among girls' sports, the proportion of NTL injuries reported ranged from 78.7% in soccer to 100.0% in golf. Football reported the highest proportion of TL injuries at 21.9%.

The highest overall injury rates among boys' and girls' sports were reported by boys' football (IR = 15.28/1000 AEs; 95% CI = 15.06, 15.52) and girls' lacrosse (IR = 11.32/1000 AEs; 95% CI = 10.67, 11.98; Tables 4 and 5). In regard to TL injuries, boys' football reported the highest injury rate (IR = 3.35/1000 AEs; 95% CI = 3.24, 3.46), followed closely by boys' wrestling (IR = 2.49/1000 AEs; 95% CI = 2.29, 2.69) and girls' basketball (IR = 2.01/1000 AEs; 95% CI = 1.80, 2.22).

Table 2. Time-Loss and Non–Time-Loss Injuries Reported for Boys' Sports, National Athletic Treatment, Injury and Outcomes Network (NATION) Surveillance Program, 2011–2012 Through 2013–2014

Boys' Sport	Team Seasons	Frequencies				Proportion of Non–Time-Loss Injuries, %
		Injuries			Athlete-Exposures	
		Time Loss[a]	Non–Time Loss[b]	Total		
Baseball	120	168	968	1136	208 802	85.2
Basketball	144	580	2089	2669	364 544	78.3
Crew	13	0	59	59	24 681	100.0[c]
Cross-country	125	100	1045	1145	258 566	91.3
Football	163	3709	13 222	16 931	1 107 485	78.1
Golf	62	0	6	6	28 068	100.0[c,d]
Indoor track	62	73	1433	1506	221 814	95.2
Lacrosse	61	281	1506	1787	166 889	84.3
Outdoor track	105	161	1440	1601	279 030	89.9
Soccer	102	323	1579	1902	208 643	83.0
Swimming and diving	56	19	85	104	81 523	81.7
Tennis	55	9	110	119	45 987	92.4[c]
Wrestling	123	593	2170	2763	237 807	78.5
Total	1191	6016	25 712	31 728	3 233 840	81.0

Note: Insufficient data existed to report on ice hockey, volleyball, and water polo.

[a] *Time-loss injuries* are defined as injuries that (1) were evaluated or treated (or both) by an athletic trainer, physician, or other health care professional; (2) restricted the student-athlete from participation for at least 24 hours past the day of injury; and (3) occurred during a sanctioned practice or competition. Time-loss injuries also included all fractures, concussions, and dental injuries, regardless of time loss.

[b] *Non–time-loss injuries* are defined as injuries that (1) were evaluated or treated (or both) by an athletic trainer, physician, or other health care professional; (2) did not restrict the student-athlete from participation for at least 24 hours past the day of injury; and (3) occurred during a sanctioned practice or competition. All fractures, concussions, and dental injuries were classified as time-loss injuries.

[c] Fewer than 10 time-loss injuries were reported. Therefore, the percentage should be interpreted with caution.

[d] Fewer than 10 non–time-loss injuries were reported. Therefore, the percentage should be interpreted with caution.

DISCUSSION

The purpose of our study was to describe the methods of the NATION surveillance program and provide descriptive epidemiology of TL and NTL injuries in high school athletes. We are the first to report both TL and NTL injuries across a wide range of sports in the high school setting, thereby supplying a more comprehensive summary, relative to previous reports, of injuries managed by ATs. This is

Table 3. Time-Loss and Non–Time-Loss Injuries Reported for Girls' Sports, National Athletic Treatment, Injury and Outcomes Network (NATION) Surveillance Program, 2011–2012 Through 2013–2014

Girls' Sport	Team Seasons	Frequencies				Proportion of Non–Time-Loss Injuries, %
		Injuries			Athlete-Exposures	
		Time Loss[a]	Non–Time Loss[b]	Total		
Basketball	143	513	1896	2409	288 566	78.7
Crew	17	5	185	190	22 097	97.4[c]
Cross-country	122	150	1058	1208	197 644	87.6
Field hockey	75	223	1465	1688	149 166	86.8
Golf	39	0	2	2	6344	100.0[c,d]
Gymnastics	62	47	232	279	30 148	83.2
Indoor track	52	88	1430	1518	174 624	94.2
Lacrosse	57	163	982	1145	101 128	85.8
Outdoor track	103	162	1273	1435	219 928	88.7
Soccer	101	349	1505	1854	173 603	81.2
Softball	118	179	882	1061	140 109	83.1
Swimming and diving	55	27	131	158	69 115	82.9
Tennis	59	21	154	175	43 599	88.0
Volleyball	143	306	1858	2164	296 446	85.9
Total	1146	2233	13 053	15 286	1 912 515	85.4

Note: Insufficient data existed to report on water polo.

[a] *Time-loss injuries* are defined as injuries that (1) were evaluated or treated (or both) by an athletic trainer, physician, or other health care professional; (2) restricted the student-athlete from participation for at least 24 hours past the day of injury; and (3) occurred during a sanctioned practice or competition. Time-loss injuries also included all fractures, concussions, and dental injuries, regardless of time loss.

[b] *Non–time-loss injuries* are defined as injuries that (1) were evaluated or treated (or both) by an athletic trainer, physician, or other health care professional; (2) did not restrict the student-athlete from participation for at least 24 hours past the day of injury; and (3) occurred during a sanctioned practice or competition. All fractures, concussions, and dental injuries were classified as time-loss injuries.

[c] Fewer than 10 time-loss injuries were reported. Therefore, the percentage should be interpreted with caution.

[d] Fewer than 10 non–time-loss injuries were reported. Therefore, the percentage should be interpreted with caution.

Table 4. Injury Rates per 1000 Athlete-Exposures for Boys' Sports, National Athletic Treatment, Injury and Outcomes Network (NATION) Surveillance Program, 2011–2012 Through 2013–2014

	Injuries, Rate per 1000 Athlete-Exposures (95% Confidence Interval)		
Boys' Sports	Time Loss[a]	Non–Time Loss[b]	Total
Baseball	0.80 (0.68, 0.93)	4.64 (4.34, 4.93)	5.44 (5.12, 5.76)
Basketball	1.59 (1.46, 1.72)	5.73 (5.48, 5.98)	7.32 (7.04, 7.60)
Crew[c]	0.00	2.39 (1.78, 3.00)	2.39 (1.78, 3.00)
Cross-country	0.39 (0.31, 0.46)	4.04 (3.80, 4.29)	4.43 (4.17, 4.68)
Football	3.35 (3.24, 3.46)	11.94 (11.74, 12.14)	15.28 (15.06, 15.52)
Golf[d]	0.00	0.21 (0.04, 0.38)	0.21 (0.04, 0.38)
Indoor track	0.33 (0.25, 0.40)	6.46 (6.13, 6.79)	6.79 (6.45, 7.13)
Lacrosse	1.68 (1.49, 1.88)	9.02 (8.57, 9.48)	10.71 (10.21, 11.20)
Outdoor track	0.58 (0.49, 0.67)	5.16 (4.89, 5.43)	5.74 (5.46, 6.02)
Soccer	1.55 (1.38, 1.72)	7.57 (7.19, 7.94)	9.12 (8.71, 9.53)
Swimming and diving	0.23 (0.13, 0.34)	1.04 (0.82, 1.26)	1.28 (1.03, 1.52)
Tennis[c]	0.07 (0.07, 0.32)	2.39 (1.94, 2.84)	2.59 (2.12, 3.05)
Wrestling	2.49 (2.29, 2.69)	9.13 (8.74, 9.51)	11.62 (11.19, 12.05)
Total	1.86 (1.81, 1.91)	7.95 (7.85, 8.05)	9.81 (9.70, 9.92)

Note: Insufficient data existed to report on ice hockey, volleyball, and water polo.

[a] *Time-loss injuries* are defined as injuries that (1) were evaluated or treated (or both) by an athletic trainer, physician, or other health care professional; (2) restricted the student-athlete from participation for at least 24 hours past the day of injury; and (3) occurred during a sanctioned practice or competition. Time-loss injuries also included all fractures, concussions, and dental injuries, regardless of time loss.

[b] *Non–time-loss injuries* are defined as injuries that (1) were evaluated or treated (or both) by an athletic trainer, physician, or other health care professional; (2) did not restrict the student-athlete from participation for at least 24 hours past the day of injury; and (3) occurred during a sanctioned practice or competition. All fractures, concussions, and dental injuries were classified as time-loss injuries.

[c] Fewer than 10 time-loss injuries were reported. Therefore, the rate should be interpreted with caution.

[d] Fewer than 10 non–time-loss injuries were reported. Therefore, the rate should be interpreted with caution.

also the first study to include high school sports such as crew, cross-country, golf, indoor and outdoor track, and swimming and diving, which generated predominantly NTL injuries.

Few authors[15,16] have reported both TL and NTL injuries. The Appropriate Medical Coverage in Intercollegiate Athletics study[15] was the first to systematically report both TL and NTL injuries in a comprehensive manner. This investigation was a 2-year effort to describe the nature and frequency of injuries and treatments in 22 sports across 50 colleges and universities, 10 each from NCAA Divisions I, II, and III and 10 each from the National Association of Intercollegiate Athletics and the National Junior College Athletic Association.[15] The NTL injuries were defined in a

Table 5. Injury Rates per 1000 Athlete Exposures for Girls' Sports, National Athletic Treatment, Injury and Outcomes Network (NATION) Surveillance Program, 2011–2012 Through 2013–2014

	Injuries, Rate per 1000 Athlete-Exposures (95% Confidence Interval)		
Girls' Sports	Time Loss[a]	Non–Time Loss[b]	Total
Basketball	1.78 (1.62, 1.93)	6.57 (6.27, 6.87)	8.35 (8.01, 8.68)
Crew[c]	0.23 (0.03, 0.42)	8.37 (7.17, 9.58)	8.60 (7.38, 9.82)
Cross-country	0.76 (0.64, 0.88)	5.35 (5.03, 5.68)	6.11 (5.77, 6.46)
Field hockey	1.49 (1.30, 1.69)	9.82 (9.32, 10.32)	11.32 (10.78, 11.86)
Golf[d]	0.00	0.32 (0.00, 0.75)	0.32 (0.00, 0.75)
Gymnastics	1.56 (1.11, 2.00)	7.70 (6.71, 8.69)	9.25 (8.17, 10.34)
Indoor track	0.50 (0.40, 0.61)	8.19 (7.76, 8.61)	8.69 (8.26, 9.13)
Lacrosse	1.61 (1.36, 1.86)	9.71 (9.10, 10.32)	11.32 (10.67, 11.98)
Outdoor track	0.74 (0.62, 0.85)	5.79 (5.47, 6.11)	6.52 (6.19, 6.86)
Soccer	2.01 (1.80, 2.22)	8.67 (8.23, 9.11)	10.68 (10.19, 11.17)
Softball	1.28 (1.09, 1.46)	6.30 (5.88, 6.71)	7.57 (7.12, 8.03)
Swimming and diving	0.39 (0.24, 0.54)	1.90 (1.57, 2.22)	2.29 (1.93, 2.64)
Tennis	0.48 (0.28, 0.69)	3.53 (2.97, 4.09)	4.01 (3.42, 4.61)
Volleyball	1.03 (0.92, 1.15)	6.27 (5.98, 6.55)	7.30 (6.99, 7.61)
Total	1.17 (1.12, 1.22)	6.83 (6.71, 6.94)	7.99 (7.87, 8.12)

Note: Insufficient data existed to report on water polo.

[a] Time-loss injuries are defined as injuries that (1) were evaluated or treated (or both) by an athletic trainer, physician, or other health care professional; (2) restricted the student-athlete from participation for at least 24 hours past the day of injury; and (3) occurred during a sanctioned practice or competition. Time-loss injuries also included all fractures, concussions, and dental injuries, regardless of time loss.

[b] Non–time-loss injuries are defined as injuries that (1) were evaluated or treated (or both) by an athletic trainer, physician, or other health care professional; (2) did not restrict the student-athlete from participation for at least 24 hours past the day of injury; and (3) occurred during a sanctioned practice or competition. All fractures, concussions, and dental injuries were classified as time-loss injuries.

[c] Fewer than 10 time-loss injuries were reported. Therefore, the rate should be interpreted with caution.

[d] Fewer than 10 non–time-loss injuries were reported. Therefore, the rate should be interpreted with caution.

manner similar to ours. In that study, 78% and 84% of the injuries sustained by male and female collegiate student-athletes, respectively, were classified as NTL.[15] Our estimates of 82% and 87% for boys and girls, respectively, were very similar. The small differences may be the result of including different sports and different overall numbers of sports in each study. Whereas the previous study consisted of 11 men's and 11 women's collegiate sports, the NATION program consisted of an additional 2 boys' sports (crew, lacrosse) and 3 girls' sports (crew, gymnastics, lacrosse) in the high school setting.

The TL, NTL, and overall rates of injury reported in the collegiate setting[15] are generally higher than those reported in the high school setting across all sports. The reason for this difference is unknown, but at least 2 explanations are possible. First, in the collegiate setting, many sports had dedicated ATs, compared with most high schools, which had only 1 AT for all sports. This disparity may result in underreporting of injuries in high school athletes, and, consequently, lower rates of TL and NTL injuries. Second, the level of competition and intensity may be such that high school student-athletes experience fewer injuries.

Compared with girls' sports, boys' sports displayed higher injury rates. However, consistent with reports that indicate women are more likely to seek health care,[18] the proportion of injuries that were NTL was higher among the girls' sports. This may have important clinical implications because many overuse injuries are thought to be preventable through early intervention, before TL is required. Female student-athletes may have a lower rate of TL injury because they are more likely to seek care before the injury becomes more serious.[18]

Surveillance of NTL Injuries

The NATION-SP data demonstrate that the number of NTL injuries managed by ATs in the high school setting is substantially higher than the number of TL injuries. Thus, surveillance data that use a TL definition substantially underreport the true burden of injury experienced by student-athletes and managed by ATs.[6–8] However, there are valid reasons for limiting some surveillance to TL injuries. Typically, TL injuries have a greater effect on daily life and productivity of students and families than NTL injuries, require more clinical resources, and can be captured in greater detail than NTL injuries within the inherent limitations of an injury-surveillance system. Thus, we have an important public health need for standalone surveillance systems that focus on TL injuries. Additionally, existing, well-established surveillance systems—such as High School RIO and the NCAA ISP—provide an extensive historical time series of retrospective data that are invaluable for monitoring injury trends over time. Yet reliably quantifying the number of NTL injuries managed is necessary to quantify the services provided by ATs in the high school setting. Additionally, the capture of repetitive microtrauma (overuse) injuries is questionable in TL-only surveillance data, but these NTL injuries can have a major effect on student-athletes' daily lives and can consume significant clinical recources.[19]

The value of the NATION-SP lies in its ability to extract surveillance data from commercial injury-tracking software widely used by ATs and to quantify the burden of NTL injuries. Given the large number of NTL injuries, the continued growth in commercial injury-tracking software, and the lower respondent burden associated with NATION-SP (no need to enter the data twice), this method will likely provide an invaluable supplement to standalone injury-surveillance systems that focus on TL injuries, such as High School RIO. Furthermore, given its similar methods to those of the NCAA ISP,[14] differences in the epidemiology of sport-related injuries by playing level (eg, college versus high school) are more easily demonstrated.

Strengths and Limitations

The NATION program is the first study to use CDEs to collect sport-injury data from several different injury-documentation applications. This reduced the workload for participating ATs and we hope will enhance future recruitment, participation, and retention rates. Injury and exposure data were all documented by sports medicine professionals (ie, ATs), which helps to assure a high level of data quality and consistency.[20] However, exposure data remain one of the key variables generally not captured by ATs and continue to pose a substantial barrier to participation in an injury-surveillance program such as the NATION program. Authors of future descriptive injury-epidemiology studies should seek alternative methods for collecting and estimating exposure data.

This study is based on a convenience sample of high schools with AT support. Because only 70% of US public high schools and 55% of public high school student-athletes had access to an AT,[21] our findings may not represent all high school student-athletes. Specific details regarding student body size, urban or rural setting, etc, were not systematically tracked for purposes of this project; as a result, we cannot examine differences between participants and nonparticipants. Additionally, our sample included part-time and full-time ATs, which may also result in differences among high school data. Future analyses from the NATION program will explore those differences in terms of injury incidence, treatment patterns, and patient-reported health outcomes. Last, a few sports included in this report had too few team seasons available to provide more detailed analyses. Additional years of observation are required before more stable estimates can be determined.

Future Research

Future investigators using NATION data will explore numerous aspects not presented in this article. These include more in-depth, sport-specific analyses, as well as analyses related to time in season (ie, preseason, regular season, postseason, off-season) and injury severity, treatment, and outcomes. The NATION data will soon be available to external researchers through a data-request system similar to that used for the NCAA ISP.[14]

CONCLUSIONS

The NTL injuries accounted for a substantial amount of the total number of injuries sustained by high school student-athletes. Surveillance data that are limited to TL injuries will substantially underestimate the number of injuries managed by ATs in the high school setting. Our findings also suggest that routine capture of both TL and

NTL injuries in the high school sports setting is feasible through the collection of CDEs extracted from multiple injury-documentation applications. As participation in high school sports continues to increase,[1] it will become important to use such data to monitor injury trends and estimate utilization of clinical resources, including ATs' time. Sports injury-surveillance systems such as the NATION program also can inform the development of interventions that will help to reduce the frequency and severity of injuries sustained by high school student-athletes.

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