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The First Decade of Web-Based Sports Injury Surveillance: Descriptive Epidemiology of Injuries in US High School Boys' Wrestling (2005–2006 Through 2013–2014) and National Collegiate Athletic Association Men's Wrestling (2004–2005 Through 2013–2014)

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Context: The advent of Web-based sports injury surveillance via programs such as the High School Reporting Information Online system and the National Collegiate Athletic Association Injury Surveillance Program has aided the acquisition of wrestling injury data.

Objective: To describe the epidemiology of injuries sustained in high school boys' wrestling in the 2005–2006 through 2013–2014 academic years and collegiate men's wrestling in the 2004–2005 through 2013–2014 academic years using Web-based sports injury surveillance.

Design: Descriptive epidemiology study.

Setting: Online injury surveillance from wrestling teams of high school boys (annual average = 100) and collegiate men (annual average = 11).

Patients or Other Participants: Male wrestlers who participated in practices and competitions during the 2005–2006 through 2013–2014 academic years in high school or the 2004–2005 through 2013–2014 academic years in college.

Main Outcome Measure(s): Athletic trainers collected time-loss (≥24 hours) injuries and exposure data during this time period. Injury rates per 1000 athlete-exposures (AEs), injury rate ratios with 95% confidence intervals, and injury proportions by body site and diagnosis were calculated.

Results: The High School Reporting Information Online documented 3376 time-loss injuries during 1 416 314 AEs; the National Collegiate Athletic Association Injury Surveillance Program documented 2387 time-loss injuries during 257 297 AEs. The total injury rate was higher in college than in high school (9.28 versus 2.38/1000 AEs; injury rate ratio = 3.89; 95% confidence interval = 3.69, 4.10). In high school, the most commonly injured body parts for both practices and competitions were the head/face (practices = 19.9%, competitions = 21.4%) and shoulder/clavicle (practices = 14.1%, competitions = 21.0%). In college, the most frequently injured body parts for both practices and competitions were the knee (practices = 16.7%, competitions = 30.4%) and head/face (practices = 12.1%, competitions = 14.6%).

Conclusions: Injury rates were higher in collegiate than in high school players, and the types of injuries sustained most often differed. Based on these results, continued study of primary and secondary prevention of injury in wrestlers across levels of competition is warranted.

Key Words: concussions, musculoskeletal injuries, skin infections, injury prevention

Key Points

- The injury rate was higher in collegiate men's wrestling than in high school boys' wrestling.
- During competitions, concussions and knee sprains were common injuries.
- A variety of skin infections were reported in high school and collegiate wrestlers.

Wrestling has existed as an athletic contest for thousands of years, as evidenced by images depicting wrestling competitions found on Egyptian tombs dating to earlier than 2000 BC.[1] In more recent centuries, wrestling was one of the first sports contested in the modern Olympics.[2] The 3 styles of wrestling—Greco-Roman, freestyle, and folkstyle—have different rules for areas of the body that can be attacked and amounts of time spent on the feet versus on the mat; the former 2 are contested in international competitions, whereas the latter is mainly contested in North American high schools and universities. The total number of collegiate teams has been stable over the past decade. In 2013–2014, 226 US collegiate wrestling teams in the National Collegiate Athletic Association (NCAA) had 6982 participants and an average squad size of 30.9 members.[3] In 2004–2005, 224 collegiate wrestling teams had 5939 participants and an average squad size of 26.5 members. This relative stability in total number of teams over the past decade, however, belies changes by division of competition. Specifically, declines occurred in Division I (86 in 2004–2005 and 77 in 2013–2014) and Division III (99 in 2004–2005 and 91 in 2013–2014), while Division II increased (39 in 2004–2005 and 58 in 2013–2014). Resources invested in the athletic department tend to be greatest in Division I schools; Division III schools do not offer athletic scholarships. Consequently, differences often exist in competitiveness by division, and changing participation levels by division may theoretically affect the intensity or nature of competition. At the high school level, participation has declined over the past decade. In 2004–2005, 2512 schools sponsored boys' wrestling for 59 589 participants.[4] In 2013–2014, 2089 schools sponsored boys' wrestling for 49 547 participants.

Although wrestling has fewer participants than many other sports, the nature of the sport means that the risk of injury is high; wrestling is a fast-paced combat sport in which contact occurs. Research[5] conducted at the high school level showed that wrestling was second to football in the rate of severe injuries (*severe* was defined as an injury that resulted in 3 or more weeks lost from sport participation). Wrestling is also unique among high school and collegiate sports because athletes compete in weight classes, which have changed over time. Currently, US high schools have 14 weight categories, ranging from 106 lb (48 kg) to heavyweight (up to 285 lb [129.3 kg])[6]; the NCAA has 10 categories, ranging from 125 lb (56.7 kg) to heavyweight (up to 285 lb [129.3 kg]).[7] Athletes are required to weigh in several hours before competition. Historically, to gain a competitive advantage based on body size, many athletes dehydrated themselves before the weigh-in and then rehydrated before their match. This practice resulted in several deaths, which led to a variety of rules in recent years aimed at controlling the practice. These consisted of more stringent rules regarding when weigh-ins occur (1 hour before the match start at dual-meet weigh-ins and 2 hours or less for tournaments) as well as a preseason weight certification, when the lowest weight category at which the athlete is allowed to compete that season is determined.[6,7] More variability and less opportunity exists for centralized enforcement at the high school level as compared with the collegiate level. The National Federation of State High School Associations rules state that every state high school association must create and implement a weight-control program that will deter wrestling student-athletes from engaging in activities that promote excessive weight reduction and fluctuation.[6]

Since the 2004–2005 academic year, the NCAA has used a Web-based platform to collect collegiate sports injury and exposure data via athletic trainers (ATs).[8] Although this NCAA-based surveillance system has had several names, we herein denote it as the *NCAA Injury Surveillance Program* (ISP). A year later, High School Reporting Information Online (HS RIO), a similar Web-based high school sports injury-surveillance system, was launched.[9] As denoted in the van Mechelen et al[10] framework, injury prevention benefits from ongoing monitoring of injury incidence, and updated descriptive epidemiology is needed. A previous NCAA-ISP report[11] for the 1988–1989 through 2003–2004 academic years documented men's wrestling competition and practice injury rates of 26.4 and 5.7/1000 athlete-exposures (AEs), respectively. In addition, it is important to use HS RIO data to document injury incidence at the high school level and compare findings between the settings. The purpose of this article is to summarize the descriptive epidemiology of injuries sustained in high school boys and collegiate men's wrestling during the first decade of Web-based sports injury surveillance (2004–2005 through 2013–2014 academic years).

METHODS

Data Sources and Study Period

This study used data collected by HS RIO and the NCAA-ISP, sports ISPs for the high school and collegiate levels, respectively. Use of the HS RIO data was approved by the Nationwide Children's Hospital Subjects Review Board (Columbus, OH). Use of the NCAA-ISP data was approved by the Research Review Board at the NCAA.

An average of 100 high schools sponsoring boys' wrestling provided data to the HS RIO random sample during the 2005–2006 through 2013–2014 academic years (2005–2006 was the first year HS RIO collected data). An average of 11 NCAA member institutions (Division I = 5, Division II = 2, Division III = 4) sponsoring men's wrestling participated in the NCAA-ISP during the 2004–2005 through 2013–2014 academic years. The methods of HS RIO and the NCAA-ISP are summarized in the following sections. In-depth information on the methods and analyses for this special series of articles on Web-based sports injury surveillance can be found in the previously published methodologic article.[12] In addition, earlier publications have described the sampling and data collection of HS RIO[9,13] and the NCAA-ISP[8] in depth.

High School RIO

High School RIO consists of a sample of high schools with 1 or more National Athletic Trainers' Association–affiliated ATs with valid e-mail addresses. The ATs from participating high schools reported injury incidence and AE information weekly throughout the academic year using a secure Web site. For each injury, the AT completed a detailed report on the injured athlete (age, height, weight, etc), the injury (site, diagnosis, severity, etc), and the injury event (activity, mechanism, etc). Throughout each academ-

ic year, participating ATs were able to view and update previously submitted reports as needed with new information (eg, time loss).

Data for HS RIO during the 2005–2006 through 2013–2014 academic years originated from a random sample of 100 schools that were recruited annually. Eligible schools were randomly selected from 8 strata (12 or 13 per stratum) based on school population (enrollment $\leq$1000 or $>$1000) and US Census geographic region.[14] Athletic trainers from these schools reported data for the 9 sports of interest (boys' baseball, basketball, football, soccer, and wrestling, and girls' basketball, soccer, softball, and volleyball). If a school dropped out of the system, a replacement from the same stratum was selected.

National Estimates. In HS RIO, national injury estimates were calculated from injury counts obtained from the sample. A weighting algorithm based on the inverse probability of participant schools' selection into the study (based on geographic location and high school size) was applied to individual case counts to calculate the national injury estimates.

National Collegiate Athletic Association Injury Surveillance Program

The NCAA-ISP depends on a convenience sample of teams with ATs voluntarily reporting injury and exposure data.[8] Participation in the NCAA-ISP, while voluntary, is available to all NCAA institutions. For each injury event, the AT completes a detailed event report on the injury or condition (eg, site, diagnosis) and the circumstances (eg, activity, mechanism, event type [ie, competition or practice]). The ATs are able to view and update previously submitted information as needed during the course of a season. In addition, ATs provide the number of student-athletes participating in each practice and competition. Data collection for the 2004–2005 through 2013–2014 academic years is described in the following paragraph.

During the 2004–2005 through 2008–2009 academic years, ATs used a Web-based platform launched by the NCAA to track injury and exposure data.[8] This platform integrated some of the functional components of an electronic medical record, such as athlete demographic information and preseason injury information. During the 2009–2010 through 2013–2014 academic years, the Datalys Center for Sports Injury Research and Prevention, Inc (Datalys Center, Indianapolis, IN), introduced a common data element (CDE) standard to improve process flow. The CDE standard allowed data to be gathered from different electronic medical record and injury-documentation applications, including the Athletic Trainer System (Keffer Development, Grove City, PA), Injury Surveillance Tool (Datalys Center), and the Sports Injury Monitoring System (FlanTech, Iowa City, IA). The CDE export standard allowed ATs to document injuries as they normally would as part of their daily clinical practice, as opposed to asking them to report injuries solely to participate in an ISP. Data were de-identified and sent to the Datalys Center, where they were examined by data quality-control staff and a verification engine.

National Estimates. To calculate national estimates of the number of injuries and AEs, poststratification sample weights based on sport, division, and academic year were applied to each reported injury and AE. Weights for all data were further adjusted to correct for underreporting, consistent with Kucera et al,[15] who estimated that the ISP captured 88.3% of all time-loss medical-care injury events. Weighted counts were scaled up by a factor of (0.883^{-1}). In-depth information on the formula used to calculate national estimates can be found in the previously published methodologic article.[12]

Definitions

Injury. A reportable *injury* in both HS RIO and the NCAA-ISP was defined as an injury that (1) occurred as a result of participation in an organized practice or competition, (2) required medical attention by a certified AT or physician, and (3) resulted in restriction of the student-athlete's participation for 1 or more days beyond the day of injury. *Injury* also included dermatologic infections and lesions that may occur during wrestling participation. Since the 2007–2008 academic year, HS RIO has also captured all concussions, fractures, and dental injuries, regardless of time loss. In the NCAA-ISP, multiple injuries occurring from 1 injury event could be included, whereas in HS RIO, only the principal injury was captured. Beginning in the 2009–2010 academic year, the NCAA-ISP also began to monitor all non–time-loss injuries. A *non–time-loss injury* was defined as any injury that was evaluated or treated (or both) by an AT or physician but did not result in restriction from participation beyond the day of injury. However, because HS RIO captures only time-loss injuries (to reduce the time burden on high school ATs), for this series of publications, only time-loss injuries (with the exception of concussions, fractures, and dental injuries as noted earlier) were included.

Athlete-Exposure. For both surveillance systems, a reportable *AE* was defined as 1 student-athlete participating in 1 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. Preseason scrimmages were considered practice exposures, not competition exposures.

Statistical Analysis

Data were analyzed using SAS-Enterprise Guide software (version 5.4; SAS Institute Inc, Cary, NC). Because the data collected from HS RIO and the NCAA-ISP are similar, we opted to recode data when necessary to increase the comparability between high school and collegiate student-athletes. We also opted to ensure that categorizations were consistent among all sport-specific articles within this special series. Because methodologic variations may lead to small differences in injury reporting among these surveillance systems, caution must be taken when interpreting these results.

We examined injury counts, national estimates, and distributions by event type (practice and competition), time in season (preseason, regular season, postseason), time loss (1–6 days, 7–21 days, $>$21 days, including injuries resulting in a premature end to the season), body part injured, diagnosis, mechanism of injury, activity during injury, and weight class. For weight class, we created tertiles. High School RIO tertiles were $<$135 lb ($<$61.2 kg), 135–160 lb (61.2–72.6 kg), and $>$160 lb ($>$72.6 kg); the

Table 1. Injury Rates by School Size or Division and Type of Athlete-Exposure in High School Boys' and Collegiate Men's Wrestling[a]

Surveillance System and School Size or Division	Exposure Type	Injuries in Sample, No. (%)	National Estimates, No. (%)	Athlete-Exposures	Injury Rate/1000 Athlete-Exposures (95% Confidence Interval)
HS RIO (2005–2006 through 2013–2014)					
≤1000 students	Practice	668 (58.0)	322 572 (58.6)	337 440	1.98 (1.83, 2.13)
	Competition	484 (42.0)	227 488 (41.4)	121 629	3.98 (3.62, 4.33)
	Total	1152 (100.0)	550 059 (100.0)	459 069	2.51 (2.36, 2.65)
>1000 students	Practice	1329 (59.8)	186 948 (59.6)	706 126	1.88 (1.78, 1.98)
	Competition	895 (40.2)	126 481 (40.4)	251 119	3.56 (3.33, 3.80)
	Total	2224 (100.0)	313 429 (100.0)	957 245	2.32 (2.23, 2.42)
Total	Practice	1997 (59.2)	509 520 (59.0)	1 043 566	1.91 (1.83, 2.00)
	Competition	1379 (40.8)	353 969 (41.0)	372 748	3.70 (3.50, 3.89)
	Total	3376 (100.0)	863 488 (100.0)	1 416 314	2.38 (2.30, 2.46)
NCAA-ISP (2004–2005 through 2013–2014)					
Division I	Practice	914 (70.6)	17 480 (70.6)	119 689	7.64 (7.14, 8.13)
	Competition	381 (29.4)	7265 (29.4)	13 314	28.62 (25.74, 31.49)
	Total	1295 (100.0)	24 745 (100.0)	133 003	9.74 (9.21, 10.27)
Division II	Practice	239 (61.3)	4893 (61.6)	47 107	5.07 (4.43, 5.72)
	Competition	151 (38.7)	3049 (38.4)	4933	30.61 (25.73, 35.49)
	Total	390 (100.0)	7941 (100.0)	52 039	7.49 (6.75, 8.24)
Division III	Practice	454 (64.7)	12 842 (63.9)	62 233	7.30 (6.62, 7.97)
	Competition	248 (35.3)	7246 (36.1)	10 022	24.75 (21.67, 27.83)
	Total	702 (100.0)	20 087 (100.0)	72 255	9.72 (9.00, 10.43)
Total	Practice	1607 (67.3)	35 214 (66.7)	229 028	7.02 (6.67, 7.36)
	Competition	780 (32.7)	17 559 (33.3)	28 269	27.59 (25.66, 29.53)
	Total	2387 (100.0)	52 773 (100.0)	257 297	9.28 (8.91, 9.65)

Abbreviations: HS RIO, High School Reporting Information Online; NCAA-ISP, National Collegiate Athletic Association Injury Surveillance Program.

[a] High school data originated from HS RIO surveillance data, 2005–2006 through 2013–2014; collegiate data originated from NCAA-ISP surveillance data, 2004–2005 through 2013–2014. Injuries included in the analysis were those that (1) occurred during a sanctioned practice or competition; (2) were evaluated or treated (or both) by an athletic trainer, physician, or other health care professional; and (3) restricted the student-athlete from participation for at least 24 hours past the day of injury. All concussions, fractures, and dental injuries were included in the analysis, regardless of time loss. Data may include multiple injuries that occurred at 1 injury event. National estimates and athlete-exposures may not sum to totals due to rounding error.

NCAA-ISP tertiles were <149 lb (<67.6 kg), 149–179 lb (67.6–81.2 kg), and >179 lb (>81.2 kg). We also calculated injury rates per 1000 AEs and injury rate ratios (IRRs). The IRRs focused on comparisons by level of play (high school and college), event type (practice and competition), school size in high school (≤1000 and >1000 students), division in college (Divisions I, II, and III), and time in season (preseason, regular season, and postseason). All IRRs with 95% confidence intervals (CIs) not containing 1.0 were considered statistically significant.

Lastly, we used linear regression to analyze linear trends across time for injury rates and compute average annual changes (ie, mean differences). Because of the 2 separate data-collection methods for the NCAA-ISP during the 2004–2005 through 2008–2009 and 2009–2010 through 2013–2014 academic years, linear trends were calculated separately for each time period. All mean differences with 95% CIs not containing 0.0 were considered statistically significant.

RESULTS

Total Injury Frequency, National Estimates, and Injury Rates

Between 2004–2005 and 2013–2014, ATs reported a total of 5763 time-loss injuries in boys' and men's wrestling (high school = 3376, college = 2387; Table 1). This equated to a national estimate of 863 488 high school injuries (annual average of 95 939) and 52 773 collegiate injuries (annual average of 5277). The total injury rate for high school boys' wrestling was 2.38/1000 AEs (95% CI = 2.30, 2.46). The total injury rate for collegiate men's wrestling was 9.28/1000 AEs (95% CI = 8.91, 9.65). The total injury rate was higher in college than in high school (IRR = 3.89; 95% CI = 3.69, 4.10).

School Size and Division

In high school, the total injury rate was higher in high schools with ≤1000 students than in high schools with >1000 students (IRR = 1.08; 95% CI = 1.01, 1.16; Table 1). In college, total injury rates varied by division. Division I had a higher total injury rate than Division II (IRR = 1.30; 95% CI = 1.16, 1.45) but not higher than Division III (IRR = 1.00; 95% CI = 0.91, 1.10). The total injury rate was also higher in Division III than in Division II (IRR = 1.30; 95% CI = 1.15, 1.47).

Event Type

The majority of injuries occurred during practices in both high school (59.2%) and college (67.3%; Table 1). However, the competition injury rate was higher than the practice injury rate in both high school (IRR = 1.93; 95% CI = 1.81, 2.07) and college (IRR = 3.93; 95% CI = 3.61, 4.28).

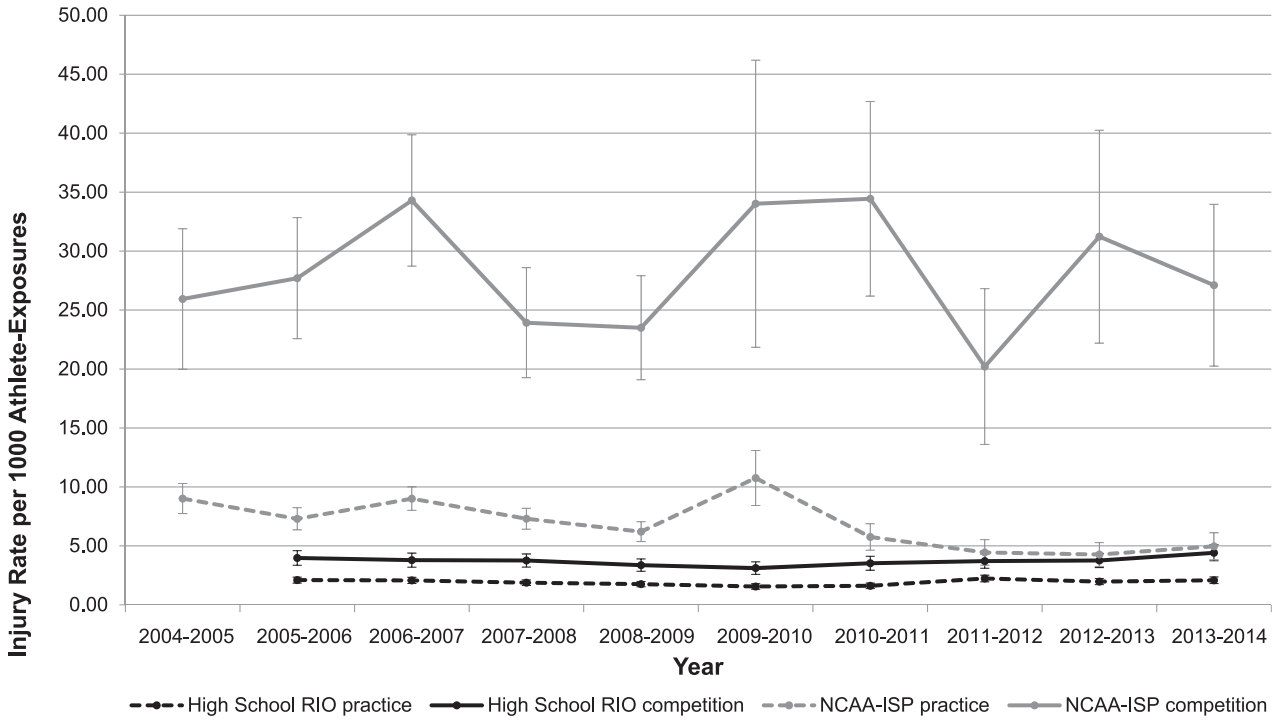

Figure. Injury rates by year and type of athlete-exposure (AE) in high school boys' and collegiate men's wrestling. Annual average changes for linear trend test for injury rates are as follows: High School Reporting Information Online (RIO; practices = <0.01/1000 AEs, 95% confidence interval [CI] = –0.05, 0.06; competitions = 0.03/1000 AEs, 95% CI = –0.06, 0.11); National Collegiate Athletic Association Injury Surveillance Program (NCAA-ISP) 2004–2005 through 2008–2009 (practices = –0.56/1000 AEs, 95% CI = –1.03, –0.10; competitions = –0.86/1000 AEs, 95% CI = –3.17, 1.44); NCAA-ISP 2009–2010 through 2013–2014 (practices = –1.31/1000 AEs, 95% CI = –2.27, –0.34; competitions = –1.70/1000 AEs, 95% CI = –4.62, 1.22). A negative rate indicates a decrease in annual average change between years, and a positive rate indicates an increase in annual average change; 95% CIs including 0.00 are not significant.

No linear trends were found for the annual injury rates for high school practices (average annual change of <0.01/1000 AEs; 95% CI = –0.05, 0.06) or competitions (average annual change of 0.03/1000 AEs; 95% CI = –0.06, 0.11; Figure). Decreases were seen in collegiate practice injury rates during the 2004–2005 through 2008–2009 (average annual change of –0.56/1000 AEs; 95% CI = –1.03, –0.10) and 2009–2010 through 2013–2014 (average annual change of –1.31/1000 AEs; 95% CI = –2.27, –0.34) academic years. No linear trends were observed for collegiate competition injury rates during the 2004–2005 through 2008–2009 (average annual change of –0.86/1000 AEs; 95% CI = –3.17, 1.44) and 2009–2010 through 2013–2014 (average annual change of –1.70/1000 AEs; 95% CI = –4.62, 1.22) academic years.

Time in Season

In both high school and college, most injuries occurred during the regular season (high school = 79.4%, college = 63.8%; Table 2). In college, the preseason had a higher injury rate than the regular season (IRR = 1.15; 95% CI = 1.06, 1.26) and postseason (IRR = 2.53; 95% CI = 2.02, 3.16). In addition, the injury rate was higher during the regular season than during the postseason (IRR = 2.19; 95% CI = 1.76, 2.73). Injury rates by time in season could not be calculated for high school as AEs were not stratified by time in season.

Time Loss From Participation

In both high school and college, the largest proportion of injuries during practices resulted in time loss of less than 1 week (high school = 43.2%, college = 48.0%; Table 3). In contrast, the largest proportion of injuries during competitions resulted in time loss of 1 to 3 weeks (high school = 37.5%, college = 38.3%).

Body Parts Injured and Diagnoses

High School. The most commonly injured body parts for both practices and competitions were the head/face (practices = 19.9%, competitions = 21.4%), shoulder/clavicle (practices = 14.1%, competitions = 21.0%), and knee (practices = 14.4%, competitions = 15.2%; Table 4). The most frequent injury diagnoses were ligament sprains (practices = 21.7%, competitions = 23.9%), followed by muscle/tendon strains (practices = 15.6%, competitions = 15.9%) and concussions (practices = 11.3%, competitions = 15.9%; Table 5).

College. The most commonly injured body parts during both practices and competitions were the knee (practices = 16.7%, competitions = 30.4%) and head/face (practices = 12.1%, competitions = 14.6%; Table 4). The most frequent diagnoses for both practices and competitions were ligament sprains (practices = 21.0%, competitions = 35.8%), muscle/tendon strains (practices = 11.1%, competitions = 13.3%), and concussions (practices = 5.9%, competitions = 10.1%; Table 5).

Table 2. Injury Rates by Time in Season and Type of Athlete-Exposure in High School Boys' and Collegiate Men's Wrestling[a]

		HS RIO (2005–2006 Through 2013–2014)		NCAA-ISP (2004–2005 Through 2013–2014)			
Time in Season	Exposure Type	Injuries in Sample, No. (%)	National Estimates, No. (%)	Injuries in Sample, No. (%)	National Estimates, No. (%)	Athlete-Exposures	Injury Rate/1000 Athlete-Exposures (95% Confidence Interval)
Preseason	Practice	522 (94.2)	131 146 (94.9)	772 (99.0)	17 167 (99.2)	72 846	10.60 (9.85, 11.35)
	Competition	32 (5.8)	7113 (5.1)	8 (1.0)	138 (0.8)	220	36.36 (11.16, 61.56)
	Total	554 (100.0)	138 259 (100.0)	780 (100.0)	17 305 (100.0)	73 066	10.68 (9.93, 11.42)
Regular season	Practice	1399 (52.7)	357 843 (52.6)	789 (51.8)	16 875 (50.6)	138 279	5.71 (5.31, 6.10)
	Competition	1258 (47.3)	322 916 (47.4)	734 (48.2)	16 461 (49.4)	26 082	28.14 (26.11, 30.18)
	Total	2657 (100.0)	680 759 (100.0)	1 523 (100.0)	33 336 (100.0)	164 361	9.27 (8.80, 9.73)
Postseason	Practice	58 (42.7)	12 172 (38.0)	46 (54.8)	1173 (55.0)	17 904	2.57 (1.83, 3.31)
	Competition	78 (57.3)	19 822 (62.0)	38 (45.2)	960 (45.0)	1967	19.32 (13.18, 25.46)
	Total	136 (100.0)	31 994 (100.0)	84 (100)	2133 (100.0)	19 870	4.23 (3.32, 5.13)

Abbreviations: HS RIO, High School Reporting Information Online; NCAA-ISP, National Collegiate Athletic Association Injury Surveillance Program.

[a] Excluded 6 injuries reported in HS RIO due to missing data for time in season. Injury rates by time in season could not be calculated for high school as athlete-exposures were not stratified by time in season. National estimates and athlete-exposures may not sum to totals due to rounding error. High school data originated from HS RIO surveillance data, 2005–2006 through 2013–2014; collegiate data originated from NCAA-ISP surveillance data, 2004–2005 through 2013–2014. Injuries included in the analysis were those that (1) occurred during a sanctioned practice or competition; (2) were evaluated or treated (or both) by an athletic trainer, physician, or other health care professional; and (3) restricted the student-athlete from participation for at least 24 hours past the day of injury. All concussions, fractures, and dental injuries were included in the analysis, regardless of time loss. Data may include multiple injuries that occurred at 1 injury event.

Mechanisms of Injury and Activities

High School. The most common mechanisms of injury for both practices and competitions were contact with another person (practices = 45.3%, competitions = 50.0%), followed by contact with the playing surface (practices = 28.5%, competitions = 35.9%; Table 6). Illness/infection (which includes skin infections) accounted for 12.4% of injuries during practices. The most frequent activities during injury for both practices and competitions were takedowns (practices = 44.3%, competitions = 54.3%) and sparring (practices = 24.1%, competitions = 12.5%; Table 7).

College. The most common mechanism of injury for both practices and competitions was contact with another person (practices = 44.3%, competitions = 63.2%), followed by contact with the playing surface (practices = 11.4%, competitions = 16.1%) and no contact (practices = 13.2%, competitions = 14.6%; Table 6). Illness/infection also accounted for 26.0% of injuries during practices. The most frequent activities during injury for both practices and competitions were takedowns (practices = 43.0%, competitions = 47.4%) and sparring (practices = 26.4%, competitions = 18.2%; Table 7).

Table 3. Number of Injuries and Injury Rates by Time Loss and Type of Athlete-Exposure in High School Boys' and Collegiate Men's Wrestling[a]

	Practice			Competition		
Surveillance System and Time Loss Category	Injuries in Sample, No. (%)	National Estimates, No. (%)	Injury Rate/1000 Athlete-Exposures (95% Confidence Interval)	Injuries in Sample, No. (%)	National Estimates, No. (%)	Injury Rate/1000 Athlete-Exposures (95% Confidence Interval)
HS RIO (2005–2006 through 2013–2014)						
1 d to <1 wk	828 (43.2)	216 724 (44.5)	0.79 (0.74, 0.85)	408 (31.1)	104 721 (30.8)	1.09 (0.99, 1.20)
1 to 3 wk	604 (31.5)	154 250 (31.6)	0.58 (0.53, 0.62)	491 (37.5)	126 858 (37.4)	1.32 (1.20, 1.43)
>3 wk[b]	483 (25.2)	116 522 (23.9)	0.46 (0.42, 0.50)	412 (31.4)	108 051 (31.8)	1.11 (1.00, 1.21)
NCAA-ISP (2004–2005 through 2013–2014)						
1 d to <1 wk	754 (48.0)	17 031 (49.6)	3.29 (3.06, 3.53)	201 (26.8)	4 530 (27.0)	7.11 (6.13, 8.09)
1 to 3 wk	481 (30.6)	10 184 (29.7)	2.10 (1.91, 2.29)	287 (38.3)	6 331 (37.7)	10.15 (8.98, 11.33)
>3 wk[b]	336 (21.4)	7125 (20.8)	1.47 (1.31, 1.62)	261 (34.9)	5 938 (35.4)	9.23 (8.11, 10.35)

Abbreviations: HS RIO, High School Reporting Information Online; NCAA-ISP, National Collegiate Athletic Association Injury Surveillance Program.

[a] Excluded 150 injuries reported in HS RIO and 67 injuries reported in the NCAA-ISP due to missing data for time loss. Percentages may not add up to 100.0 due to rounding error. High school data originated from HS RIO surveillance data, 2005–2006 through 2013–2014; collegiate data originated from NCAA-ISP surveillance data, 2004–2005 through 2013–2014. Injuries included in the analysis were those that (1) occurred during a sanctioned practice or competition; (2) were evaluated or treated (or both) by an athletic trainer, physician, or other health care professional; and (3) restricted the student-athlete from participation for at least 24 hours past the day of injury. All concussions, fractures, and dental injuries were included in the analysis, regardless of time loss. Data may include multiple injuries that occurred at 1 injury event.

[b] Included injuries that resulted in time loss over 3 weeks, medical disqualification, the athlete choosing not to continue, the athlete being released from team, or the season ending before the athlete returned to activity.

Table 4. Number of Injuries, National Estimates, and Injury Rates by Body Part Injured and Type of Athlete-Exposure in High School and Collegiate Wrestling[a]

	Practice			Competition		
Surveillance System and Body Part Injured	Injuries in Sample, No. (%)	National Estimates, No. (%)	Injury Rate/1000 Athlete-Exposures (95% Confidence Interval)	Injuries in Sample, No. (%)	National Estimates, No. (%)	Injury Rate/1000 Athlete-Exposures (95% Confidence Interval)
HS RIO (2005–2006 through 2013–2014)						
Head/face	396 (19.9)	95 489 (18.8)	0.38 (0.34, 0.42)	293 (21.4)	74 700 (21.3)	0.79 (0.70, 0.88)
Neck	97 (4.9)	29 257 (5.8)	0.09 (0.07, 0.11)	53 (3.9)	15 596 (4.4)	0.14 (0.10, 0.18)
Shoulder/clavicle	281 (14.1)	71 127 (14.0)	0.27 (0.24, 0.30)	288 (21.0)	74 731 (21.3)	0.77 (0.68, 0.86)
Arm/elbow	199 (10.0)	53 485 (10.5)	0.19 (0.16, 0.22)	139 (10.1)	36 941 (10.5)	0.37 (0.31, 0.43)
Hand/wrist	180 (9.0)	46 646 (9.2)	0.17 (0.15, 0.20)	87 (6.3)	20 944 (6.0)	0.23 (0.18, 0.28)
Trunk	186 (9.3)	51 174 (10.1)	0.18 (0.15, 0.20)	108 (7.9)	29 928 (8.5)	0.29 (0.24, 0.34)
Hip/thigh/upper leg	65 (3.3)	17 704 (3.5)	0.06 (0.05, 0.08)	34 (2.5)	9308 (2.7)	0.09 (0.06, 0.12)
Knee	286 (14.4)	70 676 (13.9)	0.27 (0.24, 0.31)	209 (15.2)	48 950 (13.9)	0.56 (0.48, 0.64)
Lower leg	65 (3.3)	15 571 (3.1)	0.06 (0.05, 0.08)	22 (1.6)	5807 (1.7)	0.06 (0.03, 0.08)
Ankle	137 (6.9)	33 274 (6.6)	0.13 (0.11, 0.15)	91 (6.6)	24 103 (6.9)	0.24 (0.19, 0.29)
Foot	34 (1.7)	11 835 (2.3)	0.03 (0.02, 0.04)	22 (1.6)	6321 (1.8)	0.06 (0.03, 0.08)
Other	65 (3.3)	11 755 (2.3)	0.06 (0.05, 0.08)	26 (1.9)	4236 (1.2)	0.07 (0.04, 0.10)
NCAA-ISP (2004–2005 through 2013–2014)						
Head/face	194 (12.1)	4673 (13.3)	0.85 (0.73, 0.97)	114 (14.6)	2899 (16.5)	4.03 (3.29, 4.77)
Neck	70 (4.4)	1454 (4.1)	0.31 (0.23, 0.38)	30 (3.9)	557 (3.2)	1.06 (0.68, 1.44)
Shoulder/clavicle	158 (9.8)	3356 (9.5)	0.69 (0.58, 0.80)	109 (14.0)	2212 (12.6)	3.86 (3.13, 4.58)
Arm/elbow	58 (3.6)	1680 (4.8)	0.25 (0.19, 0.32)	41 (5.3)	939 (5.4)	1.45 (1.01, 1.89)
Hand/wrist	67 (4.2)	1405 (4.0)	0.29 (0.22, 0.36)	16 (2.1)	339 (1.9)	0.57 (0.29, 0.84)
Trunk	160 (10.0)	3579 (10.2)	0.70 (0.59, 0.81)	84 (10.8)	1813 (10.3)	2.97 (2.34, 3.61)
Hip/thigh/upper leg	61 (3.8)	1491 (4.2)	0.27 (0.20, 0.33)	36 (4.6)	804 (4.6)	1.27 (0.86, 1.69)
Knee	269 (16.7)	5468 (15.5)	1.17 (1.03, 1.31)	237 (30.4)	5459 (31.1)	8.38 (7.32, 9.45)
Lower leg	19 (1.2)	522 (1.5)	0.08 (0.05, 0.12)	8 (1.0)	357 (2.0)	0.28 (0.09, 0.48)
Ankle	97 (6.0)	2173 (6.2)	0.42 (0.34, 0.51)	57 (7.3)	1180 (6.7)	2.02 (1.49, 2.54)
Foot	18 (1.1)	454 (1.3)	0.08 (0.04, 0.11)	15 (1.9)	308 (1.8)	0.53 (0.26, 0.80)
Other	436 (27.1)	8960 (25.5)	1.90 (1.73, 2.08)	33 (4.2)	695 (4.0)	1.17 (0.77, 1.57)

Abbreviations: HS RIO, High School Reporting Information Online; NCAA-ISP, National Collegiate Athletic Association Injury Surveillance Program.

[a] Excluded 13 injuries reported in HS RIO due to missing data for body part. Percentages may not add up to 100.0 due to rounding error. High school data originated from HS RIO surveillance data, 2005–2006 through 2013–2014; collegiate data originated from NCAA-ISP surveillance data, 2004–2005 through 2013–2014. Injuries included in the analysis were those that (1) occurred during a sanctioned practice or competition; (2) were evaluated or treated (or both) by an athletic trainer, physician, or other health care professional; and (3) restricted the student-athlete from participation for at least 24 hours past the day of injury. All concussions, fractures, and dental injuries were included in the analysis, regardless of time loss. Data may include multiple injuries that occurred at 1 injury event.

Weight Class-Specific Injuries During Competitions

The 2 leading injuries during competitions were concussions and knee sprains, and their relative frequency did not vary by weight class. During high school competitions, the most common injury among the 3 weight-class tertiles (<135, 135–160, >160 lb) was concussion (18.2%, 16.6%, and 11.9%, respectively; Table 8). Many of these concussions were due to contact with the playing surface. During collegiate competitions, the most frequent injury among the 3 weight-class tertiles (<149, 149–174, >174 lb) was knee sprain (17.8%, 26.8%, and 15.9%, respectively). Many of these knee sprains were due to contact with another person.

Illnesses/Infections

In high school, the most common illnesses/infections were bacterial infections (practices = 50.3%, competitions = 53.3%) and tinea lesions (practices = 38.5%, competitions = 33.3%; Table 9). In college, the most frequent illnesses/infections were herpetic lesions (practices = 44.1%, competitions = 40.0%) and bacterial infections (practices = 34.4%, competitions = 36.0%); the majority were cases of impetigo.

DISCUSSION

Given the number of athletes who wrestle during high school and college,[3,4] it is essential to acquire up-to-date information to help drive the timely development of injury-prevention interventions specific to the sport. This report compares high school and collegiate wrestling data and demonstrates that, although the majority of injuries occurred during practices, the rates of injury were higher during competitions. This was true for both the high school and collegiate settings. Among high school wrestlers, the most common injuries during competitions were concussions, followed by knee or ankle sprains, whereas during collegiate wrestling, the most common competition injury was knee sprain, followed by concussion. These injury patterns were consistent across weight classes. Contact with another person or the mat was the most frequent mechanism of injury, and takedowns were the most often cited activity at the time of injury for both high school and collegiate wrestlers.

Comparison of Injury Rates With Previous Research

The NCAA wrestling injury rates were slightly higher than those reported[11] using similar surveillance data from

Table 5. Number of Injuries, National Estimates, and Injury Rates by Diagnosis and Type of Athlete-Exposure in High School and Collegiate Wrestling[a]

Surveillance System and Diagnosis	Practice			Competition		
	Injuries in Sample, No. (%)	National Estimates, No. (%)	Injury Rate/1000 Athlete-Exposures (95% Confidence Interval)	Injuries in Sample, No. (%)	National Estimates, No. (%)	Injury Rate/1000 Athlete-Exposures (95% Confidence Interval)
HS RIO (2005–2006 through 2013–2014)						
Concussion	226 (11.3)	52 130 (10.2)	0.22 (0.19, 0.24)	218 (15.9)	56 412 (16.0)	0.58 (0.51, 0.66)
Contusion	120 (6.0)	34 191 (6.7)	0.11 (0.09, 0.14)	78 (5.7)	20 024 (5.7)	0.21 (0.16, 0.26)
Dislocation[b]	103 (5.2)	23 793 (4.7)	0.10 (0.08, 0.12)	123 (9.0)	31 302 (8.9)	0.33 (0.27, 0.39)
Fracture/avulsion	187 (9.4)	48 900 (9.6)	0.18 (0.15, 0.20)	139 (10.1)	34 704 (9.9)	0.37 (0.31, 0.43)
Laceration	34 (1.7)	7823 (1.5)	0.03 (0.02, 0.04)	16 (1.2)	3286 (0.9)	0.04 (0.02, 0.06)
Ligament sprain	432 (21.7)	113 076 (22.2)	0.41 (0.37, 0.45)	328 (23.9)	86 337 (24.5)	0.88 (0.78, 0.98)
Muscle/tendon strain	311 (15.6)	83 242 (16.4)	0.30 (0.26, 0.33)	218 (15.9)	64 086 (18.2)	0.58 (0.51, 0.66)
Other	582 (29.2)	145 758 (28.6)	0.56 (0.51, 0.6)	253 (18.4)	55 875 (15.9)	0.68 (0.60, 0.76)
NCAA-ISP (2004–2005 through 2013–2014)						
Concussion	94 (5.9)	2427 (6.9)	0.41 (0.33, 0.49)	79 (10.1)	2064 (11.8)	2.79 (2.18, 3.41)
Contusion	55 (3.4)	1146 (3.3)	0.24 (0.18, 0.30)	34 (4.4)	791 (4.5)	1.20 (0.80, 1.61)
Dislocation[b]	20 (1.2)	530 (1.5)	0.09 (0.05, 0.13)	16 (2.1)	440 (2.5)	0.57 (0.29, 0.84)
Fracture/avulsion	62 (3.9)	1428 (4.1)	0.27 (0.20, 0.34)	28 (3.6)	729 (4.2)	0.99 (0.62, 1.36)
Laceration	55 (3.4)	1063 (3.0)	0.24 (0.18, 0.30)	15 (1.9)	245 (1.4)	0.53 (0.26, 0.80)
Ligament sprain	337 (21.0)	7239 (20.6)	1.47 (1.31, 1.63)	279 (35.8)	6354 (36.2)	9.87 (8.71, 11.03)
Muscle/tendon strain	178 (11.1)	4147 (11.8)	0.78 (0.66, 0.89)	104 (13.3)	2439 (13.9)	3.68 (2.97, 4.39)
Other	806 (50.2)	17 234 (48.9)	3.52 (3.28, 3.76)	225 (28.9)	4499 (25.6)	7.96 (6.92, 9.00)

Abbreviations: HS RIO, High School Reporting Information Online; NCAA-ISP, National Collegiate Athletic Association Injury Surveillance Program.

[a] Excluded 8 injuries reported in HS RIO due to missing data for diagnosis. Percentages may not add up to 100.0 due to rounding error. High school data originated from HS RIO surveillance data, 2005–2006 through 2013–2014; collegiate data originated from NCAA-ISP surveillance data, 2004–2005 through 2013–2014. Injuries included in the analysis were those that (1) occurred during a sanctioned practice or competition; (2) were evaluated or treated (or both) by an athletic trainer, physician, or other health care professional; and (3) restricted the student-athlete from participation for at least 24 hours past the day of injury. All concussions, fractures, and dental injuries were included in the analysis, regardless of time loss. Data may include multiple injuries that occurred at 1 injury event.

[b] Included separations.

Table 6. Number of Injuries, National Estimates, and Injury Rates by Mechanism of Injury and Type of Athlete-Exposure in High School and Collegiate Wrestling[a]

Surveillance System and Mechanism of Injury	Practice			Competition		
	Injuries in Sample, No. (%)	National Estimates, No. (%)	Injury Rate/1000 Athlete-Exposures (95% Confidence Interval)	Injuries in Sample, No. (%)	National Estimates, No. (%)	Injury Rate/1000 Athlete-Exposures (95% Confidence Interval)
HS RIO (2005–2006 through 2013–2014)						
Contact with another person	846 (45.3)	211 131 (44.6)	0.81 (0.76, 0.87)	661 (50.0)	169 603 (49.6)	1.77 (1.64, 1.91)
Contact with playing surface	532 (28.5)	138 205 (29.2)	0.51 (0.47, 0.55)	474 (35.9)	120 764 (35.3)	1.27 (1.16, 1.39)
Contact with playing equipment	14 (0.8)	4980 (1.1)	0.01 (0.01, 0.02)	6 (0.5)	1830 (0.5)	0.02 (0.00, 0.03)
Contact with out of bounds object	2 (0.1)	227 (0.1)	<0.01 (0.00, <0.01)	2 (0.2)	712 (0.2)	0.01 (0.00, 0.01)
No contact	187 (10.0)	51 220 (10.8)	0.18 (0.15, 0.20)	132 (10.0)	38 811 (11.4)	0.35 (0.29, 0.41)
Overuse/chronic	55 (3.0)	14 451 (3.1)	0.05 (0.04, 0.07)	13 (1.0)	3598 (1.1)	0.03 (0.02, 0.05)
Illness/infection	231 (12.4)	53 236 (11.2)	0.22 (0.19, 0.25)	34 (2.6)	6536 (1.9)	0.09 (0.06, 0.12)
NCAA-ISP (2004–2005 through 2013–2014)						
Contact with another person	700 (44.3)	15 254 (44.6)	3.06 (2.83, 3.28)	479 (63.2)	10 621 (62.7)	16.94 (15.43, 18.46)
Contact with playing surface	180 (11.4)	4404 (12.9)	0.79 (0.67, 0.90)	122 (16.1)	2934 (17.3)	4.32 (3.55, 5.08)
Contact with playing equipment	3 (0.2)	155 (0.5)	0.01 (0.00, 0.03)	3 (0.4)	89 (0.5)	0.11 (0.00, 0.23)
Contact with out of bounds object	27 (1.7)	702 (2.1)	0.12 (0.07, 0.16)	4 (0.5)	162 (1.0)	0.14 (0.00, 0.28)
No contact	208 (13.2)	3978 (11.6)	0.91 (0.78, 1.03)	111 (14.6)	2227 (13.2)	3.93 (3.20, 4.66)
Overuse/chronic	52 (3.3)	1442 (4.2)	0.23 (0.17, 0.29)	14 (1.9)	407 (2.4)	0.50 (0.24, 0.75)
Illness/infection	410 (26.0)	8282 (24.2)	1.79 (1.62, 1.96)	25 (3.3)	492 (2.9)	0.88 (0.54, 1.23)

Abbreviations: HS RIO, High School Reporting Information Online; NCAA-ISP, National Collegiate Athletic Association Injury Surveillance Program.

[a] Mechanism of injury excluded 187 injuries reported in HS RIO and 49 injuries reported in the NCAA-ISP due to missing data or athletic trainer reporting *Other* or *Unknown*. Percentages may not add up to 100.0 due to rounding error. High school data originated from HS RIO surveillance data, 2005–2006 through 2013–2014; collegiate data originated from NCAA-ISP surveillance data, 2004–2005 through 2013–2014. Injuries included in the analysis were those that (1) occurred during a sanctioned practice or competition; (2) were evaluated or treated (or both) by an athletic trainer, physician, or other health care professional; and (3) restricted the student-athlete from participation for at least 24 hours past the day of injury. All concussions, fractures, and dental injuries were included in the analysis, regardless of time loss. Data may include multiple injuries that occurred at 1 injury event.

Table 7. Number of Injuries, National Estimates, and Injury Rates by Activity During Injury and Type of Athlete-Exposure in High School and Collegiate Wrestling[a]

	Practice			Competition		
Surveillance System and Activity During Injury	Injuries in Sample, No. (%)	National Estimates, No. (%)	Injury Rate/1000 Athlete-Exposures (95% Confidence Interval)	Injuries in Sample, No. (%)	National Estimates, No. (%)	Injury Rate/1000 Athlete-Exposures (95% Confidence Interval)
HS RIO (2005–2006 through 2013–2014)						
Conditioning	130 (8.8)	35 660 (9.4)	0.12 (0.10, 0.15)	7 (0.6)	2429 (0.8)	0.02 (0.00, 0.03)
Escape	80 (5.4)	21 140 (5.6)	0.08 (0.06, 0.09)	71 (6.0)	19 133 (6.2)	0.19 (0.15, 0.23)
Fall	103 (7.0)	26 958 (7.1)	0.10 (0.08, 0.12)	79 (6.7)	20 788 (6.8)	0.21 (0.17, 0.26)
Near fall	37 (2.5)	11 520 (3.0)	0.04 (0.02, 0.05)	100 (8.5)	28 236 (9.2)	0.27 (0.22, 0.32)
Reversal	55 (3.7)	13 147 (3.5)	0.05 (0.04, 0.07)	51 (4.3)	13 241 (4.3)	0.14 (0.10, 0.17)
Riding	61 (4.1)	17 199 (4.5)	0.06 (0.04, 0.07)	84 (7.1)	24 306 (7.9)	0.23 (0.18, 0.27)
Sparring	354 (24.1)	88 024 (23.3)	0.34 (0.30, 0.37)	147 (12.5)	39 366 (12.8)	0.39 (0.33, 0.46)
Takedown	652 (44.3)	165 009 (43.6)	0.62 (0.58, 0.67)	641 (54.3)	160 337 (52.1)	1.72 (1.59, 1.85)
NCAA-ISP (2004–2005 through 2013–2014)						
Conditioning	78 (7.2)	2100 (9.4)	0.34 (0.26, 0.42)	7 (1.0)	162 (1.1)	0.25 (0.06, 0.43)
Escape	84 (7.7)	1652 (7.4)	0.37 (0.29, 0.45)	59 (8.6)	1268 (8.7)	2.09 (1.55, 2.62)
Fall	55 (5.1)	1215 (5.4)	0.24 (0.18, 0.30)	40 (5.8)	1242 (8.5)	1.41 (0.98, 1.85)
Near fall	24 (2.2)	527 (2.4)	0.10 (0.06, 0.15)	24 (3.5)	587 (4.0)	0.85 (0.51, 1.19)
Reversal	32 (3.0)	498 (2.2)	0.14 (0.09, 0.19)	18 (2.6)	422 (2.9)	0.64 (0.34, 0.93)
Riding	59 (5.4)	1208 (5.4)	0.26 (0.19, 0.32)	89 (12.9)	1588 (10.9)	3.15 (2.49, 3.80)
Sparring	286 (26.4)	6084 (27.2)	1.25 (1.10, 1.39)	125 (18.2)	2823 (19.3)	4.42 (3.65, 5.20)
Takedown	467 (43.0)	9108 (40.7)	2.04 (1.85, 2.22)	326 (47.4)	6505 (44.6)	11.53 (10.28, 12.78)

Abbreviations: HS RIO, High School Reporting Information Online; NCAA-ISP, National Collegiate Athletic Association Injury Surveillance Program.

[a] Mechanism of injury excluded 187 injuries reported in HS RIO and 49 injuries reported in the NCAA-ISP due to missing data or athletic trainer reporting *Other* or *Unknown*. Percentages may not add up to 100.0 due to rounding error. High school data originated from HS RIO surveillance data, 2005–2006 through 2013–2014; collegiate data originated from NCAA-ISP surveillance data, 2004–2005 through 2013–2014. Injuries included in the analysis were those that (1) occurred during a sanctioned practice or competition; (2) were evaluated or treated (or both) by an athletic trainer, physician, or other health care professional; and (3) restricted the student-athlete from participation for at least 24 hours past the day of injury. All concussions, fractures, and dental injuries were included in the analysis, regardless of time loss. Data may include multiple injuries that occurred at 1 injury event.

the 1988–1989 through 2003–2004 academic years for competitions (27.59 versus 26.4/1000 AEs) and practices (7.02 versus 5.7/1000 AEs). However, at the high school level, wrestling injury rates were lower than the findings[16] from the 1995–1997 seasons for competitions (3.70 versus 8.2/1000 AEs) and practices (1.91 versus 4.8/1000 AEs). A major driver of the overall increase in injury incidence at the collegiate level appeared to be concussions. Compared with data from Agel et al,[11] concussion rates in our study were higher during competitions (2.79 versus 1.3/1000 AEs) and practices (0.41 versus 0.1/1000 AEs). This increase in concussion incidence is consistent with data across a number of sports[17] and may reflect greater awareness and more

Table 8. Most Common Injuries Associated With Position in Competitions in High School Boys' and Collegiate Men's Wrestling[a]

	HS RIO (2005–2006 Through 2013–2014)			NCAA-ISP (2004–2005 Through 2013–2014)		
Weight Class Tertiles[b]	Most Common Injuries	Injuries Within Position (%)	Most Frequent Mechanism of Injury for This Injury Within Position	Most Common Injuries	Injuries Within Position (%)	Most Frequent Mechanism of Injury for This Injury Within Position
1	Concussion	18.2	Contact with playing surface	Knee sprain	17.8	Contact with another person
	Knee sprain	4.9	Contact with another person	Concussion	13.0	Contact with another person
2	Concussion	16.6	Contact with playing surface	Knee sprain	26.8	Contact with another person
	Knee sprain	8.4	Contact with another person	Concussion	8.6	Contact with another person
3	Concussion	11.9	Contact with playing surface	Knee sprain	15.9	Contact with another person
	Ankle sprain	8.6	Contact with another person	Concussion	10.5	Contact with another person

Abbreviations: HS RIO, High School Reporting Information Online; NCAA-ISP, National Collegiate Athletic Association Injury Surveillance Program.

[a] Excluded 81 competition injuries reported in HS RIO and 9 competition injuries reported in the NCAA-ISP due to position not being indicated. The table reads as follows: For the first tertile of weight class in high school, concussions comprised 18.2% of all competition injuries to that weight-class tertile. The most common mechanism of injury for this specific injury for this specific position was contact with playing surface. High school data originated from HS RIO surveillance data, 2005–2006 through 2013–2014; collegiate data originated from NCAA-ISP surveillance data, 2004–2005 through 2013–2014. Injuries included in the analysis were those that (1) occurred during a sanctioned practice or competition; (2) were evaluated or treated (or both) by an athletic trainer, physician, or other health care professional; and (3) restricted the student-athlete from participation for at least 24 hours past the day of injury. All concussions, fractures, and dental injuries were included in the analysis, regardless of time loss. Data may include multiple injuries that occurred at 1 injury event.

[b] High School RIO tertiles: <135, 135–160, >160 lb; the NCAA-ISP tertiles: <149, 149–174, >174 lb.

Table 9. Illnesses/Infections Reported by Type of Athlete-Exposure in High School Boys' and Collegiate Men's Wrestling[a]

Surveillance System and Illness/Infection Type	No. (%) Practice	Competition
HS RIO (2005–2006 through 2013–2014)		
Bacterial infection	81 (50.3)	24 (53.3)
Tinea lesions (eg, ringworm)	62 (38.5)	15 (33.3)
Herpetic lesions[b]	12 (7.5)	5 (11.1)
Scabies, head lice	1 (0.6)	0 (0.0)
Other	5 (3.1)	1 (2.2)
NCAA-ISP (2004–2005 through 2013–14)		
Herpetic lesions[b]	181 (44.1)	10 (40.0)
Bacterial infection	141 (34.4)	9 (36.0)
Impetigo	64 (15.6)	4 (16.0)
Staph infection (nonmethicillin-resistant *Staphylococcus aureus*)	29 (7.1)	2 (8.0)
Boil, abscess, furuncle, carbuncle	15 (3.7)	1 (4.0)
Methicillin-resistant *Staphylococcus aureus*	13 (3.2)	1 (4.0)
Folliculitis	12 (2.9)	1 (4.0)
Cellulitis	8 (2.0)	0 (0.0)
Tinea lesions (eg, ringworm)	27 (6.6)	2 (8.0)
Conjunctivitis	6 (1.5)	0 (0.0)
Respiratory infection	5 (1.2)	0 (0.0)
Other	50 (12.2)	4 (16.0)

Abbreviations: HS RIO, High School Reporting Information Online; NCAA-ISP, National Collegiate Athletic Association Injury Surveillance Program.

[a] Excluded 7 infections/illnesses reported in HS RIO due to missing data. Percentages may not add up to 100.0 due to rounding error. High school data originated from HS RIO surveillance data, 2009–2010 through 2013–2014 (specific skin infection data was not collected from 2005–2006 through 2008–2009); collegiate data originated from NCAA-ISP surveillance data, 2004–2005 through 2013–2014. Injuries included in analysis were those that (1) occurred during a sanctioned practice or competition; (2) were evaluated or treated (or both) by an athletic trainer, physician, or other health care professional; and (3) restricted the student-athlete from participation for at least 24 hours past the day of injury.

[b] Included herpes simplex, fever blisters/cold sores, zoster, gladiatorum.

frequent diagnoses of concussion as opposed to an increase in the true incidence rate.

Similar to Agel et al,[11] our injury rates differed notably depending on the time of season, with the highest during the preseason and the lowest during the postseason. One reason for this difference may be different dynamics of practices in the postseason (eg, state or national championship competitions in high school and national qualifying and national competitions in college). Teams may shift the focus of practice to preparing those athletes who have qualified for postseason tournaments, decreasing the intensity of training for other team members. This difference may also reflect conditioning or competitive pressures. Emery[18] reviewed risk factors for injury in youth sport and found evidence of modifiable factors that included poor endurance and a lack of preseason training. Limited conditioning at the outset of the season, coupled with an unrelenting sport culture and pressure to secure one's spot in the lineup, may equate to injuries occurring frequently during this time period.

It is also possible that internal expectations may lead athletes to underreport some types of injuries as the season progresses. Concussion underreporting is a prevalent concern across a number of high school and collegiate sports,[19] although we are unaware of any researchers to date who have looked specifically at underreporting behavior in wrestlers. A recent survey of collegiate wrestling coaches showed that they were more likely to support continued participation in a match by a concussed athlete during the championship phase of the season as compared with an early-season match.[20] To combat the influence of this attitude on injury identification and removal from play, the NCAA[21] has recently instituted rules limiting how proximate coaches can be to medical evaluations during matches. These changes have occurred as the NCAA was instituting concussion protocols[22] and new policies outlining the unchallengeable independent medical authority of athletic medicine personnel.[23] Continued injury surveillance will help determine the effects of these changes and could suggest the need to institute policies at the high school level to limit the influence of late-season competitive pressures on injury identification.

Comparison of High School and Collegiate Findings

The total injury rate was higher in college than in high school, consistent with prior findings[24] of high school and collegiate wrestling injuries during the 2005–2006 academic year using HS RIO and the NCAA-ISP data. At both levels, the largest proportion of injuries during practices resulted in time loss of less than 1 week, whereas during competitions, the largest proportion of injuries resulted in time loss of 1 to 3 weeks. A notable difference in injury incidence rates between high school and college was in concussions (2.79 versus 0.58/1000 AEs in collegiate versus high school competitions, respectively). The speed of movements, overall body mass, and force of impacts may be greater in collegiate than in high school wrestlers. This may explain the overall greater injury incidence. It is important to note that nearly half of the collegiate wrestling teams in the present sample (5/11) competed in NCAA Division I, which may not represent the distribution of wrestlers across divisions. Thus, if the risk of injury increases at higher levels of competition, the resulting

injury rates may not represent the totality of US collegiate wrestlers. At the high school level, schools with fewer students had greater injury incidences. It is possible that this reflects differences in the medical or safety resources allocated to the wrestling team. It could also reflect differences in participants: at larger schools, there may be more competition for a given spot on the team, and thus, the team may comprise more dominant competitors who are less likely to be injured during matches. At the high school level, the injury incidence was relatively similar during practices and competitions, whereas at the collegiate level, injuries were more likely to occur during competitions. Perhaps collegiate coaches were more skilled than high school coaches in limiting opportunities for injury during practice, given the greater potential cost of a key athlete who is unable to compete. Research is needed to explore the cause of this difference.

The difference in concussion incidence between high school and college is striking and raises the question about other potential mediating factors. Among high school football and soccer athletes, concussions were diagnosed more frequently when an AT was present.[25] However, not all high schools have an AT on staff, even in a part-time capacity.[26] Although all schools in our study had an AT on staff, it is possible that they were not present at all wrestling practices and matches due to staffing constraints and multiple sports. Consequently, concussions may be underdiagnosed in high school wrestlers. Additionally, the effectiveness of policies in facilitating concussion identification and removal from play may differ.[27] The NCAA's concussion policy requires the removal from play for medical evaluation of any athlete who is experiencing symptoms of a possible concussion.[22] All US states have passed legislation related to concussion that applies to high school athletes, with many requiring that athletes be educated about concussion,[28] but these policies may not be as strongly worded or as consistently enforced as those at the collegiate level. Further study is needed to understand what is driving the difference in concussion incidences between high school and college, whether it is underdiagnosis at the high school level, increased risk at the collegiate level, or some combination of the two.

As noted in data from the previous decade of injury surveillance,[11] knee injuries continued to be among the most frequently sustained injuries. However, this injury rate reflects an increase over the prior time period for collegiate wrestlers (8.38 versus 6.0/1000 AEs in competitions, 1.17 versus 0.8/1000 AEs in practices). Further study is warranted to determine why knee injuries occurred more often in collegiate wrestling and why the incidence was substantially higher in college than in high school. The intensity of collegiate wrestling may be greater than that in high school wrestling, and it is possible that the bodies of athletes transitioning to this higher level of competition may not be conditioned appropriately for the rapidly shifting lateral movement. Also, by virtue of their prior participation in the sport, wrestlers who continue competing in collegiate wrestling are more likely to have a history of knee injury than high school wrestlers, potentially making them more vulnerable to knee injury in college. It is less clear why knee injuries increased, although following the same logic, early sport specialization may further burden young wrestlers' bodies and is a possible cause of this increase that requires further exploration.

Infections and illnesses were experienced frequently at both the high school and collegiate levels, particularly during practices. However, they occurred at a higher rate in college as compared with high school (1.79 versus 0.22/1000 AEs, respectively, during practices). Additionally, the types of infections differed notably. In high school, the most common infection was bacterial, followed by tinea lesions such as ringworm. In college, the most frequent infection was herpetic lesions, followed by bacterial infections. Because wrestlers with skin infections cannot participate in matches, more seasoned wrestlers may be particularly attuned to the early signs of bacterial infections. Also, wrestling rooms where good hygiene standards are practiced, particularly to the extent that they have dedicated janitorial staffs, can help mitigate the spread of such infections. Conversely, because herpetic lesions are the result of a blood-borne virus, cumulative lifetime exposure to time on the mat increases the likelihood of carrying the virus. Continued efforts to maintain hygienic wrestling environments at both the high school and collegiate levels will help to minimize wrestlers' risk of infections. The NCAA and National Federation of State High School Associations offer guidance to medical providers on the nature and management of skin infections in wrestling and other sports.[29–31] We acknowledge that accurate and complete reporting of skin lesions and infections relies on the experience and knowledge of ATs and team medical staff.

Injury Prevention: Recent Developments and Needs

Perhaps one of the most important changes during the past decade has been policies at the NCAA and state level related to concussion education and the removal from play of athletes experiencing symptoms of a possible concussion. Through this lens, the increase in concussion incidence in our data relative to the Agel et al[11] data should be viewed as a positive development, potentially reflecting less underdiagnosis. However, it likely does not reflect the full extent of the injury, as research on other high school and collegiate sports has demonstrated evidence of intentional nondisclosure of concussion symptoms.[19] Wrestling is unlikely to prove an exception to these relatively consistent data from other sports. Thus, research is needed to help us understand whether wrestling-specific rules and norms influence injury care-seeking behavior. Such prevention work previously focused on hydration and weight-cutting practices with the aim of minimizing the risk of dehydration, acute injuries, and although rare, death from cardiac arrest, heat stroke, or renal failure. We advocate for the wrestling community to examine how past successes with injury prevention can be applied to current concerns regarding concussion.

Whereas other sports have proposed substitution rules to facilitate the removal from play of potentially concussed athletes, the competitive structure of a wrestling match does not make this possible. Teams participate through the combined scoring of representatives in each weight class competing head to head. In such a one-on-one scenario, a midmatch substitution for an injured athlete would unfairly penalize the opponent. Further, as a result of the intense

one-on-one nature of wrestling competition, interruptions for the evaluation of possible concussions may be abused by deconditioned athletes seeking a competitive advantage. Ensuring that all athletes who have sustained a possible concussion are evaluated early and removed from play if necessary is critical for reducing the health burden of concussion attributable to delayed or missed diagnosis. Grappling with how to facilitate this identification within the competitive structure of the sport is an important challenge and may be particularly crucial at the high school level, where the gap in incidence relative to college raises the possibility of substantial underdiagnosis.

In collegiate football, recent efforts have focused on educating game officials about concussion symptoms so that they are better able to call injury timeouts if they suspect a concussion has occurred. In a study[32] conducted among collegiate football officials, those with a greater knowledge of concussion were more confident in their ability to call an injury timeout. Such efforts may be warranted in the sport of wrestling and perhaps particularly at the high school level, where medical personnel are not guaranteed to be present at competitions. Research is also needed to determine whether wrestlers have knowledge gaps related to concussion identification and whether they are aware of the benefits of concussion reporting (for example, shortening the duration of recovery). Developing wrestling-specific education is necessary because the structure of the sport, in terms of not wanting to forfeit a match and often not having a suitable backup in one's weight class, makes reporting a suspected concussion a uniquely challenging proposition.

Limitations

Our findings may not be generalizable to other playing levels, such as youth, middle school, and professional programs, nor to collegiate programs at non-NCAA institutions or high schools without National Athletic Trainers' Association-affiliated ATs. Furthermore, we were unable to account for factors potentially associated with injury occurrence, such as AT coverage, implemented injury-prevention programs, and athlete-specific characteristics (eg, previous injury, functional capabilities). Also, although HS RIO and the NCAA-ISP are similar injury-surveillance systems, it is important to consider the variations that do exist between the systems; this is most evident in that HS RIO used a random sample, whereas the NCAA-ISP used a convenience sample. In addition, differences may exist between high school and college in regard to the length of the season in total, as well as the preseason, regular season, and postseason; the potentially longer collegiate season may increase the injury risk. We calculated injury rates using AEs, which may not be as precise an at-risk exposure measure as minutes, hours, or total number of game plays across a season. However, collecting such exposure data is more laborious than collecting AE data and may be too burdensome for ATs participating in both HS RIO and the NCAA-ISP.

Although our study is, to our knowledge, one of few to examine injury incidences across multiple levels of play (eg, high school versus college and competitions versus practices), we were unable to examine differences between starters and nonstarters in competitions; analyses that group both types of players may confound and thus weaken the possible exposure-outcome association for some known injury risk factors. Differences may also exist among the freshman, junior varsity, and varsity teams due to differences in maturation status. Playing positions may vary in physical demands and resulting injury risk. Athlete-exposures were not collected by position, preventing the calculation of position-specific injury rates.

CONCLUSIONS

These data represent the most comprehensive current information about injuries in US high school and collegiate wrestling. Such surveillance data can help us identify areas where interventions are needed and provide insight into whether injury-prevention efforts are working. The high incidence of concussion in collegiate wrestling warrants further exploration and may reflect the positive effect of NCAA concussion policies in facilitating concussion identification. If this is the case, we must still appreciate how frequently this injury is occurring and determine whether approaches to primary prevention can be implemented at both the high school and collegiate levels. Clinicians need to consider strategies that will help wrestlers understand the importance of disclosure, proper diagnosis, and management of concussion. Recent increases in knee injuries are also concerning. Similar to concussions, prevention strategies to mitigate their incidence and severity must be considered by clinicians.

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