

An Epidemiologic Comparison of High School and College Wrestling Injuries

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Background: Wrestling holds worldwide popularity, and large numbers of United States high school and college males participate. However, the sport's arduous nature results in high injury rates.

Hypothesis: Wrestling injury rates and patterns will differ between high school and college practice and match exposures.

Study Design: Descriptive epidemiology study.

Methods: Wrestling-related injury data were collected during the 2005-2006 academic year from 74 nationally representative high schools via High School Reporting Information Online (RIO) and from 15 Division I, II, and III colleges via the National Collegiate Athletic Association Injury Surveillance System.

Results: Certified athletic trainers reported 387 injuries among participating high school wrestlers during 166 279 athlete-exposures, for an injury rate of 2.33 injuries per 1000 athlete-exposures. Nationally, high school wrestlers sustained an estimated 99 676 injuries and 8741 skin infections during the 2005-2006 season. In college, 258 injuries occurred among participating wrestlers during 35 599 athlete-exposures, for an injury rate of 7.25 injuries per 1000 athlete-exposures. The injury rate per 1000 athlete-exposures was higher in college than high school (rate ratio [RR] = 3.11, 95% confidence interval [CI]: 2.66-3.64) and was higher in matches than in practice in high school (RR = 2.12, 95% CI: 1.73-2.59) and college (RR = 5.07, 95% CI: 3.96-6.50). Diagnoses in greater proportions of college wrestlers included lacerations (injury proportion ratio [IPR] = 5.98, 95% CI: 2.27-15.74) and cartilage injuries (IPR = 2.69, 95% CI: 1.26-5.74). Body parts injured in greater proportions of high school wrestlers included elbow (IPR = 3.90, 95% CI: 1.66-9.14) and hand (IPR = 2.59, 95% CI: 1.21-5.54). Almost half of all injured high school (44.9%) and college (42.6%) wrestlers resumed wrestling within <1 week. Skin infections represented 8.5% and 20.9% of all reported high school and college events, respectively, and frequently affected the head/face/neck (50.0%).

Conclusions: Rates and patterns of wrestling injury differ between high school and college and between practice and matches.

Keywords: wrestling; injury; skin infection; high school; National Collegiate Athletic Association

With roots dating back to early civilization,²³ wrestling continues to hold worldwide popularity, especially among high school and college-aged male athletes. In the United States (US), over 250 000 high school boys wrestled during the 2005-2006 academic year (a 3.5% increase from 2004-2005),²⁸ making it the sixth most common boys' high school sport.²⁷ Although college participation in the sport has decreased in recent years, annual National Collegiate

Athletic Association (NCAA) participation has remained at 6 000 men since 2000.³⁷ Like all sports, wrestling offers great benefits to its participants and has been linked to better grades, fewer school absences, and better behavior.²⁹ However, the sport's arduous nature has led to reported match injury rates as high as 30.7 injuries per 1000 athlete-exposures among college wrestlers, second only to injury rates among college football players.¹⁷

The several studies published on the epidemiology of US wrestling injuries primarily focused on injuries occurring during tournament wrestling,^{19,22,36} on specific types of injury,^{1,8,9,14,18,21,24,25,35,38,39} or on unique cases.^{7,10,12,32} Although important for educating medical professionals, the limited scope of these studies precludes describing overall injury patterns, the first step toward comprehensive injury prevention. A few studies have followed high school^{5,13,16,30,31} or college^{17,34} wrestlers through the course of one or more seasons. While

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providing a more complete review of injury patterns, these studies are restricted by sample size^{5,13,30,34} or geographic location,^{5,13,34} or are outdated.^{5,13,16,17,31,34} Additionally, studies have collected data on only high school or college wrestlers and used varying definitions of injury and athlete-exposure, making comparisons difficult.

The objective of this study is to describe and compare high school and college wrestling injuries. The specific aims are to (1) calculate rates of injury among high school and college wrestlers during the 2005-2006 academic year, (2) characterize the general incidence and type of high school and college wrestling injuries, and (3) compare risk factors for high school and college wrestling injuries.

MATERIALS AND METHODS

Data Collection

Two Internet-based sports injury surveillance systems, High School Reporting Information Online (RIOTM) and the NCAA Injury Surveillance System (ISS), used similar methodology to conduct prospective surveillance of wrestling injuries during the 2005-2006 academic year.

High School RIO^{11,33} and the NCAA ISS²⁶ have been described in detail previously. Briefly, in High School RIO, all eligible schools (ie, all US high schools with a National Athletic Trainers' Association [NATA]-affiliated certified athletic trainer [ATC] willing to serve as a reporter) were categorized into 8 sampling strata by geographic location (northeast, midwest, south, and west) and high school size (enrollment ≤ 1000 or >1000 students). Participant schools were then randomly selected from each substratum to obtain 100 study schools. Five high schools dropped out during the course of the study and were replaced with schools randomly selected from the same substratum. A weighting algorithm based on the inverse probability of selection into the study was applied to each reported adverse event in order to calculate national estimates. Because multiple sports were studied and participating schools were not required to have all sports, 74 participating schools reported wrestling data. The NCAA ISS was open to all 227 NCAA institutions sponsoring varsity wrestling programs during the 2005-2006 academic year. Fifteen schools (6.6%) participated and reported data to the system (Division I = 6, Division II = 4, and Division III = 5). Because the NCAA ISS is a voluntary sample that does not use random sampling, national estimates cannot be calculated.

Both surveillance systems had ATCs log onto Internet-based data collection systems to report injury and exposure data for all weeks that wrestling was in session, using identical definitions of injury and athlete-exposure. However, while High School RIO captured only the primary injury sustained during each injury event, the NCAA ISS allowed multiple injuries to be reported from a single injury event. To minimize potential selection bias, participant incentives were offered. High School RIO offered a \$300 honorarium along with individualized injury reports following the study's conclusion. Although the ISS offers no monetary honoraria, participants have access to a permanent, Web-based athletic training room record.

Definition of Injury and Exposure

An athlete-exposure consisted of 1 athlete participating in 1 wrestling practice or match. An injury was defined as one that met all of the following criteria: (1) occurred as a result of participation in an organized high school or college wrestling practice or match, (2) required medical attention by an ATC or a physician, and (3) resulted in restriction of the student wrestler's participation for 1 or more days beyond the day of injury (if no athletic activity was scheduled for the following day, the ATC evaluated whether the athlete would have been able to participate if there had been an athletic activity). In addition to injuries, skin infections were also captured by both surveillance systems. For each adverse event, the ATC completed a detailed report that described characteristics of the affected wrestler (age, weight, year in school, etc), the adverse event itself (body site, diagnosis, severity, etc), and the circumstances leading to the adverse event (activity, presence of illegal activity, etc). Throughout the study ATCs were able to view all the data they submitted and update reports as needed (need for surgery, days until resumption of wrestling, etc).

Statistical Analysis

Data were analyzed using SPSS software, version 14.0 (SPSS, Chicago, Ill) and Epi Info, version 6.0 (CDC, Atlanta, GA). Injuries and skin infections were analyzed separately. All rate calculations and skin infection analyses used unweighted case counts (ie, the absolute number of reported injuries and skin infections). Additional high school injury analyses used national estimates, with the standard errors for comparisons between high school practices and matches adjusted for the High School RIO sampling plan using the SPSS Complex Samples module. All college injury analyses used unweighted injury counts, with the standard errors for comparisons between college practices and matches not adjusted because the NCAA ISS does not calculate national estimates. All injury comparisons between high school and college used high school national estimates and college unweighted injury counts, and it was not possible to adjust these standard errors.

Rates of injury and skin infection were calculated as the ratio of unweighted case counts per 1000 athlete-exposures. Rate ratios (RRs) and injury proportion ratios (IPRs) were calculated with 95% confidence intervals (CIs) and *P* values. An RR or IPR >1.00 suggests a risk association, while an RR or IPR <1.00 suggests a protective association. Confidence intervals not including 1.00 or *P* values $< .05$ were considered statistically significant. For example, the calculation comparing the overall rate of injury between high school and college is as follows:

$$RR = \frac{(\text{total \# unweighted college injuries} / \text{total \# college athlete-exposures}) \times 1000}{(\text{total \# unweighted HS injuries} / \text{total \# HS athlete-exposures}) \times 1000}$$

As an example of IPR calculation, the following compares the proportion of concussions between high school and college:

$$IPR = \frac{(\text{\# national estimated HS concussions} / \text{total \# national estimated HS injuries})}{(\text{\# unweighted college concussions} / \text{total \# unweighted college injuries})}$$

TABLE 1
US High School and College Wrestling Adverse Event Rates by Type of Exposure, High School Sports-Related Injury Surveillance Study and NCAA Injury Surveillance System, 2005-2006 School Year^a

	No. Events	No. Exposures	Event Rate (per 1000 athlete-exposures)	National Estimate ^b
High school overall adverse events	423	166 279	2.54	108 417
Injury	387	166 279	2.33	99 676
Practice	231	126 059	1.83	62 774
Match	156	40 220	3.88	36 902
Skin infection	36	166 279	0.22	8741
College overall adverse events	326	35 599	9.16	
Injury	258	35 599	7.25	
Practice	157	31 592	4.97	
Match	101	4007	25.21	
Skin infection	68	35 599	1.91	

^aNCAA, National Collegiate Athletic Association.

^bFor the High School Sports-Related Injury Surveillance Study, national estimates were calculated via a weighting algorithm based on the inverse probability of selection into the study. The NCAA Injury Surveillance System does not calculate national estimates.

This study was approved by the Columbus Children's Research Institute Institutional Review Board.

RESULTS

Rates of Adverse Events

The ATCs reported 387 injuries among participating high school wrestlers during 166 279 athlete-exposures, for an injury rate of 2.33 injuries per 1000 athlete-exposures (Table 1). In college, 258 injuries occurred among participating wrestlers during 35 599 athlete-exposures, for an injury rate of 7.25 injuries per 1000 athlete-exposures. The injury rate was higher in college than in high school (RR = 3.11, 95% CI: 2.66-3.64, *P* < .01) and was also higher in matches than in practices both in high school (RR = 2.12, 95% CI: 1.73-2.59, *P* < .01) and college (RR = 5.07, 95% CI: 3.96-6.50, *P* < .01). In high school, the reported 387 injuries reflect an estimated 99 676 injuries that occurred nationally during the 2005-2006 academic year.

The ATCs reported 36 skin infections among participating high school wrestlers, for a skin infection rate of 0.22 skin infections per 1000 athlete-exposures (Table 1). In college, 68 skin infections occurred, for a skin infection rate of 1.91 skin infections per 1000 athlete-exposures. The skin infection rate was higher in college than in high school (RR = 8.82, 95% CI: 5.89-13.21, *P* < .01). In high school, the reported 36 skin infections reflect an estimated 8741 skin infections that occurred nationally during the 2005-2006 academic year.

Characteristics of Injuries and Injury Events

Injuries. Overall, strains/sprains accounted for half of all high school (48.1%) and college (49.2%) injuries (Figure 1). There was little variation between high school practice and match injuries. In college, a greater proportion of lacerations were sustained in practices (12.1%) than in matches (1.0%) (IPR = 12.22, 95% CI: 1.66-89.89, *P* < .01). Overall, compared with high school wrestlers, college wrestlers sustained greater proportions of lacerations (IPR = 8.34, 95% CI: 5.45-12.76, *P* < .01) and cartilage injuries (IPR = 2.18, 95% CI: 1.39-3.41, *P* = .01).

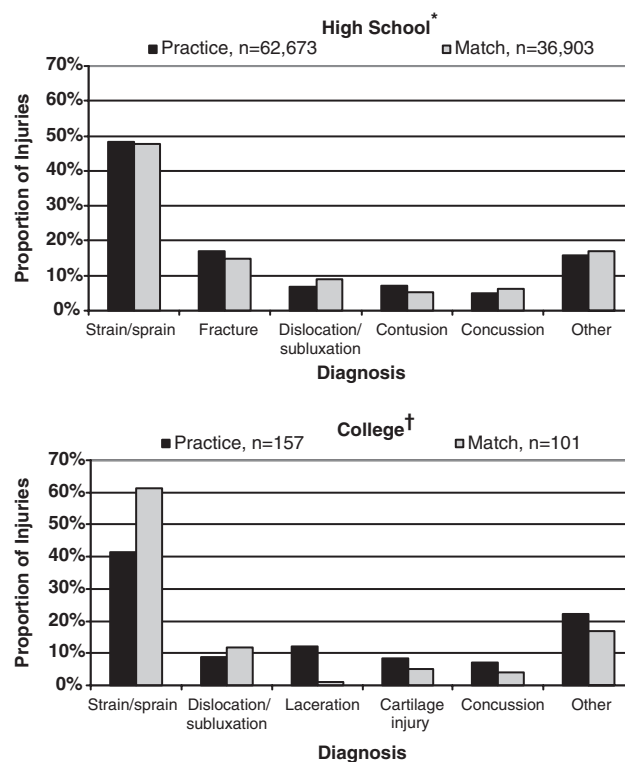


Figure 1. Most frequent diagnoses of US high school and college wrestling injuries by type of exposure, High School Sports-Related Injury Surveillance Study and NCAA Injury Surveillance System, 2005-2006 school year. *These frequencies reflect a national estimate of 99 576 high school wrestling injuries because a few high school injury reports did not specify injury diagnosis. †These frequencies reflect the 258 reported college wrestling injuries. NCAA, National Collegiate Athletic Association.

Overall, the shoulder (18.6%) and knee (15.4%) were the most common high school injury sites, while the knee (24.8%), shoulder (17.8%), and head/face (16.6%) were the most common college injury sites (Figure 2). There was little variation between

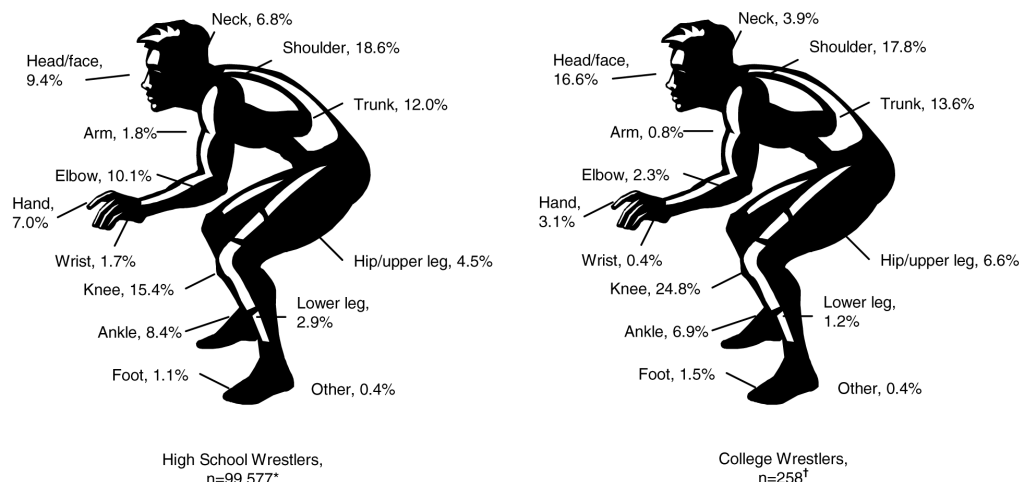


Figure 2. Body sites of US high school and college wrestling injuries, High School Sports-Related Injury Surveillance Study and NCAA Injury Surveillance System, 2005-2006 school year. *These frequencies reflect a national estimate of 99 577 high school wrestling injuries because a few high school injury reports did not specify body site of injury. †These frequencies reflect the 258 reported college wrestling injuries. NCAA, National Collegiate Athletic Association.

high school practice and match injury sites (see appendix, available in the online version of this article at <http://ajsm.sagepub.com/supplemental>). A greater proportion of college practice injuries were head/face injuries (22.3%) compared with college match injuries (7.9%) (IPR = 2.81, 95% CI: 1.36-5.82, $P < .01$). Overall, college wrestlers sustained greater proportions of knee injuries (IPR = 1.61, 95% CI: 1.30-2.00, $P < .01$), while high school wrestlers sustained greater proportions of elbow (IPR = 4.34, 95% CI: 1.97-9.58, $P < .01$) and hand (IPR = 2.25, 95% CI: 1.14-4.45, $P = .02$) injuries. In practice, a greater proportion of college injuries (22.3%) were head/face injuries compared with high school (10.0%) (IPR = 2.23, 95% CI: 1.66-2.99, $P < .01$).

More specifically, the most frequent high school injuries were shoulder strains/sprains (8.5%), ankle strains/sprains (7.6%), knee strains/sprains (7.0%), trunk strains/sprains (6.0%), neck strains/sprains (5.4%), and concussions (5.4%). The most frequent college injuries were knee strains/sprains (17.1%), shoulder strains/sprains (8.1%), shoulder dislocations/subluxations (8.1%), head/face lacerations (7.4%), ankle strains/sprains (7.0%), concussions (5.8%), trunk strains/sprains (5.0%), and upper leg/hip strains/sprains (5.0%).

In both high school and college, similar proportions of injured wrestlers resumed wrestling in <1 week (44.9% and 42.6%, respectively), in 1 to 3 weeks (29.1% and 30.2%, respectively), and in >3 weeks (26.0% and 27.1%, respectively) (Figure 3). In high school, there was little variation in time loss between practice and match. In college, a greater proportion of match injuries (39.6%) resulted in >3 weeks time loss compared with practice (19.1%) injuries (IPR = 2.07, 95% CI: 1.39-3.10, $P < .01$). In matches, a greater proportion of college injuries resulted in >3 weeks time loss (39.6%) compared with high school (23.3%) injuries (IPR = 1.70, 95% CI: 1.33-2.16, $P < .01$). In high school, the most common injuries resulting in >3 weeks time loss were shoulder dislocations/subluxations (11.8%) and fractures to the hand (10.1%), shoulder (8.7%), and elbow (8.6%). In college, the most common injuries resulting in >3 weeks time loss

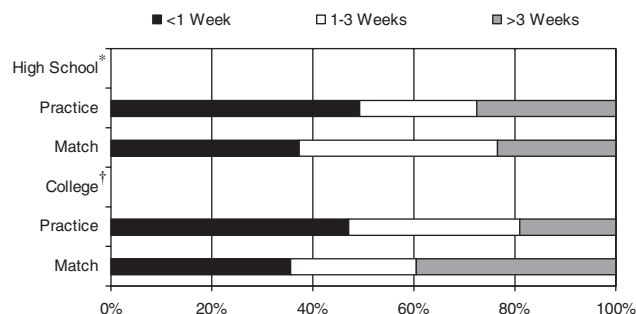


Figure 3. Time loss from US high school and college wrestling injuries by type of exposure, High School Sports-Related Injury Surveillance Study and NCAA Injury Surveillance System, 2005-2006 school year. *These frequencies reflect a national estimate of 96 796 high school wrestling injuries because a few high school injury reports did not specify time loss. †These frequencies reflect the 258 reported college wrestling injuries. NCAA, National Collegiate Athletic Association.

were knee strains/sprains (24.3%), shoulder dislocations/subluxations (15.7%), knee cartilage injuries (8.6%), and shoulder strains/sprains (7.1%).

Half of all high school (51.3%) and college (54.0%) injuries were evaluated by a nurse or physician after initial review by the ATC. Surgery was required after 7.8% of high school injuries, with similar proportions in practice (8.1%) and matches (7.3%). Of all high school injuries that required surgery, the most common were elbow fractures (13.5%), shoulder dislocations/subluxations (11.7%), and hand fractures (9.3%). In college, surgery was required for 7.9% of injuries and was more common after match injuries (12.2%) than practice injuries (5.2%) (IPR = 2.37, 95% CI: 1.01-5.60, $P = .07$). Of all college injuries that required surgery, the most common were knee strains/sprains (25.0%), knee cartilage tears (20.0%), and shoulder dislocations/subluxations (15.0%).

Injury Events. In both high school and college, takedown (39.0% and 41.9%, respectively) and sparring (14.7% and 27.1%, respectively) were the most commonly cited activities

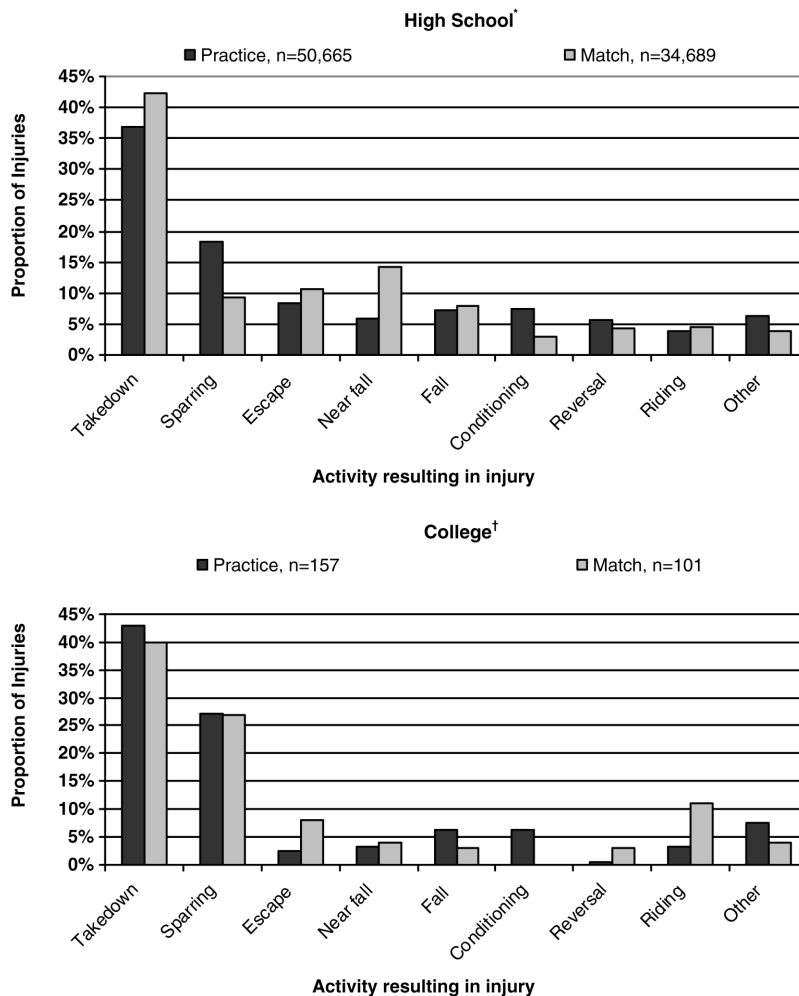


Figure 4. Activity resulting in US high school and college wrestling injuries by type of exposure, High School Sports-Related Injury Surveillance Study and NCAA Injury Surveillance System, 2005-2006 school year. *These frequencies reflect a national estimate of 85 354 high school wrestling injuries because a few high school injury reports did not specify activity resulting in injury. †These frequencies reflect the 258 reported college wrestling injuries. NCAA, National Collegiate Athletic Association.

leading to injury (Figure 4). In high school, a greater proportion of match injuries than practice injuries resulted from a near fall (14.3% and 5.8%, respectively) (IPR = 2.47, 95% CI: 1.02-5.96, $P = .04$), while a greater proportion of practice injuries resulted from sparring (18.4% and 9.2%, respectively) (IPR = 2.00, 95% CI: 0.99-4.04, $P = .05$), although the latter was statistically insignificant. In college, there was little variation in activity leading to practice and match injuries. Overall, compared with college injuries, high school injuries resulted more frequently from escape (9.3% and 4.7%, respectively) (IPR = 2.00, 95% CI: 1.15-3.47, $P = .01$), while college injuries resulted more frequently from sparring (IPR = 1.85, 95% CI: 1.51-2.26, $P < .01$). In matches, college injuries (11.0%) resulted more frequently from riding compared with high school injuries (4.6%) (IPR = 2.39, 95% CI: 1.37-4.18, $P < .01$), while high school match injuries resulted more frequently from a near fall (14.3%) compared with college match injuries (4.0%) (IPR = 3.59, 95% CI: 1.37-9.37, $P < .01$).

In high school, illegal activity was the cause of 6.4% of match injuries, most often during the escape (39.3%), takedown

(33.4%), and fall (22.8%). Although not statistically significant, in high school a greater proportion of injuries related to illegal activity were concussions (22.7%) compared to injuries not attributed to illegal activity (5.3%) (IPR = 4.27, 95% CI: 0.70-26.28).

Skin Infections. Skin infections represented 8.5% of all reported high school adverse events and 20.3% of all reported college adverse events. Although the majority (83.3%) of high school skin infections included a physician evaluation, a specific diagnosis was missing in two-thirds of the reports. Those reports specifying diagnosis ($n = 10$) cited impetigo most often (30.0%), followed by herpes (20.0%) and ringworm (20.0%). In college, 79.3% of skin infections included a physician evaluation. Herpes (47.1%) was cited most frequently, followed by impetigo (36.8%), tinea corporis (7.4%), cellulitis (5.9%), and methicillin-resistant *Staphylococcus aureus* (2.9%).

In high school, skin infections occurred on the head/face (41.7%), arm (13.9%), and neck (8.3%) most frequently (Table 2). All individuals with skin infections resumed wrestling during the season, with the majority of both high

TABLE 2
Skin Infections Sustained by US High School and College Wrestlers, High School Sports-Related Injury Surveillance Study and NCAA Injury Surveillance System, 2005-2006 School Year^a

	High School No. Cases (%)	College No. Cases (%)
No. Cases ^b	36 (100)	68 (100)
Body site ^c		
Head/face/neck	18 (50.0)	
Upper extremity	8 (22.3)	
Lower extremity	5 (13.9)	
Trunk	2 (5.6)	
Other	3 (8.3)	
Time loss ^d		
1 to 2 days	7 (20.6)	8 (11.8)
3 to 6 days	16 (47.1)	42 (61.8)
7 to 9 days	8 (23.5)	8 (11.8)
10 to 21 days	3 (8.8)	10 (14.7)
>21 days	0 (0.0)	0 (0)

^aNCAA, National Collegiate Athletic Association.

^bDue to the small number of reported skin infections, these numbers reflect the number of unweighted reported skin infections.

^cBody sites for skin infections were not collected by the NCAA Injury Surveillance System.

^dTwo cases from the High School Sports-Related Injury Surveillance Study did not specify time loss.

school (67.7%) and college (70.5%) wrestlers missing <1 week. In high school, skin infections tended to cluster in schools. Of the 74 high schools reporting wrestling data, 60 schools (81.1%) reported 0 skin infections, 8 schools (10.8%) reported 1 skin infection, and 6 schools (8.1%) reported between 2 and 8 skin infections each. Two high school wrestlers each sustained 2 different skin infections during the season.

DISCUSSION

Our study, the first nationally representative research comparing US high school and college wrestling injuries, found that the injury rate was 3 times higher in college wrestling than in high school, with college and high school match injury rates 2 and 5 times higher than respective practice injury rates. Additionally, injury diagnosis, body site, and severity differed between high school and college practices and matches. The large population of young wrestlers underscores the need to identify patterns and causes of injuries and skin infections to lay the foundation for developing and implementing evidence-based, targeted preventive interventions.

In our study, high school and college injury rates per 1000 athlete-exposures (2.32 and 7.25, respectively) were lower than previously reported high school (5.6³¹ to 7.6¹⁶ injuries per 1000 athlete-exposures) and college (9.6 injuries per 1,000 athlete-exposures) injury rates.¹⁷ Our lower injury rates may be attributable to study methodological differences, such as different injury definitions.

However, because most of the prior studies were conducted several years ago, rule and equipment changes over time may have successfully reduced injury rates. We found a higher injury rate among college wrestlers compared to high school wrestlers, especially during matches. This is likely due in part to increased match exposure time. Regulation college wrestling matches last 7 minutes—1 minute longer than high school matches. This may also be due to a higher level of competition in college.

We found similar overall severity between high school and college wrestling injuries. Although half of both injured high school and college wrestlers resumed wrestling in <1 week, one-fourth missed >3 weeks and almost 8% needed surgery. Previous high school wrestling studies reported that only 14.8%³¹ to 16.0%¹⁶ of injured wrestlers missed >3 weeks of wrestling and only 2.0%³¹ needed surgery. Similarly, a previous college wrestling study found that over 60% of injured wrestlers returned in <1 week.¹⁷ Part of this may be due to more inclusive injury definitions during previous studies that resulted in a greater proportion of minor injuries being captured. Alternatively, our data, when compared with previous studies, may suggest that wrestling injuries are increasing in severity over time, although further studies are needed to confirm this and to determine reasons for this. Finally, we found that college matches resulted in the greatest proportion of severe injuries, suggesting that a higher level of competition during college matches causes not only a higher injury rate but also increased injury severity.

Injury patterns in our study are similar to previous research, with strains/sprains accounting for half of all high school and college injuries^{17,30,31,36} and the shoulder, knee, and trunk injured most frequently.^{16,17,30,31,34} College wrestlers sustained a larger proportion of knee injuries than high school wrestlers. A previous study of college wrestling knee injuries hypothesized that a gradual degeneration of knee tissues may lead to knee injuries.³⁹ Given that most college wrestlers spend more years wrestling than high school wrestlers, this is a potential explanation. Meanwhile, high school wrestlers sustained larger proportions of elbow and hand fractures compared to college wrestlers. One potential explanation is that high school wrestlers may have less experience falling properly and may be more likely to injure their upper extremities while breaking a fall. Also, because most high school-age wrestlers are more skeletally immature than college-age wrestlers, they may be more susceptible to supracondylar fractures and dislocations. Further study is needed to test our suggested hypotheses about why these differences exist.

The wrestling takedown has been reported to be the most common move leading to injury,^{8,16,17,19,30,36,39} and this study was no exception. The takedown consists of a rapid, high-energy struggle that ends with a wrestler being thrown to the mat. Although the takedown itself is relatively brief, because all matches begin with both wrestlers standing in a neutral position and attempting a takedown, and because a relatively high number of points are awarded for a successful takedown, high school and college wrestlers are encouraged to attempt multiple takedowns throughout a match.

Skin infections accounted for 8.5% of all reported high school events and 20.9% of all reported college events. This higher proportion among college wrestlers may be an artifact of the nonrandom surveillance system detecting localized outbreaks occurring in 1 or 2 colleges that affected multiple athletes, which could have greatly influenced these numbers. Consistent with previous studies, we found that the majority of high school skin infections were on the head/face/neck and arms.^{4,30} Although contaminated wrestling mats and equipment were previously thought to be the main source of skin infection,²⁰ it is now believed that skin-to-skin transmission may be the primary culprit because the lock-up position places the head/face/neck and arms of competing wrestlers in direct contact.^{4,20} Thus, although earlier guidelines stressed mat cleanliness and wrestler hygiene as ways to decrease transmission rates, our results support recent recommendations that focus on early identification and quarantine of infected athletes.^{3,6,15}

In a press release issued in 2003, the American College of Sports Medicine announced that in collaboration with the National Federation of State High School Associations, they would work to ensure medical professionals closely monitor and treat signs and symptoms of herpes gladiatorum infection among wrestlers, prohibit potentially infected wrestlers from competing, and provide educational material to coaches.³ Currently, although all high school and college wrestlers are screened immediately prior to matches, these skin checks may be performed by nonmedical personnel. Although not highlighted in our data, because of the high incidence of skin infections we recommend that all officials performing skin checks receive training on identifying infectious skin conditions. We also recommend that wrestling coaches or ATCs screen wrestlers weekly before practice. To be most effective, practice screenings should be conducted midweek so they occur halfway between match screenings.

This study is not without limitations. Only high schools with a NATA-affiliated ATC were eligible for the study. Although this may limit the generalizability of our findings, the use of only medically trained personnel increased data quality and consistency. High school and college ATCs were not asked to report on minor injuries not requiring medical attention or resulting in no time loss (nosebleeds, small cuts, etc). Thus, these data are an underestimate of the true injury burden. However, this limitation was necessary to reduce reporter burden. Exposure time was calculated as athlete-exposures rather than athlete-minutes because it was not feasible for ATCs to attend all practices and matches and record the exact number of minutes that each wrestler participated. The use of athlete-exposures is appropriate because an athlete is exposed to the possibility of injury every time they practice or compete, and using athlete-exposures made it easier to compare our rates with previous studies using athlete-exposures. Although NCAA ISS reporters could record both primary and secondary injuries from a single injury event while High School RIO reporters could record only the primary injury, this likely had little influence on our results because <2% of reported college injures were secondary injuries. The NCAA ISS does not calculate national estimates, and the sampling

scheme precluded being able to adjust standard errors when comparing within college data or between high school and college data. Finally, potential selection bias exists because only 6.6% of all NCAA collegiate wrestling teams contributed data that qualified for inclusion in the national sample during the 2005-2006 academic year. These numbers were lower than usual due to the learning curve resulting from the recent conversion of the ISS from a paper-based to a Web-based data collection system. The deterministic rather than random sample was used to balance the dual needs of maintaining a reasonably representative sample of NCAA institutions while accommodating the needs of the voluntary participants. However, the NCAA ISS is the most current, nationally representative data on collegiate wrestling injuries. As exemplified in a recent 16-year overview of ISS paper-based wrestling-related injury data,² the high-quality injury, exposure, and risk factor ISS data have been used to develop many successful preventive interventions since collection began in 1982.

This study highlights areas where preventive injury interventions can have a large impact. Because of the increased rate and severity of match injuries, wrestling coaches should attempt to integrate wrestling drills of potentially high-risk situations, such as the takedown, into controlled practice conditions that simulate the higher intensity of matches. Coaches should keep current with the latest training techniques that yield the best performance while maintaining the highest possible level of safety. Specifically, high school coaches should focus on preventing upper extremity fractures while college coaches should focus on preventing knee injuries, as these were the injuries that resulted in the most time loss for high school and college wrestlers, respectively. In match situations, referees should continue to pay close attention to wrestlers during the takedown to ensure that wrestlers are executing moves as safely as possible. Although only 6.4% of high school match injuries resulted from illegal activity, because a greater proportion of these injuries were concussions, referees need to continue to closely monitor for foul play, being especially alert for potentially illegal moves resulting in blows to the head. Although not highlighted in our data, because wrestling is a physically demanding sport, coaches should ensure that all wrestlers are in adequate physical shape before they are permitted to engage in full-contact drills or matches.

CONCLUSION

This study is the first to compare injury rates and patterns between high school and college wrestlers. We found that injury rates and patterns differed between high school and college practices and matches and that skin infections make up a large proportion of adverse events. Continued prospective surveillance of wrestling exposure and injury incidence is necessary to monitor injury and skin infection rates and patterns over time and assess the effect of potential rule and equipment changes. Video analysis of specific actions leading to injury, such as the mechanics leading to injury during takedown, would provide coaches and ATCs

with the scientifically based evidence needed to develop targeted interventions. Additional case control studies of skin infection outbreaks would provide further insights into preventing and managing such incidents. To maximize the benefits that can be gained from participating in sports such as wrestling, physicians, ATCs, coaches, and researchers must work together to identify interventions effective in making wrestling as safe as possible.

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