Decreasing Incidence of Youth Wrestling Injuries

A 10-Year Analysis of National Injury Data

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Background: Wrestling is among the most common youth sports in the United States, with about 260,000 high school participants annually. There is a lack of literature investigating wrestling injury profiles and mechanisms of injuries. In the past 15 years, urgent care utilization has increased, and National Federation of State High School Associations (NFHS) concussion protocols have been developed and implemented.

Purpose/Hypothesis: The purpose of this study was to analyze causes, diagnoses, body parts, and trends associated with wrestling injuries presenting to US emergency departments. It was hypothesized that there would be (1) decreased overall injuries presenting to emergency departments because of increased urgent care utilization and (2) decreased concussions because of the NFHS rule implementation and revision.

Study Design: Descriptive epidemiology study; Level of evidence, 3.

Methods: Youth wrestling injuries presenting to US emergency departments between January 1, 2013, and December 31, 2022, were queried from the National Electronic Injury Surveillance System database. The data included date of presentation, age, sex, race, body part, injury diagnosis, disposition, and a brief injury narrative. National estimates (NE) were calculated using the associated statistical weight of the reporting hospital. Linear regressions were performed to investigate the relationship between year and NE for overall injuries, diagnoses, body parts, mechanisms of injury, and other subanalyses. Statistical significance was set at $P < .05$.

Results: A total of 8628 (NE = 296,502) wrestling injuries met the inclusion criteria for this study. The mean age at presentation was 14.3 $\pm$ 2.6 years (range, 3 to 18 years). The shoulder (NE = 43,207 [14.6%]), head (NE = 40,875 [13.8%]), and knee (NE = 30,218 [10.2%]) were the most injured body parts. The most common diagnoses were strain/sprain (NE = 91,924 [31%]), other/not stated (NE = 53,736 [18.1%]), and fracture (NE = 52,261 [17.6%]). Common mechanisms of injury included not specified (NE = 148,169 [50%]), impact with mat (NE = 61,557 [20.8%]), and abnormal rotation/strain (NE = 37,449 [12.6%]). Overall injuries ($P = .01$) (coefficient: –1763 [95% CI, –2963 to −563]) and concussions ($P = .01$) (coefficient: –178 [95% CI, –302 to −55]) statistically significantly decreased.

Conclusions: Our study showed a trend in the decrease in overall injuries and concussions in high school wrestlers. Strains/sprains were the most common diagnoses with the shoulder being the most common site. Youth wrestlers would benefit from future research analyzing risks associated with these injuries as well as advances in protective gear.

Keywords: concussion; epidemiology; general sports trauma; head injuries/concussion; injuries; injury prevention; orthopaedics; pediatric sports medicine; wrestling; youth

Wrestling is one of the oldest sports, with a history dating back beyond the original Olympic Games.[4,8] Wrestling is among the most common youth sports in the United States, with about 260,000 high school participants annually.[9]

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Wrestling inherently carries a risk of injury because of its nature as an intensive contact sport involving minimal protective gear.[17] Injury risk may be elevated in youth wrestlers because of physiological factors—such as decreased musculature, increased head-to-body ratio, insufficient myelination, and bone mass deficits.[1,12,18] Moreover, recent trends in early athletic specialization and year-round training further increase injury risk in youth athletes.[14,18] Considering the large youth population at risk of wrestling injuries, a comprehensive, up-to-date understanding of these injuries is imperative.

Recent literature has analyzed the prevalence of youth wrestling injuries categorized by diagnoses and body parts.[5,15] Other recent studies have investigated the prevalence of youth wrestling concussions, spinal injuries, and craniomaxillofacial injuries.[3,16,17] Apart from the craniomaxillofacial injuries study,[17] none of the aforementioned studies analyzed the mechanism of injury. To our knowledge, the most recent national study[8] of all youth wrestling injuries focusing on the mechanism of injury included data between 2000 and 2006. However, the sport of wrestling has undergone several changes since then. In the past 15 years, the National Federation of State High School Associations (NFHS) has illegalized several maneuvers—including back flip from standing position (wrestler standing anterior to opponent, wrestler performs standing back flip over opponent to get behind opponent) (2008-2009), rear-standing double-knee kickback (wrestler holding opponent from behind in standing position, wrestler uses both feet or both knees to simultaneously apply pressure to the posterior knees of the opponent) (2010-2011), figure 4 around the head (wrestler wraps legs in a formation resembling the number 4 and squeezes to apply pressure to opponent's head/neck) (2011-2012), and straight-back salto (wrestler and opponent standing anterior to each other, wrestler throws opponent backward over top of wrestler's head/shoulder and slams opponent into mat while wrestler lands on own face or head) and suplay (wrestler standing behind opponent, wrestler throws opponent backward over top of wrestler's head/shoulder and slams opponent into mat while wrestler lands on own face or head) (2017-2018).[10] In addition, NFHS updated[10,19] its concussion recognition and management protocols, which were initially introduced in 2003-2004, 2010-2011, 2011-2012, 2012-2013, and 2019-2020. These rule changes may have resulted in new youth wrestling injury patterns.

This study aimed to analyze causes, diagnoses, body parts, and trends associated with concussions and other wrestling injuries presenting to US emergency departments (EDs) over the past 10 years. We hypothesized that there would be (1) decreased overall injuries presenting to EDs because of increased urgent care utilization and (2) decreased concussions because of the NFHS rule implementation and revision.

METHODS

Data Collection

Data were accessed via the National Electronic Injury Surveillance System (NEISS) database, a publicly available national database from the US Consumer Product Safety Commission. This database contains information from 100 hospital-associated emergency departments (EDs) with 24-hour services and a minimum of 6 beds. These EDs were selected as a representative probability sample of the 5000 US hospital EDs after stratifying all US hospitals by geographic location, size, and ED data volume. A statistical sample weight is assigned for each hospital, allowing for the calculation of national estimates (NE), and thus providing reliable and reproducible epidemiologic data.

All wrestling-related injuries (product code 1270: wrestling [activity, apparel, or equipment]) were queried for patients aged $\leq$18 years between January 1, 2013, and December 31, 2022. All diagnoses and dispositions were included.

The data included the date of presentation, age, sex, race, body part, injury diagnosis, disposition, and a brief narrative of the injury documented by the provider. Each narrative was reviewed to classify mechanisms of injury. Mechanisms of injury were defined as impact with mat, impact with an opponent, abnormal rotation/strain, crush injury, impact with self, headlock/chokehold, other, or not specified.

Exclusion Criteria

Narratives were also screened to identify wrestling injuries and exclude injuries sustained outside of organized wrestling. Injuries sustained in a setting other than organized wrestling competition or practice (eg home, school

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Ethical approval was not sought for the present study.

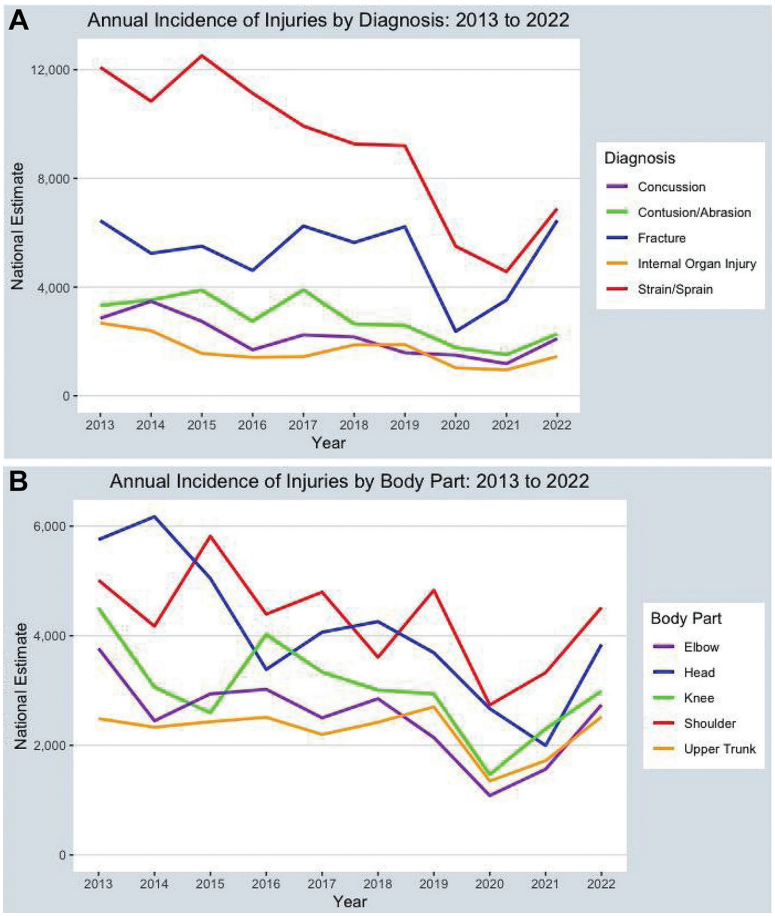

Figure 1. National estimates of the annual incidence of injuries by (A) the top 5 most common diagnoses and (B) the top 5 most common body parts.

TABLE 1
Patient Characteristics[a]

Patient Characteristics	Study Participants	National Estimate
Mean age at diagnosis, y	14.3 ± 2.6 (3-18)	14.4 ± 2.5 (3-18)
Male patients	7950 (92.1)	273,827 (92.4)
Female patients	678 (7.9)	273,827 (7.6)
Total	8628	296,502

[a]Data are presented as mean ± SD (range), n (%), or n.

playground) were excluded. Injuries at wrestling competitions or practices that did not occur while grappling (eg, fitness drills, playing on wrestling mats) were excluded.

Statistical Analysis

Statistical analyses were conducted using RStudio Software Version 2023.06.0 + 421 (Posit, PBC). Linear regressions were performed to investigate the relationship between year and NE for overall injuries, diagnoses, body parts, mechanisms of injury, and other subanalyses. Similar analyses were conducted excluding data from 2020 to investigate the effects of the pandemic. Statistical significance was set at $P < .05$. NEs were calculated by multiplying each queried raw data point by the associated statistical weight of the reporting hospital.

RESULTS

There were 9910 cases (NE = 349,890) of ED-diagnosed wrestling-related injuries between January 1, 2013, and December 31, 2022. Application of the inclusion and exclusion criteria after reviewing the narratives resulted in 8628 cases (NE = 296,502) included in the analysis (Table 1). The mean age at presentation was 14.3 ± 2.6 years (range, 3-18 years). Also, 92.1% (NE = 92.4%) of the included patients were male. There were 4780 (NE = 175,986 [59.4%]) White, 2326 (NE = 81,646 [27.5%]) unspecified race, 820 (NE = 16,406 [5.5%]) Black/African American, 537 (NE = 17,095 [5.8%]) other race, 122 (NE = 3719 [1.3%]) Asian, 28 (NE = 1093 [0.4%]) American Indian/Alaska Native, and 15 (NE = 554 [0.2%]) Native Hawaiian/Pacific Islander patients.

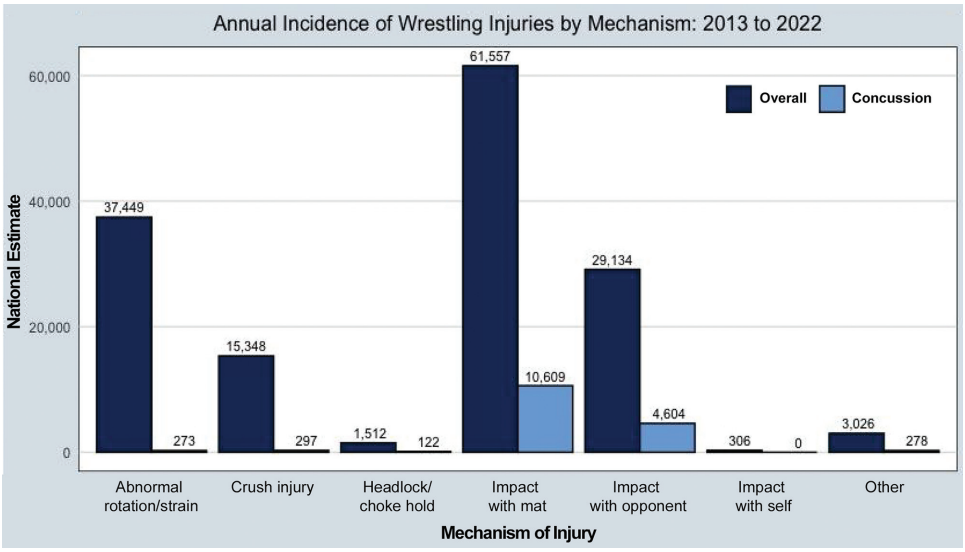

Figure 2. National estimates of the annual incidence of wrestling injuries by mechanism.

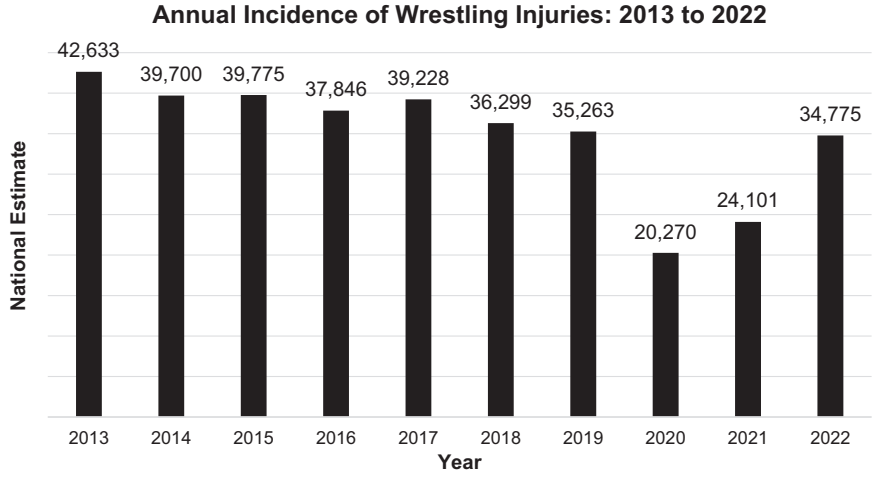

Figure 3. National estimates of annual incidence of wrestling injuries between 2013 and 2022.

The most common diagnoses were strain/sprain (NE = 91,924 [31%]), other/not stated (NE = 53,736 [18.1%]), fracture (NE = 52,261 [17.6%]), contusion/abrasion (NE = 28,179 [9.5%]), and concussion (NE = 21,533 [7.3%]) (Figure 1A). The most injured body parts were the shoulder (NE = 43,207 [14.6%]), head (NE = 40,875 [13.8%]), knee (NE = 30,218 [10.2%]), elbow (NE = 25,052 [8.4%]), and upper trunk (NE = 22,661 [7.6%]) (Figure 1B). The body parts most likely to be fractured were the shoulder (NE = 9368 [17.9%]), lower arm (NE = 7392 [14.1%]), finger (NE = 6354 [12.2%]), elbow (NE = 4819 [9.2%]), and lower leg (NE = 3906 [7.5%]).

Common mechanisms of injury based on a review of the narrative included not specified (NE = 148,169 [50%]), impact with mat (NE = 61,557 [20.8%]), abnormal rotation/strain (NE = 37,449 [12.6%]), impact with an opponent (NE = 29,134 [9.8%]), and crush injury (NE = 15,348 [5.2%]) (Figure 2). The impact of the mat mechanism in this study consisted predominantly of injuries occurring during falls and takedowns. Common mechanisms of fractures included not specified (NE = 23,742 [45.4%]), impact with mat (NE = 14,032 [26.8%]), and abnormal rotation/strain (NE = 7082 [13.6%]). Impact with mat (NE = 10,609 [49.3%]), not specified (NE = 5346 [24.8%]), and impact with opponent (NE = 4604 [21.4%]) were the most common mechanisms of concussions.

A statistically significant decrease was found in overall injuries between 2013 and 2022 (P = .010) (coefficient: –1763 [95% CI, –2963 to −563]) (Figure 3). The results showed significant decreases in head (P = .005) (coefficient: –347 [95% CI, –552 to −141]), finger (P = .018) (coefficient: –187 [95% CI, –332 to −42]), face (P = .001) (coefficient: –173 [95% CI, –245 to −101]), elbow (P = .043) (coefficient: –164 [95% CI, –321 to −7]), neck

(P = .018) (coefficient: –110 [95% CI, –195 to −25]), and lower trunk (P = .002) (coefficient: –75 [95% CI, –114 to −36]) injuries. A similar analysis for diagnoses found significant decreases in strains/sprains (P = .001) (coefficient: –801 [95% CI, –1135 to −468]), contusions/abrasions (P = .007) (coefficient: –217 [95% CI, –355 to −79]), concussions (P = .010) (coefficient: –178 [95% CI, –302 to −55]), internal organ injuries (P = .016) (coefficient: –133 [95% CI, –235 to −32]), and lacerations (P = .002) (coefficient: –114 [95% CI, –172 to −55]). Injuries caused by impact with opponent significantly decreased ($P < .001$) (coefficient: –339 [95% CI, –441 to −237]).

To account for the coronavirus 2019 pandemic, similar analyses were conducted, with all data from 2020 excluded. This subgroup analysis demonstrated a statistically significant decrease in overall injuries (P = .009) (coefficient: –1444 [95% CI, –2407 to −481]). Significant decreases in the head (P = .011) (coefficient: –327 [95% CI, –554 to −99]), finger (P = .038) (coefficient: –172 [95% CI, –332 to −12]), face (P = .001) (coefficient: –156 [95% CI, –220 to −92]), neck (P = .034) (coefficient: –108 [95% CI, –205 to −11]), and lower trunk (P = .006) (coefficient: –72 [95% CI, –115 to −29]) injuries were found. Significant decreases were also found in strains/sprains (P = .001) (coefficient: –739 [95% CI, –1070 to −409]), contusions/abrasions (P = .015) (coefficient: –199 [95% CI, –346 to −51]), concussions (P = .023) (coefficient: –171 [95% CI, –310 to −31]), internal organ injuries (P = .035) (coefficient: –122 [95% CI, –233 to −11]), and lacerations (P = .003) (coefficient: –100 [95% CI, –152 to −48]). There was a decrease in injuries caused by impact with an opponent ($P < .001$) (coefficient: –318 [95% CI, –416 to −220]).

DISCUSSION

The major findings of our study demonstrated significant decreases in overall wrestling injuries between 2013 and 2022 as well as injuries involving particular mechanisms, body parts, and diagnoses. The shoulder, head, and knee were most injured. The most common diagnoses were strain/sprain, other/not stated, and fracture. Common mechanisms of injury included not specified, impact with mat, and abnormal rotation. Statistically significant decreases were observed in overall injuries (P = .01) and concussions (P = .01).

This study identified significant decreases in head injuries, face injuries, neck injuries, and concussion diagnoses between 2013 and 2022. This contrasts with findings by Stanbouly et al,[17] who found an increase in head and neck wrestling injuries between 2000 and 2019, with the most common diagnosis being a concussion. This discrepancy may be explained by an apparent increase in craniomaxillofacial injuries starting in 2000 and peaking in 2011, followed by a more gradual decrease through 2019. The results of the present study suggest that the downward trend in head and neck injuries has continued through 2022, thus supporting our initial hypothesis that concussion diagnoses would decrease because of NFHS concussion rule implementations and revisions. This conclusion is further supported by a discrepancy in the proportion of concussions reported over time. The proportion of concussions among youth wrestling injuries was 5.4% between 2005 and 2006 in 1 study, while another study reported a proportion of 6% for traumatic brain injury (TBI) between 2000 and 2006.[8,20] Notably, the TBI variable overestimated the proportion of diagnosed concussions, as TBI was diagnosed as either concussion, internal injury of the head, or fracture of the head. In contrast, the present study demonstrated that the mean proportion of concussion diagnoses was 8.5% between 2013 and 2015, with a linear decrease over time (7.3% from 2013 to 2022). These differences suggested an increase in concussion diagnoses in the late 2000s and early 2010s because of heightened concussion awareness, followed by a subsequent decrease in concussion diagnoses between 2013 and 2022 after the NFHS concussion rule implementation. Similar studies in other sports—such as an analysis of the effects of the targeting rule implementation in football—have shown rule implementation to successfully decrease concussion incidence in youth athletes.[12] Youth wrestlers would likely benefit from continuous NFHS concussion rule implementations and revisions.

Several results from this study are consistent with those reported in previous literature. Similar to Myers et al,[8] this study showed that nearly 75% of injuries affected body parts above the waist. Previous literature also found that the most common diagnoses were strain/sprain, fracture, and contusion/abrasion.[3,8,20] Although a change in the number of youth wrestling injuries was observed in this study, the relative proportions of body parts injured and injury diagnoses, except concussion, aligned with those reported in previous literature. These findings suggest that specific rule implementation and technique modifications over time are not responsible for the decrease in wrestling injuries below the head in this study. While these findings support previous literature reporting contact injuries were the most common cause of wrestling injuries, impact with the mat was more common than other contact mechanisms such as impact with opponent or crush injuries.[6,8,13] While impact with opponent injuries decreased ($P < .001$), no significant change was found in impact with mat and crush injuries. Further research analyzing alternative mat composition and/or the risks associated with takedowns may provide valuable information to increase the safety of youth wrestling.

To our knowledge, this is the first study to identify decreasing trends in overall injuries as well as specific mechanisms, diagnoses, and body parts between 2013 and 2022. Although we cannot delineate definite causes contributing to this decline, multiple studies have elucidated potential factors. First, organized wrestling matches often have certified individuals to provide point-of-care management of injuries (eg, athletic trainers and team physicians).[2] Improved ability to diagnose and manage these injuries on-site may be contributing to the decreasing trend. Second, the progressive expansion of urgent care clinics throughout the United States provides patients with an accessible, convenient alternative to EDs.[7,11]

In addition, this was the first study to investigate the prevalence of fractures among specific body parts in all youth wrestlers between 2013 and 2022. This study found the shoulder (17.9%) to be the most common fracture location, followed by the lower arm (14.1%), finger (12.2%), and elbow (9.2%). Considering that the upper extremities were the most common site of fracture location and impact with mat was the most common specified mechanism of upper extremity fracture injuries, further studies examining more detailed mechanisms of upper extremity fractures may inform rule development which decreases fracture prevalence among youth wrestlers.

Limitations

There were some limitations associated with the utilization of the NEISS database. First, data collection was limited to what was included in the database; thus, it was not possible to assess some variables—including wrestling maneuver, severity of injury, time missed from play, and surgical intervention. Second, cases were limited to ED presentations and therefore did not account for injuries managed by athletic trainers, primary care physicians, specialists, or urgent care clinics. This may also have skewed the data to include more severe injuries. Third, the database utilized a relatively small sample of 100 EDs in the United States to generate national estimates; thus, the true incidence of wrestling injuries presented to US EDs cannot be confirmed. Furthermore, data include athletes aged between 3 and 18 years, although age differences result in anatomical changes and variations in styles of wrestling. An age subanalysis was not conducted as there are no established metrics guiding age categorizations. Last, 50% of the injury narratives did not specify the mechanism of injury, although this proportion is consistent with that reported in previous NEISS studies. Consequently, relative proportions of specified mechanisms of injury may differ slightly from actual proportions. The injuries with unspecified mechanisms, however, were included to gain perspective on overall injury trends. Therefore, NE provides reliable analyses of youth wrestling injuries.

CONCLUSION

Our study showed a trend in the decrease in overall injuries and concussions in high school wrestlers. Strains/sprains were the most common diagnoses with the shoulder being the most common site. Youth wrestlers would benefit from future research analyzing risks associated with these injuries as well as advances in protective gear.

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