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Original Research

Upper Quarter Injury Rates and Risk in United States High School Athletes Prior To and During the Prolonged Sport Stoppage

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Background

Upper quarter injuries are a serious problem in high school sports. The distinctive differences in males and females and within sports concerning specific upper quarter body parts necessitates the need to evaluate these injuries across these groups. The COVID-19 pandemic has created an opportunity to evaluate the potential added burden abrupt and prolonged sport stoppage had on upper quarter injury risk.

Hypothesis/Purpose

To 1) describe and compare upper quarter injury rates and risk in high school athletes in the 2019-2020 and 2020-2021 academic school years; 2) examine injuries by gender, sport, injury type, and location of injury.

Methods

An ecological study of the athletes from 176 high schools over six states, matching high schools between 2019-2020 (19-20) and 2020-2021 (20-21) years was performed. Injuries were reported by at least one high school athletic trainer assigned to each school into a centralized database and data collected from July 1, 2019, to June 30, 2021. Injury rates were calculated per 1,000 athletes per academic year. Interrupted time series models assessed the incidence ratio between academic years.

Results

A total of 98,487 athletes from all sports participated in 19-20 and 72,521 in 20-21. Upper quarter injury rates increased in from 19-20 [41.9 (40.6, 43.1)] to 20-21 [50.7 (48.1, 51.3)]. Upper quarter injury risk [1.5 (1.1, 2.2)] was greater in 20-21 compared to 19-20. Females did not demonstrate increased injury rates between 19-20 [31.1 (29.4, 32.7)] to 20-21 [28.1 (26.4, 30.0)]. Males reported increased injury rates from 19-20 [50.3 (48.5, 52.2)] to 20-21 [67.7 (65.2, 70.2)]. Increased injury for the shoulder, elbow, and hand were reported in 20-21. Collision, field, and court upper quarter injury rates were increased in 20-21.

Discussion

Upper quarter injury rates and injury risk were greater during the 2020-2021 school year than in the prior year. Males demonstrated increased upper quarter injury rates, while females did not. Return to play protocols for high school athletes should be considered following abrupt sport stoppage.

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Level of Evidence

2

INTRODUCTION

Upper quarter injuries are a serious problem in high school athletes,[1–3] with 21% of all athletic injuries sustained to the upper extremity.[1] Almost 600,000 acute traumatic arm fractures occur annually, representing one in ten of all injuries sustained in high school athletes annually.[4] The highest incidence of upper extremity injury is in the shoulder and elbow, with almost half of adolescent upper quarter injuries occurring at the shoulder.[5] Upper quarter injuries have a high medical burden, costing over $13,000 per injury in high school athletes.[6]

There are distinct differences in high school athlete upper quarter injury incidence between genders, with male high school athletes more likely to suffer severe injuries compared to females.[7] When comparing similar sports between high school males and females, males have a greater prevalence of upper quarter injuries, with up to 2.04 times greater odds and 18.3 upper quarter injuries per 100,000 athletes.[8,9] Different sports also have dissimilarities in upper quarter incidence. Athletes in collision sports have suffered up to 42% of total injuries to the upper quarter[7,10]; while athletes in field and court sports have sustained up to 55% of upper quarter injuries.[10,11]

The escalation of COVID-19 infections within the United States led to the cancellation of high school sports, beginning in March 2020.[12] The sudden and prolonged interruption of high school practices and competition led to decreased physical activity and sport training over time.[13] This sport specific training and competition stoppage resulted in decreased cardiovascular fitness, strength and power,[14,15] potentially increasing musculoskeletal injury risk during return to sport the following academic year. The interruption of high school sport practice and competition, coinciding with the COVID-19 pandemic, provides a distinctive chance to evaluate upper quarter injury patterns in high school athletes following an abrupt sport stoppage. While COVID-19 is the exact mechanism for sport stoppage, this provides an opportunity to consider the effects of abrupt sport stoppage on upper quarter injury incidence and risk, when resuming sport.

There are currently no studies comprehensively evaluating upper quarter injury that occur in high school sports. The distinctive differences in males and females, and within sports concerning specific upper quarter joints, necessitates the evaluation of injuries across these groups. The COVID-19 pandemic has created an opportunity to evaluate the potential added burden abrupt and prolonged sport stoppage has on upper quarter injury risk. Therefore, the purpose of this study was to 1) describe and compare upper quarter injury rates and risk in high school athletes in the 2019-2020 and 2020-2021 academic school years; 2) examine injuries by gender, sport, injury type, and location of injury.

MATERIALS AND METHODS

STUDY DESIGN

An ecological study on high school upper quarter injuries was performed. The Strengthening the Reporting of Observational Studies in Epidemiology for Sport Injury and Illness Surveillance (STROBE-SIIS) were followed (Please see STROBE checklist as supplement).[16] This study was approved by the PRISMA Health Institutional Review Board. Data cannot be shared for ethical/privacy reasons.

PARTICIPANTS

High school athletes, from six states [Alabama (AL); Delaware (DE); Illinois (IL); Maryland (MD); Michigan (MI); Pennsylvania (PA)] were included in this study. High schools were matched between 2019-2020 and 2020-2021 academic years. High school matching was based on participating in high school sports during the 2020-2021 academic year. High schools had to at minimum participate in a portion of all three sport seasons (e.g., fall, winter, and spring). If the high school did not report or participate in high school athletics during the 2020-2021 year, they were excluded from the analyses (Refer to Appendix 1 for study flow chart). All injury records were also matched for months of sport participation. As sport participation abruptly stopped in March 2020, injury records for the 2020-2021 academic year were matched through March 1, 2021. A total of 176 high schools were included.

DATA COLLECTION

Athlete injuries reported their injuries to the high school athletic trainer. The athletic trainer recorded all injuries by date and recorded time loss during any team-sponsored practices or games. Athletic trainer sport coverage was based on the individual high school sport participation, not on high school or school district funding or socioeconomic status. Athletic trainers checked high school athlete participation daily. Athlete health was monitored by the full-time athletic trainer assigned to each school. Internal validity data checks were performed by the regional athletic trainer supervisor and the regional and national quality control supervisors on a quarterly basis.[17,18]

ATHLETE EXPOSURE

An athlete-exposure (AE) was defined as one athlete participating in one practice or competition where a player was at risk of sustaining an injury.[10] Athlete exposure was not calculated for days of school suspension, medical visits that were not musculoskeletal related (e.g., general medical visit), or extramural school activities not related to sport. School holidays and teacher work days (e.g., Thanksgiving and Christmas) and high school or school district level stoppage of in person academic learning and sport partic-

ipation due to COVID-19 were marked and not considered athlete exposure. Due to the ecological nature of this study, it was not possible to obtain individual athlete exposure for epidemiological calculations, only if an athlete sustained a time loss illness or injury that was related to athlete exposure. Exposure was calculated per high school.

INJURY DEFINITION

An injury was defined as tissue damage or other derangement of normal physical function occurring during any training session or competition that resulted in at least one day lost to training and/or competition and required medical attention.[16] Athlete complaints that resulted in cessation of a competition or training session but the athlete returned to training or competition the same session or following day were recorded as zero days of time loss and did not result in a recorded injury.[16] Injured body segments and body parts were defined by the Orchard Sports Injury Classification System.[19] Due to the nature and mechanism of injury, concussions were excluded from this analyses. Specific anatomic body parts were recorded. Injury type was categorized as a cartilage injury, contusion, dislocation/subluxation/instability, fracture, sprain, strain, or other.[19] Injury time loss was calculated in number of days.[16] Injury severity was calculated as overall time loss, with injury severity stratified using 8-28 days (moderate) and >28 (severe) days.[16]

CONFOUNDERS

Self-identified gender, state, sport, and socioeconomic status were identified as confounders. Socioeconomic status was controlled through 1:1 high school matching between academic years. Due to the large number of sports played, sport was collapsed into four categories: collision (American football, lacrosse, wrestling, ice hockey, rugby), field and court (basketball, field hockey, soccer, tennis, volleyball, gymnastics, softball, baseball), individual (track and field, swimming, mixed rifle, mixed skiing, golf, dance, diving, cross country, bowling, archery, rowing, cheerleading), and other. The category of "other" was utilized for non-descript sport records.

STATISTICAL ANALYSES

All data were assessed for missingness prior to analyses (Gender: 0%; Age: 0%; Date of Injury: 3%; Sport: 1.7%; Body Part: 1.6%; Return to Play: <0.1%), and complete case analyses were performed. Participant statistics were described using mean (standard deviation) for continuous normally distributed variables, median (25^{th} quartile, 75^{th} quartile) for non-normally distributed continuous variables, and frequencies (percentages) for categorical variables. Injury rates, with 95% confidence intervals (95% CI) was calculated per 1,000 athletes that participated within one academic year (August through March, per matching).[6] Results were stratified by academic year, gender, state, sport, mechanism of injury, and type of injury.

To assess potential differences in upper quarter injury incidence between academic years, a mixed effects negative binomial interrupted time series model with robust errors was performed. Potential excess injuries for the 2020-2021 academic year were calculated on the expected upper quarter injury count from the 2019-2020 year. A dummy variable was included for the 2019-2020 academic year (0) and the 2020-2021 academic year (1). Further, an interaction between academic calendar year and month was included in the model. Random effects were modeled at the high school level. Model fixed effects were controlled using state, school holidays, and seasonality. To account for changes in athlete exposure due to the academic calendar, the number of school holidays, teacher work days, and days lost to COVID-19 exposure per month were included as a continuous variable. Seasonality was controlled for by assessing potential nonlinear relationships between month as a continuous variables and injury incidence through fractional polynomials. Non-linear relationship was observed to be a 2, -2 non-linear term. The log of high school athlete participation was included as an offset. All analyses were performed in R version 4.01 (R Core Team (2013). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org/), using the *naniar* package for missingness assessment and the *GLMMadaptive* package for zero inflated mixed effects negative binomial modelling.

RESULTS

A total of 98,487 athletes (Female: 43,249; Male: 55,238) participated in high school sport in 2019-2020 and 72,521 athletes (Female: 32,968; Male: 39,553) in the 2020-2021 academic year. A total of 4,125 upper quarter injuries occurred in the 2019-2020 academic year and 3,606 upper quarter injuries in the 2020-2021 academic year. The median time loss suffered from an upper quarter injury was 21 (1, 46) days during the 2019-2020 academic year and 17 (1, 34) days during the 2020-2021 academic year. The median time loss suffered from upper quarter injury for females was 21 (1, 47) days during the 2019-2020 academic year and 16 (1, 33) days during the 2020-2021 academic year. The median time loss suffered from upper quarter injury for males was 21 (1, 46) days during the 2019-2020 academic year and 17 (1, 35) days during the 2020-2021 academic year.

UPPER QUARTER INJURY RATES AND RISK

There was an overall increase in upper quarter injury rates per 1,000 athletes between the 2019-2020 and 2020-2021 academic years and for males (Table 1). The greatest increase in male upper quarter injury rates were in the category of moderate injuries. For upper quarter injury rates stratified by state, please refer to Appendix 2. Crude analyses demonstrated that upper quarter injuries increased by a ratio of 1.2 [(95% CI: 1.1, 1.3), $p < 0.001$] during the 2020-2021 academic school year. When accounting for calendar month and days lost to shelter in place and school holidays throughout the academic year, upper quarter in-

jury increased by a ratio of 1.5 [(95% CI: 1.1, 2.2), p = 0.022] during the 2020-2021 academic school year.

UPPER QUARTER INJURY RATES BY INJURY TYPES

The 2020-2021 academic demonstrated increased upper quarter injury rates per 1,000 athletes for contusions, dislocation/subluxation/instability, sprains, and strains compared to the 2019-2020 academic year (Table 2).

UPPER QUARTER INJURY RATES BY SPORT

Collision and field and court sports reported increased upper quarter injury rates per 1,000 athletes during the 2020-2021 academic year compared to the 2019-2020 academic year. Individual sport upper quarter injury rates per 1,000 athletes were similar between academic years (Table 3). Injury rates by body part for collision and field and court are reported in Appendix 3.

UPPER QUARTER INJURY RATES BY BODY PART AND ANATOMIC LOCATION

There were increased shoulder/proximal humerus, elbow, wrist, and hand injury rates per 1,000 athletes in the 2020-2021 compared to the 2019-2020 academic year (Table 4). Concerning shoulder specific injuries, there were increased acromioclavicular, clavicle, labrum, and rotator cuff injury rates per 1,000 athletes in 2020-2021 compared to the 2019-2020 academic year. Concerning elbow injuries, there were increased ulnar collateral ligament injury rates per 1,000 athletes in 2020-2021 compared to the 2019-2020 academic year. Concerning forearm specific injuries, there were increased pronator-flexor mass injury rates per 1,000 athletes in 2020-2021 compared to the 2019-2020 academic year (Table 5).

DISCUSSION

The main findings of this study were that there was increased upper quarter injury rates during the 2020-2021 compared to 2019-2020 academic school year. When controlling for confounders, upper quarter injury risk was also increased. Male upper quarter injury rates increased, while female injury rates were similar between academic years. Shoulder, elbow, and hand injury rates increased in the 2020-2021 academic year. Collision and field and court sport upper quarter injury rates increased, while individual sports demonstrated similar injury rates between academic years.

Upper quarter injury rates and risk were greater for the 2020-2021 academic year. This is not surprising considering the long layoff period and delayed return to sport for these high school athletes. High school sport interruption and the sudden subsequent resuming of sport may have influenced the increase in upper quarter injury rates and risk. In a survey of 13,000 high school athletes during the recent high school sport pause, they reported a 20% reduction in physical activity compared to pre-pandemic physical activity levels.[20] In another study, high school athletes during the cessation of sport reported performing almost two hours less of strength training, 1.5 hours less of endurance training, and over 6 hours less sport specific training per week.[21] A decrease in physical activity and exercise has been recognized as an important injury risk factor in high school physical education students[22] and college athletes.[14] The resultant deconditioning and lower load tolerance from decreased training may predispose the athlete to excessive loads upon returning to high school sport, potentially increasing upper quarter injury risk.[15] Further research is needed to understand the implications of deconditioning and load tolerance on upper quarter injury risk in high school athletes.

Male high school athletes reported increased upper quarter injury rates, compared to female athletes that sustained similar upper quarter injury rates between academic school years. The greatest increase in male injury rates were in the category of moderate injuries. These gender differences may be attributed to potential discrepancies in style of play,[7,9,23] sports played,[24] or overall gender specific differences in injury risk.[23,25,26] Previous researchers have observed that high school male athletes are more likely to sustain severe upper quarter musculoskeletal injuries and traumatic injuries compared to female athletes.[7,9] Male high school athletes are also more likely to suffer head/neck, shoulder, and hand injuries that require surgery compared to females in comparable sports.[24] Within high school baseball and softball, male baseball players are more likely to suffer an initial upper extremity injury compared to female softball players.[27]

Athletes in collision and field and court sports demonstrated increased injury rates during the 2020-2021 academic year. Field and court sports, such as tennis and baseball use the upper extremity for ball propulsion.[28] This results in increased upper extremity injury risk.[27] However, other field and court sports such as basketball and soccer have demonstrated a high prevalence of shoulder injuries due to player contact and guarding, suggesting moderate upper extremity sport involvement.[29] Collision sports such as football, lacrosse, and wrestling have also previously demonstrated high injury prevalence and incidence in high school athletes. Athletes in collision sports are more susceptible to traumatic upper quarter injuries, which may be related to decreased collision physical preparedness as they return to sport.[1,8] General decreased upper extremity involvement in individual sports, such as cross country running or track and field, has demonstrated less upper extremity injury prevalence compared to the trunk or lower extremity.[30]

Shoulder, elbow, and hand/finger injury rates were greater during the 2020-2021 academic year. These findings support previous research, with the shoulder, elbow and hand/finger demonstrating the greatest prevalence in injuries to the upper quarter in high school athletes.[7,10,11] Hand/finger injuries are predominantly traumatic fracture injuries,[31,32] while shoulder and elbow injuries have previously been identified as traumatic or overuse injuries.[7,10,11] Within sport, overuse injuries predominantly occur from

Table 1. Upper Quarter Injury Rates per 1,000 Athletes per Academic Year by Gender and Severity. All injury rates are reported per 1,000 athletes, with 95% confidence intervals

	Upper Quarter Injury		Upper Quarter Injury Severity					
			Minor		Moderate		Severe	
	19-20	20-21	19-20	20-21	19-20	20-21	19-20	20-21
Overall 19-20: n = 98,487 20-21: n = 72, 521	41.9 (40.6, 43.1)	50.7 (48.1, 51.3)	13.0 (12.3, 13.7)	14.0 (13.2, 14.9)	10.7 (10.1, 11.4)	17.8 (16.8, 18.8)	18.0 (17.2, 18.8)	17.5 (16.5, 18.4)
Female 19-20: n = 43,250 20-21: n = 32,968	31.1 (29.4, 32.7)	28.1 (26.4, 30.0)	10.2 (9.3, 11.1)	8.7 (7.7, 9.7)	7.3 (6.5, 8.1)	9.5 (8.4, 10.5)	13.4 (12.2, 14.4)	9.4 (8.4, 10.5)
Male 19-20: n = 55,239 20-21: n = 39,554	50.3 (48.5, 52.2)	67.7 (65.2, 70.2)	16.1 (14.1, 16.2)	18.5 (17.2, 19.8)	13.5 (12.5, 14.5)	24.7 (23.2, 26.3)	21.7 (20.4, 22.9)	24.2 (22.7, 25.7)

19-20 = Pre-pandemic academic year
20-21 = Pandemic academic year

throwing, swinging an implement such as a golf club or tennis racket, or prolonged gripping.[33]

PRACTICAL CLINICAL IMPLICATIONS

The increase in upper quarter injury rates, most notably in males, and those participating in collision sports, and field and court sports, suggest that return to loading strategies should be considered, and may focus on acclimating athletes to collision (i.e., tackling and blocking) physical demands. Further, athletes in sports with higher upper extremity demands, such as baseball and tennis, should have a slower ramp up for throwing, serving, or other similar sport activities. Sports medical clinicians should consider educating high school athletes, sport coaches, and their parents on performing gradual increases in training and practices when returning to sport following any unexpected or prolonged sport stoppage. Sports medicine clinicians should also consider creating return to play protocols with high school sport stakeholders in their community, in case of sport stoppages such as natural disasters (i.e., hurricanes, earthquakes), prolonged illness/injury or pandemics to help reduce the risk of upper quarter injuries.

STRENGTHS AND POTENTIAL LIMITATIONS

Athletes from six states, two regions of the United States, and 176 high schools were included in this study, increasing the generalizability of these findings. Upper quarter injuries were stratified by gender, state, sport, injury type, and anatomic body part providing a comprehensive and in depth reporting and analysis of upper quarter injuries in high school athletes. The variability of sports for each high school and state required sport groupings to be collapsed, decreasing the precision in these findings. Due to the ecological nature of this study, training and competition minutes could not be obtained, preventing rate calculations, decreasing the precision in injury incidence analyses. However, the number of days missed due to holidays, workdays, and shelter in place days during the academic school year were controlled for, improving the risk analyses precision. These results may be affected by the potential confounding of selection bias of schools participated in sport participation during the 2020-2021 academic school year. One state reported an increase of over 3,000 students that participated in sports during the 2020-2021 year. The increased sport participation prevalence may be related to the exclusion of other after school activities during the 2020-2021 year. However, the exact cause is not known, increasing selection bias.

Table 2. Upper Quarter Injury Rates per 1,000 Athletes per Academic Year by Type. Injury rates are reported per 1,000 athletes per academic year, and with 95% confidence intervals.

	Academic Year	
	19-20	20-21
Cartilage	1.4 (1.2, 1.6)	1.6 (1.3, 1.9)
Contusion	4.7 (4.3, 5.1)	**5.8 (5.3, 6.4)**
Dislocation/Subluxation/ Instability	3.0 (2.7, 3.4)	**4.8 (4.3, 5.3)**
Fracture	6.4 (5.9, 6.9)	**9.7 (9.0, 10.5)**
Sprain	11.0 (10.3, 11.6)	**14.0 (13.1, 14.9)**
Strain	6.0 (5.5, 6.4)	**7.1 (6.5, 7.7)**
Other	9.1 (8.5, 9.7)	6.5 (6.0, 7.1)

19-20 = Pre pandemic academic year; Total of 98,487 athletes participated in sport
20-21 = Pandemic academic year; Total of 72,521 athletes participated in sport
Other consists of deformity, disorder, laceration, and non-descript injury type records
*Injury rates that increased from 2019-2020 to 2020-2021 are **bolded**

Table 3. Upper Quarter Injury Rates per 1,000 Athletes per Academic Year by Sport. All injury rates are reported per 1,000 athletes, with 95% confidence intervals

	Academic Year	
	19-20	20-21
Collision	17.1 (16.3, 17.9)	**26.2 (25.0, 27.3)**
Field & Court	12.2 (11.5, 12.9)	**17.9 (16.9, 18.9)**
Individual	3.7 (3.3, 4.1)	4.4 (3.9, 4.9)
Other	8.9 (8.3, 9.5)	1.2 (1.0, 1.5)

19-20 = Pre pandemic academic year; Total of 98,487 athletes participated in sport
20-21 = Pandemic academic year; Total of 72,521 athletes participated in sport
*Injury rates that increased from 2019-2020 to 2020-2021 are **bolded**

CONCLUSION

Upper quarter injury rates were greater for the 2020-2021 academic school year in this sample of high school athletes. When controlling for confounders, models demonstrated increased injury risk for the 2020-2021 academic school year. While males reported increased upper quarter injury rates, females demonstrated comparable injury rates between academic years. Shoulder, elbow, and hand injury rates among all athletes increased in the 2020-2021 academic year. Athletes participating in collision and field and court sports reported an increase in upper quarter injuries, while athletes in individual sports reported similar injury rates for both school years. The results of this research may have implications beyond the COVID-19 pandemic, including natural disasters and work stoppages. Further research is required to understand the generalizability of these findings to different abrupt sport stoppage scenarios and the safe dose response required when returning to training for high school athletes and other competition levels.

Table 4. Upper Quarter Injury Rates per 1,000 Athletes per Academic Year by Body Part. All injury rates are reported per 1,000 athletes with 95% confidence intervals

Upper Quarter Body Part	Academic Year	
	19-20	20-21
Head/Face	4.4 (4.0, 4.9)	3.7 (3.2, 4.1)
Cervical	3.5 (3.2, 3.9)	2.0 (1.6, 2.3)
Shoulder/Proximal Humerus	15.8 (15.0, 16.6)	**19.8 (18.8, 20.8)**
Elbow	4.0 (3.6, 4.4)	**5.1 (4.6, 5.6)**
Forearm	1.0 (0.8, 1.2)	1.5 (1.2, 1.8)
Wrist	4.0 (3.6, 4.4)	**6.0 (5.4, 6.5)**
Hand/Finger	9.1 (8.5, 9.7)	**11.7 (11.0, 12.5)**

19-20 = Pre pandemic academic year; Total of 98,487 athletes participated in sport
20-21 = Pandemic academic year; Total of 72,521 athletes participated in sport
*Injury rates that increased from 2019-2020 to 2020-2021 are **bolded**

Table 5. Injury Rates per 1,000 Athletes per Academic Year by Anatomic Region or Diagnosis for Shoulder and Elbow Injuries. All injury rates are reported per 1,000 athletes, with 95% confidence intervals

Anatomic Region or Diagnosis	19-20 n = 98,487	20-21 n = 72,521
Shoulder		
Acromioclavicular (AC) Joint	1.5 (1.2, 1.7)	**2.3 (1.9, 2.6)**
Bicep	0.9 (0.7, 1.1)	**1.5 (1.2, 1.8)**
Clavicle	0.6 (0.4, 0.7)	**1.3 (1.0, 1.5)**
Glenohumeral Joint	2.2 (1.9, 2.5)	2.5 (2.1, 2.9)
Labrum	0.9 (0.8, 1.1)	**1.9 (1.5, 2.2)**
Neurovascular	0.2 (0.1, 0.3)	0.5 (0.3, 0.6)
Rotator Cuff	3.5 (3.2, 3.9)	**5.9 (5.3, 6.4)**
Scapula	0.3 (0.2, 0.4)	0.4 (0.2, 0.5)
Elbow		
Olecranon	0.1 (0.05, 0.2)	0.1 (0.04, 0.2)
Neurovascular	0.1 (0.02, 0.2)	0.2 (0.1, 0.3)
Pronator-Flexor Mass	0.5 (0.4, 0.7)	**1.3 (1.0, 1.5)**
Radius	0.2 (0.1, 0.3)	0.3 (0.2, 0.5)
Triceps	0.2 (0.1, 0.3)	0.3 (0.2, 0.4)
Ulna	0.1 (0.06, 0.2)	0.2 (0.1, 0.3)
Ulna Humeral Joint	0.3 (0.2, 0.4)	0.3 (0.2, 0.4)
Ulnar Collateral Ligament	0.6 (0.5, 0.8)	**1.2 (0.9, 1.4)**

19-20 = Pre pandemic academic year
20-21 = Pandemic academic year
*Injury rates that increased from 2019-2020 to 2020-2021 are **bolded**

CONFLICT OF INTEREST

The authors have no conflicts of interest

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REFERENCES

1. Rechel JA, Yard EE, Comstock RD. An epidemiologic comparison of high school sports injuries sustained in practice and competition. *J Athl Train*. 2008;43(2):197-204. doi:10.4085/1062-6050-43.2.197

2. McCarthy MM, Bihl JH, Frank RM, Salem HS, McCarty EC, Comstock RD. Epidemiology of clavicle fractures among US high school athletes, 2008-2009 through 2016-2017. *Orthop J Sport Med*. 2019;7(7):2325967119861812. doi:10.1177/2325967119861812

3. Scheffler P, Wolter NE, Namavarian A, Propst EJ, Chan Y. Contact sport related head and neck injuries in pediatric athletes. *Int J Ped Otorhinolaryngology*. 2019;121:6-9. doi:10.1016/j.ijporl.2019.02.036

4. Swenson DM, Yard EE, Collins CL, Fields SK, Comstock RD. Epidemiology of US high school sports-related fractures, 2005-2009. *Clin J Sport Med*. 2010;20(4):293-299. doi:10.1097/jsm.0b013e3181e8fae8

5. Andrish J. Upper extremity injuries in the skeletally immature athlete. In: *The Upper Extremity in Sports Medicine*. CV Mosby St. Louis; 1990:675-690.

6. Knowles SB, Marshall SW, Guskiewicz KM. Issues in estimating risks and rates in sports injury research. *J Athl Train*. 2006;41(2):207.

7. Darrow CJ, Collins CL, Yard EE, Comstock RD. Epidemiology of severe injuries among United States high school athletes: 2005-2007. *Am J Sports Med*. 2009;37(9):1798-1805. doi:10.1177/0363546509333015

8. Emery CA, Meeuwisse WH, McAllister JR. Survey of sport participation and sport injury in Calgary and area high schools. *Clin J Sport Med*. 2006;16(1):20-26. doi:10.1097/01.jsm.0000184638.72075.b7

9. Liavaag S, Svenningsen S, Reikerås O, et al. The epidemiology of shoulder dislocations in Oslo. *Scand J Med Sci Sports*. 2011;21(6):e334-e340. doi:10.1111/j.1600-0838.2011.01300.x

10. Powell JW, Barber-Foss KD. Sex-related injury patterns among selected high school sports. *Am J Sports Med*. 2000;28(3):385-391. doi:10.1177/03635465000280031801

11. Bullock GS, Uhan J, Harriss EK, Arden NK, Filbay SR. The relationship between baseball participation and health: a systematic scoping review. *J Orthop Sports Phys Ther*. 2020;50(2):55-66. doi:10.2519/jospt.2020.9281

12. Dorn E, Hancock B, Sarakatsannis J, Viruleg E. *COVID-19 and Student Learning in the United States: The Hurt Could Last a Lifetime*. McKinsey & Company; 2020:1.

13. McGuine TA, Biese K, Hetzel SJ, et al. High School Sports During the COVID-19 Pandemic: The Effect of Sport Participation on the Health of Adolescents. *J Athl Train*. 2021;57(1):51-58. doi:10.4085/1062-6050-0121.21

14. Caterisano A, Decker D, Snyder B, et al. CSCCa and NSCA joint consensus guidelines for transition periods: safe return to training following inactivity. *Strength Cond J*. 2019;41(3):1-23. doi:10.1519/ssc.0000000000000477

15. Gabbett TJ. The training—injury prevention paradox: should athletes be training smarter*and*harder? *Br J Sports Med*. 2016;50(5):273-280. doi:10.1136/bjsports-2015-095788

16. International Olympic Committee Injury and Illness Epidemiology Consensus Group, Bahr R, Clarsen B, et al. International Olympic Committee consensus statement: methods for recording and reporting of epidemiological data on injury and illness in sports 2020 (including the STROBE extension for sports injury and illness surveillance (STROBE-SIIS)). *Orthop J Sport Med*. 2020;8(2):2325967120902908.

17. Bullock GS, Prats-Uribe A, Thigpen CA, et al. The impact of statewide limitations of practice on high school injury incidence during the COVID-19 season: An ecological study. *Sports Health*. 2022;14(5):656-664. doi:10.1177/19417381221106693

18. Shanley E, Thigpen CA, Prats-Uribe A, Norhen T, Staley T, Bullock GS. Subsequent musculoskeletal injury incidence are similar between general infection and COVID-19 among high school athletes in the Unites States despite higher illness incidence during academic years 2019-2020 and 2020-2021. *J Orthop Sport Phys Ther*. 2022;52(8):546-553. doi:10.2519/jospt.2022.11200

19. Rae K, Orchard J. The Orchard Sports Injury Classification System (OSICS) version 10. *Clin J Sport Med*. 2007;17(3):201-204. doi:10.1097/jsm.0b013e318059b536

20. McGuine TA, Biese KM, Petrovska L, et al. Mental health, physical activity, and quality of life of US adolescent athletes during COVID-19–related school closures and sport cancellations: a study of 13 000 athletes. *J Athl Train*. 2021;56(1):11-19. doi:10.4085/1062-6050-0478.20

21. Jagim AR, Luedke J, Fitzpatrick A, et al. The impact of COVID-19-related shutdown measures on the training habits and perceptions of Athletes in the United States: a brief research report. *Front Sports Act Living*. 2020;2:208. doi:10.3389/fspor.2020.623068

22. Bloemers F, Collard D, Paw MCA, Van Mechelen W, Twisk J, Verhagen E. Physical inactivity is a risk factor for physical activity-related injuries in children. *Br J Sports Med*. 2012;46(9):669-674. doi:10.1136/bjsports-2011-090546

23. McQuillan R, Campbell H. Gender differences in adolescent injury characteristics: a population-based study of hospital A&E data. *Public Health*. 2006;120(8):732-741. doi:10.1016/j.puhe.2006.02.011

24. Rechel JA, Collins CL, Comstock RD. Epidemiology of injuries requiring surgery among high school athletes in the United States, 2005 to 2010. *J Trauma Acute Care Surg*. 2011;71(4):982-989. doi:10.1097/ta.0b013e318230e716

25. Garrick JG, Requa RK. Injuries in high school sports. *Pediatrics*. 1978;61(3):465-469. doi:10.1542/peds.61.3.465

26. Lenaway DD, Ambler AG, Beaudoin DE. The epidemiology of school-related injuries: new perspectives. *Am J Prevent Med*. 1992;8(3):193-198. doi:10.1016/s0749-3797(18)30831-6

27. Shanley E, Rauh MJ, Michener LA, Ellenbecker TS. Incidence of injuries in high school softball and baseball players. *J Athl Train*. 2011;46(6):648-654. doi:10.4085/1062-6050-46.6.648

28. Roetert EP, Ellenbecker TS, Reid M. Biomechanics of the tennis serve: implications for strength training. *Strength Cond J*. 2009;31(4):35-40. doi:10.1519/ssc.0b013e3181af65e1

29. Durand WM, Goodman AD, Giglio P, Etzel C, Owens BD. Epidemiology of upper extremity soccer injuries among high school and college-aged players in the United States: an analysis of the 1999-2016 NEISS Database. *Sports Health*. 2018;10(6):552-557. doi:10.1177/1941738118795483

30. Rauh MJ, Margherita AJ, Rice SG, Koepsell TD, Rivara FP. High school cross country running injuries: a longitudinal study. *Clin J Sport Med*. 2000;10(2):110-116. doi:10.1097/00042752-200004000-00005

31. Aitken S, Court-Brown CM. The epidemiology of sports-related fractures of the hand. *Injury*. 2008;39(12):1377-1383. doi:10.1016/j.injury.2008.04.012

32. Rettig AC. Epidemiology of hand and wrist injuries in sports. *Clin Sports Med*. 1998;17(3):401-406. doi:10.1016/s0278-5919(05)70092-2

33. Ciccotti MC, Schwartz MA, Ciccotti MG. Diagnosis and treatment of medial epicondylitis of the elbow. *Clin Sports Med*. 2004;23(4):693-705. doi:10.1016/j.csm.2004.04.011

SUPPLEMENTARY MATERIALS

Appendix 1

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Appendix 2

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