

Differences in Overuse Injuries in Gender-Comparable Sports: A Nationally Representative Sample of High School Athletes

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Context: Participation in high school sports has physical, physiological, and social development benefits, while also increasing the risk of acute and overuse injuries. Risk of sport-related overuse injury differs between boys and girls.

Objective: To investigate differences in overuse injuries among US high school athletes participating in the gender-comparable sports of soccer, basketball, and baseball/softball.

Design: Descriptive epidemiology study using a nationally representative sample from the High School Reporting Information Online (RIO) database.

Setting: High schools.

Patients or Other Participants: Athletes with overuse injuries during the 2006–2007 through 2018–2019 academic years.

Main Outcome Measure(s): National estimates and rates of overuse injuries were extrapolated from weighted observed numbers with the following independent variables: sport, gender, academic year, class year, event type, body site, diagnosis, recurrence, activity, and position.

Results: Among an estimated 908 295 overuse injuries nationally, 43.9% (n = 398 419) occurred in boys' soccer, basketball, and

baseball, whereas 56.1% (n = 509 876) occurred in girls' soccer, basketball, and softball. When comparing gender across sports, girls were more likely to sustain an overuse injury than boys (soccer, injury rate ratio [IRR]: 1.37, 95% CI = 1.20–1.57; basketball, IRR: 1.82, 95% CI = 1.56–2.14; baseball/softball, IRR: 1.21, 95% CI = 1.04–1.41). Most overuse injuries in soccer and basketball for both genders occurred to a lower extremity (soccer: 83.9% [175 369/209 071] for boys, 90.0% [243 879/271 092] for girls; basketball: 77.0% [59 239/76 884] for boys, 80.5% [81 826/101 709] for girls), whereas most overuse injuries in baseball and softball were to an upper extremity (72.5% [81 363/112 213] for boys, 53.7% [73 557/136 990] for girls). For boys' baseball, pitching (43.5% [47 007/107 984]) was the most common activity associated with an overuse injury, which differed from the most common activity of throwing (31.7% [39 921/126 104]) for girls' softball.

Conclusions: Gender differences observed in this study can help guide future strategies that are more specific to gender and sport to reduce overuse injuries among high school athletes.

Key Words: RIO, injury prevention

Key Points

- Girls were more likely to sustain an overuse injury than boys (soccer, injury rate ratio [IRR]: 1.37, 95% CI = 1.20–1.57; basketball, IRR: 1.82, 95% CI = 1.56–2.14; baseball/softball, IRR: 1.21, 95% CI = 1.04–1.41).
- Findings from this study can help guide future strategies that are more specific to gender and sport to reduce overuse injuries among high school athletes.

Participation in high school sports has physical, physiological, and social development benefits, while also increasing the risk of acute and overuse injuries.¹ Factors such as increased muscle-tendon tightness, decreased physical strength during growth spurts, and bone mineralization lagging behind linear bone growth contribute to overuse injuries among high school athletes.² Risk of sport-related overuse injury differs between boys and girls due, in part, to differences in anatomy, hormones, strength, flexibility, and skills levels.^{2,3} Improved understanding of the differences in the number and rate of overuse injuries in girls' versus boys' sports is needed to

better design and implement effective prevention strategies in high school athletics.

Previous studies on gender differences in sports injuries have had several limitations, including the use of non-nationally representative samples, focusing on acute injury, not using recent data, or focusing on only 1 sport.^{4–14} These limitations reduce generalizability to all US high school athletes, overuse injuries, current injury rates, and gender-comparable sports.⁸ The objective of this study was to investigate differences in overuse injuries among high school athletes participating in the gender-comparable sports of boys' and girls' basketball and

soccer and boys' baseball and girls' softball using nationally representative data from the 2006–2007 to 2018–2019 academic years.

METHODS

Source of Data

We obtained data for this study from High School Reporting Information Online (RIO), the National High School Sports-Related Injury Surveillance Study. Methods of High School RIO data collection have been discussed in detail elsewhere.^{15,16} Each year, 100 high schools are randomly chosen from 8 strata (based on geographic region and school size) to form a nationally representative sample of high schools. Each of these high schools must have at least 1 certified athletic trainer (AT) who is responsible for documenting details of injury events and submitting them to High School RIO, including information about injured athletes' gender, class, sport, primary type of injury, body part injured, injury severity, injury setting (practice versus competition), postinjury assessment and care, recurrence of injury, and return-to-play timeline. All athletes participating in 9 common high school sports in the 100 high schools are included to form a nationally representative sample of high school athletes. A weighting algorithm is used to generate national estimates based on data collected from participating high schools.

Study Population and Gender-Comparable Sports

The study population consisted of high school athletes who sustained overuse injuries while participating in 3 girls' sports (soccer, basketball, and softball) and 3 boys' sports (soccer, basketball, and baseball) during the academic years of 2006–2007 through 2018–2019. Because the High School RIO database did not include “overuse/chronic” as a mechanism of injury during the 2005 to 2006 school year, we excluded data from that year. Data from 2019–2020 and 2020–2021 were also excluded because of the effects of the coronavirus disease 2019 pandemic on high school athletic activities during those academic years. High School RIO categorizes boys' and girls' sports but does not specify whether these categorizations are based on gender identity or biological sex.¹ Because state high school athletic associations determine the category for transgender athletes, the term gender was used in this study.⁸ Basketball, soccer, and baseball/softball are considered to be gender-comparable sports based on similar rules and play.

Definitions of Injury and Athlete Exposure

High School RIO defines an *injury* as one that (1) occurred because 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. Although heat illness, dental injury, fracture, or concussion with less than 1 day of time lost meet the High School RIO definition of injury, there was only 1 overuse injury case that met these criteria, and it was included in the study.¹⁵ Athletic trainers can update information on these injuries as new information is reported. In this study, we investigated overuse injuries, which are a subset of injuries in the High School RIO database. Athletic trainers record a diagnosis and a “basic mechanism” for each injury. The basic mechanism variable includes the

category “chronic/overuse.” An *overuse injury* in this study was defined by using both the diagnosis and basic mechanism variables. Using the algorithm described by Ritzer et al,³ we defined an overuse injury as an injury that had (1) a diagnosis of blister, bursitis, inflammation, stress fracture, tendonitis, apophysitis, plantar fasciitis, shin splints, or spondylolysis or (2) a basic mechanism of “chronic/overuse.” Only overuse injuries associated with the 6 gender-comparable sports were included in the final analyses. Although this methodology has been used previously,³ there is potential for misclassification. For example, sprains and strains are diagnoses that are typically considered to be acute injuries; however, 7.5% of them were categorized by the AT as having a chronic/overuse basic mechanism and were therefore included in the analyses as overuse injuries.

An *athlete exposure*⁶ (AE) was defined in this study as 1 student-athlete participating in 1 school-sanctioned practice or competition of the 6 gender-comparable sports.¹⁵ To assess the effect of potential misclassification of sprains and strains as overuse injuries, we conducted a sensitivity analysis by recalculating the injury rate ratios (IRRs) and injury proportion ratios (IPRs) while excluding these cases from the dataset. This analysis aimed to determine whether our conclusions remained consistent after removing these types of injuries.

Some overuse injuries were grouped together because of similar diagnoses. For example, muscle strain (incomplete tear), muscle strain (unknown severity), and muscle strain were grouped into the category “muscle strain (any severity).” The same was done with “tendon strain (any severity)” and “ligament sprain (any severity).” The “other” injury diagnosis category included overuse diagnoses that were only recorded in a few sports, made up a smaller percentage of overuse injuries in a particular sport, or classified as an “other” injury with an overuse mechanism of action reported by the AT.

Additional Study Variables

Injured body regions were broadly categorized as (1) upper extremity, (2) lower extremity, and (3) other (including the High School RIO categories head/face, eye[s], neck/cervical spine, chest/thoracic spine/ribs, abdomen, lower back/lumbar spine/pelvis, clavicle/collar bone, male genitalia, and other). Injuries were categorized as (1) a new injury, (2) a recurrent injury, (3) other, and (4) unknown. The “unknown” category only included data from 2016–2017 through 2018–2019 for girls' basketball, boys' baseball, and girls' softball due to a coding change made in High School RIO. Overuse injuries were analyzed by sport activity (what the athlete was doing when the injury was sustained) and position (what the athlete's position was in the sport) using variable categories provided by High School RIO. The sport activity categories of general play, conditioning, pitching, and throwing are not defined by High School RIO; therefore, ATs determined for themselves how to define and use these categories. Outcome categories included (1) returned to play in less than 1 week, (2) returned to play in 1 to 3 weeks, (3) returned to play in greater than 3 weeks or medical disqualification, and (4) other (including athletes choosing not to continue the sport, athletes being released from the team, the season ending before athletes returned to activity, and other).

Statistical Analysis

IBM SPSS Statistics for Windows (version 28; IBM Corp) and SAS 9.4 (SAS Institute, Inc) were used to analyze data

for this study. National estimates were calculated using sampling weights provided by High School RIO. Descriptive statistics included national estimates with 95% CIs. Injury rates were calculated as the number of unweighted injuries per 10 000 AEs. Injury rate ratios with 95% CIs were estimated using Poisson regression, with the rate of injuries among boys as the reference. Other analyses included calculation of IPRs. All analyses used weighted frequencies except IRRs. The level of significance was set at $\alpha = .05$ for all analyses. This manuscript follows Strengthening the Reporting of Observational Studies in Epidemiology reporting guidelines for observational studies.

The following is an example of an IRR calculation:

$$\begin{aligned} \text{IRR} = & \left[\left(\frac{\text{number of overuse injuries in the 2006–2007 school year among girls}}{\text{number of AEs in the 2006–2007 school year among girls}} \right) \times 10\,000 \right] \\ & \div \left[\left(\frac{\text{number of overuse injuries in the 2006–2007 school year among boys}}{\text{number of AEs in the 2006–2007 school year among boys}} \right) \times 10\,000 \right] \end{aligned}$$

The following is an example of an IPR calculation:

$$\begin{aligned} \text{IPR} = & \left[\frac{\text{number of overuse soccer injuries resulting in} < 1 \text{ week time loss among girls}}{\text{total number of overuse soccer injuries among girls}} \times 100 \right] \\ & \div \left[\frac{\text{number of overuse soccer injuries resulting in} < 1 \text{ week time loss among boys}}{\text{total number of overuse soccer injuries among boys}} \times 100 \right] \end{aligned}$$

Ethical Considerations

This study was determined to be exempt from approval by the institutional review board of the authors' institution.

RESULTS

Injury Frequency and National Estimates

From the 2006–2007 through the 2018–2019 school year, there were 21 412 injuries reported in the 6 sports analyzed in this study, representing a national estimate of 8 622 771 injuries, of which 88.4% were acute injuries, 10.5% were overuse injuries, and 1.0% were other injuries. Among overuse injuries, an estimated 398 419 injuries were reported among boys' soccer, basketball, and baseball, representing 43.9% of overuse injuries nationally, and an estimated 509 876 injuries were reported among girls' soccer, basketball, and softball, representing 56.1% of overuse injuries nationally (Table 1).

Among the 3 high school boys' sports included in this study, soccer had the highest national estimated percentage of overuse injuries (52.5%), followed by baseball (28.2%) and basketball (19.4%). The 3 girls' sports followed a similar trend, with soccer accounting for 53.2% of all girls' overuse injuries, followed by softball (26.9%) and basketball (20.0%; Table 1).

Across class year, distributions of overuse injuries were different between girls' and boys' sports. Among boys' sports, the estimated number of overuse injuries generally increased

with increasing class year, whereas among girls' sports, the estimated number of overuse injuries decreased with increasing class year (Figure A). Most overuse injuries for both boys (72.6%) and girls (73.4%) occurred during practice rather than competition (Table 1). This was true for all 6 sports (Figure B).

Injury Rates and IRRs

Overall, girls (19.69 per 100 000 AEs) were more likely than boys (13.63 per 100 000 AEs) to sustain an overuse injury (IRR: 1.44; 95% CI = 1.33–1.57; Table 2). After excluding sprains and strains from the analyses, the relationship remained the same (IRR: 1.44; 95% CI = 1.30–1.60). When comparing overuse injury rates among sports, boys and girls both had higher rates for soccer, followed by baseball/softball and basketball. When comparing boys and girls by sport, girls had higher rates of overuse injuries than boys for basketball (IRR: 1.82; 95% CI = 1.56–2.14), followed by soccer (IRR: 1.37; 95% CI = 1.20–1.57) and baseball/softball (IRR: 1.21; 95% CI = 1.04–1.41). These relationships did not change after exclusion of sprains and strains from analyses (basketball [IRR: 1.74; 95% CI = 1.45–2.08], soccer [IRR: 1.37; 95% CI = 1.16–1.62], and baseball/softball [IRR: 1.25; 95% CI = 1.02–1.52]). Compared with boys, girls had higher overuse injury rates during practice (IRR: 1.50; 95% CI = 1.36–1.66), which was consistent across all sports. Likewise, the rate of overuse injuries during competition was higher among girls than boys (IRR: 1.30; 95% CI = 1.10–1.53), which was consistent for soccer and basketball but showed no difference in baseball/softball. After excluding sprains and strains from analyses, the rate of overuse injuries during practice (IRR: 1.49; 95% CI = 1.32–1.68) and competition (IRR: 1.30; 95% CI = 1.06–1.60) remained higher among girls than boys.

Body Site, Time Loss, and Diagnosis

Although most overuse injuries in soccer (83.9% in boys' soccer and 90.0% in girls' soccer) and basketball (77.0% in boys' basketball and 80.5% in girls' basketball) occurred to a lower extremity, baseball and softball overuse injuries primarily involved an upper extremity (72.5% in boys' baseball and 53.7% in girls' softball; Figure C). Compared with girls, boys were equally likely to sustain an overuse injury to a lower extremity (versus another body site) in soccer or basketball; however, boys were at an increased risk of sustaining an overuse injury to an upper extremity (versus another body site) in baseball/softball (IPR: 1.35; 95% CI = 1.16–1.57) compared with girls. After excluding sprains and strains, these relationships remained the same for soccer, basketball, and baseball/softball.

Across all 6 sports studied, most high school athletes returned to their sport less than 1 week after an overuse injury diagnosis (Figure D). Comparing girls' softball with boys' baseball overuse injuries, the proportion of girls returning to play within less than 1 week of injury (60.4%) was higher than that for boys (43.7%; IPR: 1.38; 95% CI = 1.15–1.65; following exclusion of sprains and strains, IPR: 1.49; 95% CI = 1.17–1.89). In addition, the proportion of girls returning to play in greater than 3 weeks (3.4%) was lower than for boys (10.6%; IPR: 0.32; 95% CI = 0.15–0.70); however, statistical significance was lost following the exclusion of sprains and strains. No statistically significant gender differences in the time to return to play were found for soccer or basketball.

Table 1. Number of Reported and Estimated Overuse Injuries by Gender and by Academic Year, Sport, Class Year, and Event Type

Variable	Boys			Girls		
	Number	National Estimate (%) ^a	95% CI	Number	National Estimate (%) ^a	95% CI
Academic year						
2006–2007	103	38 122 (9.6)	29 886–46 358	105	48 644 (9.5)	36 873–60 415
2007–2008	86	30 518 (7.7)	22 878–38 158	111	39 284 (7.7)	29 840–48 727
2008–2009	75	29 805 (7.5)	21 135–38 476	84	40 337 (7.9)	28 736–51 939
2009–2010	67	35 551 (8.9)	25 506–45 596	65	30 039 (5.9)	21 375–38 703
2010–2011	71	29 113 (7.3)	19 889–38 338	74	34 969 (6.9)	23 081–46 857
2011–2012	67	31 252 (7.8)	21 731–40 773	70	35 334 (6.9)	23 368–47 300
2012–2013	69	28 234 (7.1)	20 351–36 117	63	24 456 (4.8)	16 956–31 955
2013–2014	73	26 664 (6.7)	19 130–34 197	88	31 862 (6.2)	22 819–40 904
2014–2015	48	19 176 (4.8)	12 007–26 344	55	21 237 (4.2)	12 101–30 373
2015–2016	88	32 248 (8.1)	23 646–40 850	97	41 636 (8.2)	30 697–52 574
2016–2017	57	25 544 (6.4)	17 190–33 898	90	40 023 (7.8)	29 285–50 761
2017–2018	95	37 223 (9.3)	28 433–46 014	121	58 108 (11.4)	45 700–70 517
2018–2019	98	34 969 (8.8)	26 234–43 704	123	63 948 (12.5)	50 478–77 418
Sport						
Soccer	380	209 071 (52.5)	185 536–232 606	454	271 092 (53.2)	241 501–300 683
Basketball	267	77 135 (19.4)	67 352–86 917	380	101 794 (20.0)	90 955–112 634
Baseball/softball	350	112 213 (28.2)	99 611–124 815	312	136 990 (26.9)	119 615–154 364
Class year						
Freshman	211	87 960 (22.1)	73 818–102 102	336	148 914 (29.2)	128 543–169 285
Sophomore	229	92 951 (23.3)	78 467–107 436	291	119 985 (23.5)	102 662–137 307
Junior	263	109 126 (27.4)	93 528–124 724	259	118 699 (23.3)	100 156–137 242
Senior	277	101 318 (25.4)	86 898–115 737	234	106 074 (20.8)	89 025–123 122
Unknown	17	7064 (1.8)	3026–11 102	26	16 205 (3.2)	8139–24 271
Event type						
Competition	279	109 054 (27.4)	94 170–123 938	287	135 575 (26.6)	116 059–155 090
Practice	718	289 365 (72.6)	266 862–311 868	859	374 301 (73.4)	346 289–402 313
Total	997	398 419 (100.0)	374 639–422 198	1146	509 876 (100.0)	479 831–539 921

^a Column percentages may not add to 100.0% due to a rounding error.

Tendonitis was the most common diagnosis in 4 of the 6 sports (girls' soccer, 22.5%; boys' basketball, 25.4%; girls' basketball, 21.4%; and boys' baseball, 32.9%), followed by muscle strain (girls' soccer, 20.3%; boys' basketball, 17.8%; girls' basketball, 19.4%; and boys' baseball, 20.4%). However, in boys' soccer and girls' softball, muscle strain was more common (25.3% and 34.9%, respectively) than tendonitis (19.2% and 29.7%, respectively; Table 3).

Sport Activity and Position

The sport activities associated with overuse injury were similar for boys' and girls' soccer, with most injuries associated with general play (boys, 60.1%; girls, 65.6%), followed by conditioning (boys, 16.3%; girls, 18.0%). Like soccer, the sport activities associated with overuse injury were similar for boys' and girls' basketball, with most injuries associated with general play (boys, 63.3%; girls, 66.2%), followed by conditioning (boys, 11.9%, girls, 14.9%). Pitching (43.5%) was the most common activity in boys' baseball associated with overuse injury, and throwing (31.7%) was the most common activity in girls' softball. The pitcher position had the greatest percentage of overuse injuries for both genders (boys, 48.0%; girls, 21.6%), followed by catchers (boys, 10.6%; girls, 13.8%).

DISCUSSION

This study found that high school girls had higher overuse injury rates in soccer, basketball, and softball than boys participating in gender-comparable sports. These findings

did not change after a sensitivity analysis was performed by excluding overuse injury cases involving sprains and strains. Differences in anatomical, physiological, and psychological factors between girls and boys may play a role in the observed differences. Anatomical considerations for females that may increase their risk of overuse injuries include having shorter and smaller limbs, a wider pelvis resulting in an increased Q angle, increased general joint laxity, and decreased muscular strength.^{17–20} Other female factors include varying hormone levels and percentage of body fat compared with boys, a smaller heart size per body weight, and the female athlete triad (linking eating disorders, menstrual dysfunction, and osteoporosis).^{18,21,22} The higher rate of overuse injuries among girls in this study may also be attributable, in part, to girls being more likely than boys to report an overuse injury at the high school level.⁶ Further efforts are needed to develop and implement interventions tailored to male and female athletes that reduce risk factors and enhance protective factors to effectively prevent overuse injuries.

Although overuse injuries to a lower extremity were most common in both boys' and girls' soccer and basketball, overuse injuries to an upper extremity were most common in baseball/softball. These findings are consistent with previous reports and are influenced by the types of repetitive movements associated with the specific sport and player position.^{11,12} Thus, sport- and position-specific prevention strategies are needed. The 11+ (previously called the FIFA 11+) warm-up has been shown to reduce overall injury rates in soccer players 14 years and older.^{23,24} Another program, KIPP (Knee Injury Prevention

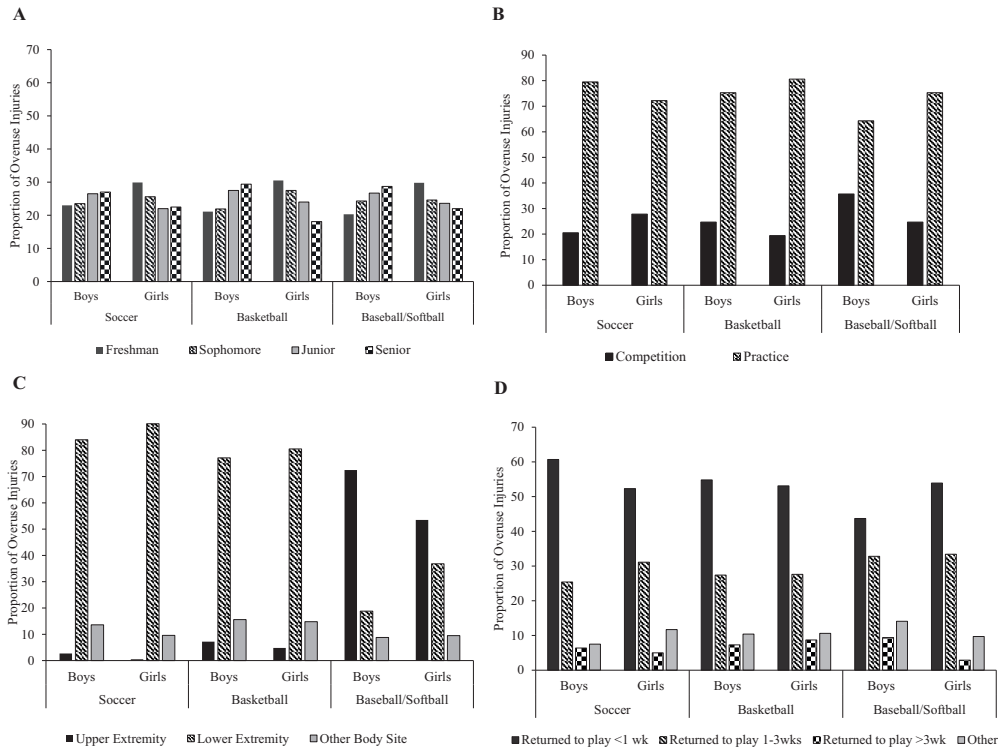


Figure. A, Proportion of overuse injuries by class year, gender, and sport. B, Proportion of overuse injuries by type of event, gender, and sport. C, Proportion of overuse injuries by body site of injury, gender, and sport. D, Proportion of overuse injuries by amount of time lost from sport participation, gender, and sport. Abbreviation: RTP, return to play.

Program), which focuses on coach education and provides a neuromuscular warm-up routine targeted at female youth injury prevention, also decreases noncontact overall and overuse lower limb injuries among adolescent female soccer and basketball

athletes.²³ Through increased use of programs like 11+ and KIPP, lower extremity overuse injuries could be reduced in high school soccer and basketball. Other potentially useful interventions include improving athlete flexibility, coordination,

Table 2. Injury Rates and Injury Rate Ratios by Gender and by Academic Year, Sport, and Event Type

Variable	Boys			Girls			Injury Rate Ratio (95% CI)
	Number	AEs ^a	Incidence Rate per 10 000 AEs ^a	Number	AEs ^a	Incidence Rate per 10 000 AEs ^a	
Academic year							
2006–2007	103	547 347	1.88	105	454 183	2.31	1.23 (0.94–1.61)
2007–2008	86	638 763	1.35	111	517 171	2.15	1.59 (1.20–2.11)
2008–2009	75	637 740	1.18	84	517 147	1.62	1.38 (1.01–1.89)
2009–2010	67	530 377	1.26	65	440 222	1.48	1.17 (0.83–1.64)
2010–2011	71	539 610	1.32	74	441 655	1.68	1.27 (0.92–1.76)
2011–2012	67	533 786	1.26	70	421 735	1.66	1.32 (0.95–1.85)
2012–2013	69	585 715	1.18	63	457 701	1.38	1.17 (0.83–1.64)
2013–2014	73	578 943	1.26	88	465 071	1.89	1.50 (1.11–2.07)
2014–2015	48	528 131	0.91	55	417 668	1.32	1.45 (0.98–2.13)
2015–2016	88	553 027	1.59	97	440 700	2.20	1.38 (1.04–1.85)
2016–2017	57	515 030	1.11	90	386 033	2.33	2.11 (1.51–2.94)
2017–2018	95	551 095	1.72	121	424 495	2.85	1.65 (1.26–2.16)
2018–2019	98	574 069	1.71	123	435 841	2.82	1.65 (1.27–2.16)
Sport							
Soccer	380	2 298 919	1.65	454	2 001 410	2.27	1.37 (1.20–1.57)
Basketball	267	2 806 929	0.95	380	2 189 892	1.74	1.82 (1.56–2.14)
Baseball/softball	350	2 207 785	1.59	312	1 628 320	1.92	1.21 (1.04–1.41)
Event type							
Competition	279	2 321 593	1.20	287	1 841 996	1.56	1.30 (1.10–1.53)
Practice	718	4 992 040	1.44	859	3 977 625	2.16	1.50 (1.36–1.66)
Total	997	7 313 633	13.63	1146	5 819 621	19.69	1.44 (1.33–1.57)

Abbreviation: AE, athletic exposure.

^a An AE is 1 student-athlete participating in 1 school-sanctioned practice or competition of the 6 selected sports.

Table 3. Overuse Injury Diagnosis by Sport and Gender

Diagnosis	Soccer		Basketball		Baseball/Softball	
	Boys n (%) ^a	Girls n (%) ^a	Boys n (%) ^a	Girls n (%) ^a	Boys n (%) ^a	Girls n (%) ^a
Bursitis	19 322 (9.4)	11 577 (4.3)	6 149 (8.0)	2 420 (2.4)	2 509 (2.2)	1 332 (1.0)
Inflammation	7 097 (3.4)	8 031 (3.0)	926 (1.2)	2 006 (2.0)	2 608 (2.3)	3 891 (2.8)
Stress fracture	14 017 (6.8)	28 112 (10.4)	6 664 (8.6)	11 711 (11.5)	5 775 (5.1)	1 130 (0.8)
Tendonitis	39 574 (19.2)	60 828 (22.5)	19 599 (25.4)	21 762 (21.4)	36 959 (32.9)	40 625 (29.7)
Apophysitis	2 653 (1.3)	4 268 (1.6)	1 410 (1.8)	351 (0.3)	1 875 (1.7)	1 535 (1.1)
Plantar fasciitis	4 701 (2.3)	1 892 (0.7)	470 (0.6)	1 377 (1.4)	188 (0.2)	258 (0.2)
Shin splints	11 219 (5.4)	24 818 (9.2)	2 069 (2.7)	7 071 (7.0)	809 (0.7)	1 937 (1.4)
Spondylolysis	741 (0.4)	61 (0.0)	1 357 (1.8)	0 (0.0)	281 (0.3)	460 (0.3)
Ligament sprain (any severity)	1 048 (0.5)	9 007 (3.3)	2 083 (2.7)	3 806 (3.7)	10 400 (9.3)	9 963 (7.3)
Muscle strain (any severity)	52 300 (25.3)	54 780 (20.3)	13 725 (17.8)	19 672 (19.4)	22 917 (20.4)	47 824 (34.9)
Tendon strain (any severity)	11 160 (5.4)	11 967 (4.4)	4 143 (5.4)	3 704 (3.6)	8 208 (7.3)	5 034 (3.6)
Other	42 643 (20.7)	54 683 (20.4)	18 539 (23.9)	27 784 (27.2)	19 683 (17.5)	23 000 (16.7)

^a Column percentages may not add to 100.0% because of a rounding error.

strength, and balance; being more aware of muscle fatigue and duration of playing time; and understanding an athlete's psychological state.²⁵⁻²⁸

The activities and player positions associated with overuse injury were similar across genders for soccer and basketball; however, this was not true for baseball/softball. When comparing boys' baseball and girls' softball, pitching was associated with overuse injuries among boys and throwing among girls; these findings are consistent with those described previously.²⁹ Possible explanations for this gender difference include pitch speed differences between boys and girls, overhand pitching in baseball versus underhand/windmill pitching in softball, how often individual athletes are pitching, and differences in musculoskeletal development and maturity between genders.²⁹ Among baseball pitchers specifically, possible factors associated with upper extremity overuse injury are pitching mechanics, pitch types, and pitch counts.^{30,31} Many of the preventive measures in youth baseball apply to high school baseball as well, including pitch count limits, strengthening and stretching programs, use of protective gear, and continuation of proper mechanics.^{24,25}

The estimated number of overuse injuries generally increased with increasing class year for boys but decreased with increasing class year for girls. The reason for this difference in distribution is unknown. It is possible that more boys, but fewer girls, stay involved in sports through the upper classes. Our findings are supported by the report from Canadian Women & Sport, which shows that girls' participation in sports drops off sharply during the teen years. By their late teens, 1 in 3 girls who used to play sports have quit, compared with just 1 in 10 boys. This gender difference persists into adulthood.³² Thus, the retention of girls in sport is a critical concern and requires collective efforts from girls, parents, coaches, and society.

Study Limitations

This study has some limitations. (1) The High School RIO sample was limited to high schools with ATs; therefore, our results may not be generalizable to high schools without ATs. (2) Some overuse injuries may not have been included in this study because they did not result in time loss from sport participation, thus potentially leading to an underreported number of injuries. There is also potential for misclassification of overuse injuries. (3) The definition of an overuse injury used

in this study agrees with that in the study by Ritzer et al³ but may be subject to potential misclassification and/or differ from other studies, which can make comparisons of findings more difficult. (4) Because overuse injuries are gradual in onset, the characteristics described in this study for these injuries represent those that existed at the moment that the injury was recognized and documented. This "snapshot" of the injury provides useful information but cannot fully describe the dynamic nature of these injuries. (5) We were unable to adjust for some potential covariates, such as height, weight, type of shoes, and training load, because of database limitations. Therefore, our results may be biased due to uncontrolled confounding factors. (6) Although data for additional sports that are predisposed to overuse injuries, such as track and field sports and swimming, are included in High School RIO, they are not able to be extrapolated to national estimates and therefore were not included in this study. Therefore, our results may not be representative of overuse injuries in those sports. Despite these limitations, High School RIO is a high-quality database that has been the basis for more than 100 peer-reviewed publications.

CONCLUSIONS

When comparing gender across sports, girls were more likely to sustain an overuse injury than boys. For both genders, soccer accounted for the most overuse injuries, followed by baseball/softball and then basketball. The estimated number of overuse injuries generally increased with increasing class year for boys but decreased with increasing class year for girls. Gender differences in soccer, basketball, and baseball/softball observed in this study can help guide future strategies that are more specific to gender and sport to reduce overuse injuries among high school athletes.

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FINANCIAL DISCLOSURES

We declare that we have no conflicts of interest.

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