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Epidemiology of Overuse Injuries in US Secondary School Athletics From 2014–2015 to 2018–2019 Using the National Athletic Treatment, Injury and Outcomes Network Surveillance Program

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Context: With 8 million annual US high school student-athletes, the epidemiology of sport-related injuries has garnered significant interest. The most recent studies examining overuse injury rates in high school sports were based on data from 2012 to 2013 and, therefore, may not reflect current overuse injury rates in high school sports.

Objective: To (1) determine overuse time-loss (TL) and non–time-loss (NTL) injury rates among high school student-athletes using National Athletic Treatment, Injury and Outcomes Network Surveillance Program (NATION-SP) data collected from 2014–2015 to 2018–2019 and (2) compare overuse injury rates based on student-athlete sex defined by whether it was a boys' sport or a girls' sport, the sport itself, and the injury location.

Design: Descriptive epidemiology study.

Setting: Online injury surveillance from 211 high schools (345 individual years of high school data).

Patients or Other Participants: Athletes who participated in secondary school–sponsored boys' or girls' sports.

Main Outcome Measure(s): Boys' and girls' overuse injury data from the NATION-SP during the 2014–2015 to 2018–2019 school years were analyzed. Overuse injuries were identified using a combination of the reported injury mechanism and diagnosis. Time-loss injuries resulted in restriction from participation beyond the day of injury; NTL injuries did not result in restriction from participation beyond the day of injury or involved no lost time due to the injury. Injury counts, rates, and rate ratios (IRRs) were reported with 95% CIs.

Results: The total overuse injury rate was 5.3/10 000 athlete-exposures (AEs; 95% CI = 5.1, 5.7), the NTL overuse injury rate was 3.4/10 000 AEs (95% CI = 3.1, 3.6), and the TL overuse injury rate was 2.0/10 000 AEs (95% CI = 1.8, 2.2). The overuse injury rate was greater in girls' sports compared with boys' sports (IRR = 1.9; 95% CI = 1.7, 2.1). The highest rates of overuse injury were observed in girls' cross-country (19.2/10 000 AEs; 95% CI = 15.0, 24.2), girls' track and field (16.0/10 000 AEs; 95% CI = 13.5, 18.8), and girls' field hockey (15.1/10 000 AEs; 95% CI = 10.2, 21.6). Overuse injury rates were higher for the lower extremity than the upper extremity (IRR = 5.7; 95% CI = 4.9, 6.7) and for the lower extremity than the trunk and spine (IRR = 8.9; 95% CI = 7.3, 10.8).

Conclusions: Awareness of the overuse injury risk, as well as prevention and intervention recommendations, is necessary and should be specifically targeted at cross-country, field hockey, and track and field athletes.

Key Words: high school athletes, injury surveillance, time-loss injuries, non–time-loss injuries

Key Points

- Using National Athletic Treatment, Injury and Outcomes Network Surveillance Program data collected from 2014–2015 through 2018–2019, we found that non–time-loss overuse injuries represented a significant burden of the total overuse injury rates observed among high school athletes.
- Overuse injury rates were greater in girls' sports compared with boys' sports and for the lower extremity compared with the upper extremity. With respect to sport, overuse injuries were most frequent in girls' cross-country, girls' track and field, girls' field hockey, and boys' lacrosse.

An estimated 12 million student-athletes between the ages of 5 and 22 sustain a sport-related injury annually, leading to an estimated 20 million lost days of school and generating approximately $33 billion in injury-related medical costs.[1] With nearly 8 million annual participants in US high school athletics, the epidemiology of sport-related injuries in high school athletics has garnered significant research interest.[2] Large-scale injury-surveillance systems such as the National Athletic Treatment, Injury and Outcomes Network Surveillance Program (NATION-SP) and the High School Reporting Information Online (HS-RIO) database allow injury rates to be investigated in national samples of high school athletes.[3] The authors[4–11] of previous large-scale epidemiologic studies of injury at the high school level have typically focused on examining general sport-related injuries, rates of

common injuries such as sport-related concussions or ankle sprains, or injury rates in specific sports.

To our knowledge, only 3 groups[12–14] have specifically focused on the epidemiology of overuse injuries in high school athletes; however, the data used for these analyses were collected before 2014. Researchers[13,14] in 2 studies used data from the HS-RIO database to examine overuse injury rates in high school sports over 6- and 7-year periods ending in 2011–2012 and 2012–2013, respectively. They reported that overuse injury rates were higher among girls than boys and greatest in girls' track and field and girls' cross-country; the lower extremity and lower leg were the most commonly injured sites.[13,14] However, these studies included only *time-loss (TL) overuse injuries*, which were defined as those resulting in the participant missing $\geq$1 day of sport participation. *Non–time-loss (NTL) injuries*, which were defined as those resulting in the participant missing $<$1 day of sport participation, represented a significant proportion of all sport-related injuries and were therefore important to include in order to determine the total burden of overuse injuries in high school athletics.[15] The NATION-SP reporting system, which was implemented after those investigations, also included NTL injuries, which may have better represented the total burden of overuse injuries in high school sports.[15] Additionally, the lack of a consensus definition for overuse injury made comparisons among various injury-surveillance systems difficult.[16]

Thus, the purpose of our study was to describe overuse TL and NTL injury rates among high school student-athletes using NATION-SP data collected over 5 consecutive school years (2014–2015 to 2018–2019). A secondary purpose was to compare overuse injury rates based on the sport sex (ie, whether it was a boys' sport or a girls' sport), the sports themselves, and the injury location. We hypothesized that total overuse rates would be greater in girls' sports than in boys' sports and would differ between injury types (TL versus NTL) and among injury locations.

METHODS

Participants

The NATION-SP project received approval from the Western Institutional Review Board. The NATION-SP was developed by the Datalys Center for Sports Injury Research and Prevention, Inc (NATION, Datalys Center), and implemented in 2011.[17] Over the course of the 2014–2015 through 2018–2019 school years, the NATION-SP documented TL and NTL injuries from a total of 211 high schools (345 individual years of high school data). We examined 23 high school sports during preseason, regular season, and postseason competitions and practices: 12 boys' sports (baseball, basketball, cross-country, football, ice hockey, lacrosse, soccer, swimming, tennis, track and field, volleyball, and wrestling) and 11 girls' sports (basketball, cross-country, field hockey, gymnastics, lacrosse, softball, soccer, swimming, tennis, track and field, and volleyball).

Instrumentation

The NATION-SP relied on a convenience sample of US high schools with access to athletic trainers (ATs) via a rolling recruitment model.[3] The ATs at participating schools could be on staff either full time or part time, and they volunteered to contribute data through electronic medical records systems.[3] Common data elements among available systems were deidentified and sent to the Datalys Center using secure data-transmission protocols.[3] A reportable *injury* was defined as one that occurred as a result of participation in an organized high school–sanctioned athletic event for a school-sponsored sport and required attention from an AT or physician, regardless of time loss.[3] The ATs completed detailed reports on each injury, including the type of injury, severity, mechanism, and session type (practice or competition).[3] Information about each competition and practice was also recorded, including the number of athletes participating.[3] The ATs were able to view and update records over the course of an academic year.[3] The NATION-SP was compliant with the Health Insurance Portability and Accountability Act (HIPAA) and the Federal Educational Rights and Privacy Act (FERPA).[3] Complete methods and quality control procedures have been described previously.[3]

Definitions

Athlete-Exposures. An athlete-exposure (AE) was defined as 1 player's participation in 1 high school–sanctioned practice or competition.

Injuries. All injuries that occurred during a sanctioned practice or competition and were evaluated by an AT, physician, or other health care professional were included in this study.[3] A TL injury resulted in restriction from participation beyond the day of injury; an NTL injury either did not result in restriction from participation beyond the day of injury or resulted in no lost time due to the injury.[3]

Overuse Injuries. For the NATION-SP reporting system, ATs were not instructed how to document "overuse" and were not provided with a definition for overuse injuries during their training. Therefore, as did earlier authors,[13,16] we defined *overuse injuries* as injuries for which the mechanism was recorded by the AT as overuse or gradual onset. We then used that definition to include or exclude injuries that may not have been accurately recorded as overuse due to the limitations of the NATION reporting system. For example, to capture overuse injuries that might have been missed due to this singular inclusion criterion, we also included injuries that listed no apparent contact as the injury mechanism and had a chronic injury category (eg, arthritis, avascular necrosis, bursitis, capsulitis, cartilage injury, chondromalacia, compartment syndrome, dislocation [chronic]), effusion, entrapment/impingement, exostosis, stress fracture, inflammation, myositis ossificans, osteochondritis, subluxation, synovitis, tendinosis, tendinitis, and tenosynovitis), as had been reported previously.[12] The primary investigator (E.G.P.) manually checked the records of all injuries that met these criteria for the diagnosis and basic mechanism. We also manually reviewed all injuries with a mechanism of overuse or gradual onset in order to remove those that were clearly not overuse injuries: all joint sprains, muscle tears, illnesses, general medical conditions, abrasions, contusions, and concussions.

Table 1. Total and Sport Sex-Specific Overuse Injury Count and Athlete-Exposures

Sport	Overuse Injuries, No.			Total AEs, No.	Injury Rate Per 10 000 Athlete-Exposures (95% CI)			Injury Rate Ratio, NTL vs TL Injuries (95% CI)
	Total	TL	NTL		Total	TL	NTL	
Total	1404	524	880	2 617 169	5.3 (5.1, 5.7)	2.0 (1.8, 2.2)	3.4 (3.1, 3.6)	1.7 (1.5, 1.9)
Sports (B)	691	274	417	1 692 924	4.1 (3.8, 4.4)	1.6 (1.4, 1.8)	2.5 (2.2, 2.7)	1.5 (1.3, 1.8)
Sports (G)	713	250	463	924 245	7.7 (7.2, 8.3)[a]	2.7 (2.4, 3.1)[a]	5.0 (4.6, 5.5)[a]	1.9 (1.6, 2.2)
Baseball (B)	59	23	36	133 556	4.4 (3.4, 5.7)	1.7 (1.1, 2.6)	2.7 (1.9, 3.7)	1.6 (0.9, 2.8)
Basketball (B)	96	36	60	317 230	3.0 (2.5, 3.7)	1.1 (0.8, 1.6)	1.9 (1.4, 2.4)	1.7 (1.1, 2.6)
Basketball (G)	80	29	51	215 244	3.7 (2.9, 4.6)	1.3 (0.9, 1.9)	2.4 (1.8, 3.1)	1.8 (1.1, 2.9)
Cross-country (B)	54	20	34	52 707	10.2 (7.7, 13.4)	3.8 (2.3, 5.9)	6.5 (4.5, 9.0)	1.7 (1.0, 3.1)
Cross-country (G)	71	30	41	37 016	19.2 (15.0, 24.2)	8.1 (5.5, 11.6)	11.1 (8.0, 15.0)	1.4 (0.8, 2.3)
Football (B)	229	89	140	706 836	3.2 (2.8, 3.7)	1.3 (1.0, 1.5)	1.9 (1.7, 2.3)	1.6 (1.2, 2.1)
Field hockey (G)	30	9	21	19 844	15.1 (10.2, 21.6)	4.5 (2.1, 8.6)	10.6 (6.6, 16.2)	2.3 (1.0, 5.8)
Gymnastics (G)	1	0	1	2686	3.7 (0.1, 2.1)	NA	3.7 (0.1, 2.1)	-
Ice hockey (B)	3	1	2	9954	3.0 (0.6, 8.8)	1.0 (0.0, 5.6)	2.0 (0.2, 7.3)	2.0 (0.1, 117.9)
Lacrosse (B)	38	17	21	49 246	7.7 (5.5, 10.6)	3.5 (2.0, 5.5)	4.3 (2.6, 6.5)	1.2 (0.6, 2.5)
Lacrosse (G)	117	40	77	119 316	9.8 (8.1, 11.8)	3.4 (2.4, 4.6)	6.5 (5.1, 8.1)	1.9 (1.3, 2.9)
Softball (G)	63	25	38	87 719	7.2 (5.5, 9.2)	2.9 (1.8, 4.2)	4.3 (3.1, 5.9)	1.5 (0.9, 2.6)
Soccer (B)	61	31	30	177 656	3.4 (2.6, 4.4)	1.7 (1.2, 2.5)	1.7 (1.1, 2.4)	0.9 (0.6, 1.6)
Soccer (G)	85	27	58	119 045	7.1 (5.7, 8.8)	2.3 (1.5, 3.3)	4.9 (3.7, 6.3)	2.1 (1.3, 3.5)
Swimming (B)	5	0	5	8167	6.1 (2.0, 14.3)	NA	6.1 (2.0, 14.3)	-
Swimming (G)	12	4	8	15 195	7.9 (4.1, 13.8)	2.6 (0.7, 6.7)	5.3 (2.3, 10.4)	2.0 (0.5, 9.1)
Tennis (B)	2	0	2	7019	2.8 (0.3, 10.3)	NA	2.8 (0.3, 10.3)	-
Tennis (G)	4	2	2	18 230	2.2 (0.6, 5.6)	1.1 (0.1, 3.9)	1.1 (0.1, 4.0)	-
Track and field (B)	101	42	59	107 204	9.4 (7.7, 11.4)	3.9 (2.8, 5.3)	5.5 (4.2, 7.1)	1.4 (0.9, 2.1)
Track and field (G)	149	65	84	93 301	16.0 (13.5, 18.8)	7.0 (5.4, 8.9)	9.0 (7.2, 11.1)	1.3 (0.9, 1.8)
Volleyball (B)	3	1	2	10 519	2.9 (0.6, 8.3)	1.0 (0.0, 5.3)	1.9 (0.2, 6.9)	2.0 (0.1, 117.9)
Volleyball (G)	101	19	82	196 649	5.1 (4.2, 6.2)	1.0 (0.6, 1.5)	4.2 (3.3, 5.2)	4.3 (2.5, 7.5)
Wrestling (B)	40	14	26	112 830	3.5 (2.5, 4.8)	1.2 (0.7, 2.1)	2.3 (1.5, 3.4)	1.8 (0.9, 3.8)

Abbreviations: B, boys; G, girls; NA, not applicable; NTL, non–time loss; TL, time loss.

[a] Different between girls' and boys' sports ($P < .05$).

Statistical Analysis

Injury rates and corresponding 95% CI were calculated for overuse injuries using the formula (number of overuse injuries/number of AEs) × 10 000. Injury rates overall were initially calculated by sport sex (ie, boys' sport or girls' sport) and by TL or NTL category. After this primary analysis, we examined injury rates over time (2014–2015, 2015–2016, 2016–2017, 2017–2018, and 2018–2019) for boys' and girls' sports. We classified the overuse injuries into 3 body region categories: lower extremity (LE), upper extremity (UE), and trunk and spine (TS). For these categories, we calculated the total overuse injury rate by sport sex and TL or NTL category. Additionally, injury rate ratios (IRRs) with 95% CIs were calculated for main comparisons of interest (boys' versus girls' sports, TL versus NTL). Frequencies were then calculated for the top 3 body parts and specific injury diagnoses for the main comparisons (boys' versus girls' sports, TL versus NTL, body region). All analyses were performed using SAS Enterprise Guide software (version 4.3; SAS Institute).

RESULTS

Comparison of Boys' and Girls' Sports

The total number of overuse injuries, total AEs, and overuse injury rates (total, TL, and NTL) with 95% CIs are provided in Table 1 for the overall sample and separately for each boys' and girls' sport. The total overuse injury rate was 5.3/10 000 AEs (95% CI = 5.1, 5.7) and was greater in girls' compared with boys' sports (girls = 7.7/10 000 AEs; 95% CI = 7.2, 8.3 versus boys = 4.1/10 000 AEs; 95% CI = 3.8, 4.4; IRR = 1.9; 95% CI = 1.7, 2.1). Similarly, injury rates were greater in girls' than in boys' sports for both TL (IRR = 1.7; 95% CI = 1.4, 2.0) and NTL (IRR = 2.0; 95% CI = 1.8, 2.3) overuse injuries.

The most frequent body parts injured and specific injury diagnoses by sport sex and TL are presented in Table 2. For both boys' and girls' sports, the 2 most common body parts injured were the lower leg (boys = 24.9%, girls = 31.7%), followed by the knee (boys = 20.5%, girls = 20.1%). The 2 most common specific diagnoses were also identical between boys' and girls' sports, with medial tibial stress syndrome the most frequently reported diagnosis (boys = 10.1%, girls = 18.0%), followed by patellar tendinitis (boys = 9.1%, girls = 8.3%).

Comparison of TL and NTL Injuries

For the overall sample, the NTL overuse injury rate was greater than the TL injury rate (NTL = 3.4/10 000 AEs; 95% CI = 3.1, 3.6 versus TL = 2.0/10 000 AEs; 95% CI = 1.8, 2.2; IRR = 1.7; 95% CI = 1.5, 1.9). Similarly, the NTL overuse injury rate was greater than the TL injury rate both for girls' sports overall (IRR = 1.9; 95% CI = 1.6, 2.2) and for boys' sports overall (IRR = 1.5; 95% CI = 1.3, 1.8).

The highest rates of overuse injury, regardless of sport sex, were reported in girls' cross-country (19.2/10 000 AEs; 95% CI = 15.0, 24.2), girls' track and field (16.0/10 000 AEs; 95% CI = 13.5, 18.8), and girls' field hockey (15.1/10 000 AEs; 95% CI = 10.2, 21.6; Table 1). Among boys' sports, the overuse injury rate was greatest in cross-country (10.2/10 000 AEs; 95% CI = 7.7, 13.4), track and field (9.4/10 000 AEs; 95% CI = 7.7, 11.4), and lacrosse (7.7/10 000

Table 2. Most Frequent Body Parts Injured and Specific Injury Diagnoses

Injuries (Total)	Recurrence, Frequency, No. (%)		
	Most Frequent	Second Most Frequent	Third Most Frequent
Body part			
Girls (713)	Lower leg = 226 (31.7)	Knee = 143 (20.1)	Thigh = 83 (11.6)
Boys (691)	Lower leg = 172 (24.9)	Knee = 142 (20.5)	Shoulder = 77 (11.1)
Time loss (524)	Lower leg = 140 (26.7)	Knee = 95 (18.1)	Thigh = 84 (16.0)
Non–time loss (880)	Lower leg = 262 (29.8)	Knee = 194 (22.0)	Shoulder = 102 (11.6)
Specific diagnosis			
Girls (713)	MTSS = 128 (18.0)	Patellar tendinitis = 59 (8.3)	PFPS = 33 (4.6)
Boys (691)	MTSS = 70 (10.1)	Patellar tendinitis = 63 (9.1)	Rotator cuff tendinitis = 30 (4.3)
Time loss (524)	PFPS = 64 (12.2)	Achilles tendinitis = 38 (7.3)	MTSS = 34 (6.4)
Non–time loss (880)	MTSS = 164 (18.6)	Patellar tendinitis = 114 (12.9)	Rotator cuff tendinitis = 30 (3.4)
Specific lower extremity diagnosis			
Girls (573)	MTSS = 128 (22.3)	Patellar tendinitis = 59 (10.3)	PFPS = 33 (5.8)
Boys (517)	MTSS = 70 (13.5)	Patellar tendinitis = 63 (12.2)	Achilles tendinitis = 30 (5.8)
Specific upper extremity diagnosis			
Girls (85)	Rotator cuff tendinitis = 21 (24.7)	Shoulder impingement = 12 (14.1)	Multidirectional instability = 8 (9.4)
Boys (106)	Rotator cuff tendinitis = 24 (22.6)	Biceps tendinitis = 13 (12.2)	Shoulder impingement = 10 (9.4)
Specific trunk or spine diagnosis			
Girls (55)	Low back pain[a] = 23 (41.8)	Sacroiliac dysfunction = 10 (18.2)	Paralumbar muscle strain = 10 (18.2)
Boys (68)	Low back pain[a] = 22 (32.3)	Paralumbar muscle strain = 13 (19.1)	Pars stress fracture or reaction = 6 (8.8)

Abbreviations: MTSS, medial tibial stress syndrome (shin splints); NTL, non–time loss; PFPS, patellofemoral pain syndrome; TL, time loss.

[a] Nonspecific or mechanical.

AEs; 95% CI = 5.5, 10.6; Table 1). The NTL overuse injury rate was greater than the TL overuse injury rate in boys' and girls' basketball, boys' cross-country, boys' football, girls' field hockey, girls' lacrosse, girls' soccer, and girls' volleyball. It is important to note that no sport demonstrated a TL overuse injury rate that was greater than the NTL overuse injury rate (Table 1).

The 3 most common body parts sustaining TL injuries were the lower leg (26.7%), knee (18.1%), and thigh (16.0%; Table 2). The 3 most frequent body parts sustaining NTL injuries were nearly identical, with the lower leg most common (29.8%), followed by the knee (22.0%), and then the shoulder (11.6%). For TL injuries, patellofemoral pain syndrome was the most frequent specific diagnosis (12.2%), followed by Achilles tendinitis (7.3%) and medial tibial stress syndrome (6.4%). For NTL injuries, medial tibial stress syndrome was the most common specific diagnosis (18.6%), followed by patellar tendinitis (12.9%) and rotator cuff tendinitis (3.4%).

Comparison of Body Regions

Overuse injury rates (total and by sport sex) by body region are presented in Table 3. Overall, overuse injury rates were highest for the LE compared with the UE and TS (LE = 4.2/10 000 AEs; 95% CI = 3.9, 4.4 versus UE = 0.8/10 000 AEs; 95% CI = 0.6, 0.8; IRR = 5.7; 95% CI = 4.9, 6.7 and LE = 4.2/10 000 AEs; 95% CI = 3.9, 4.4 versus TS = 0.5/10 000 AEs; 95% CI = 0.4, 0.6; IRR = 8.9, 95% CI = 7.3, 10.8), respectively. Additionally, the overuse injury rate was higher for UE than TS (UE = 0.8/10 000 AEs; 95% CI = 0.6, 0.8 versus TS = 0.5/10 000 AEs; 95% CI = 0.4, 0.6; IRR = 1.6; 95% CI = 1.2, 2.0). Total overuse injury rates were greater in girls' sports compared with boys' sports for LE (IRR = 2.0; 95% CI = 1.8, 2.3), UE (IRR = 1.5; 95% CI = 1.1, 1.9), and TS (IRR = 1.5; 95% CI = 1.1, 2.1) injuries. The NTL overuse injury rate was greater than the TL injury rate for LE (IRR = 1.4; 95% CI = 1.3, 1.6), UE (IRR = 3.5; 95% CI = 2.5, 5.1), and TS (IRR = 2.5; 95% CI = 1.7, 3.8) injuries.

The 2 most common specific LE diagnoses were identical for boys' and girls' sports: medial tibial stress syndrome (boys = 13.5%, girls = 22.3%), followed by patellar tendinitis (boys = 12.2%, girls = 10.3%). For the UE, rotator cuff tendinitis was the most frequent diagnosis for both boys' (22.6%) and girls' (24.7%) sports. Finally, nonspecific low back pain was the most common specific TS diagnosis for both boys' (32.3%) and girls' (41.8%) sports.

DISCUSSION

Our findings provide important information regarding how overuse injuries affect high school-aged athletes in both boys' and girls' sports. Consistent with previous results, greater overuse injury rates were observed in girls' sports compared with boys' sports. The LE was more consistently affected than the UE and TS. Lastly, the sports most affected by overuse injuries were cross-country, track and field, field hockey, and lacrosse. Understanding the scope of overuse injuries and how they affect players is critical to preventing these injuries among high school athletes.

To our knowledge, this is the first research examining overuse injury rates in the high school sport setting using the most recent available injury-surveillance data (2014–2015 through 2018–2019) that includes both TL and NTL injuries. Among the high school athletes in this study, both the TL overuse injury rate (2.0 per 10 000 AEs) and the NTL overuse injury rate (3.4 per 10 000 AEs) were greater than rates reported in earlier investigations[13,14] of TL injuries only. Using HS-RIO data, which consists of only TL injuries, both Roos et al[13] and Schroeder et al[14] assessed overuse injury rates in high school sports over a 6- to 7-year year time period ending in 2012 and 2013 and noted rates of 1.64 per 10 000 AEs and 1.50 per 10 000 AEs, respectively. These rates are similar to the TL overuse

Table 3. Total and Sport Sex Overuse Injury Rates by Body Region

Body Region	Injury Rate Per 10 000 Athlete-Exposures (95% CI)			Injury Rate Ratio: Non–Time-Loss vs Time-Loss Injuries (95% CI)
	Total	Time Loss	Non–Time Loss	
Lower extremity				
Total	4.2 (3.9, 4.4)[a,b]	1.7 (1.6, 1.9)	2.5 (2.3, 2.7)	1.4 (1.3, 1.6)
Girls	6.2 (5.7, 6.7)[c]	2.5 (2.2, 2.8)	3.7 (3.3, 4.1)	1.5 (1.3, 1.8)
Boys	3.1 (3.0, 3.3)	1.3 (1.1, 1.5)	1.8 (1.6, 2.0)	1.4 (1.1, 1.6)
Upper extremity				
Total	0.8 (0.6, 0.8)	0.2 (0.1, 0.3)	0.6 (0.5, 0.7)	3.5 (2.5, 5.1)
Girls	0.9 (0.7, 1.4)[c]	0.1 (0.01, 0.2)	0.8 (0.6, 1.0)	7.5 (3.9, 16.3)
Boys	0.6 (0.5, 0.8)	0.2 (0.1, 0.3)	0.4 (0.3, 0.5)	2.3 (1.5, 3.6)
Trunk or spine				
Total	0.5 (0.4, 0.6)	0.2 (0.01, 0.3)	0.3 (0.2, 0.4)	2.5 (1.7, 3.8)
Girls	0.6 (0.4, 0.8)[c]	0.1 (0.01, 0.2)	0.5 (0.3, 0.6)	4.0 (2.0, 8.6)
Boys	0.4 (0.3, 0.5)	0.1 (0.01, 0.2)	0.3 (0.2, 0.4)	1.8 (1.1, 3.2)

[a] Difference between the lower extremity and upper extremity ($P < .05$).
[b] Difference between the lower extremity and trunk or spine ($P < .05$).
[c] Difference between girls' and boys' sports ($P < .05$).

injury rate we captured but much lower than the total overuse injury rate, which includes NTL injuries. This suggests that NTL overuse injuries may be more prevalent in this population, which has not been identified previously.

We believe several explanations are possible for the different overuse injury rates observed between our study and the earlier research. First, the lack of a consensus definition makes overuse injuries difficult to capture accurately. Our definition may have included more injuries than previous studies due to differences in how overuse injuries were defined and reported in different injury-surveillance systems. For example, we included injuries that listed *no apparent contact* as the mechanism and had a specific diagnosis that was chronic in nature but excluded injuries reported as overuse that were clearly not overuse. Second, in contrast to earlier authors, we included both TL and NTL injuries, which may explain our increased overuse injury rate. Therefore, the different injury definitions and data-collection procedures between our study and the previous research makes it difficult to compare "apples with apples" and highlights the need for greater consensus regarding documentation of overuse injuries.

Our overuse injury rate in our research was greater among girls (7.7/10 000 AEs) compared with boys (4.1/10 000 AEs), for an IRR of 1.9. This finding agrees with consistent results at the high school and collegiate level that overuse injury rates were greater in female sports compared with male sports, even when only sex-matched sports were examined.[13,14] Girls were also more likely than boys to have higher rates of certain overuse injuries, such as anterior knee pain.[18] We determined that overuse injury rates specifically of the LE were 2 times greater in girls' sports than in boys' sports (IRR = 2.0). Potential reasons for these differences may include training volume, sport specialization practices, and biomechanics.[19–21] For example, a number of authors have described increased rates of sport specialization among female athletes versus male athletes,[22,23] and sport specialization has been identified as a risk factor for overuse injury.[24] However, the causes of these injuries are most likely multifactorial.

Similar to earlier investigators, the highest rates of overuse injuries in our data were among cross-country, track and field, and field hockey athletes. Roos et al[13] observed that cross-country and track and field were the sports with the highest rates of overuse injury, in both collegiate and high school athletes. Similarly, Schroeder et al[14] noted that girls' track and field and field hockey had the greatest overuse injury rates in high school student-athletes. We also found that the LE was the most common site of overuse injuries compared with the UE and TS, which was similar to the results of Roos et al[13] and Schroeder et al.[14] For example, Schroeder et al[14] reported that 69.5% of all overuse injuries were LE injuries, compared with only 14.3% to the UE and 10.7% to the low back/spine/pelvis. Taken together, these outcomes suggest that sports with a highly repetitive and lower extremity–specific movement profile present a greater risk for overuse injury.

Several recommendations to reduce the risk of overuse injuries among youth athletes have been developed as a result of growing concern regarding the association of early sport specialization and increased overuse injury.[25,26] These include not participating in a single sport for >8 months during the year, on multiple teams at the same time, or in a single sport for more hours per week than the athlete's age.[25,26] However, approximately 80% of coaches and parents indicated no awareness of any of these recommendations.[27,28] We suggest that dissemination of these recommendations should be targeted at the specific sports that place athletes at greater risk of overuse injury, particularly girls' cross-country, girls' track and field, girls' field hockey, boys' cross-country, boys' track and field, and boys' lacrosse. Athlete education regarding the risks of excessive and repetitive sport volume with the goal of reducing overuse injury rates may be beneficial for these athletes due to their increased overuse injury risk profile.[29,30]

Our study had several limitations. First, as mentioned previously, overuse injuries are difficult to capture accurately due to the lack of a consensus definition.[16,31] As an example, for the NATION-SP, ATs are not instructed how to document *overuse*, and the term is not defined during training. This limitation required us to include or exclude injuries based on their mechanism and also based on our mechanism and injury diagnosis. For instance, we

chose to categorize certain diagnoses (such as subluxation) that were accompanied by a mechanism of no apparent contact as overuse injuries. Differences in data-collection procedures among injury-surveillance programs make it difficult to compare results with previous research on the topic and highlight the importance of developing consensus regarding the documentation of overuse injuries. Additionally, the database used to capture these injuries requires that injuries be reported to the AT for entry in the system. Therefore, it is possible that only the most severe overuse injuries were reported to ATs and a proportion of overuse injuries might have been missed. However, both TL and NTL injuries are documented in NATION-SP, and we examined both in order to fully capture the burden of overuse injuries in high school athletics. Secondary school ATs who did not track injuries or did not provide rehabilitative services were not included. The NATION-SP relies on a convenience sample of ATs. Thus, our findings may not be generalizable to schools without access to an AT or to all US high school athletes. Nonetheless, these large networks serve as a valuable resource for exploring trends over time.

CONCLUSIONS

Using NATION-SP data collected over 5 consecutive school years (2014–2015 through 2018–2019), we found that NTL overuse injuries represented a significant burden of the total overuse injury rates observed among high school athletes. Overuse injury rates were greater in female athletes compared with male athletes and for the lower extremity compared with the upper extremity and were greatest in girls' cross-country, girls' track and field, girls' field hockey, and boys' lacrosse. Awareness of the overuse injury risk among all stakeholders in the athletic health care team is important for reducing injury rates. Additionally, injury-prevention and -intervention recommendations are needed and should be specifically targeted at cross-country, track and field, and field hockey athletes.

REFERENCES

1. Simon JE, Wikstrom EA, Grooms DR, Docherty CL, Dompier TP, Kerr ZY. Athletic training service characteristics for patients with ankle sprains sustained during high school athletics. *J Athl Train*. 2019;54(6):676–683. doi:10.4085/1062-6050-449-16
2. High school sports participation increases for 29th consecutive year. National Federation of State High School Associations. Published 2018. Accessed September 4, 2018. https://www.nfhs.org/articles/high-school-sports-participation-increases-for-29th-consecutive-year/
3. Morris SN, Chandran A, Wasserman EB, Quetant SL, Robison HJ, Collins C. Methods of the National Athletic Treatment, Injury and Outcomes Network Surveillance Program (NATION-SP), 2014–2015 through 2018–2019. *J Athl Train*. 2021;56(5):529–533. doi:10.4085/284-20
4. Allen AN, Wasserman EB, Williams RM, et al. Epidemiology of secondary school boys' and girls' basketball injuries: National Athletic Treatment, Injury and Outcomes Network. *J Athl Train*. 2019;54(11):1179–1186. doi:10.4085/1062-6050-330-18
5. Clifton DR, Hertel J, Onate JA, et al. The first decade of web-based sports injury surveillance: descriptive epidemiology of injuries in US high school girls' basketball (2005–2006 through 2013–2014) and National Collegiate Athletic Association women's basketball (2004–2005 through 2013–2014). *J Athl Train*. 2018;53(11):1037–1048. doi:10.4085/1062-6050-150-17
6. Clifton DR, Onate JA, Hertel J, et al. The first decade of web-based sports injury surveillance: descriptive epidemiology of injuries in US high school boys' basketball (2005–2006 through 2013–2014) and National Collegiate Athletic Association men's basketball (2004–2005 through 2013–2014). *J Athl Train*. 2018;53(11):1025–1036. doi:10.4085/1062-6050-148-17
7. Kerr ZY, Gregory AJ, Wosmek J, et al. The first decade of web-based sports injury surveillance: descriptive epidemiology of injuries in US high school girls' volleyball (2005–2006 through 2013–2014) and National Collegiate Athletic Association women's volleyball (2004–2005 through 2013–2014). *J Athl Train*. 2018;53(10):926–937. doi:10.4085/1062-6050-162-17
8. Wasserman EB, Sauers EL, Register-Mihalik JK, et al. The first decade of web-based sports injury surveillance: descriptive epidemiology of injuries in US high school boys' baseball (2005–2006 through 2013–2014) and National Collegiate Athletic Association men's baseball (2004–2005 through 2013–2014). *J Athl Train*. 2019;54(2):198–211. doi:10.4085/1062-6050-239-17
9. Rosenthal JA, Foraker RE, Collins CL, Comstock RD. National high school athlete concussion rates from 2005–2006 to 2011–2012. *Am J Sports Med*. 2014;42(7):1710–1715. doi:10.1177/0363546514530091
10. Fernandez WG, Yard EE, Comstock RD. Epidemiology of lower extremity injuries among U.S. high school athletes. *Acad Emerg Med*. 2007;14(7):641–645. doi:10.1197/j.aem.2007.03.1354
11. Reeser JC, Gregory A, Berg RL, Comstock RD. A comparison of women's collegiate and girls' high school volleyball injury data collected prospectively over a 4-year period. *Sports Health*. 2015;7(6):504–510. doi:10.1177/1941738115600143
12. Morris K, Simon JE, Grooms DR, Starkey C, Dompier TP, Kerr ZY. The epidemiology of overuse conditions in youth football and high school football players. *J Athl Train*. 2017;52(10):976–981. doi:10.4085/1062-6050-52.10.04
13. Roos KG, Marshall SW, Kerr ZY, et al. Epidemiology of overuse injuries in collegiate and high school athletics in the United States. *Am J Sports Med*. 2015;43(7):1790–1797. doi:10.1177/0363546515580790
14. Schroeder AN, Comstock RD, Collins CL, Everhart J, Flanigan D, Best TM. Epidemiology of overuse injuries among high-school athletes in the United States. *J Pediatr*. 2015;166(3):600–606. doi:10.1016/j.jpeds.2014.09.037
15. Kerr ZY, Dompier TP, Dalton SL, Miller SJ, Hayden R, Marshall SW. Methods and descriptive epidemiology of services provided by athletic trainers in high schools: The National Athletic Treatment, Injury and Outcomes Network study. *J Athl Train*. 2015;50(12):1310–1318. doi:10.4085/1062-6050-51.1.08
16. Roos KG, Marshall SW. Definition and usage of the term "overuse injury" in the US high school and collegiate sport epidemiology literature: a systematic review. *Sport Med*. 2014;44(3):405–421. doi:10.1007/s40279-013-0124-z
17. Dompier TP, Marshall SW, Kerr ZY, Hayden R. The National Athletic Treatment, Injury and Outcomes Network (NATION): methods of the surveillance program, 2011–2012 through 2013–2014. *J Athl Train*. 2015;50(8):862–869. doi:10.4085/1062-6050-50.5.04
18. Hall R, Barber Foss K, Hewett TE, Myer GD. Sport specialization's association with an increased risk of developing anterior knee pain in adolescent female athletes. *J Sport Rehabil*. 2015;24(1):31–35. doi:10.1123/jsr.2013-0101
19. Post EG, Biese KM, Schaefer DA, et al. Sport-specific associations of specialization and sex with overuse injury in youth athletes. *Sports Health*. 2020;12(1):36–42. doi:10.1177/1941738119886855
20. DiCesare CA, Montalvo A, Foss KDB, et al. Sport specialization and coordination differences in multisport adolescent female

basketball, soccer, and volleyball athletes. *J Athl Train*. 2019;54(10):1105–1114. doi:10.4085/1062-6050-407-18
21. Mendiguchia J, Ford KR, Quatman CE, Alentorn-Geli E, Hewett TE. Sex differences in proximal control of the knee joint. *Sports Med*. 2011;41(7):541–557. doi:10.2165/11589140-000000000-00000
22. Rugg CM, Coughlan MJ, Li JN, Hame SL, Feeley BT. Early sport specialization among former National Collegiate Athletic Association athletes: trends, scholarship attainment, injury, and attrition. *Am J Sports Med*. 2021;49(4):1049–1058. doi:10.1177/0363546520988727
23. Biese KM, Post EG, Schaefer DA, et al. Evaluation of adolescent sport specialization and injury mechanism by sex: a secondary analysis. *J Sci Med Sport*. 2020;23(8):721–725. doi:10.1016/j.jsams.2020.01.012
24. Bell DR, Post EG, Biese K, Bay C, Valovich McLeod T. Sport specialization and risk of overuse injuries: a systematic review with meta-analysis. *Pediatrics*. 2018;142(3):e20180657. doi:10.1542/peds.2018-0657
25. LaPrade RF, Agel J, Baker J, et al. AOSSM early sport specialization consensus statement. *Orthop J Sport Med*. 2016;4(4):2325967116644241. doi:10.1177/2325967116644241
26. Jayanthi N, Pinkham C, Dugas L, Patrick B, Labella C. Sports specialization in young athletes: evidence-based recommendations. *Sports Health*. 2013;5(3):251–257. doi:10.1177/1941738112464626
27. Post EG, Trigsted SM, Schaefer DA, et al. Knowledge, attitudes, and beliefs of youth sports coaches regarding sport volume recommendations and sport specialization. *J Strength Cond Res*. 2020;34(10):2911–2919. doi:10.1519/JSC.0000000000002529
28. Bell DR, Post EG, Trigsted SM, Schaefer DA, McGuine TA, Brooks MA. Parents' awareness and perceptions of sport specialization and injury prevention recommendations. *Clin J Sport Med*. 2018;30(6):539–543. doi:10.1097/JSM.0000000000000648
29. Brenner JS; American Academy of Pediatrics Council on Sports Medicine and Fitness. Overuse injuries, overtraining, and burnout in child and adolescent athletes. *Pediatrics*. 2007;119(6):1242–1245. doi:10.1542/peds.2007-0887
30. Valovich McLeod TC, Decoster LC, Loud KJ, et al. National Athletic Trainers' Association position statement: prevention of pediatric overuse injuries. *J Athl Train*. 2011;46(2):206–220. doi:10.4085/1062-6050-46.2.206
31. Roos KG, Kucera KL, Golightly YM, Myers JB, Rosamond WD, Marshall SW. Variability in the identification and reporting of overuse injuries among sports injury surveillance data collectors. *Athl Train Sports Health Care*. 2019;11(3):143–146. doi:10.3928/19425864-20190214-01

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