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Epidemiology of Injuries Requiring Emergency Transport Among Collegiate and High School Student-Athletes

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Context: Data regarding the epidemiology of emergency-transport incidents (ETIs) of patients with sport-related injuries are lacking. Understanding the use of emergency services by athletic trainers can help improve emergency preparedness and prehospital care for injured student-athletes.

Objective: To determine the frequencies and types of ETIs resulting from athletic participation.

Design: Descriptive epidemiology study.

Setting: Participating colleges and high schools during 2009–2010 to 2014–2015 and 2011–2012 to 2013–2014, respectively.

Patients or Other Participants: Student-athletes in 23 high school and 25 intercollegiate sports.

Main Outcome Measure(s): Data on injuries requiring emergency transport were collected by each team's athletic trainer via their respective online injury-tracking software. Athletic trainers also collected data on athlete-exposures (AEs). Emergency-transport incident frequencies and injury rates per 10 000 AEs with 95% confidence intervals (CIs) were reported. For each ETI, the sport, body part, injury mechanism, and final diagnosis were recorded.

Results: A total of 339 and 146 ETIs were reported in collegiate and high school players, respectively. Collegiate women's ice hockey had the highest ETI rate (1.28/10 000 AEs; 95% CI = 0.71, 1.86). In high school, football had the highest rate at 0.80 per 10 000 AEs (95% CI = 0.64, 0.97). Athletes with head or face injuries required the most transports in college (n = 71, 20.9%) and high school (n = 33, 22.6%) across all sports. Strains (n = 50, 14.7%) and fractures (n = 35, 24.0%) were the leading diagnoses for patients undergoing transport in college and high school, respectively.

Conclusions: Athletic trainers should maintain a high level of emergency preparedness when working with sports that have high rates and numbers of ETIs. Athletes with injuries to the head/face required the most frequent transport across competition levels. Athletic trainers should have the appropriate equipment and protocols in place to handle these patients. Future researchers should examine the differences between field and hospital diagnoses to help improve prehospital care and decrease the likelihood of unnecessary emergency transports.

Key Words: incidents, prehospital care, sports, football, concussions, hockey, strains, fractures

Key Points

- The proportion of emergency-transport incidents was higher at the collegiate level than at the high school level.
- Emergency-transport incidents occurred most frequently during competition and as a result of player contact in both competition levels.
- The highest rates of emergency-transport incidents at the collegiate level occurred in men's and women's ice hockey as well as men's wrestling; and at the high school level, in football, girls' gymnastics, and boys' wrestling.

According to the most recent data, more than 7 million student-athletes participated in high school athletics[1] and 480 000 in the National Collegiate Athletic Association (NCAA).[2] The risk of injury accompanies participation in any sport and at any level. When injuries do occur, an athletic trainer (AT) is often the first health care provider on the scene to provide initial care.[3–6] If the AT determines the patient needs immediate access to a higher level of care, he or she calls for emergency medical services (EMS) to transport the patient as instructed by the emergency action plan developed for the site.[3]

Decoster et al[7] found that ATs in the high school setting activated EMS significantly more frequently than in the collegiate setting; however, this study was a self-reported retrospective survey and may not accurately reflect each clinical setting. Little information is available on the use of EMS by ATs, despite studies[8–11] examining patients with severe and catastrophic injuries who may have necessitated emergency transport. The National Center for Catastrophic Sports Injury Research demonstrated that the majority of direct catastrophic injuries (ie, those resulting directly from sport participation) were to the head and neck (70%). Additionally, cardiac (69%) and heat-related (10%) events comprised the majority of indirect catastrophic events (ie, those resulting from systemic failure as a result of exertion while participating in a sport activity).[11] Further, 14% of patients with life-threatening injuries who presented to the emergency department (ED) cited sport participation as the cause.[12] Few epidemiologic studies have addressed severe injuries (ie, resulting in >21 days lost from sport participation) across multiple sports at the collegiate[9] and high school[8] levels. High school student-athletes had a lower rate of severe injuries than their collegiate counterparts. Sprains, strains, and fractures were commonly reported as being severe in nature or having undergone evaluation in the ED.[8,9,13] It is important to note that, although an injury may be considered severe, we cannot assume that the athlete would have required transportation by EMS, as few of the aforementioned studies included this information.

Among the general public, the frequent use of EMS transportation for nonemergent conditions is problematic because fewer ambulance units are then available when a true medical emergency arises, delaying appropriate prehospital care.[14] Previous researchers[14,15] have shown that individuals who were not classified as having "true medical emergencies" frequently used EMS. Many of these individuals had an alternative means of transportation but still chose to be transported by EMSs. When an AT is available, student-athletes have the advantage of a medical professional who can determine if EMS transport is necessary. The National Athletic Trainers' Association has published position statements[3,16,17] regarding the recognition and management of emergent conditions and emergency planning in athletics, but more epidemiologic data are needed to support and further develop these guidelines to prevent unnecessary ambulance transports and determine a safe means of alternative transportation when possible. These findings demonstrate the need for research analyzing emergency transports across settings.

At this time, no authors have published epidemiologic studies that examined the use of EMS transportation resulting from athletic injuries, nor have these incidents been compared across competition levels. The purpose of our study was to (1) estimate emergency-transport incident (ETI) rates by sport, (2) determine patterns of ETIs based on event type, body part, injury mechanism, or final diagnosis at hospital discharge, and (3) directly compare ETIs between collegiate and high school athletes.

METHODS

Data Collection

For this prospective epidemiologic study, we used data that were collected as part of 2 larger independent injury-surveillance programs. These programs, operated by the Datalys Center for Sports Injury Research and Prevention, Inc (Indianapolis, IN), are the National Athletic Treatment, Injury and Outcomes Network (NATION) and the NCAA Injury Surveillance Program (ISP). The NATION captures data reported by ATs working in the high school setting, while the ISP captures data reported by ATs working at colleges and universities within the NCAA. A descriptive epidemiology design was used to report ETIs that occurred in 23 high school sports and 25 collegiate sports. Although both surveillance systems captured additional sports, we opted to exclude such sports due to low injury counts. All sports included were the same, except that men's and women's ice hockey data were captured only in the NCAA-ISP. Both programs used the same common data elements (ie, injury diagnosis and exposure information) with slight variations for setting and level of competition.

Each competition level was distinct and included its own individual teams. During the 2011–2012 through 2013–2014 seasons, the NATION system consisted of 147 secondary school programs that provided 1845 team-seasons of data. During the 2009–2010 through 2014–2015 seasons, the NCAA system consisted of 166 institutions that provided 2048 team-seasons of data.

Methods of each surveillance program have been previously described.[18,19] Deidentified injury and exposure information was reported by ATs using an export application that extracts common data elements from electronic medical records.[18] Commonly used by ATs in sports medicine settings, these electronic injury-documentation applications include the Athletic Trainer System (Keffer Development, Grove City, PA), Injury Surveillance Tool (Datalys Center), and Sports Injury Monitoring System (FlanTech, Iowa City, IA). This approach allowed ATs to document injuries as part of their normal clinical practice, thus eliminating the need to enter data more than once.

Procedures

Participating ATs recorded data on athlete-exposures (AEs) and injuries. An *AE* was defined as 1 athlete participating in 1 team-sanctioned game or practice.[18–20] A reportable *injury* was an injury that occurred as a result of participation in an organized practice or game and required attention from a health care provider (eg, AT, physician). Athletic trainers could denote whether an injury was an ETI; that is, an injury in which the local EMS transported the player from the athletic location. For each ETI event, ATs recorded the sport played, event type, body part (ie, knee, neck), injury mechanism (ie, player contact, surface contact), and final diagnosis (ie, concussion, strain). Data were reviewed via both automated and manual quality-control processes before inclusion in the research database. An automated verification engine reviewed the imported information and flagged invalid data. Quality-control staff then worked with the participating ATs to correct any errors before the data were entered into the research database.[18]

Statistical Analysis

Data were analyzed in 2016 using SAS-Enterprise Guide software (version 5.4; SAS Institute Inc, Cary,

Table 1. Counts and Incidence Rates of Injuries Requiring Emergency Transport Among Collegiate and High School Student-Athletes[a]

Sport	College		High School	
	All Reported Sport Injuries, No. (%)	Incidence Rate/10 000 Athlete-Exposures (95% Confidence Interval)	All Reported Sport Injuries, No. (%)	Incidence Rate/10 000 Athlete-Exposures (95% Confidence Interval)
Men's or boys' baseball	11 (1.1)	0.49 (0.20, 0.78)	3 (0.3)	0.14 (0.00, 0.31)
Men's or boys' basketball	16 (0.7)	0.56 (0.29, 0.84)	7 (0.3)	0.19 (0.05, 0.33)
Men's or boys' cross country	2 (0.7)	0.35 (0.00, 0.82)	0 (0.0)	0.00
Men's or boys' football	121 (1.1)	1.08 (0.89, 1.27)	89 (0.5)	0.80 (0.64, 0.97)
Men's ice hockey[b]	44 (1.2)	1.09 (0.77, 1.41)	NA	NA
Men's or boys' lacrosse	16 (1.5)	0.80 (0.41, 1.20)	1 (0.1)	0.06 (0.00, 0.18)
Men's or boys' soccer	15 (1.0)	0.79 (0.39, 1.18)	7 (0.4)	0.34 (0.09, 0.58)
Men's or boys' swimming and diving	0 (0.0)	0.00	0 (0.0)	0.00
Men's or boys' tennis	0 (0.0)	0.00	0 (0.0)	0.00
Men's or boys' indoor track	1 (0.2)	0.06 (0.00, 0.19)	0 (0.0)	0.00
Men's or boys' outdoor track	4 (1.1)	0.38 (0.01, 0.75)	2 (0.1)	0.07 (0.00, 0.17)
Men's or boys' wrestling	11 (0.9)	1.10 (0.45, 1.75)	10 (0.4)	0.42 (0.16, 0.68)
Women's or girls' basketball	9 (0.6)	0.38 (0.13, 0.62)	8 (0.3)	0.28 (0.09, 0.47)
Women's or girls' cross country	1 (0.3)	0.18 (0.00, 0.54)	1 (0.1)	0.05 (0.00, 0.15)
Women's or girls' field hockey	1 (0.5)	0.21 (0.00, 0.62)	1 (0.1)	0.07 (0.00, 0.20)
Women's or girls' gymnastics	6 (1.2)	1.06 (0.21, 1.91)	2 (0.7)	0.66 (0.00, 1.58)
Women's ice hockey[b]	19 (2.0)	1.28 (0.71, 1.86)	NA	NA
Women's or girls' lacrosse	8 (1.1)	0.56 (0.17, 0.95)	1 (0.1)	0.10 (0.00, 0.29)
Women's or girls' soccer	24 (1.1)	0.90 (0.54, 1.26)	2 (0.1)	0.12 (0.00, 0.27)
Women's or girls' softball	13 (1.3)	0.62 (0.28, 0.96)	3 (0.3)	0.21 (0.00, 0.46)
Women's or girls' swimming and diving	1 (0.4)	0.06 (0.00, 0.19)	1 (0.6)	0.23 (0.00, 0.68)
Women's or girls' tennis	0 (0.0)	0.00	0 (0.0)	0.00
Women's or girls' indoor track	0 (0.0)	0.00	1 (0.1)	0.06 (0.00, 0.17)
Women's or girls' outdoor track	2 (0.5)	0.22 (0.00, 0.52)	5 (0.3)	0.23 (0.03, 0.43)
Women's or girls' volleyball	14 (1.1)	0.71 (0.34, 1.07)	2 (0.1)	0.07 (0.00, 0.16)
Men's or boys' sports total[c]	109 (1.0)	0.61 (0.50, 0.73)	20 (0.2)	0.11 (0.06, 0.16)
Women's or girls' sports total[c]	77 (0.9)	0.51 (0.40, 0.62)	22 (0.2)	0.16 (0.09, 0.22)
Overall total	339 (1.0)	0.70 (0.63, 0.78)	146 (0.3)	0.29 (0.24, 0.33)

Abbreviation: NA, not applicable.

[a] Collegiate data originated from the National Collegiate Athletic Association Injury Surveillance Program (2009–2010 through 2014–2015) and high school data from the National Athletic Treatment, Injury and Outcomes Network (2011–2012 through 2013–2014).

[b] National Athletic Treatment, Injury and Outcomes Network data did not include boys' or girls' ice hockey.

[c] Only included sports in which both sexes participated (ie, baseball or softball, basketball, cross-country, ice hockey, lacrosse, soccer, swimming and diving, tennis, indoor track, and outdoor track).

NC). Descriptive analyses included the calculation of injury frequencies, proportions, and rates per 10 000 AEs for sport, event type, body part, injury mechanism, and diagnosis. Comparative analysis across competition levels included injury rate ratios (IRRs) and injury proportion ratios (IPRs). An IRR was selected to examine if the occurrence of an ETI per unit of person-time (in this study, AE) differed between the 2 groups (high school versus college). An IPR examined how the distribution of the occurrences in total may have differed between the 2 groups. Because we were concerned that the distributions of ETIs in football may have varied from those in other sports and could have potentially confounded our effect estimates, we analyzed all sports (including football), football only, and all other sports (excluding football). The IRRs and IPRs with 95% confidence intervals (CIs) not including 1.00 were considered significant. The NATION protocol was reviewed and approved by the Western Institutional Review Board (Puyallup, WA); the NCAA-ISP protocol was reviewed and approved by the NCAA Research Review Board (Indianapolis, IN).

RESULTS

Counts and Injury Rates

During the study period, 339 ETIs were reported in college and 146 were reported in high school (Table 1). Athletes with injuries that required emergency transport accounted for 1% and 0.3% of all injuries reported in college and high school, respectively. This proportion was higher at the collegiate level than at the high school level (IPR = 3.24; 95% CI = 2.67, 3.93).

The collegiate sports with the highest incidence rates of ETIs were women's ice hockey (1.28/10 000 AEs), men's wrestling (1.10/10 000 AEs), and men's ice hockey (1.09/10 000 AEs; Table 1). The high school sports with the highest incidence rates of ETIs were football (0.80/10 000 AEs), girls' gymnastics (0.66/10 000 AEs), and boys' wrestling (0.42/10 000 AEs). Overall, among sex-comparable sports, no sex differences were found in collegiate (IRR = 1.19; 95% CI = 0.89, 1.60) or high school (IRR = 0.70; 95% CI = 0.38, 1.28) athletes.

Table 2. Counts of Injuries Requiring Emergency Transport Among Collegiate and High School Student-Athletes by Body Part Injured[a]

Body Part Injured	College, No. (%)			High School, No. (%)			College Versus High School Injury Proportion Ratio (95% CI)		
	Football	All Other Sports	All Sports	Football	All Other Sports	All Sports	Football	All Other Sports	All Sports
Ankle	4 (3.3)	17 (7.8)	21 (6.2)	13 (14.6)	3 (5.3)	16 (11.0)	0.23 (0.08, 0.67)[b]	1.48 (0.45, 4.88)	0.57 (0.3, 1.05)
Arm/elbow	4 (3.3)	11 (5.0)	15 (4.4)	11 (12.4)	4 (7.0)	15 (10.3)	0.27 (0.09, 0.81)[b]	0.72 (0.24, 2.17)	0.43 (0.22, 0.86)[b]
Foot	0	5 (2.3)	5 (1.5)	2 (2.2)	1 (1.8)	3 (2.1)	NA	1.31 (0.16, 10.97)	0.72 (0.17, 2.96)
Hand/wrist	12 (9.9)	13 (6.0)	25 (7.4)	7 (7.9)	0	7 (4.8)	1.26 (0.52, 3.07)	NA	1.54 (0.68, 3.48)
Head/face	16 (13.2)	55 (25.2)	71 (20.9)	16 (18.0)	17 (29.8)	33 (22.6)	0.74 (0.39, 1.39)	0.85 (0.53, 1.34)	0.93 (0.64, 1.33)
Hip/groin	3 (2.5)	7 (3.2)	10 (2.9)	0	0	0	NA	NA	NA
Knee	14 (11.6)	6 (2.8)	20 (5.9)	8 (9.0)	7 (12.3)	15 (10.3)	1.29 (0.56, 2.94)	0.22 (0.08, 0.64)[b]	0.57 (0.3, 1.09)
Lower leg	3 (2.5)	18 (8.3)	21 (6.2)	6 (6.7)	5 (8.8)	11 (7.5)	0.37 (0.09, 1.43)	0.94 (0.37, 2.43)	0.82 (0.41, 1.66)
Neck	26 (21.5)	17 (7.8)	43 (12.7)	10 (11.2)	7 (12.3)	17 (11.6)	1.91 (0.97, 3.76)	0.63 (0.28, 1.46)	1.09 (0.64, 1.85)
Shoulder	4 (3.3)	13 (6.0)	17 (5.0)	7 (7.9)	3 (5.3)	10 (6.8)	0.42 (0.13, 1.39)	1.13 (0.33, 3.84)	0.73 (0.34, 1.56)
Thigh	5 (4.1)	9 (4.1)	14 (4.1)	2 (2.2)	0	2 (1.4)	1.84 (0.37, 9.26)	NA	3.01 (0.69, 13.1)
Trunk	13 (10.7)	25 (11.5)	38 (11.2)	1 (1.1)	3 (5.3)	4 (2.7)	9.56 (1.27, 71.76)	2.18 (0.68, 6.96)	4.09 (1.49, 11.25)
Systemic conditions	17 (14.0)	22 (10.1)	39 (11.5)	6 (6.7)	7 (12.3)	13 (8.9)	2.08 (0.86, 5.07)	0.82 (0.37, 1.83)	1.29 (0.71, 2.35)
Total	121 (100.0)	218 (100.0)	339 (100.0)	89 (100.0)	57 (100.0)	146 (100.0)	NA	NA	NA

Abbreviations: CI, confidence interval; NA, not applicable.

[a] Collegiate data originated from the National Collegiate Athletic Association Injury Surveillance Program (2009–2010 through 2014–2015) and high school data from the National Athletic Treatment, Injury and Outcomes Network (2011–2012 through 2013–2014).

[b] Statistically significant 95% CI.

Event Type

The highest frequencies of ETIs occurred during competitions in collegiate (n = 196, 57.8%) and high school (n = 78, 53.4%) players. The ETI rates were higher for competitions than practices at both the collegiate (2.16 versus 0.36/10 000 AEs; IRR = 6.06; 95% CI = 4.88, 7.52) and high school (0.75 versus 0.17/10 000 AEs; IRR = 4.41; 95% CI = 3.19, 6.11) levels.

Body Part Injured

The most commonly injured body part among ETIs in both collegiate and high school players was the head and face (college = 71, 20.9%; high school = 33, 22.6%), followed by the neck (college = 43, 12.7%; high school = 17, 11.6%; Table 2). However, in collegiate football, the most frequently injured body part among ETIs was the neck (n = 26, 21.5%). A larger proportion of ETIs involved the trunk in college than in high school (IPR = 4.09; 95% CI = 1.49, 11.25).

Injury Mechanism

Player contact was the leading mechanism of injury for ETIs in all collegiate and high school players (college = 141, 41.6%; high school = 80, 54.8%; Table 4). The proportion of ETIs due to player contact was smaller in college than in high school (IPR = 0.76; 95% CI = 0.63, 0.92). Surface contact was the second most frequent mechanism of injury at both levels (college = 56, 16.5%; high school = 20, 13.7%). Also, the proportion of ETIs resulting from ball/puck contact was larger in college than in high school (IPR = 4.31; 95% CI = 1.34, 13.89).

Diagnosis

Among collegiate athletes, the most often cited diagnosis for ETIs was strain (n = 50, 14.7%), but strains were also typical among high school athletes (n = 18, 12.3%; Table 3). Of the 50 ETIs diagnosed as strains in collegiate players, the majority were to the neck (n = 21), followed by the thigh (n = 10) and hip or groin (n = 6). Of the 18 ETIs diagnosed as strains in high school athletes, the majority were to the neck (n = 14), followed by the knee (n = 3). All neck strains at both levels were specifically diagnosed as *cervical strain/whiplash*.

In high school sports, the most common diagnosis among ETIs was fracture (n = 35, 24.0%; Table 3). Fractures accounted for 13.9% of ETIs at the collegiate level, a smaller proportion than at the high school level (IPR = 0.58; 95% CI = 0.39, 0.86). Of the 47 ETIs diagnosed as fractures in collegiate athletes, the largest proportion was to the lower leg (n = 10), followed by the trunk (n = 9), head and face (n = 8), and arm and elbow (n = 7). Of the 35 ETIs diagnosed as fractures in high school athletes, the largest proportion was to the lower leg (n = 9), followed by the arm and elbow (n = 3).

Concussion was a frequent diagnosis in ETIs at both levels (college = 49, 14.5%; high school = 24, 16.4%). Although not seen as often, heat-related events accounted for 5.6% of ETIs in collegiate sports and 4.1% among high school sports. Heat-related events resulting in ETIs were reported as heat cramps, [isolated] dehydration, heat syncope, heat exhaustion, and [exertional] heat hyponatremia; none were reported as exertional heat stroke (EHS).

Table 3. Counts of Injuries Requiring Emergency Transport Among Collegiate and High School Student-Athletes by Diagnosis[a]

	College, No. (%)			High School, No. (%)			College Versus High School Injury Proportion Ratio (95% CI)		
Diagnosis	Football	All Other Sports	All Sports	Football	All Other Sports	All Sports	Football	All Other Sports	All Sports
Concussion	15 (12.4)	34 (15.6)	49 (14.5)	15 (16.9)	9 (15.8)	24 (16.4)	0.74 (0.38, 1.42)	0.99 (0.5, 1.94)	0.88 (0.56, 1.38)
Contusion	8 (6.6)	27 (12.4)	35 (10.3)	0	0	0	NA	NA	NA
Dislocation	12 (9.9)	15 (6.9)	27 (8.0)	11 (12.4)	5 (8.8)	16 (11.0)	0.8 (0.37, 1.73)	0.78 (0.3, 2.07)	0.73 (0.4, 1.31)
Fracture	10 (8.3)	37 (17.0)	47 (13.9)	23 (25.8)	12 (21.1)	35 (24.0)	0.32 (0.16, 0.64)[b]	0.81 (0.45, 1.44)	0.58 (0.39, 0.86)[b]
Heat-related event	9 (7.4)	10 (4.6)	19 (5.6)	4 (4.5)	2 (3.5)	6 (4.1)	1.65 (0.53, 5.2)	1.31 (0.29, 5.8)	1.36 (0.56, 3.34)
Inflammatory condition	0	4 (1.8)	4 (1.2)	1 (1.1)	1 (1.8)	2 (1.4)	NA	1.05 (0.12, 9.18)	0.86 (0.16, 4.65)
Laceration	1 (0.8)	11 (5.0)	12 (3.5)	3 (3.4)	3 (5.3)	6 (4.1)	0.25 (0.03, 2.32)	0.96 (0.28, 3.32)	0.86 (0.33, 2.25)
Nervous system injury	7 (5.8)	4 (1.8)	11 (3.2)	0	0	0	NA	NA	NA
Sprain	12 (9.9)	17 (7.8)	29 (8.6)	9 (10.1)	6 (10.5)	15 (10.3)	0.98 (0.43, 2.23)	0.74 (0.31, 1.79)	0.83 (0.46, 1.51)
Strain	23 (19.0)	27 (12.4)	50 (14.7)	11 (12.4)	7 (12.3)	18 (12.3)	1.54 (0.79, 2.99)	1.01 (0.46, 2.2)	1.2 (0.72, 1.98)
Stress fracture	0	1 (0.5)	1 (0.3)	0	0	0	NA	NA	NA
Subluxation	1 (0.8)	1 (0.5)	2 (0.6)	0	1 (1.8)	1 (0.7)	NA	0.26 (0.02, 4.12)	0.86 (0.08, 9.43)
Other	23 (19.0)	30 (13.8)	53 (15.6)	7 (7.9)	9 (15.8)	16 (11.0)	2.42 (1.09, 5.38)	0.87 (0.44, 1.73)	1.43 (0.84, 2.41)
Total	121 (100.0)	218 (100.0)	339 (100.0)	89 (100.0)	57 (100.0)	146 (100.0)	NA	NA	NA

Abbreviations: CI, confidence interval; NA, not applicable.

[a] Collegiate data originated from the National Collegiate Athletic Association Injury Surveillance Program (2009–2010 through 2014–2015) and high school data from the National Athletic Treatment, Injury and Outcomes Network (2011–2012 through 2013–2014).

[b] Statistically significant 95% CI.

Table 4. Counts of Injuries Requiring Emergency Transport Among Collegiate and High School Student-Athletes by Injury Mechanism[a]

	College, No. (%)			High School, No. (%)			Collegiate Versus High School Injury Proportion Ratio (95% CI)		
Injury Mechanism	Football	All Other Sports	All Sports	Football	All Other Sports	All Sports	Football	All Other Sports	All Sports
Ball/puck contact	3 (2.5)	27 (12.4)	30 (8.8)	0	3 (5.3)	3 (2.1)	NA	2.35 (0.74, 7.48)	4.31 (1.34, 13.89)[b]
Bat/stick contact	0	2 (0.9)	2 (0.6)	0	1 (1.8)	1 (0.7)	NA	0.52 (0.05, 5.67)	0.86 (0.08, 9.43)
Illness/Infection	6 (5.0)	11 (5.0)	17 (5.0)	3 (3.4)	0	3 (2.1)	1.47 (0.38, 5.72)	NA	2.44 (0.73, 8.2)
Noncontact	21 (17.4)	24 (11.0)	45 (13.3)	10 (11.2)	8 (14.0)	18 (12.3)	1.54 (0.77, 3.12)	0.78 (0.37, 1.65)	1.08 (0.65, 1.79)
Other contact	0	22 (10.1)	22 (6.5)	1 (1.1)	4 (7.0)	5 (3.4)	NA	1.44 (0.52, 4.01)	1.89 (0.73, 4.91)
Overuse	1 (0.8)	10 (4.6)	11 (3.2)	1 (1.1)	0	1 (0.7)	0.74 (0.05, 11.6)	NA	4.74 (0.62, 36.36)
Player contact	70 (57.9)	71 (32.6)	141 (41.6)	62 (69.7)	18 (31.6)	80 (54.8)	0.83 (0.68, 1.02)	1.03 (0.67, 1.58)	0.76 (0.63, 0.92)[b]
Surface contact	17 (14.0)	39 (17.9)	56 (16.5)	6 (6.7)	14 (24.6)	20 (13.7)	2.08 (0.86, 5.07)	0.73 (0.43, 1.25)	1.21 (0.75, 1.93)
Other/unknown	3 (2.5)	12 (5.5)	15 (4.4)	6 (6.7)	9 (15.8)	15 (10.3)	0.37 (0.09, 1.43)	0.35 (0.15, 0.79)[b]	0.43 (0.22, 0.86)[b]
Total	121 (100.0)	218 (100.0)	339 (100.0)	89 (100.0)	57 (100.0)	146 (100.0)	NA	NA	NA

Abbreviations: CI, confidence interval; NA, not applicable.

[a] Collegiate data originated from the National Collegiate Athletic Association Injury Surveillance Program (2009–2010 through 2014–2015) and high school data from the National Athletic Treatment, Injury and Outcomes Network (2011–2012 through 2013–2014).

[b] Statistically significant 95% CI.

Three cardiac-related ETIs were due to other cardiovascular disorder (n = 1) and arrhythmia (n = 2). Of these, none resulted in sudden cardiac arrest. The most common systemic conditions reported were cardiovascular conditions, psychological disorders, general illnesses, and injuries and illnesses affecting the respiratory system.

DISCUSSION

In our study, ETIs accounted for a small percentage of overall sport-related injuries. Collegiate athletes had a higher incidence rate of ETIs than high school athletes. Our findings differ from a retrospective survey[7] of ATs in which EMS was called more frequently in high school than in collegiate settings. The conflicting results may reflect our prospective analysis of actual injuries as opposed to self-reported data. Previous researchers[8,9] demonstrated a higher rate of severe injuries (ie, resulting in >21 days lost from sport participation) in collegiate than in high school athletes. When comparing event types, we found that ETI rates were higher during competitions than during practices in both settings. This finding was expected as earlier investigators[8,9,21,22] showed higher injury rates during competitions than during practices. Tracking ETIs as a part of injury surveillance can provide valuable information at the institutional level and aid in determining appropriate medical coverage and availability of emergency equipment.

Sports involving player contact had the highest ETI rates. The highest ETI rates were in collegiate women's ice hockey and men's wrestling, both of which had high rates of catastrophic injuries in previous research.[11] Wrestling and women's gymnastics also had higher rates of severe injuries than football at the collegiate level.[9] These results differ those of other studies[8,11,21,22] that showed football consistently had the highest overall injury rate at both competition levels as well as the highest rate of severe injuries in high school athletes. It is important for ATs, coaches, athletic administrators, and emergency personnel to recognize the high rates of severe and catastrophic injuries that can result in ETIs during sports and plan medical coverage accordingly, especially when 1 AT may be covering multiple high-risk sports with overlapping or concurrent seasons. In these situations, data may aid in justifying additional AT coverage for these events. Implementing policies and procedures that require appropriate medical coverage (ie, AT and EMS coverage) for high-risk events may be beneficial. For example, if an institution is hosting a wrestling tournament and a women's ice hockey game at the same time at different venues, the AT and administrators should have a policy in place specifying the medical coverage that will be provided for each event as well as what emergency equipment will be available. Standby EMS is an expensive and limited resource; however, an onsite EMS presence may reduce response times and increase access to care for patients with emergent conditions that occur as a result of sport participation.

Overall, the head and face was the most commonly injured body part across competition levels and sports, which is a new finding compared with previous work.[21,22] However, neck injuries in collegiate football comprised a larger percentage of ETIs than in all other sports at the collegiate and high school levels, another new finding.[23] The most frequent mechanisms of neck injuries are typical during football, and patients may initially present with more serious signs and symptoms warranting ETI. The majority of neck injuries in our study were diagnosed as strains. This may suggest that head and face or neck injuries were more likely to require an advanced level of care to rule out severe injury because these structures surround the central nervous system; therefore, a heightened index of suspicion exists for the AT when evaluating players with these injuries. Emergency medical personnel use evidence-based algorithms to evaluate patients with cervical spine injuries in the prehospital setting, effectively reducing unnecessary immobilization.[24–26] Not only should ATs be familiar with the National Athletic Trainers' Association recommendations,[16] but they should also understand the protocols used by their local EMS systems for cervical spine injuries to ensure proper continuity of care for the injured athlete and reduce the likelihood of unnecessary immobilization and transport. The best way to accomplish this is by including local EMS in the preparation and rehearsal of emergency actions plans. Including evidence-based algorithms in athletic training education may also be beneficial. Future researchers should examine the use of these cervical spine clearance protocols in the athletic setting.

Concussions accounted for 14.5% and 16.4% of collegiate and high school ETIs, respectively, which are larger proportions than have been previously reported in epidemiologic studies[27,28] of patients with sport-related injuries. Earlier authors have attributed high numbers of sport-related concussions to player contact, which was likely a contributing factor in our results as well.[28–30] The use of emergency transport for concussion injuries and specifically why the transport was deemed necessary (eg, deteriorating mental status, prolonged loss of consciousness, abnormal cranial nerve evaluation) should be further examined.

Strains and sprains are common injuries in athletes across competition levels[9,13,22,23,31,32]; however, they are not typically considered conditions necessitating emergency transport. In our study, strains were the leading diagnosis among ETIs in collegiate sports and the third leading diagnosis among ETIs in high school sports. Although this finding was initially surprising, strains composed 16.9% of severe injuries in collegiate athletes[9] and, in the current study, most frequently involved the neck. Strains and sprains also accounted for large proportions of injured players presenting to the ED due to sports.[13] In our protocol, an AT could update the diagnosis after the student-athlete was discharged from the hospital. It is possible for concomitant injuries to have occurred on the field (eg, both a dislocation and a strain), in which case both diagnoses would be recorded as ETIs; however, the more severe injury prompted the decision to call EMS. In this study, the frequency of strain diagnoses is understandable given that the majority were to the neck, for which ATs may be concerned about a more serious diagnosis and therefore recommend EMS transport as a precaution. Future researchers should examine strains to other body parts in athletes who were sent to the ED via EMS, as emergency transport for these injuries may not be necessary.

Fractures were the leading diagnosis for ETIs among high school players and the fourth most frequent among collegiate players. Our results concur with those of previous authors[13] who cited fractures as a frequent diagnosis in athletes presenting to the ED. The lower leg was the most commonly affected body part at both competition levels. In skeletally immature adolescents, bone failure occurs before injury to connected ligaments and tendons, putting adolescents at increased risk of sustaining a fracture.[33] This may explain why a larger proportion of ETIs in high school than in college were the result of fractures. Fractures warrant emergency transport if the distal neurovascular supply is compromised, an open wound or gross deformity is present, or compartment syndrome is suspected.[34] When patients did not meet these criteria, it is possible they were transported from the high school setting due to a lack of emergency equipment (ie, splints) or alternative transportation or because the parent or guardian preferred ambulance transport.

Our study highlights the need for further research on trunk injuries and heat illnesses resulting from athletic participation, even though they were not as common as the previously discussed injuries. Intra-abdominal injury and vital organ damage have been reported[35,36] as the causes of student-athlete deaths; however, few earlier investigators[37,38] described sport-related intra-abdominal injury rates. Crushing or internal injury is a frequent diagnosis resulting in hospitalization among patients with sport-related injuries reporting to the ED.[13] Given the potential for a life-threatening or sport-disqualifying injury to occur from trauma to this body region, it is paramount that ATs understand how to promptly recognize serious signs and symptoms and ensure quick access to higher-level care for diagnosis and management.

In one study,[11] heat-related events accounted for 10% of indirect catastrophic injuries. Although no EHS cases were reported to the surveillance systems, it is possible that these heat-related events, apart from exertional hyponatremia, could have been misdiagnosed. Signs and symptoms that accompany EHS (ie, altered mental status, core body temperature >40.5°C) warrant immediate and aggressive cooling via cold-water immersion, followed by EMS transport.[39–41] In previous research,[42] an exact heat-related diagnosis was not made in 52% of patients seen in the ED, indicating that health care providers struggled to diagnosis EHS accurately. Future authors should examine why ATs and EDs may continue to inappropriately or inaccurately diagnose heat injuries.[40,41] Cardiac conditions are a leading cause of catastrophic injuries,[11] yet we found only 3 ETIs, 2 of which involved the same student-athlete. More cardiac-related ETIs, including sudden cardiac arrests, may have occurred during the study time period but not been captured in our small sample. Even though cardiac conditions occur less frequently than others during athletic participation, ATs need to maintain and update their education to be confident in their ability to promptly recognize and manage these potentially life-threatening injuries.

Limitations

We examined only schools with access to certified ATs, so the results may not be generalizable to institutions that do not have access to an AT in their athletics programs. It is possible that having an AT present contributed to the overall low ETI rates in this study; however, our study did not directly examine the effect of AT coverage on the rate, proportion, or distribution of injuries requiring ETI. Previous studies[31,43,44] have shown ATs were able to manage and treat patients with less severe injuries without referral to the ED, and the presence of an AT has been associated with improved medical care of student-athletes. We did not consider other factors the AT must consider in his or her decision-making process (eg, the emotional stability of the athlete or the availability of alternative transportation), which may have resulted in an ETI for a nonemergent condition. Given the inability to ascertain a complete clinical picture for each ETI, we could not determine the proportion of ETIs that may not have required treatment in the ED. Because ATs had the opportunity to update the diagnosis after the athlete was discharged, the diagnosis given by the AT or team physician, if one was present at the time of the injury, is unknown. Future investigators should compare the AT's differential diagnoses with the final diagnosis and determine why the AT deemed emergency transport necessary. Athlete-exposures were unit based rather than time based, and they were not based on position played. Therefore, it was not possible to determine ETI rates by hours of sport participation or position.

CONCLUSIONS

Collegiate athletes had a higher rate of ETIs than their high school counterparts, with the majority of ETIs occurring during competition and resulting from player contact. Institutions need to ensure that appropriate coverage, including the on-scene presence of EMS, is being provided for high-risk sports, especially those involving contact and during competitions. Athletic trainers should also have the necessary equipment to handle patients with potentially emergent conditions, notably fractures, cervical spine injuries, cardiac emergencies, and EHS. Strategies aimed at reducing EMS transports for nonemergent conditions should be examined, including considering evidence-based cervical spine clearance protocols and ensuring that the rules and regulations of athletic play are properly enforced. Athletic trainers and EMS should maintain a strong working relationship to best prepare for ETIs when they occur and should develop appropriate emergency action plans. Future research on ETIs will contribute to improving the evaluation and prehospital care of athletic emergencies.

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