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Original Research

Characteristics of Injuries Occurring During Cross-Country: A Report from the Athletic Training Practice-Based Research Network

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Context: Cross-country is a popular sport activity, particularly in adolescent populations. Although epidemiologic investigations have provided insight into patient and injury characteristics associated with running injuries, little is known about how these injuries are managed at the point of care.

Objective: To describe injury and treatment characteristics of injuries sustained during cross-country.

Design: Cross-sectional study.

Setting: High school athletic training clinics within the Athletic Training Practice-Based Research Network.

Patients or Other Participants: Patient cases were included if the patient was diagnosed with an injury that occurred during interscholastic cross-country participation. All patients received usual care by an athletic trainer.

Main Outcome Measure(s): We used summary statistics to describe injury (sex, age, participation level, time of injury, mechanism of injury, body part, injury type, diagnosis) and treatment (type, amount, duration, number of services) characteristics.

Results: Most cross-country injuries occurred to the lower extremity and were musculotendinous or ligamentous in nature. The most common injury types were sprain/strain (43.8%), tendinopathy (18.5%), and general pain (9.5%). Injured body parts and diagnoses were typically similar between sexes. The most frequently used treatment was therapeutic exercises or activities (28.7%), and patients received an average of 7.4 ± 17.4 total athletic training services during 5.5 ± 15.1 episodes of care over 27.8 ± 87.5 days.

Conclusions: Adolescent cross-country student-athletes frequently sustained non–time-loss injuries that required up to 1 month of treatment and management. These findings will generate awareness surrounding the role of athletic trainers in providing care for cross-country athletes.

Key Words: running, adolescent athletes, non–time-loss injuries, practice characteristics

Key Points

- More than two-thirds of the injuries incurred by adolescent cross-country student-athletes resulted in no time loss.
- Continued participation by cross-country athletes after injury may contribute to a longer time spent receiving care.
- Athletic trainers should consider incorporating gait retraining when treating cross-country patients, especially for chronic injuries.

Running is a popular physical activity, particularly in adolescent athletes. In fact, cross-country running was ranked as the fourth and fifth most popular sport among American high school boys and girls, respectively.[1] Furthermore, approximately half a million adolescent athletes are estimated to participate in high school cross-country annually.[1] As with all sport activities, running is associated with many health benefits, but the risk of injury is also a concern.

For example, researchers who conducted a retrospective study[2] of musculoskeletal injuries in high school cross-country runners reported an overall incidence of 17.0/1000 athlete-exposures, with a higher rate in girls (19.6/1000 athlete-exposures) versus boys (15.0/1000 athlete-exposures). According to comparative data from collegiate and high school injury-reporting systems, the highest rates of overuse injuries were among womens' and girls' cross-country, followed by mens' and boys' cross-country.[3] Unlike acute injuries that may limit participation in sport, many athletes with overuse injuries continue to train, resulting in non–time-loss injuries that require ongoing evaluation and treatment by medical providers.

Despite the number of epidemiologic studies[3–5] in which researchers described injury rates in cross-country runners, data are limited regarding the treatment of these injuries, particularly in adolescent athletes. The few investigations of medical services have focused on those used by elite track and field athletes participating in an Olympic trial.[6] These medical services were reported generally and provided for a relatively short time (ie, 2 weeks), but athletes were treated for 3 ± 1.13 visits and most often obtained medical services from massage therapists or chiropractors, with athletic trainers (ATs) being the least used medical providers. In the secondary school setting, running athletes have greater access to ATs and may seek athletic training services for injuries and preventive treatments. In other studies from the Athletic Training Practice-Based Research Network (AT-PBRN), cross-country athletes accounted for 2.1% of daily patient encounters[7] and 4.8% and 1.7% of athletic training services provided to girl and boy runners, respectively.[8] Although cross-country athletes make up a relatively small percentage of all athletes who receive medical treatment, an understanding of the types of injuries and treatment characteristics associated with these injuries may offer insight into the athletic training services needed for adolescent athletes participating in cross-country. The purpose of our study was to describe the injury and treatment characteristics of injuries sustained during cross-country participation by high school athletes.

METHODS

Study Design

We conducted a retrospective analysis of deidentified patient records collected within the AT-PBRN. The AT-PBRN and its infrastructure have been described in detail in previous work, including its clinicians,[9] web-based electronic medical record (EMR; CORE-AT EMR),[9] data-collection processes,[8] and quality assurance procedures.[8] For the current study, data were collected at 104 clinical practice sites across 22 states (Arizona, California, Colorado, Delaware, Florida, Georgia, Indiana, Kansas, Massachusetts, Michigan, Minnesota, Missouri, New Hampshire, Oregon, Pennsylvania, Texas, Utah, Vermont, Virginia, Washington, Wisconsin, Wyoming) and Washington, DC. The A.T. Still University Institutional Review Board exempted the study because it was a retrospective analysis of unidentified patient records.

Patients

Patients who were diagnosed with an injury that occurred during cross-country participation between 2009 and 2019 were included in this study. An *injury* was defined as a condition diagnosed by an AT at a participating clinical practice site[10]; both time-loss (participation restriction for at least 24 hours) and non–time-loss (participation restriction for less than 24 hours)[11] injuries were included. All patients were secondary school athletes under the care of a certified AT within the AT-PBRN.

Data Collection

All data were collected using a web-based EMR (CORE-AT EMR) by an AT who was providing care within the AT-PBRN. Clinicians within the AT-PRBN use the EMR as a routine documentation system to record injury evaluations, daily treatment notes, and discharge summaries. Thus, for this study, we did not attempt to change the way clinicians diagnosed or treated patients. For data quality purposes, each AT was required to complete a formal training session[9] before using the EMR.

Data Extraction

We reviewed data from the injury demographics, injury evaluation, daily treatment, and discharge forms in the EMR. Following standard data-extraction procedures,[7–9] 1 member of the research team (A.N.M.) reviewed patient records from AT-PBRN clinical practice sites for the study period to ensure data integrity. In short, patient cases were first identified using the cross-country sport code and then, using the unique identifier (ie, injury identification number) of each patient case, all other patient case data were identified within the EMR database and extracted for analysis.

Instrumentation

The CORE-AT EMR (www.core-at.com) is a web-based EMR used by ATs within the AT-PBRN. The EMR, including its standards (eg, Health Insurance Portability and Accountability Act compliance, Safe Harbor Method) and major system components, has been described in detail.[8,9] The forms used to compile the extracted data have been described in previous investigations.[8,12] In brief, patient and injury characteristics were extracted from the injury demographic and injury evaluation forms. Treatment characteristics were extracted from the injury evaluation, daily treatment, and discharge forms.

Statistical Analysis

We used summary statistics (frequencies, percentages, means ± standard deviations [SDs], medians, and interquartile ranges [IQRs]) to describe patient (sex, age), injury (participation level, time of injury, mechanism of injury, body part, injury type, International Classification of Disease and Related Health Problems version 9 or 10 [ICD-9, ICD-10] codes), and treatment (type, amount, duration, and number of services) characteristics. Medians and IQRs were calculated due to the presence of outliers. Using previously reported definitions,[8,13] we defined *type of care* as the athletic training service provided (Current Procedural Terminology [CPT] codes), *amount of care* as the number of episodes of care (ie, visits to the athletic training facility) over the duration of care, and *duration of care* as the number of days from intake (completion of the injury demographics form) to the last documented episode of care. Shapiro-Wilk tests were significant for the amount of care, duration of care, and number of services between groups (non–time loss, time loss), indicating non-normally distributed data. Therefore, Mann-Whitney U tests were used to evaluate group differences. Analyses were conducted using SPSS /(version 26; IBM Corp, Armonk, NY).

RESULTS

Injury Characteristics

A total of 681 patient cases (girls = 415, age = 15.2 ± 1.2 years, and boys = 266, age = 15.4 ± 1.3 years) were recorded during the study period. The number of exposed clinical practice sites (ie, high schools with student-athletes participating in cross-country and at risk for injury) was not different between sexes for each academic year (mean ± SD: girls = 19.2 ± 14.9, boys = 18.0 ± 14.0, $P = .86$). A detailed summary of injury demographics, including participation level, time of injury, and mechanism of injury, is provided in Table 1. Most injuries were non–time loss (69.3%, n = 472), reported by varsity-level athletes (72.7%, n = 495), sustained during in-season practice (67.4%, n = 459, Table 2), and the result of a noncontact (42.0%, n = 286) or insidious or unknown (41.6%, n = 283)

Table 1. Injury Demographics by Sex

Characteristic	n (%) Girls	Boys
Participation level		
Freshman	32 (7.7)	18 (6.8)
Junior varsity	91 (21.9)	45 (16.9)
Varsity	292 (70.4)	203 (76.3)
Time of injury		
Preseason conditioning	13 (3.1)	9 (3.4)
Preseason weights	2 (0.5)	0 (0.0)
In-season practice	283 (68.2)	176 (66.2)
In-season meet/race	59 (14.2)	40 (15.0)
Postseason practice	2 (0.5)	1 (0.4)
Off-season practice	9 (2.2)	4 (1.5)
Off-season conditioning	14 (3.4)	10 (3.8)
Off-season weights	0 (0.0)	1 (0.4)
Non–sport related	33 (8.0)	25 (9.4)
Mechanism of injury		
Contact	11 (2.7)	14 (5.3)
Noncontact	175 (42.2)	111 (41.7)
Fall	21 (5.1)	17 (6.4)
Twisting	27 (6.5)	22 (8.3)
Insidious onset (unknown)	181 (43.6)	102 (38.3)
Time loss after injury?		
Time loss	130 (31.3)	79 (29.7)
Non–time loss	285 (68.7)	187 (70.3)

mechanism of injury. The most commonly injured body parts were the knee (21.4%, n = 146), ankle (20.4%, n = 139), and calf (17.5%, n = 119). More than 70% of all injuries were recorded as a sprain or strain (43.6%, n = 297), tendinopathy (18.5%, n = 126), or general pain (9.5%, n = 65). The 5 most frequently recorded ICD-10 diagnoses were S73.109A (sprain/strain of the thigh/hip/groin: 13.7%, n = 93), S93.409A (sprain/strain of the ankle: 9.3%, n = 63), S83.90XA (unspecified thigh sprain/strain [distal end]: 8.8%, n = 60), M76.8 (anterior/posterior tibialis tendinitis: 8.1%, n = 55), and M25.569 (knee pain: 5.7%, n = 39). In general, injured body parts (Table 3) and diagnosis types (Table 4) were similar between girls and boys.

Treatment Characteristics

A total of 3621 athletic training services were documented across 2641 episodes of care. The most commonly used procedures were therapeutic activities or exercises (n = 1039, 28.7%), hot or cold packs (n = 945, 26.1%), and athletic training evaluation or reevaluation (n = 848, 23.4%; Table 5). The least used procedures were upper extremity strapping (ie, elbow or wrist, hand or finger, shoulder; n = 2, 0.1%), contrast bath (n = 5, 0.1%), and gait training (n = 5, 0.1%; Table 5). An overwhelming majority of athletic training services were administered to patients whose injuries occurred in-season (n = 3096, 85.5%; Table 6) and to varsity-level athletes (n = 2639, 72.9%; Figure). Additionally, patients with non–time-loss injuries received more athletic training services (n = 2396, 66.2%) than those with time-loss injuries (n = 1225, 33.8%; Table 7). Across all patient cases, the average amount and duration of care were 5.5 ± 15.1 (median = 2, IQR = 1–4) episodes of care and 27.8 ± 87.5 (median = 1, IQR = 1–14) days,

Table 2. Diagnosis Type According to Time of Injury, n (%)

Diagnosis Type	Preseason Conditioning	Preseason Weights	In-Season Practice	In-Season Competition	Postseason Practice	Off-Season Practice	Off-Season Conditioning	Off-Season Weights	Non–Sport Related	Total
Bursitis	0 (0.0)	0 (0.0)	3 (0.7)	1 (1.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	4 (0.6)
Cartilage injury	0 (0.0)	0 (0.0)	5 (1.1)	2 (2.0)	0 (0.0)	1 (7.7)	1 (4.2)	1 (100.0)	0 (0.0)	10 (1.5)
Concussion	0 (0.0)	0 (0.0)	1 (0.2)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	8 (13.8)	9 (1.3)
Contusion	2 (9.1)	0 (0.0)	15 (3.3)	5 (5.1)	1 (33.3)	1 (7.7)	0 (0.0)	0 (0.0)	6 (10.3)	30 (4.4)
Dislocation or subluxation	0 (0.0)	0 (0.0)	2 (0.4)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.7)	3 (0.4)
Fascial injury	4 (18.2)	0 (0.0)	34 (7.4)	2 (2.0)	0 (0.0)	1 (7.7)	4 (16.7)	0 (0.0)	0 (0.0)	45 (6.6)
Fracture	0 (0.0)	0 (0.0)	5 (1.1)	3 (3.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	5 (8.6)	13 (1.9)
General medical condition	0 (0.0)	0 (0.0)	11 (2.4)	5 (5.1)	0 (0.0)	0 (0.0)	1 (4.2)	0 (0.0)	1 (1.7)	18 (2.6)
Nervous system injury	0 (0.0)	0 (0.0)	4 (0.9)	1 (1.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	5 (0.7)
Pain	4 (18.2)	1 (50.0)	41 (8.9)	3 (3.0)	0 (0.0)	1 (7.7)	3 (12.5)	0 (0.0)	12 (20.7)	65 (9.5)
Sprain or strain	4 (18.2)	0 (0.0)	201 (43.8)	57 (57.6)	2 (66.7)	5 (38.5)	7 (29.2)	0 (0.0)	21 (36.2)	297 (43.6)
Stress fracture	0 (0.0)	0 (0.0)	29 (6.3)	3 (3.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	32 (4.7)
Tendinopathy	7 (31.8)	0 (0.0)	92 (20.0)	13 (13.1)	0 (0.0)	3 (23.1)	7 (29.2)	0 (0.0)	4 (6.9)	126 (18.5)
Other	1 (4.5)	1 (50.0)	16 (3.5)	4 (4.0)	0 (0.0)	1 (7.7)	1 (4.2)	0 (0.0)	0 (0.0)	24 (3.5)
Total	22 (3.2)	2 (0.3)	459 (67.4)	99 (14.5)	3 (0.4)	13 (1.9)	24 (3.5)	1 (0.1)	58 (8.5)	681 (100.0)

Table 3. Injured Body Part by Sex and Time Lost Due to Injury, n (%)

Body Part	Girls	Boys	Total
Knee			
TL	23 (5.5)	16 (6.0)	39 (5.7)
NTL	62 (14.9)	44 (16.5)	107 (15.7)
Ankle			
TL	35 (8.4)	14 (5.3)	49 (7.2)
NTL	50 (12.1)	40 (15.0)	90 (13.2)
Calf			
TL	17 (4.1)	10 (3.8)	27 (4.0)
NTL	65 (15.7)	27 (10.2)	92 (13.5)
Hip			
TL	17 (4.1)	6 (2.3)	23 (3.4)
NTL	26 (6.3)	17 (6.4)	43 (6.3)
Thigh			
TL	12 (2.9)	10 (3.8)	22 (3.2)
NTL	26 (6.3)	17 (6.4)	43 (6.3)
Foot			
TL	8 (1.9)	7 (2.6)	15 (2.2)
NTL	25 (6.0)	15 (5.6)	40 (5.9)
Back			
TL	3 (0.7)	3 (1.1)	6 (0.9)
NTL	14 (3.4)	10 (3.8)	24 (3.5)
General medical			
TL	7 (1.7)	4 (1.5)	11 (1.6)
NTL	2 (0.5)	5 (1.9)	7 (1.0)
Head			
TL	3 (0.7)	4 (1.5)	7 (1.0)
NTL	1 (0.2)	3 (1.1)	4 (0.6)
Toe			
TL	2 (0.5)	1 (0.4)	3 (0.4)
NTL	5 (1.2)	2 (0.8)	7 (1.0)
Chest			
TL	0 (0.0)	1 (0.4)	1 (0.2)
NTL	4 (1.0)	2 (0.8)	6 (0.9)
Forearm			
TL	1 (0.2)	2 (0.8)	3 (0.4)
NTL	0 (0.0)	1 (0.4)	1 (0.2)
Finger			
TL	0 (0.0)	0 (0.0)	0 (0.0)
NTL	1 (0.2)	2 (0.8)	3 (0.4)
Trunk			
TL	1 (0.2)	0 (0.0)	1 (0.2)
NTL	0 (0.0)	2 (0.8)	2 (0.3)
Shoulder			
TL	1 (0.2)	0 (0.0)	1 (0.2)
NTL	1 (0.2)	0 (0.0)	1 (0.2)
Wrist			
TL	0 (0.0)	0 (0.0)	0 (0.0)
NTL	1 (0.2)	0 (0.0)	1 (0.2)
Neck			
TL	0 (0.0)	0 (0.0)	0 (0.0)
NTL	1 (0.2)	0 (0.0)	1 (0.2)
Hand			
TL	0 (0.0)	1 (0.4)	1 (0.2)
NTL	0 (0.0)	0 (0.0)	0 (0.0)
Total	415 (100.0)	266 (100.0)	681 (100.0)

Abbreviations: NTL, non–time loss; TL, time loss.

Table 4. Diagnosis Type by Sex and Time Lost Due to Injury, n (%)

Diagnosis Type	Girls	Boys	Total
Sprain or strain			
TL	56 (13.5)	37 (13.9)	93 (13.7)
NTL	117 (28.2)	87 (32.7)	204 (30.0)
Tendinopathy			
TL	20 (4.8)	7 (2.6)	27 (4.0)
NTL	65 (15.7)	34 (12.8)	99 (14.5)
Pain			
TL	11 (2.7)	4 (1.5)	16 (2.2)
NTL	34 (8.2)	16 (6.0)	50 (7.3)
Fascial injury			
TL	8 (1.9)	2 (0.8)	10 (1.5)
NTL	22 (5.3)	13 (4.9)	35 (5.1)
Stress fracture			
TL	8 (1.9)	6 (2.3)	14 (2.1)
NTL	13 (3.1)	5 (1.9)	18 (2.6)
Contusion			
TL	4 (1.0)	2 (0.8)	6 (0.9)
NTL	13 (3.1)	11 (4.1)	24 (3.5)
Other			
TL	5 (1.2)	3 (1.1)	8 (1.2)
NTL	9 (2.2)	7 (2.6)	16 (2.3)
General medical condition			
TL	7 (1.7)	4 (1.5)	11 (1.6)
NTL	2 (0.5)	5 (1.9)	7 (1.0)
Fracture			
TL	3 (0.7)	1 (0.4)	4 (0.6)
NTL	3 (0.7)	6 (2.3)	9 (1.3)
Cartilage injury			
TL	2 (0.5)	1 (0.4)	3 (0.4)
NTL	3 (0.7)	4 (1.5)	7 (1.0)
Concussion			
TL	3 (0.7)	4 (1.5)	7 (1.0)
NTL	1 (0.2)	1 (0.4)	2 (0.3)
Nervous system injury			
TL	1 (0.2)	1 (0.4)	2 (0.3)
NTL	2 (0.5)	1 (0.4)	3 (0.4)
Bursitis			
TL	1 (0.2)	1 (0.4)	2 (0.3)
NTL	1 (0.2)	1 (0.4)	2 (0.3)
Dislocation or subluxation			
TL	1 (0.2)	1 (0.4)	2 (0.3)
NTL	0 (0.0)	1 (0.4)	1 (0.1)
Total	415 (100.0)	266 (100.0)	681 (100.0)

Abbreviations: NTL, non–time loss; TL, time loss.

respectively. Patients received an average of 7.4 ± 17.4 (median = 3; IQR = 2–6; range, 1–206) total athletic training services, with 1.9 ± 1.0 (median = 2; IQR = 1–2; range, 1–8) services per episode of care. According to the mean, the diagnosis types with the greatest amount of care, duration of care, and total number of services were dislocations/subluxations (n = 3; 21.3 ± 33.5 visits, duration = 24.7 ± 22.6 days, services = 21.7 ± 19.2), contusions (n = 30; 14.8 ± 48.7 visits, duration = 32.0 ± 88.5 days, services = 23.1 ± 13.7), and tendinopathy (n = 126; 6.5 ± 14.2 visits, duration = 44.1 ± 114.8 days,

Table 5. Athletic Training Services Recorded for Patients With Cross-Country Injuries

Treatment or Procedure	Current Procedural Terminology Code(s)	n (%)		
		Girls	Boys	Total
Therapeutic activities or exercises	97110, 97530	740 (29.5)	299 (26.9)	1039 (28.7)
Hot or cold packs	97010	668 (26.6)	277 (25.0)	945 (26.1)
Athletic training evaluation or reevaluation	97005, 97006	570 (22.7)	278 (25.0)	848 (23.4)
Manual therapy techniques or massage	97140, 97124	202 (8.1)	73 (6.6)	275 (7.6)
Electrical stimulation	97014	114 (4.6)	48 (4.3)	162 (4.5)
Strapping: lower extremity (ankle/foot, hip, knee, toes)	29540, 29520, 29230, 29550	81 (3.2)	48 (4.3)	129 (3.6)
Ultrasound	97035	55 (2.2)	53 (4.8)	108 (3.0)
Vasopneumatic devices	97016	16 (0.6)	20 (1.8)	36 (1.0)
Neuromuscular reeducation	97112	28 (1.1)	0 (0.0)	28 (0.8)
Whirlpool	97022	15 (0.6)	8 (0.7)	23 (0.6)
Physical performance test or measurement	97750	6 (0.2)	4 (0.4)	10 (0.3)
Infrared	97026	6 (0.2)	0 (0.0)	6 (0.2)
Contrast bath	97034	2 (0.1)	3 (0.3)	5 (0.1)
Gait training	97116	4 (0.2)	1 (0.1)	5 (0.1)
Strapping: upper extremity (elbow or wrist, hand or finger, shoulder)	29280, 29260, 29240	1 (0.1)	1 (0.1)	2 (0.1)
Total		2508 (100.0)	1113 (100.0)	3621 (100.0)

Table 6. Athletic Training Services According to Time of Injury

Treatment or Procedure	Current Procedural Terminology Code(s)	n (%)					
		Preseason	In-Season	Postseason	Off-Season	Non–Sport Related	Total
Therapeutic activities or exercises	97110, 97530	22 (24.2)	814 (26.3)	0 (0.0)	132 (53.7)	56 (30.6)	1024 (28.3)
Hot or cold packs	97010	25 (27.5)	843 (27.2)	0 (0.0)	39 (15.9)	38 (20.8)	945 (26.1)
Athletic training evaluation or reevaluation	97005, 97006	36 (39.6)	724 (23.4)	4 (80.0)	28 (11.4)	56 (30.6)	848 (23.4)
Manual therapy techniques or massage	97140, 97124	5 (5.5)	258 (8.3)	0 (0.0)	5 (2.0)	22 (12.0)	290 (8.0)
Electrical stimulation	97014	0 (0.0)	155 (5.0)	0 (0.0)	5 (2.0)	2 (1.1)	162 (4.5)
Lower extremity strapping	29540, 29520, 29230, 29550	3 (3.3)	110 (3.6)	0 (0.0)	10 (4.1)	6 (3.3)	129 (3.6)
Whirlpool	97022	0 (0.0)	104 (3.4)	1 (20.0)	0 (0.0)	3 (1.6)	108 (3.0)
Vasopneumatic devices	97016	0 (0.0)	36 (1.2)	0 (0.0)	0 (0.0)	0 (0.0)	36 (1.0)
Neuromuscular reeducation	97112	0 (0.0)	2 (0.1)	0 (0.0)	26 (10.6)	0 (0.0)	28 (0.8)
Ultrasound	97035	0 (0.0)	23 (0.7)	0 (0.0)	0 (0.0)	0 (0.0)	23 (0.6)
Physical performance test or measurement	97750	0 (0.0)	10 (0.3)	0 (0.0)	0 (0.0)	0 (0.0)	10 (0.3)
Infrared	97026	0 (0.0)	6 (0.2)	0 (0.0)	0 (0.0)	0 (0.0)	6 (0.2)
Contrast bath	97034	0 (0.0)	5 (0.2)	0 (0.0)	0 (0.0)	0 (0.0)	5 (0.1)
Gait training	97116	0 (0.0)	4 (0.1)	0 (0.0)	1 (0.4)	0 (0.0)	5 (0.1)
Upper extremity strapping	29280, 29260, 29240	0 (0.0)	2 (0.1)	0 (0.0)	0 (0.0)	0 (0.0)	2 (0.1)
Total		91 (2.5)	3096 (85.5)	5 (0.1)	246 (6.8)	183 (5.1)	3621 (100.0)

Table 7. Athletic Training Services by Time Lost Due to Injury

Treatment or Procedure	Current Procedural Terminology Code(s)	Injuries, n (%)		
		Non–Time Loss	Time Loss	Total
Therapeutic activities or exercises	97110, 97530	658 (27.5)	381 (31.1)	1024 (28.3)
Hot or cold packs	97010	649 (27.1)	296 (24.2)	945 (26.1)
Athletic training evaluation or reevaluation	97005, 97006	563 (23.5)	285 (23.3)	848 (23.4)
Manual therapy techniques or massage	97140, 97124	200 (8.3)	75 (6.1)	290 (8.0)
Electrical stimulation	97014	113 (4.7)	49 (4.0)	162 (4.5)
Lower extremity strapping	29540, 29520, 29230, 29550	101 (4.2)	28 (2.3)	129 (3.6)
Whirlpool	97022	47 (2.0)	61 (5.0)	108 (3.0)
Vasopneumatic devices	97016	21 (0.9)	15 (1.2)	36 (1.0)
Neuromuscular reeducation	97112	27 (1.1)	1 (0.1)	28 (0.8)
Ultrasound	97035	9 (0.4)	14 (1.1)	23 (0.6)
Physical performance test or measurement	97750	4 (0.2)	6 (0.5)	10 (0.3)
Infrared	97026	1 (<0.1)	5 (0.4)	6 (0.2)
Contrast bath	97034	1 (<0.1)	4 (0.3)	5 (0.1)
Gait training	97116	2 (0.1)	3 (0.2)	5 (0.1)
Upper extremity strapping	29280, 29260, 29240	0 (0.0)	2 (0.2)	2 (0.1)
Total		2396 (66.2)	1225 (33.8)	3621 (100.0)

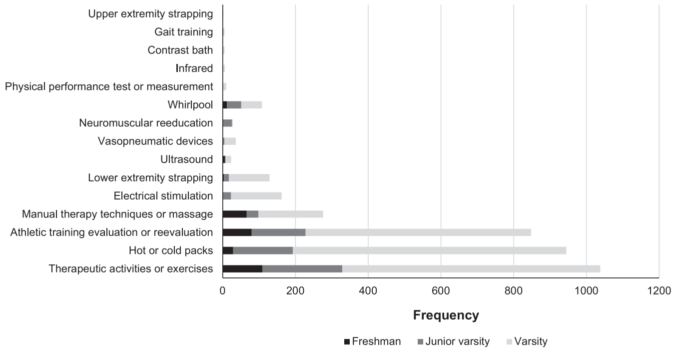

Figure. Athletic training services according to participation level.

services = 8.8 ± 1.7; Table 8). Based on the median and IQR, the amount of care, duration of care, and total number of services were similar across diagnosis types (Table 8). Median values for the amount (non–time loss = 2.0 [IQR = 1–4] visits, time loss = 2.0 [IQR = 1–5.5] visits) and duration of care (non–time loss = 0.0 [IQR = 0.0–18.25] days; time loss = 1.0 [IQR = 0.0–17.5] days) were not different between groups (amount: $P = .08$; duration: $P = .46$); however, patients with time-loss injuries received more total athletic training services than patients with non–time-loss injuries (time-loss = 4.0 [IQR = 2–8] services, non–time-loss = 3.0 [IQR = 2–6] services, $P = .001$).

DISCUSSION

To our knowledge, this is the first study to describe the injury and treatment characteristics related to cross-country injuries in adolescent athletes and provide insight into the workloads of ATs treating these patients. Previous investigations of athletic injuries have been specific to population (eg, youth,[14] adolescents,[15] college students[16]), joint (eg, ankle,[13,17] knee[18]) injury (eg, concussion,[12] anterior cruciate ligament injury[19]) or sport (eg, basketball,[20] football[21]). However, a focus on injury and treatment patterns specific to adolescent cross-country student-athletes has not existed until now.

Our findings suggest that ATs were predominantly treating patients with lower extremity (ie, knee, ankle, calf) injuries, most of which appeared to be musculotendinous or ligamentous, as indicated by diagnoses of a sprain or strain or tendinopathy. Grooms et al[18] reported that although knee abrasions, contusions, sprains, and strains were all documented as occurring in cross-country athletes, strains resulted in the greatest number of athletic training services per injury (boys: mean = 21, median = 6, IQR = 2–14; girls: mean = 17, median = 7, IQR = 3–32). Patients with several injury types received a greater number of visits (sprain or strain: mean = 5.6, median = 2, IQR = 1–5 visits; tendinopathy: mean = 6.5, median = 2, IQR = 1–5 visits; contusion: mean = 14.8, median = 2, IQR = 1–2 visits; dislocation or subluxation: mean = 21.3, median = 2, IQR = 2–2 visits) and total number of services (sprain or strain: mean = 3.0, median = 3, IQR = 2–2 services; tendinopathy: mean = 8.8, median = 4, IQR = 2–8 services; contusion: mean = 21.3, median = 3, IQR = 2–5 services; dislocation or subluxation: mean = 21.7, median = 3, IQR = 2–3 services) than sprains or strains, yet these categories had fewer documented injuries (n = 126, 30, and 3 injuries, respectively) than sprains or strains (n = 297). As a result, the medians and IQRs for these categories aid in the interpretation of potentially skewed data due to small sample sizes.

On average, patients required between 7 and 8 athletic training services over approximately 1 month, most often therapeutic activities or exercises. In recent studies of treatment characteristics of ankle[13,17] and knee[18] injuries, researchers cited therapeutic exercise as one of the most frequently documented athletic training services. Furthermore, both Simon et al[17] and Marshall et al[13] reported that while ATs generally used good practice patterns when treating ankle sprains, they were still underusing services with high Strength of Recommendation Taxonomy evidence, such as therapeutic exercise/activities (grade A evidence)[22] and manual therapies (grade B evidence).[22]

Authors[2,23] of epidemiologic studies have described the most common injuries related to running activities as lower extremity sprains, strains, tendinitis, and inflammation. Our

Table 8. Amount and Duration of Treatment for Cross-Country Injuries by Diagnosis Type

		Amount, Visits			Services Per Injury			Duration, d		
Diagnosis	n	Mean ± SD	Median (IQR)	Range	Mean ± SD	Median (IQR)	Range	Mean ± SD	Median (IQR)	Range
Sprain or strain	297	5.6 ± 12.7	2 (1–5)	1–128	3.0 ± 1.8	3 (2–7)	1–127	26.1 ± 75.7	1 (1–15)	1–423
Tendinopathy	126	6.5 ± 14.2	2 (1–5)	1–115	8.8 ± 1.7	4 (2–8)	1–114	44.1 ± 114.8	1 (1–23)	1–781
Pain	65	3.6 ± 4.4	2 (1–4)	1–22	4.7 ± 0.8	3 (1–6)	1–25	22.1 ± 99.9	1 (1–9)	1–793
Fascial injury	45	4.0 ± 5.0	2 (1–6)	1–21	5.1 ± 0.9	3 (2–6)	1–22	23.0 ± 98.0	1 (1–11)	1–658
Stress fracture	32	2.8 ± 4.7	1 (1–2)	1–26	3.8 ± 1.3	2 (1–5)	1–25	5.9 ± 11.8	1 (1–2)	1–56
Contusion	30	14.8 ± 48.7	2 (1–2)	1–207	23.1 ± 13.7	3 (2–5)	1–206	32.0 ± 88.5	1 (1–11)	1–421
Other[a]	24	6.8 ± 11.2	2 (1–7)	1–48	8.4 ± 2.9	3 (2–8)	1–50	64.1 ± 141.1	3 (1–31)	1–423
General medical condition	18	1.7 ± 0.8	2 (1–2)	1–4	2.1 ± 0.3	2 (1–3)	1–3	4.3 ± 7.2	1 (1–3)	1–22
Fracture	13	2.0 ± 1.8	1 (1–2)	1–6	2.4 ± 0.6	1 (1–5)	1–5	6.5 ± 13.3	1 (1–2)	1–38
Cartilage injury	10	2.9 ± 3.1	2 (1–4)	1–11	4.1 ± 1.7	2 (1–5)	1–14	10.4 ± 21.0	1 (1–16)	1–82
Concussion	9	1.8 ± 1.6	1 (1–2)	1–6	2.3 ± 1.3	1 (1–1)	1–5	1.8 ± 1.4	1 (1–3)	1–5
Nervous system injury	5	1.8 ± 1.8	1 (1–3)	1–5	2.5 ± 1.5	3 (1–3)	1–4	10.4 ± 21.0	1 (1–25)	1–48
Bursitis	4	2.0 ± 1.4	2 (1–4)	1–4	3.0 ± 0.9	3 (1–5)	1–5	17.3 ± 31.2	2 (1–49)	1–64
Dislocation or subluxation	3	21.3 ± 33.5	2 (2–2)	2–60	21.7 ± 19.2	3 (2–3)	2–60	24.7 ± 22.6	27 (1–27)	1–46

Abbreviation: IQR, interquartile range.

[a] Other diagnoses: knee plica, shoulder impingement syndrome, slipped capital femoral epiphysis, Baker cyst, calcaneal apophysitis, Osgood-Schlatter syndrome, scoliosis, foot deformity, compartment syndrome (leg).

findings were similar in the most frequent diagnoses of lower extremity sprain or strains (thigh or hip/groin, ankle, distal thigh), anterior or posterior tibialis tendinitis, and knee pain, providing validity to our dataset. With recent research indicating an increased risk of overuse injury related to sport specialization[24] and the potential for distance runners to overtrain, injury-prevention programs targeting student-athletes may be a logical next step. In particular, programs that incorporate such components as monitoring training volume, eccentric exercises, improving muscle imbalances (eg, hip-abduction weakness versus medial quadriceps strength), proprioception and balance exercises, and intrinsic foot muscle strengthening may help reduce the injury risk.[5] Additionally, biomechanical alterations were present in runners with chronic lower extremity musculoskeletal conditions,[25] and gait retraining was an effective rehabilitation strategy for these types of injuries (eg, patellofemoral pain,[26] exercise-related leg pain,[27] lower limb stress fractures[28]). However, gait retraining was one of the least documented treatment strategies in this study. Based on the evidence, ATs should consider incorporating this treatment into rehabilitation protocols for cross-country patients, especially those with chronic or overuse injuries.

We were able to identify the amount of care, duration of care, and total number of athletic training services provided for the various injuries experienced by adolescent runners. Musculotendinous or ligamentous injuries occurred most often and required the greatest amount of care, longest duration of care, and largest total number of athletic training services. Nonetheless, the results for dislocations and subluxations should be taken with caution as only 3 patients were diagnosed with this type of injury in our study. Lam et al[8] reported these variables by sport for more than 5500 injuries in high school student-athletes. Although the authors[8] did not identify the amount and duration of care provided for cross-country athletes, they determined that injured girls' track-and-field athletes received care at an average of 5.2 $\pm$ 5.1 visits over 10.1 $\pm$ 30.0 days, and injured boys' track-and-field athletes received care at an average of 5.3 visits over 18.1 $\pm$ 72.9 days. When we combined all injury types, cross-country athletes received a similar amount of care (5.5 $\pm$ 15.1 visits, median = 2, IQR = 1–4) from an AT; however, their average duration of care was 1.5 to 3 times as long (27.8 $\pm$ 30.0 days, median = 1, IQR = 1–14). Additionally, these variables did not differ between patients with non–time-loss injuries and those with time-loss injuries, indicating that the frequencies and lengths of treatment were comparable between groups. Patients with time-loss injuries received a greater number of total athletic training services than those with non–time-loss injuries, yet the difference between groups was only 1 procedure. Thus, this finding may not be meaningful from a clinical perspective. Continued participation by these adolescent cross-country athletes after injury (ie, non–time-loss injuries) may play a role in lengthening the time spent receiving care.

Interestingly, the most common injuries sustained by track and field athletes[8] (ie, ankle sprain or strain, thigh sprain or strain, anterior/posterior tibialis tendinopathy, and knee pain) were similar to those experienced by the cross-country athletes in our study. This leads us to believe that other factors may have contributed to the long duration of care provided for these injuries: eg, the cross-country season is usually in the fall and not all athletes train over the summer,[29] these athletes compete in longer races and likely have greater training volumes than those who compete solely in track events, and overuse injuries typically do not restrict participation but frequently need ongoing rehabilitation and management.[30]

Often ATs play a role in maintaining an athlete's sport participation, even when the athlete has an injury. Not only was the injury rate higher for non–time-loss injuries than time-loss injuries in youth,[14] interscholastic,[31] and intercollegiate[16] athletics, but some authors[17,31] estimated that ATs also spent more time seeing patients (ie, athletic training facility visits) with non–time-loss injuries. Furthermore, in a recent study,[15] the non–time-loss injury rate was higher in high school athletes than in collegiate athletes. These trends were also evident for runners in particular. Grooms et al[18] observed that more than 90% of athletic training facility visits for knee injuries sustained by high school cross-country student-athletes were for non–time-loss injuries, indicating that these student-athletes were continuing to run even though they were still receiving treatment for their injuries. Similarly, Rauh et al[2] noted that injuries resulting in 1 to 4 days lost from participation occurred most frequently, suggesting that most patients returned to sport relatively quickly. We found that more than two-thirds (n = 472, 69.3%) of high school cross-country injuries were non–time loss, which agrees with these previous results.[2,15,18] It was notable that even though the number of non–time-loss injuries was larger and these patients sought a greater amount of care, they were typically receiving the same types of treatments as patients with time-loss injuries (Table 7). Decisions regarding whether to allow patients to continue to participate while receiving treatment are likely contributing to ATs' overall demand as health care providers because cross-country patients with non–time-loss injuries currently represent most of the workload for that sport.

The National Athletic Trainers' Association's (NATA) document[32] on appropriate medical coverage of intercollegiate athletics (AMCIA) recommended that the appropriate medical coverage of each sport should be determined based on the relative workload (ie, injury risk $\times$ average number of treatments per injury) calculated for each sport. Traditionally, cross-country is considered a low-risk sport, but our results, in conjunction with the findings of the aforementioned studies,[2,18] provide more insight into the demands placed on ATs who provide care for cross-country teams. The AMCIA identified a base health care index for each sport according to injury risk, injury rates (from multiyear sport injury-surveillance data), and the volume of care provided for injuries in each sport. This base health care index is then adjusted for site-specific data (ie, number of athletes, days in season). Although these estimates help colleges and universities to make appropriate decisions regarding medical coverage, similar calculations do not exist for secondary school athletics. Our work contributed cross-country–specific data for high school athletes and indicated that the demand on ATs to manage non–time-loss injuries in the sport is high. Furthermore, the NATA's AMCIA recommendations and guidelines are focused on the evaluation and adjustment of medical coverage for the safety of collegiate student-athletes. However, researchers[33,34] have identified that approximately 30% of high schools in the United States lack access to athletic training services. Our results also demonstrate the level of care that high school cross-country student-athletes are not receiving when they lack access to an AT.

This study was not without limitations. The use of ICD-10 codes aligns with best practices within the health care community; still, we were unable to specify the exact diagnoses of some injuries. For example, we were unable to distinguish between a sprain and a strain in the combined diagnostic codes, determine whether a sprain or strain to the thigh involved the quadriceps or hamstrings muscles, or identify certain conditions such as medial tibial stress syndrome because it is often grouped with ankle tendinopathy. Additionally, our ability to accurately evaluate athletic training practice was limited by the documentation of the ATs participating in point-of-care research. Given the retrospective nature of this study and its focus on patient records, any misdiagnosis of injuries by ATs may have influenced our findings. Patient care documentation data compiled from a diverse collection of clinical practice sites can vary, and therefore, outliers are expected. Accordingly, we chose to report the median as it provides a better estimate of the average case. Finally, despite the compilation of data from more than 100 clinical sites across 22 states and Washington, DC, this group of high schools may not represent all high schools throughout the country.

CONCLUSIONS

We characterized the injury and treatment characteristics for injuries sustained by high school cross-country student-athletes. Specifically, our results suggested that high school cross-country student-athletes experience injuries for which they continue to seek treatment even though their participation has not been restricted. Considering early restriction of participation and refining treatment strategies to include such interventions as gait retraining may help shorten the duration of care for these patients. To our knowledge, we are the first to describe these treatment characteristics related to the sport of cross-country. These findings provide insight into the demands of the sport when determining appropriate medical coverage. Future researchers should evaluate the influence of training volume and other performance variables on the duration of care and injury recovery. Furthermore, a high school equivalent of the NATA's AMCIA document[32] would be a valuable resource for ATs. Our cross-country–specific data regarding the volume of care supplied by ATs to these student-athletes could help with the development of a base health care index for cross-country at the secondary school level.

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