

High School Athletic Trainer Services for Knee Injuries

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Context: Participation in high school athletics carries a substantial risk of musculoskeletal injury, particularly to the knee. However, limited information is available on the care being provided by athletic trainers (ATs) for athletes with these injuries.

Design: Descriptive epidemiology study.

Setting: Data on athletic training facility visits and AT services were collected from 147 high schools in 26 states.

Patients or Other Participants: High school student-athletes who participated in 13 boys' sports and 14 girls' sports and sustained a diagnosed knee injury during the 2011–2012 through 2013–2014 academic years. The ATs documented 6797 knee injuries, with 4242 sustained in boys' sports and 2555 sustained in girls' sports.

Main Outcome Measure(s): The number of athletic training facility visits and individual AT services as well as the average, median, and interquartile range of athletic training facility visits (per injury) and AT services (per injury) were calculated by sport and for time-loss (TL; participation restricted for ≥ 24 hours) and non-time-loss (NTL; participation restricted for < 24 hours) injuries.

Results: In total, 28 788 athletic training facility visits were reported, with an overall average of 4 athletic training facility visits per knee injury over the 3-year period. Most athletic training facility visits (72.6%) were associated with NTL injuries, but the majority of AT services (68.6%) were associated with TL injuries. A total of 81 245 AT services were provided for all knee injuries. Therapeutic activities or exercise were the most common type of AT service (52.5%). Overall, an average of 12 AT services were reported per knee injury. Compared with NTL injuries, TL injuries had a larger average number of AT services per injury (34 versus 9; $P < .001$).

Conclusions: Knee injuries at the high school level are a considerable health care burden. This report demonstrates a high proportion of AT attention to the evaluation and treatment of these injuries. This study confirms the recommended management of knee injuries, with neuromuscular and therapeutic activities being the primary services after knee injury.

Key Words: NATION, injury surveillance, medical care

Key Points

- Over a 3-year period, 6797 knee injuries in high school athletes were reported, with football accounting for 26.7% of the total.
- On average, non-time-loss knee injuries required 9 athletic training therapy sessions and time-loss knee injuries required 34 sessions.
- Athletic trainers primarily used neuromuscular therapy to treat knee injuries.

Participation in US high school athletics has steadily increased over the past 25 years.¹ With increased participation may come an increased incidence of musculoskeletal injuries. Researchers^{2–4} have detailed the incidence of knee injuries at the high school level. An estimated 250 000 knee injuries occur at the high school level each year, a rate of 2.98 per 10 000 athlete-exposures.² These injuries primarily consist of ligament sprains, contusions, or meniscal injuries and occur at the highest rates in football, soccer, gymnastics, and basketball.² At many high schools, the primary care provider for these athletes is an athletic trainer (AT). To date, limited data have been available regarding the therapy ATs were providing, how these injuries were being managed, and what type of AT service was given by injury type, sport, or sex.

To delay the onset of posttraumatic osteoarthritis and lessen the risk of reinjury, patients with knee injuries require appropriate and timely therapy.^{5,6} The development of posttraumatic osteoarthritis has been linked to decreased muscle strength after injury, likely associated with less-than-optimal therapy postinjury,^{7,8} whereas reinjury has recently been associated with suboptimal return-to-play therapy and rehabilitative progressions.^{9,10} These less-than-optimal outcomes indicate a potential opportunity to improve care for patients with knee injuries in the athletic training setting, but data are lacking regarding the services ATs are providing after knee injuries. Therefore, the purpose of our study was to quantify the services provided by a sample of high school ATs for athletes with knee injuries.

Table 1. Athletic Training Facility Visits for High School Student-Athletes Sustaining Knee Injuries by Sport, NATION, 2011–2012 Through 2013–2014

Sports	No. of Knee Injuries	No. of Athletic Training Facility Visits	% Athletic Training Facility Visits for Non–Time-Loss Injuries	Average No. of Athletic Training Facility Visits per Injury (Median [Interquartile Range])			P Value ^c
				Total	Time Loss ^a	Non–Time Loss ^b	
Boys' sports							
Baseball	85	382	94.8	4 (2 [1–5])	3 (3 [2–5])	5 (2 [1–5])	.2765
Basketball	397	1238	75.6	3 (1 [1–3])	7 (4 [2–9])	3 (1 [1–2])	.0037 ^d
Crew	32	65	100.0	2 (1 [1–2])	No injuries	2 (1 [1–2])	NA
Cross-country	247	1047	90.2	4 (2 [1–3])	9 (6 [3–8])	4 (2 [1–3])	.0827
Football	1815	9778	55.2	5 (2 [1–5])	13 (6 [3–14])	4 (2 [1–4])	<.0001 ^d
Golf	1	1	100.0	1 (1 [1–1])	No injuries	1 (1 [1–1])	NA
Lacrosse	273	1092	70.9	4 (2 [1–4])	9 (5 [3–11])	3 (2 [1–4])	.0015 ^d
Soccer	322	882	74.0	3 (1 [1–3])	7 (4 [2–6])	2 (1 [1–2])	.0114 ^d
Swimming and diving	8	20	95.0	3 (1 [1–3])	9 (9 [9–9])	2 (1 [1–3])	.0004 ^d
Tennis	20	38	100.0	2 (1 [1–2])	No injuries	2 (1 [1–2])	NA
Indoor track	299	1009	95.6	3 (2 [1–4])	7 (5 [3–14])	3 (2 [1–4])	.1639
Outdoor track	256	897	93.1	4 (2 [1–4])	6 (4 [3–9])	3 (2 [1–4])	.0852
Wrestling	487	1501	67.2	3 (2 [1–3])	9 (6 [3–9])	2 (1 [1–2])	<.0001 ^d
Total	4242	17 950	66.8	4 (2 [1–4])	11 (6 [3–11])	3 (2 [1–3])	<.0001 ^d
Girls' sports							
Basketball	370	1860	62.6	5 (2 [1–5])	15 (7 [4–16])	4 (2 [1–4])	.0031 ^d
Crew	73	216	99.5	3 (1 [1–4])	1 (1 [1–1])	3 (1 [1–4])	.5852
Cross-country	252	1013	92.3	4 (2 [1–5])	5 (4 [2–7])	4 (2 [1–4])	.3253
Field hockey	252	946	67.1	4 (1 [1–3])	12 (4 [1–10])	3 (1 [1–3])	.0265 ^d
Golf	1	3	100.0	3 (3 [3–3])	No injuries	3 (3 [3–3])	NA
Gymnastics	33	87	92.0	3 (1 [1–3])	4 (4 [2–5])	3 (1 [1–3])	.7301
Lacrosse	219	1024	85.0	5 (2 [1–5])	8 (7 [4–13])	4 (2 [1–4])	.0125 ^d
Soccer	355	1427	77.6	4 (2 [1–4])	8 (4 [2–12])	4 (2 [1–4])	.0024 ^d
Softball	90	433	85.5	5 (2 [1–5])	6 (5 [2–11])	5 (2 [1–4])	.6517
Swimming and diving	26	59	100.0	2 (1 [1–2])	No injuries	2 (1 [1–2])	NA
Tennis	29	106	84.0	4 (1 [1–5])	9 (9 [0–17])	3 (1 [1–5])	.6501
Indoor track	293	1296	91.8	4 (2 [1–5])	10 (7 [2–13])	4 (2 [1–5])	.1181
Outdoor track	255	1140	91.8	4 (2 [1–5])	9 (7 [3–17])	4 (2 [1–5])	.0052 ^d
Volleyball	307	1228	93.0	4 (2 [1–4])	4 (2 [1–4])	4 (2 [1–4])	.8447
Total	2555	10 838	82.2	4 (2 [1–5])	9 (5 [2–11])	4 (2 [1–4])	<.0001 ^d
Overall	6797	28 788	72.6	4 (2 [1–4])	11 (6 [3–11])	3 (2 [1–4])	<.0001 ^d

Abbreviations: NA, not applicable; NATION, National Athletic Treatment, Injury and Outcomes Network.

^a *Time-loss injuries* were those injuries resulting in participation restriction of ≥ 24 hours.

^b *Non-time-loss injuries* were those injuries resulting in participation restriction of < 24 hours.

^c *P* value is for independent-samples *t* test comparing the average number of athletic training facility visits per injury between time-loss and non-time-loss injuries.

^d *P* value $< .05$ was considered significant.

METHODS

This investigation was approved by the Western Institutional Review Board (Puyallup, WA). During the 2011–2012 through 2013–2014 school years, the National Athletic Treatment, Injury and Outcomes Network (NATION) captured injury and AT services data for 27 high school sports during preseason, regular season, and postseason practices and competitions.¹¹ A total of 147 high schools in 26 states participated during the 3-year period. The ATs were full time, part time, or contracted from nearby clinics or university graduate programs. Most of the high schools were public (84.4%), were coeducational (98.6%), were set in nonurban areas (75.5%; rural = 37.4%, suburban = 38.1%), and enrolled fewer than 1000 students (51.0%).

The NATION data-collection tools are embedded within commercially available injury-documenting software,¹¹ which allows data collection to be seamlessly integrated

into routine record keeping. Software vendors participating in NATION modified their software and undergo annual certification using benchmarking transmission data sets developed by the Datalys Center for Sports Injury Research and Prevention, Inc (Indianapolis, IN). They also embedded secure data-transmission protocols that send deidentified records to secure Datalys Center servers on an ongoing and routine basis.¹¹ This process is Health Insurance Portability and Accountability Act compliant.

The ATs completed detailed reports for each athlete with a knee injury. The data collection also captured the number of athletic training facility visits and the number of AT services provided for each injury. Detailed methods for collecting injury information and AT services have been previously documented.^{11,12} An *AT service* was defined as the application of any type of evaluation, therapy, modality, or skill used by an AT in treatment for an injury. The AT services data were captured at all school-organized varsity

competitions, regular practices, captain's practices, scrimmages, strength and conditioning sessions, skill instruction, and junior varsity and varsity competitions. The services recorded were only those administered in the AT facility or campus facilities (eg, weight room) by ATs; if a student-athlete sought therapy off campus by other providers, those services were not counted. An injury reported in NATION must have occurred during a school-sponsored sport activity and must have been evaluated or treated (or both) by an AT in conjunction with his or her respective medical staff, including physicians or other health care professionals. A *time-loss* (TL) *injury* was defined as restricting a student-athlete from participation for ≥ 24 hours past the day of injury. A *non-time-loss* (NTL) injury restricted participation for < 24 hours.

Statistical Analysis

We compiled the number of athletic training facility visits and AT services for each knee injury. Services provided by ATs were examined by categories on the basis of previous research.^{12,13} We calculated the average number of athletic training facility visits per knee injury and by knee-injury type (average athletic training facility visit = Σ athletic training facility visits / Σ knee injuries) and the average number of AT services per knee injury (average AT services = Σ AT services / Σ knee injuries). These statistics were calculated overall and for TL and NTL knee injuries. Statistics for TL and NTL injuries were compared using independent-samples *t* tests.¹⁴ All *t* statistics with *P* values $< .05$ were considered statistically significant. All data were analyzed using SAS Enterprise Guide (version 4.3; SAS Institute Inc, Cary, NC).

RESULTS

Knee-Injury Incidence

During the 3-year period (2011–2012 through 2013–2014), boys' sports contributed 1185 team-seasons across 13 sports and girls' sports contributed 1141 team-seasons across 14 sports. Overall, 6797 knee injuries were reported, with 4242 sustained in boys' sports and 2555 sustained in girls' sports. The sports with the largest percentage of knee injuries were football ($n = 1815$ [26.7%]), wrestling (487 [7.2%]), boys' basketball (397 [5.8%]), and girls' basketball (370 [5.4%]). For boys' and girls' golf, only 1 knee injury was sustained in each sport. A majority of the knee injuries were NTL (6047; 89.0%). Of the knee injuries, 74 (1.1%) did not receive any AT service, and all of these were NTL injuries.

Athletic Training Facility Visits

In total, 28 788 athletic training facility visits for knee injuries were reported, with an overall average of 4 athletic training facility visits per knee injury (Table 1). The majority of athletic training facility visits were for NTL injuries (72.6%). Similar percentages of NTL-injury athletic training facility visits were seen in boys' (66.8%) and girls' (82.2%) sports. Among boys' sports, football had the highest number of athletic training facility visits (9778) and the highest number of athletic training facility visits per knee injury (5). Among girls' sports, basketball had the

highest number of athletic training facility visits (1860); it also had the highest number of athletic training facility visits per knee injury (5), along with girls' lacrosse and softball. The average number of athletic training facility visits per knee injury was higher for TL injuries than for NTL injuries overall ($P < .001$) and for 11 individual boys' and girls' sports. No TL knee injuries were reported for crew, boys' golf, girls' golf, girls' swimming and diving, or boys' tennis.

Total AT Services

In total, 81 245 AT services were provided for all knee injuries (Table 2). Therapeutic activities or exercise were the most common types of AT service (52.5%), followed by modalities (20.0%) and AT evaluation or reevaluation (12.7%). The most frequent specific AT services were hot and cold packs (18.7%, with 13.9% specifically for ice bags), independent range of motion (15.8%), isotonic strength (11.9%), and consultation (evaluations and reevaluations not specific to a functional evaluation; 11.7%). The majority of AT services were for TL knee injuries (55 760; 68.6%). Distributions of AT service types varied by whether injuries resulted in TL or NTL. Overall, 71.4% of TL injuries and 75.9% of NTL knee injuries received therapeutic activities or modalities.

Athletic Trainer Services per Injury

An average of 12 AT services were reported per knee injury (Table 3). The largest average number of AT service per knee injury for boys' sports was seen in golf (17); however, only 1 TL knee injury occurred in golf. Other than boys' golf, the largest average numbers of AT services per knee injury in boys' and girls' sports were for baseball and football (16 each), lacrosse (12 and 14, respectively) and girls' basketball (14). The average number of AT services per knee injury was higher for TL injuries (34) than for NTL injuries (9) across all sports ($P < .0001$). The same results were seen among 10 sports. When comparing the average number of AT services per knee injury between TL and NTL injuries, we found that the results by AT service type were similar (Table 4). The greatest differences were in therapeutic activities or exercise (19.61 versus 4.65, $P < .0001$), modalities (6.17 versus 1.93, $P < .0001$), hot or cold packs (5.64 versus 1.82, $P < .0001$), and AT evaluation or reevaluation (3.85 versus 1.23, $P < .0001$).

Athletic Trainer Services by Knee Conditions

The knee injuries consisted of 1528 abrasions, 2523 contusions, 572 sprains, 604 strains, and 1570 other conditions (Table 5). Overall, patients with knee sprains received the largest average number of AT services (30) compared with knee abrasions (9), knee contusions (7), knee strains (15), and other knee injuries (16). Sprains contributed the largest average number of AT services per injury. Irrespective of injury type, therapeutic activities and exercise were the most commonly reported AT service per injury type (abrasions = 4.53, contusions = 2.58, sprains = 17.22, strains = 9.38, and other = 8.87; Table 6). Modalities were the next most frequent AT service provided per injury type (abrasions = 1.82, contusions = 1.66, sprains = 5.53, strains = 3.02, and other = 2.75). The

Table 2. Types of Athletic Trainer (AT) Services for High School Student-Athletes Sustaining Knee Injuries by Type of Service, NATION, 2011–2012 Through 2013–2014

Type of AT Service	CPT Code	n (%)			P Value ^c
		Injuries			
		Total	Time Loss ^a	Non-Time Loss ^b	
Athletic trainer evaluation or reevaluation	97005, 97006	10 313 (12.7)	7422 (13.3)	2891 (11.3)	<.001 ^d
Consultation		9514 (11.7)	6809 (12.2)	2705 (10.6)	<.001 ^d
Functional evaluation		799 (0.9)	613 (1.1)	186 (0.7)	<.001 ^d
Gait training or crutch fitting	97116	149 (0.2)	38 (<0.1)	111 (0.4)	<.001 ^d
Manual therapy techniques or massage	97140, 97124	1250 (1.5)	1049 (1.9)	201 (0.8)	<.001 ^d
Massage		1154 (1.4)	1003 (1.8)	151 (0.6)	<.001 ^d
Mobilization		96 (0.1)	46 (<0.1)	50 (0.2)	<.001 ^d
Modalities		16 287 (20.0)	11 656 (20.9)	4631 (18.2)	<.001 ^d
Cold whirlpool		33 (<0.1)	16 (<0.1)	17 (<0.1)	.013 ^d
Cryocuff ^e		810 (0.9)	396 (0.7)	414 (1.6)	<.001 ^d
Electrical modality (other)		8 (<0.1)	3 (<0.1)	5 (<0.1)	.118
Electrical stimulation	97014	553 (0.7)	330 (0.6)	223 (0.9)	<.001 ^d
Electrical stimulation		545 (0.7)	327 (0.6)	218 (0.9)	<.001 ^d
Hot or cold packs	97010	15 203 (18.7)	10 976 (19.7)	4227 (16.6)	<.001 ^d
Hot pack		2693 (3.3)	2046 (3.7)	647 (2.5)	<.001 ^d
Hot whirlpool		29 (<0.1)	17 (<0.1)	12 (<0.1)	.245
Ice bag		11 279 (13.9)	8144 (14.6)	3135 (12.3)	<.001 ^d
Ice massage		421 (0.5)	390 (0.7)	31 (0.1)	<.001 ^d
Slush bath		28 (<0.1)	26 (<0.1)	2 (<0.1)	.006 ^d
Ultrasound	97035	222 (0.3)	189 (0.3)	33 (0.1)	<.001 ^d
Vasopneumatic devices	97016	208 (0.3)	94 (0.2)	114 (0.4)	<.001 ^d
Whirlpool	97022	90 (0.1)	59 (0.1)	31 (0.1)	.529
Neuromuscular reeducation	97112	4681 (5.8)	2487 (4.5)	2194 (8.6)	<.001 ^d
Basic proprioception		744 (0.9)	274 (0.5)	470 (1.8)	<.001 ^d
Proprioception with device		3937 (4.8)	2213 (4.0)	1724 (6.8)	<.001 ^d
Paraffin bath	97018	0	0	0	NA
Contrast bath	97034	11 (<0.1)	8 (<0.1)	3 (<0.1)	>.99
Iontophoresis/phonophoresis	97033	0	0	0	NA
Physical performance test or measurement	97750	4 (<0.1)	2 (<0.1)	2 (<0.1)	.594
Strapping	29280, 29260,	3946 (4.9)	3257 (5.8)	689 (2.7)	<.001 ^d
Padding	29240, 29540,	236 (0.3)	217 (0.4)	19 (<0.1)	<.001 ^d
Splint	29520, 29230,	61 (<0.1)	16 (<0.1)	45 (0.2)	<.001 ^d
Taping	29550	1644 (2.0)	1330 (2.4)	314 (1.2)	<.001 ^d
Wrap		2005 (2.5)	1694 (3.0)	311 (1.2)	<.001 ^d
Therapeutic activities or exercise	97110, 97530	42 855 (52.5)	28 146 (50.5)	14 709 (57.7)	<.001 ^d
Bike conditioning		3323 (4.1)	2002 (3.6)	1321 (5.2)	<.001 ^d
Bike ROM		4090 (5.0)	2964 (5.3)	1126 (4.4)	<.001 ^d
Independent ROM		12 827 (15.8)	9319 (16.7)	3508 (13.8)	<.001 ^d
Isokinetic strength		247 (0.3)	101 (0.2)	146 (0.6)	<.001 ^d
Isometric strength		2532 (3.1)	1223 (2.2)	1309 (5.1)	<.001 ^d
Isotonic strength		9642 (11.9)	5899 (10.6)	3743 (14.7)	<.001 ^d
Manual resistance exercise		1564 (1.9)	1081 (1.9)	483 (1.9)	.676
Passive ROM		2739 (3.3)	2015 (3.6)	724 (2.8)	<.001 ^d
Proprioceptive neuromuscular facilitation ROM		213 (0.3)	180 (0.3)	33 (0.1)	<.001 ^d
Stair climber		392 (0.5)	164 (0.3)	228 (0.9)	<.001 ^d
Treadmill conditioning		274 (0.3)	123 (0.2)	151 (0.6)	<.001 ^d
Tubing strength		5012 (6.2)	3075 (5.5)	1937 (7.6)	<.001 ^d
Wound care	97597, 97598, 97602	1760 (2.2)	1703 (3.1)	57 (0.2)	<.001 ^d
Total		81 245 (100.0)	55 760 (100.0)	25 485 (100.0)	<.001 ^d

Abbreviations: CPT, Current Procedural Terminology; NA, not applicable; NATION, National Athletic Treatment, Injury and Outcomes Network; ROM, range of motion.

^a Time-loss injuries were those injuries resulting in participation restriction of ≥24 hours.

^b Non-time-loss injuries were those injuries resulting in participation restriction of <24 hours.

^c P value is for χ^2 or Fisher exact *t* test comparing the proportion of AT services used between time-loss and non-time-loss injuries.

^d P value < .05 was considered significant.

^e DJO Global, Vista, CA.

Table 3. Average Number of Athletic Trainer Services per Injury for High School Student-Athletes Sustaining Knee Injuries by Sport, NATION, 2011–2012 Through 2013–2014

Sports	Average No. of Athletic Trainer Services per Injury (Median [Interquartile Range])			P Value ^c
	Total	Injuries Time Loss ^a	Non-Time Loss ^b	
Boys' sports				
Baseball	16 (5 [2–15])	8 (6 [3–12])	17 (4 [2–16])	.0743
Basketball	7 (3 [1–7])	16 (9 [3–25])	6 (3 [1–6])	.0025 ^d
Crew	6 (3 [2–5])	No injuries	6 (3 [2–5])	NA
Cross-country	12 (4 [2–8])	30 (20 [5–38])	11 (3 [2–8])	.0384 ^d
Football	16 (4 [2–12])	42 (14 [5–40])	9 (3 [2–9])	<.0001 ^d
Golf	17 (17 [17–17])	No injuries	17 (17 [17–17])	NA
Lacrosse	12 (4 [2–11])	34 (14 [5–38])	9 (4 [2–9])	.00061 ^d
Soccer	8 (3 [2–7])	21 (6 [2–23])	6 (3 [2–6])	.0349 ^d
Swimming and diving	7 (4 [2–8])	31 (31 [31–31])	4 (3 [1–5])	.0002 ^d
Tennis	5 (2 [1–6])	No injuries	5 (2 [1–6])	NA
Indoor track	9 (4 [1–10])	20 (17 [6–26])	9 (3 [1–10])	.0532
Outdoor track	11 (4 [2–11])	16 (10 [4–30])	11 (4 [2–10])	.3678
Wrestling	8 (3 [1–7])	29 (16 [4–31])	5 (3 [1–5])	.0004 ^d
Total	12 (4 [2–10])	35 (13 [4–36])	9 (3 [2–8])	<.0001 ^d
Girls' sports				
Basketball	14 (4 [2–13])	43 (15 [7–44])	10 (3 [2–9])	.0113 ^d
Crew	8 (2 [1–9])	1 (1 [1–1])	8 (2 [1–10])	.5778
Cross-country	11 (4 [2–11])	14 (5 [2–23])	10 (4 [2–11])	.4127
Field hockey	12 (3 [1–8])	52 (11 [2–44])	8 (3 [1–7])	.0520
Golf	3 (3 [3–3])	No injuries	3 (3 [3–3])	NA
Gymnastics	8 (3 [2–7])	14 (14 [3–25])	7 (3 [2–7])	.6463
Lacrosse	14 (5 [2–13])	26 (16 [6–42])	13 (5 [2–10])	.0288 ^d
Soccer	11 (4 [2–11])	24 (13 [3–32])	10 (3 [2–9])	.0047 ^d
Softball	11 (3 [2–12])	12 (8 [2–15])	11 (3 [2–10])	.8783
Swimming and diving	6 (2 [1–8])	No injuries	6 (2 [1–8])	NA
Tennis	11 (3 [2–14])	18 (18 [3–32])	10 (3 [1–14])	.5286
Indoor track	13 (5 [2–14])	41 (25 [5–56])	12 (4 [2–14])	.1129
Outdoor track	13 (4 [2–13])	29 (19 [4–44])	12 (4 [2–12])	.0992
Volleyball	10 (3 [1–8])	9 (4 [1–8])	10 (3 [1–8])	.9607
Total	12 (4 [2–11])	30 (10 [3–36])	10 (4 [2–10])	<.0001 ^d
Overall	12 (4 [2–10])	34 (13 [4–36])	9 (3 [2–8])	<.0001 ^d

Abbreviations: NA, not applicable; NATION, National Athletic Treatment, Injury and Outcomes Network.

^a *Time-loss injuries* were those injuries resulting in participation restriction of ≥24 hours.

^b *Non-time-loss injuries* were those injuries resulting in participation restriction of <24 hours.

^c P value is for independent-samples *t* test comparing the average number of athletic trainer services per injury between time-loss and non-time-loss injuries.

^d P value < .05 was considered significant.

distribution of AT services per knee condition is presented in the Figure. The majority of abrasions (65%) and contusions (74%) required fewer than 5 AT services per injury, whereas only 36% of sprains resolved that quickly. Nearly half (48%) of sprains required more than 11 services compared with 20% for abrasions, 13% for contusions, and 32% for strains.

DISCUSSION

To our knowledge, this is the first report of AT services for knee injuries at the high school level. We documented AT services by sport, service type, athlete sex, and TL and NTL injuries. To date, the management of knee injuries has commonly been limited to expert opinion and physician recommendation.¹⁵ Our work highlights the variety of AT services provided, including evaluation, therapeutic exercise, and various modalities, by condition, sport, sex, and TL status. The volume of services administered in the high

school setting represents a significant contribution to the overall health care of these patients.

Comparison With Overall Treatment Data (Common AT Services)

As described in the “Methods” section and the original NATION treatment paper,¹² the knee data reported herein is part of a larger data set encompassing all injuries requiring the attention of an AT in the participating high schools. Of the total 210 773 athletic training clinic visits in the NATION data set,¹² 28 788 (13.7%) were due to knee injuries. The contribution of athletic training clinic visits for knee injuries relative to all injuries was similar for total (4.17 total; 4.24 knee) and NTL injuries (3.47 total; 3.46 knee); however, TL knee injuries required, on average, nearly 3 more clinic visits relative to all injuries (7.76 total, 10.52 knee). The services provided by ATs at the high school level for knee injuries were also in line with all injuries, with the most common being therapeutic activities

Table 4. Average Number of Athletic Trainer (AT) Services per Injury for High School Student-Athletes Sustaining Knee Injuries by Type of Service, NATION, 2011–2012 Through 2013–2014

Type of AT Service	Average No. of AT Services per Injury (Median [Interquartile Range])			
	Total	Time Loss ^a	Non–Time Loss ^b	P Value ^c
Athletic trainer evaluation or reevaluation	1.52 (1 [0–2])	3.85 (1 [0–4])	1.23 (1 [0–1])	<.0001 ^d
Gait training or crutch fitting	0.02 (0 [0–0])	0.15 (0 [0–0])	0.01 (0 [0–0])	<.0001 ^d
Manual therapy techniques or massage	0.18 (0 [0–0])	0.27 (0 [0–0])	0.17 (0 [0–0])	.1259
Modalities	2.40 (1 [0–2])	6.17 (3 [1–7])	1.93 (1 [0–2])	<.0001 ^d
Contrast bath	<0.01 (0 [0–0])	<0.01 (0 [0–0])	<0.01 (0 [0–0])	0.3862
Electrical stimulation	0.08 (0 [0–0])	0.30 (0 [0–0])	0.05 (0 [0–0])	<.0001 ^d
Hot or cold packs	2.24 (1 [0–2])	5.64 (2 [1–6])	1.82 (1 [0–2])	<.0001 ^d
Iontophoresis/phonophoresis	0	0	0	NA
Paraffin bath	0	0	0	NA
Ultrasound	0.03 (0 [0–0])	0.04 (0 [0–0])	0.03 (0 [0–0])	.6088
Vasopneumatic devices	0.03 (0 [0–0])	0.15 (0 [0–0])	0.02 (0 [0–0])	.0005 ^d
Whirlpool	0.01 (0 [0–0])	0.04 (0 [0–0])	<0.01 (0 [0–0])	.0332 ^d
Neuromuscular reeducation	0.69 (0 [0–0])	2.93 (0 [0–2])	0.41 (0 [0–0])	<.0001 ^d
Physical performance test or measurement	<0.01 (0 [0–0])	<0.01 (0 [0–0])	<0.01 (0 [0–0])	.2190
Strapping	0.58 (0 [0–0])	0.92 (0 [0–1])	0.54 (0 [0–0])	.0006 ^d
Therapeutic activities or exercise	6.30 (0 [0–4])	19.61 (4 [0–19])	4.65 (0 [0–3])	<.0001 ^d
Wound care	0.26 (0 [0–0])	0.08 (0 [0–0])	0.28 (0 [0–0])	<.0001 ^d

Abbreviations: NA, not applicable; NATION, National Athletic Treatment, Injury and Outcomes Network.

^a Time-loss injuries were those injuries resulting in participation restriction of ≥ 24 hours.

^b Non-time-loss injuries were those injuries resulting in participation restriction of < 24 hours.

^c P value is for independent-samples *t* test comparing the average number of AT services per injury between time-loss and non-time-loss injuries.

^d P value $< .05$ was considered significant.

Table 5. Average Number of Athletic Trainer Services per Injury for High School Student-Athletes Sustaining Knee Injuries by Injury and Sport, NATION, 2011–2012 Through 2013–2014

Sports	Average No. of Athletic Trainer Services per Injury (Median [Interquartile Range])				
	Abrasion (n = 1528)	Contusion (n = 2523)	Sprain (n = 572)	Strain (n = 604)	Other (n = 1570)
Boys' sports					
Baseball	11 (3 [2–16])	8 (3 [2–6])	68 (24 [5–131])	10 (4 [2–20])	27 (10 [5–24])
Basketball	4 (2 [1–5])	5 (2 [1–4])	19 (11 [3–30])	11 (4 [2–10])	11 (5 [2–12])
Crew	17 (5 [2–7])	2 (2 [1–3])	No injuries	3 (3 [2–4])	3 (2 [1–3])
Cross-country	8 (3 [2–6])	11 (2 [1–6])	12 (10 [3–19])	21 (6 [2–14])	12 (5 [2–11])
Football	10 (3 [1–8])	7 (3 [1–7])	38 (12 [4–33])	22 (7 [2–15])	19 (7 [2–18])
Golf	No injuries	No injuries	No injuries	No injuries	17 (17 [17–17])
Lacrosse	13 (5 [2–15])	7 (3 [2–6])	16 (10 [5–21])	20 (5 [3–9])	17 (5 [2–15])
Soccer	6 (3 [1–7])	5 (2 [2–4])	15 (7 [4–23])	14 (6 [2–13])	10 (4 [2–8])
Swimming and diving	No injuries	1 (1 [1–1])	No injuries	4 (4 [3–5])	15 (10 [3–31])
Tennis	5 (6 [1–7])	1 (1 [1–2])	No injuries	2 (2 [1–3])	9 (5 [2–19])
Indoor track	5 (3 [1–7])	8 (3 [1–5])	6 (4 [3–4])	9 (4 [1–12])	14 (5 [2–23])
Outdoor track	10 (4 [2–10])	5 (2 [1–5])	16 (4 [2–14])	9 (6 [3–11])	16 (7 [3–19])
Wrestling	6 (3 [1–5])	5 (2 [1–5])	22 (9 [4–29])	9 (4 [2–8])	12 (4 [2–7])
Total	8 (3 [2–7])	7 (3 [1–6])	31 (11 [4–29])	15 (5 [2–12])	15 (5 [2–16])
Girls' sports					
Basketball	8 (3 [2–8])	5 (3 [2–6])	56 (21 [8–62])	21 (11 [3–28])	18 (7 [2–18])
Crew	6 (2 [1–7])	12 (4 [1–15])	1 (1 [1–1])	12 (3 [2–14])	7 (2 [1–9])
Cross-country	10 (3 [2–9])	5 (2 [1–4])	10 (6 [4–9])	17 (7 [3–32])	13 (5 [2–14])
Field hockey	8 (3 [2–7])	5 (2 [1–4])	34 (7 [2–16])	9 (3 [2–9])	22 (6 [2–22])
Golf	3 (3 [3–3])	No injuries	No injuries	No injuries	No injuries
Gymnastics	15 (3 [2–10])	6 (6 [4–9])	12 (9 [3–20])	2 (1 [1–3])	4 (3 [2–7])
Lacrosse	14 (4 [2–7])	9 (4 [1–9])	25 (13 [4–49])	10 (6 [3–15])	20 (7 [3–26])
Soccer	9 (3 [2–10])	8 (3 [2–5])	19 (11 [2–26])	10 (4 [2–11])	17 (7 [3–27])
Softball	10 (3 [2–11])	7 (2 [2–4])	15 (7 [4–26])	12 (6 [3–12])	17 (10 [3–21])
Swimming and diving	7 (5 [1–12])	1 (1 [1–2])	2 (2 [2–2])	5 (3 [2–8])	9 (5 [1–20])
Tennis	5 (3 [2–6])	4 (3 [1–7])	1 (1 [1–1])	10 (4 [2–25])	19 (11 [2–32])
Indoor track	9 (4 [2–12])	12 (4 [1–14])	6 (5 [3–8])	17 (6 [2–25])	17 (7 [2–19])
Outdoor track	14 (5 [2–18])	6 (3 [2–7])	7 (4 [0–15])	11 (5 [2–16])	18 (6 [2–24])
Volleyball	10 (3 [1–7])	4 (2 [1–4])	13 (8 [5–9])	21 (10 [5–23])	15 (5 [2–10])
Total	10 (3 [2–10])	7 (3 [1–5])	25 (8 [3–25])	14 (6 [2–17])	16 (6 [2–17])
Overall	9 (3 [2–8])	7 (3 [1–6])	30 (10 [3–29])	15 (5 [2–14])	16 (5 [2–16])

Abbreviation: NATION, National Athletic Treatment, Injury and Outcomes Network.

Table 6. Average Number of Athletic Trainer (AT) Services per Injury for High School Student-Athletes Sustaining Knee Injuries by Injury and Type of Service, NATION, 2011–2012 Through 2013–2014

Type of AT Service	Average No. of AT Services per Injury (Median [Interquartile Range])				
	Abrasion (n = 1528)	Contusion (n = 2523)	Sprain (n = 572)	Strain (n = 604)	Other (n = 1570)
Athletic trainer evaluation or reevaluation	1.35 (1 [0–2])	0.99 (0 [0–1])	3.44 (1 [0–3])	1.35 (1 [0–2])	1.89 (1 [0–2])
Gait training or crutch fitting	<0.01 (0 [0–0])	0.01 (0 [0–0])	0.13 (0 [0–0])	<0.01 (0 [0–0])	0.03 (0 [0–0])
Manual therapy techniques or massage	0.12 (0 [0–0])	0.08 (0 [0–0])	0.18 (0 [0–0])	0.3 (0 [0–0])	0.38 (0 [0–0])
Modalities	1.82 (1 [0–2])	1.66 (1 [0–2])	5.53 (2 [1–6])	3.02 (1 [1–3])	2.75 (1 [0–3])
Contrast bath	0	<0.01 (0 [0–0])	0	0	<0.01 (0 [0–0])
Electrical stimulation	0.02 (0 [0–0])	0.05 (0 [0–0])	0.36 (0 [0–0])	0.1 (0 [0–0])	0.08 (0 [0–0])
Hot or cold packs	1.75 (1 [0–2])	1.56 (1 [0–2])	5.01 (2 [1–5])	2.85 (1 [1–3])	2.55 (1 [0–3])
Iontophoresis/phonophoresis	0	0	0	0	0
Paraffin bath	0	0	0	0	0
Ultrasound	0.04 (0 [0–0])	0.02 (0 [0–0])	0.04 (0 [0–0])	0.06 (0 [0–0])	0.04 (0 [0–0])
Vasopneumatic devices	0.01 (0 [0–0])	0.02 (0 [0–0])	0.1 (0 [0–0])	0.01 (0 [0–0])	0.05 (0 [0–0])
Whirlpool	0.01 (0 [0–0])	0.01 (0 [0–0])	0.02 (0 [0–0])	0.01 (0 [0–0])	0.03 (0 [0–0])
Neuromuscular reeducation	0.45 (0 [0–0])	0.23 (0 [0–0])	2.55 (0 [0–1])	0.57 (0 [0–0])	1.02 (0 [0–0])
Physical performance test or measurement	<0.01 (0 [0–0])	<0.01 (0 [0–0])	0	0	<0.01 (0 [0–0])
Strapping	0.59 (0 [0–0])	0.5 (0 [0–0])	0.63 (0 [0–1])	0.41 (0 [0–0])	0.75 (0 [0–0])
Therapeutic activities or exercise	4.53 (1 [0–3])	2.58 (0 [0–1])	17.22 (4 [0–17])	9.38 (2 [0–7])	8.87 (2 [0–9])
Wound care	0.16 (0 [0–0])	0.57 (0 [0–1])	0.04 (0 [0–0])	<0.01 (0 [0–0])	0.03 (0 [0–0])

Abbreviation: NATION, National Athletic Treatment, Injury and Outcomes Network.

(45% total, 52% knee) followed by modalities (18.6% total, 20% knee) and then evaluation (15% total, 12 % knee). The overall services per injury were comparable between all injuries and knee injuries (11.01 total, 11.95 knee) and for NTL injuries (9.56 total, 9.22 knee); however, TL injuries to the knee required more visits (18.6 total, 33.98 knee). The nature of instability after knee sprains requiring surgical reconstruction or extensive therapy relative to other joint sprains likely contributes to the drastic increase in services for TL knee injuries.^{16–19}

Injury Type

The majority of knee injuries fell into 4 categories: abrasion, contusion, sprain, or strain. The high volume of services provided (nearly 12 services per injury over an

average of 4 athletic training clinic visits) for knee injuries may be driven by the high number of services for knee sprains: 30 services per injury relative to only 15 for strains, 7 for contusions, and 9 for abrasions. The need for evaluation or reevaluation, more therapeutic exercise and range-of-motion sessions, and modality applications for sprains could be due to the extensive recovery time attributed to ligament injuries^{20–22} relative to muscle strains or abrasions and contusions. Despite recommendations regarding bracing after ligament injury,²³ patients with sprains did not require more strapping relative to the other conditions but did have a much higher incidence of crutch fitting and gait training. Of additional note is the high variability in the number of services across all types for sprains and strains relative to abrasions and contusions. This was probably due to the spectrum of severity

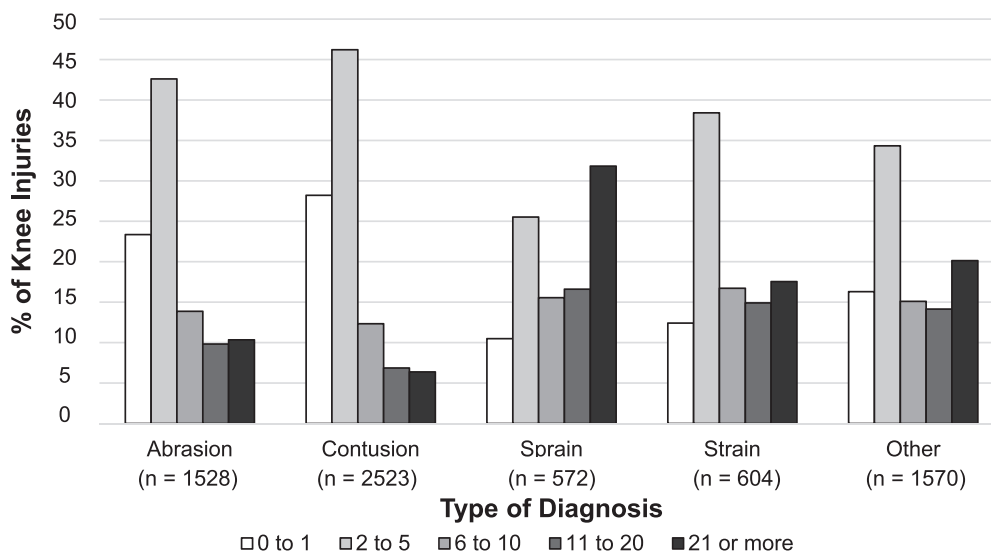


Figure. Distribution of knee injuries (percentages) requiring 0 to 1, 2 to 5, 6 to 10, 11 to 20, or 21 or more athletic trainer services per injury diagnosis.

associated with sprains and strains, ranging from mild cellular- or tissue-level damage to complete structural failure and rupture, as opposed to the likely less severe level associated with contusions or abrasions.²⁴

Abrasions and contusions had a large percentage of injuries requiring 5 or fewer AT services per injury, which is to be expected due to the typically mild nature of these injuries, whereas sprains presented as a bimodal distribution, with a large portion requiring ≥ 21 AT services and a large portion requiring ≤ 5 AT services (Figure). This probably reflects the greater spectrum of sprain-related injuries, ranging from those requiring surgical intervention to minor insults. The *other* injuries classification had a similar bimodal distribution as sprains, with slightly more injuries requiring >21 services (possibly meniscal or cartilage injuries, given that they were not captured by the other categories).

Comparison of TL and NTL Injuries

The average number of AT services per injury increased drastically when the injury was TL, requiring ≥ 24 hours of activity restriction (34 services for TL, 9 services for NTL). This was largely driven by the increased use of therapeutic activities, modalities, neuromuscular reeducation, and evaluation for TL injuries. Of note, NTL knee injuries still required, on average, more than 3 athletic training clinic visits and 9 services per injury. This indicates that ATs were expending supplies, time, and effort on injuries that may be considered minor but still demanded considerable medical attention. Typically, TL injuries required a greater number of AT services, with the exception of baseball, crew, and golf athletes.

By Sport

Football had the largest number of knee injuries and average AT visits, followed by wrestling, boys' and girls' basketball, and soccer, which is in line with previous epidemiologic work^{2,4} at the high school level. Of interest, although football had the most knee injuries and AT visits, it also had the lowest percentage of AT visits for NTL injuries. This was not driven by a low number of average AT visits for NTL injuries but by a very high average number of AT visits for TL injuries. The repeated visits for TL injuries increased the services required overall, even though NTL injuries were more numerous. Sports such as baseball, crew, cross-country, gymnastics, softball, swimming, tennis, track, and volleyball reflected an opposite paradigm, in which the vast majority of AT visits were for NTL injuries. However, this discrepancy in AT visits was not reflected in the AT services per sport: the number of services required of each TL injury was almost always higher except for baseball, crew, volleyball, and sports with minimal to zero TL injuries. These data indicate that whereas many injury-surveillance systems use TL in their definition of injury, patients with NTL injuries still demand extensive AT services.

Limitations

Some injuries may have gone unreported and some AT services undocumented. The NATION data-collection method integrates with the ATs' electronic medical record systems, which streamlines documentation; however, at

times, services may be undocumented due to time demands in the clinic. Therefore, these data are likely an underestimate of the AT services provided. In addition, the NATION data set captures both TL and NTL injuries and AT services, further increasing the burden on the AT to document all services. The AT's employment status, which may affect AT services reporting, was also not controlled in this study.²⁵ In addition, ATs may have provided services for injuries that occurred outside of the school setting, and athletes were free to seek treatment via their personal providers, both of which would go unrecorded in this data set. Future investigators may consider examining more injury classifications such as specific ligament or muscle involvement, surgical or other physician interventions (eg, injection, prescription medication, consultation), and chronic or overuse conditions.

CONCLUSIONS

The AT services for knee injuries at the high school level varied, based on participation-restriction time (TL versus NTL injuries), sport, and injury type. Therapeutic exercise was the most common service across all classifications, indicating that ATs may be following best-practice recommendations to address the functional limitations associated with knee injuries through exercise interventions as opposed to relying on modalities or palliative care. However, follow-up research is required to determine whether this is the case and to identify the influence of AT services on more specific injuries, service type, reinjury rate, and patient outcomes to learn whether ATs are indeed engaged in best-practice management of patients with knee injuries. This report can serve as a future resource for examination of AT services and the ATs' contributions to the health care of athletes with musculoskeletal injuries.

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