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Epidemiology of Bone-Stress Injuries and Health Care Use in Pac-12 Cross-Country Athletes

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Context: Bone-stress injury (BSI) is common in collegiate athletes. Injury rates and health care use in running athletes are not well documented.

Objective: To describe the rate and classification of injury and associated health care use in collegiate cross-country runners with BSI.

Design: Descriptive epidemiology study.

Setting: Sports medicine facilities participating in the Pac-12 Health Analytics Program.

Patients or Other Participants: Pac-12 Conference collegiate cross-country athletes.

Main Outcome Measure(s): Counts of injury and health care resources used for each injury. Injury rates were calculated based on athlete-seasons.

Results: A total of 168 BSIs were reported over 4 seasons from 80 team-seasons (34 men's and 46 women's team-seasons) and 1220 athlete-seasons, resulting in 1764 athletic training services and 117 physician encounters. Bone-stress injuries represented 20% of all injuries reported by cross-country athletes. The average BSI rate was 0.14 per athlete-season. Injury rates were higher in female (0.16) than male (0.10) athletes and higher in the 2019–2020 season (0.20) than the 2020–2021 (0.14), 2018–2019 (0.12), and 2021–2022 (0.10) seasons. Most BSIs occurred in the lower leg (23.8%) and the foot (23.8%). The majority of injuries were classified as overuse and time loss (72.6%) and accounted for most of the athletic training services (75.3%) and physician encounters (72.6%). We found a mean of 10.89 athletic training services per overuse and time-loss injury and 12.20 athletic training services per overuse and non–time-loss injury. Mean occurrence was lower for physician encounters (0.70), prescription medications (0.04), tests (0.75), procedures (0.01), and surgery (0.02) than for athletic training services (10.50).

Conclusions: Bone-stress injuries are common in collegiate cross-country runners and require considerable athletic training resources. Athletic trainers should be appropriately staffed for this population, and suspected BSIs should be confirmed with a medical diagnosis. Future investigators should track treatment codes associated with BSI to determine best-practice patterns.

Key Words: running, athletic training services, collegiate, stress fracture, stress reaction

Key Points

- Bone-stress injuries were a common overuse and time-loss injury, occurring in up to 14% of collegiate cross-country runners.
- Athletic training services were used frequently in the management of bone-stress injury.

Running is one of the most popular forms of physical activity in the United States, with approximately 60 million individuals running as their primary source of exercise.[1] Cross-country is a competitive form of long-distance running with unique physiologic and biomechanical demands.[2] In 2018–2019, cross-country participation was at its greatest at the high school and collegiate levels.[3,4] In that year, approximately 488 460 boys and girls participated in high school cross-country and 19 846 men and women participated in National Collegiate Athletic Association (NCAA) cross-country.[3] Unfortunately, running is also associated with a high incidence of injury.[5] In collegiate cross-country runners, the overall injury rates are estimated to be 3.96 and 4.01 injuries per 1000 athlete-exposures (AEs) in female and male athletes, respectively.[2,6] Given the increased participation and the high rate of injury, continued research is necessary to better understand the epidemiology and management of running-related injuries.

One common injury among long-distance runners is bone-stress injury (BSI).[7,8] A *BSI* is commonly classified as an overuse injury that results from an inability of the bone to withstand repetitive loading.[9] Bone loading, which commonly occurs with running, without appropriate recovery can result in structural breakdown leading to stress reactions, stress fractures, and, in some cases, complete bone fractures.[9,10] Bone-stress injuries have been suggested to occur in >20% of collegiate runners.[8] These injuries also have a high recurrence rate and can require prolonged recovery times.[8] Approximately 10% to 22% of runners with a history of BSI sustained a second BSI.[9,11,12] In addition, runners with a previous BSI were up to 6 times more likely to sustain a subsequent BSI.[11] Recovery time for a single BSI can be up to 27 weeks or longer if surgical intervention is required.[9,13] Prolonged recovery times and injury recurrence can impair performance and lead to decreased sports participation. Injured runners often do not replace lost running time with other physical activity, and injury is commonly cited as the top reason individuals quit participation altogether.[14,15] Reduced participation is not only a concern for the sport of cross-country but also has a broader effect on physical and psychosocial health.[16,17] Cross-country runners may be a population at greater risk of sustaining a BSI due to frequent exposure to repetitive loading and conditions known to affect bone health.[8,18] Bratsman et al classified BSI rates in NCAA cross-country runners, but the rates reflected injury patterns from 2009–2010 to 2013–2014 and may not be indicative of current injury rates.[19] They also primarily focused on differences in injury rates among NCAA divisions in all sports, included only a small sample of Division I institutions (n = 4) per the methods outlined by Kerr et al, and did not investigate differences in sex.[19,20] In addition, management patterns may have changed with advancing knowledge of BSI diagnosis and treatment.[9,21] Therefore, further research is needed to not only identify the current rate of BSI in this population but also to describe the management strategies used for this condition.

The description of health care use can quantify injury and treatment burden in specific populations.[22,23] Clarifying the number and types of services sought for an injury is useful in determining medical workload and the need for better prevention and treatment programs.[22] To our knowledge, health care use for BSI has not been documented in the literature. Considering the prolonged recovery times and high recurrence rate associated with BSI, identification of appropriate intervention strategies is needed. Improved outcomes in this population may be possible through a better understanding of services being provided for individuals with BSI. For example, athletic departments can determine whether athletic training services are adequately supplied for this population for prevention and treatment and whether greater attention needs to be paid to the medical diagnosis and management of this condition. Therefore, our purpose was to describe the epidemiology of individuals diagnosed with BSI in NCAA Division I cross-country runners. Specifically, we sought to identify the rate and location of injury stratified by injury mechanism (acute versus overuse) and time-loss status in all documented BSI cases. Associated health care use, including athletic training services, physician encounters, and other medical services, is also described.

METHODS

Participants

This project was approved by the Pac-12 Student-Athlete Health and Well-Being Initiative, which oversees the Pac-12 Health Analytics Program (HAP) injury registry.[24,25] Eleven institutions provided data over the first 2 collection years (July 2018 through June 2019 and July 2019 through June 2020), and 12 institutions participated in the final 2 years (July 2020 through June 2021 and July 2021 through June 2022).[22] National Collegiate Athletic Association activities were suspended from March 2020 through June 2020 due to COVID-19. As a result, the cross-country season, usually taking place in the fall, was moved to spring 2021. Student-athletes at participating institutions provided authorization for their injury data to be used in the HAP.

Procedures

Injury and health care use data were collected during the 2018–2019 through 2021–2022 competitive seasons in male and female cross-country athletes. Data quality, including null data analysis and logic checks, was evaluated and managed by the HAP as further described by Robell et al.[25] Throughout the observation period, athletic trainers (ATs) at participating institutions documented injuries and associated health care use in Presagia Sports (Kitman Labs), a web-based electronic medical record documentation system integrated into the HAP and stored via Amazon Web Services.[22] Before participation, clinicians were trained in the documentation system and followed common data elements documentation and definitions.[24] Participant data were deidentified with a unique numeric code, and only injury, sex, and health care use were linked to each student-athlete's case.[22]

All injuries sustained during an organized practice or competition were recorded by participating ATs.[24] Clinicians documented the body part injured and the associated Orchard Sports Injury Classification System (OSICS) code.[22,26] For this study, only OSICS codes associated with a BSI (*bone stress injury* or *stress reaction* or *stress fracture*) of the lumbar spine, pelvis, or lower extremity were obtained because the spine and lower extremity are the primary locations of injury in collegiate running populations.[2,6] Cases of medial tibial stress syndrome were excluded from analysis because researchers have recently suggested that this should be considered a distinct clinical diagnosis[27] separate from BSI and have its own OSICS code. Injuries were classified as acute or overuse. *Acute injuries* were defined as symptoms presenting within 24 hours after the initial onset of injury with a specific precipitating event, whereas *overuse injuries* were defined as presenting with a gradual onset with no clear precipitating event.[22] This definition of overuse injury is consistent with a "mechanism of gradual onset, and . . . underlying pathogenesis of repetitive microtrauma."[28] Injuries were also classified as *time loss* (TL) or *non–time loss* (NTL) and defined as restricting participation for ≥24 hours or <24 hours, respectively.[22] In some overuse cases, the injury was not specified as resulting in TL or NTL. Given the small population sample, these cases were retained for analysis and classified as unspecified. To provide a comprehensive description of BSI in this population, we included all cases with an associated BSI OSICS code, regardless of injury definition or classification.

Health care use associated with each injury was obtained from clinician documentation collected by the HAP as discussed by Robell et al.[25] Health care use measures included athletic training services, physician encounters, prescription medications, tests (any associated diagnostic imaging or tests), procedures (performed in a clinic without general anesthesia or the need for a preoperative visit), and surgery (performed in a hospital or surgery center with patients under general anesthesia and attending preoperative and postoperative visits).[22] Athletic training services were recorded as the number of sessions, or visits, associated with each injury case and could include any type of evaluation, manual therapy, modality, therapeutic exercise, or testing or skill session. Physician encounters, prescription medications, tests, procedures, and surgery were recorded as present or absent for each case.[22] *Present* indicated athletes had at least 1 physician encounter, prescription medication, test, procedure, or surgery associated with their BSI case.

To examine the rate of injury by sport season, we divided each team's year into the following periods: preseason, in-season, postseason, and off-season. The periods were defined as in a previous study.[22]

Statistical Analysis

We reported injury rates per athlete-season (AS) because individual AEs (in which an individual athlete participates in 1 exposure event: practice or competition) were not tracked for this study.[22] *Athlete-season* was defined as the number of athletes on the roster for each participating team before the start of the season. Approximately 86% of student-athletes across institutions provided authorization to use their information for research.[24] Therefore, AS reflects 86% participation. Injury rate ratios (IRRs) with associated 95% CIs were calculated to examine differences in injury rates between sexes and years. Given that injury rates were greatest in the 2019–2020 season, IRRs were referenced to this season for analysis.

Associated health care use was reported for athletic training services, including the number of BSIs that did not receive any services, as well as physician encounters, prescription medications, tests, procedures, and surgery. All services were reported in count and mean per BSI. Injury rates and health care use were reported for all athletes, as well as separately for male and female athletes.

Although it was not part of the original analysis, we completed a post hoc analysis of the data with the 13 acute cases removed.

Statistical analyses were performed using MedCalc for Windows (version 22.016; MedCalc Software). The α level was set at .05.

RESULTS

Over the 4 seasons of observation, 80 participating teams (34 men's and 46 women's teams) and 1220 ASs (86% participation rate) were recorded. Overall, 837 total injuries were reported, and 20% (168 of 837) had OSICS codes consistent with BSI (Figure 1). This resulted in a BSI injury rate of 0.14 per AS between 2018–2019 and 2021–2022 (Table 1). Overall, injury rates were higher in female (0.16) than male (0.10) athletes (IRR = 1.58; 95% CI = 1.13, 2.24; $P = .005$). When comparing years, injury rates were higher in the 2019–2020 season (0.20) than the 2018–2019 (0.12; IRR = 1.58; 95% CI = 1.03, 2.44; $P = .03$) and 2021–2022 (0.10; IRR = 1.99; 95% CI = 1.28, 3.17; $P = .001$) seasons (Table 2). Injury rates were greater in the 2019–2020 (0.20) than the 2020–2021 (0.14) season but were not different (IRR = 1.43; 95% CI = 0.95, 2.19; $P = .08$). Most injuries were diagnosed in-season (48.81%), followed by off-season (23.21%), preseason (18.45%), and postseason (9.52%; Table 3). Of the 82 BSIs that occurred in-season, 10 occurred between days 1 and 28, 27 between days 29 and 56, 20 between days 57 and 84, and 9 between days 85 and 112. The remaining 16 BSIs occurred during the 2020–2021 season, which was moved to spring 2021. Therefore, these 16 were classified as in-season but occurred outside the traditional 112-day season.

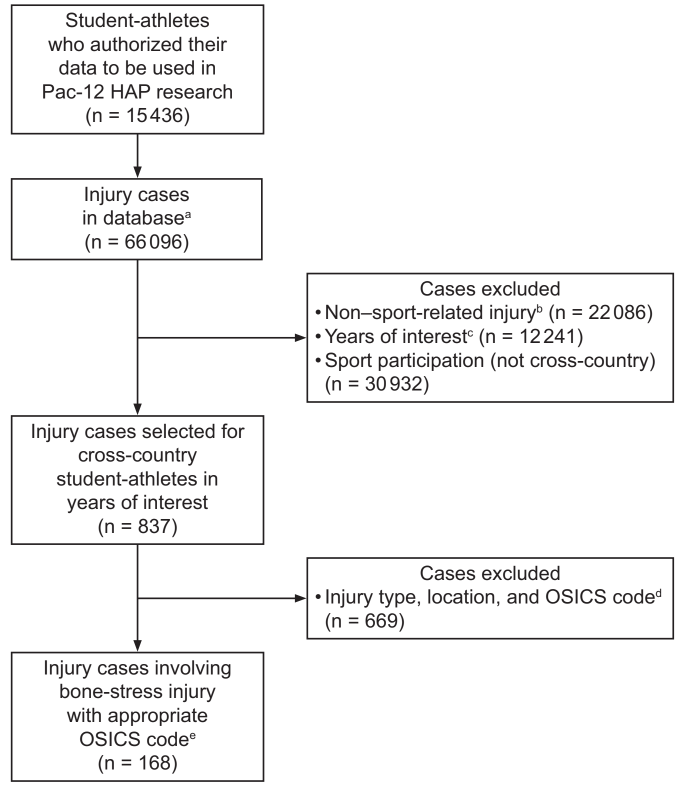

Figure 1. Flow diagram for the selection of study participants. [a] Present in the database, with authorization for research use provided and injury resolved. [b] Filtered for sport-related injury. [c] Filtered for years of inclusion (July 2018–June 2022). [d] Filtered for bone-stress injury, stress fracture, stress reaction, fracture injury type, and lower extremity and trunk-spine injury location and Orchard Sports Injury Classification System (OSICS) code related to bone-stress injury. [e] *Complete cases* defined as having demographic information (sex, sport), onset (acute versus overuse), and time-loss status (time-loss versus non–time-loss versus unspecified). Student-athletes may have had >1 injury case included in the data set. Abbreviation: HAP, Health Analytics Program.

Of all the BSIs reported between 2018–2019 and 2021–2022, 72.6% (122 of 168) were classified as overuse-TL. The remainder were classified as acute-TL (12 of 168), acute-NTL (1 of 168), overuse-TL (15 of 168), or overuse-unspecified (18 of 168). The lower leg (40 of 168) and the foot (40 of 168) were the most common injury locations. The ankle (9 of 168), knee (6 of 168), and lumbar spine (1 of 168) were the least frequently involved. Male runners had a higher proportion of injuries located in the foot (31% of all BSIs in men), whereas female runners sustained more injuries in the lower leg (25% of all BSIs in women). Figure 2 illustrates BSI by sex, classification, and location.

Associated health care use is reported in Table 4. A total of 1764 athletic training services were provided for these

Table 1. Bone-Stress Injury Rate in Pac-12 Cross-Country Runners, 2018–2019 Through 2021–2022

Group	Team Count	Athlete-Seasons, No.	Total Bone-Stress Injuries, No.	Injury Rate per Athlete-Season
Men	34	506.5	52	0.10
Women	46	713.8	116	0.16
Total	80	1220.3	168	0.14

injuries, resulting in a mean of 10.50 services per BSI. Approximately 21% (36 cases) of all BSIs received no athletic training services. Most athletic training services (n = 1329) were associated with overuse-TL injuries. On a per-case basis, the mean athletic training services per BSI was slightly larger in overuse-NTL (12.20) than overuse-TL (10.89) injuries (Table 5). The presence of service use per BSI was lower for physician encounters (0.70), prescription medications (0.04), tests (0.75), procedures (0.01), and surgery (0.02) than for athletic training services.

Results of the post hoc analysis completed with the 13 acute cases removed are provided in the Supplemental Table, available online at https://dx.doi.org/10.4085/1062-6050-0089.23.S1.

DISCUSSION

The purpose of our study was to describe the rate and location of BSI stratified by injury mechanism (acute versus overuse) and TL status, as well as the associated health care use for each BSI, in a sample of NCAA Division I cross-country runners. Bone-stress injuries occurred frequently and were commonly classified as overuse-TL injuries. Fewer injuries were classified as acute or resulted in no loss in participation. Athletic training services were frequently sought for management of this condition, but other health care resources were less frequently used.

In this sample, BSI represented 20% of all injuries reported over the 4-year observation period and occurred in approximately 14% of the total sample on average. This sample of collegiate cross-country runners from 1 athletic conference may not represent the entire collegiate population, but if the rate holds true across the NCAA, it would equate to nearly 4000 BSIs each year. This rate of injury is consistent with previous findings that cross-country runners were at high risk of BSI.[18,19] In a study examining BSI rates across collegiate athletes, Bratsman et al found that cross-country runners across 3 NCAA divisions had a BSI injury rate of 73.8 per 100 000 AEs.[19] Similarly, in a study examining risk factors associated with BSI at a single university, Tenforde et al found that the highest proportion of injured athletes participated in cross-country.[18] We found that the rate of BSI was greater in female than male athletes and is consistent with the rate reported in the literature.[8] Although we found that injury rates were higher in the 2019–2020 season, no data are currently collected in the HAP to indicate why this might be the case, as individual athletic training and competition exposures are not recorded. Future epidemiologic studies should be done to collect individual exposure characteristics to investigate reasons for year-to-year fluctuations in injury rate, as changes in training and competition volume may be reasons for this difference. We also found that a large proportion of injuries took place during the season, with more than half of all in-season BSIs (n = 47) occurring between days 29 and 84 (weeks 5 to 12). This finding of increased BSIs occurring after week 4 in the season is consistent with a previous finding of BSIs occurring several weeks after the initiation of a new training program or change in training intensity.[29] A change in training intensity after the start of the season, the addition of competition, or both might increase the susceptibility to BSI development in this population. Considering the continued high rate of injury and the proportion of runners sustaining a BSI, further research is needed to identify risk factors associated with injury. Biomechanical factors, training, genetics, diet, and nutrition have been associated with BSI, but to date, no consensus exists on the weight of any specific factor, or combination of factors, in relation to the probability that a runner will sustain an injury.[9,18] Identification of risk would help clinicians plan future prevention strategies and ultimately minimize the occurrence of BSI in this population.

Return to sport after BSI has been reported to take up to 6 to 27 weeks, and runners with BSI have a high risk of reinjury.[8,9,13] To minimize future risk and ensure an efficient return to sport, adequate access to care and appropriate intervention are needed. We found that cross-country runners in the Pac-12 Conference received a mean of 10.50 athletic training services per BSI. This is the first study to report on athletic training services used for BSI in collegiate cross-country runners. Our findings indicate a high demand on ATs tasked with managing BSI in this sample of collegiate runners. Considering the prevention and treatment requirements for all athletes under their care, the ATs working with this sample of runners are spending an extended period with each athlete at approximately 11 athletic training services, or visits, per BSI. This value is considerably larger than that reported in other studies investigating athletic training service use in other populations. Using data from the Athletic Training Practice-Based Research Network, Marshall et al found that injured high school cross-country runners received approximately 7 athletic training services per injury.[30] The number of visits reported by Marshall et al is also consistent with values reported for high school cross-country athletes in other studies in which daily patient encounters were investigated.[23,30,31] Specifically, Lam et al found that athletes received a mean of 7.5 visits per injury across all sports, whereas another study by Lam et al showed that cross-country athletes had approximately 4 services per injury.[23,31] One reason for this difference may be the type and classification of injuries between high school runners and this sample of collegiate runners. Most injuries in high school runners

Table 2. Bone-Stress Injury Rate per Athlete-Season in Pac-12 Cross-Country Runners, 2018–2019 Through 2021–2022

Group	Season				Total
	2018–2019	2019–2020	2020–2021	2021–2022	
Men	0.09	0.12	0.12	0.08	0.10
Women	0.14	0.25	0.15	0.11	0.16
Total	0.12	0.20	0.14	0.10	0.14

Table 3. **Bone-Stress Injury Rate in Pac-12 Cross-Country Runners by Season Segment, 2018–2019 Through 2021–2022, No. (%)**

Group	Season Segment				Total
	Preseason	In-Season	Postseason	Off-Season	
Men	13 (25.00)	25 (48.07)	5 (9.62)	9 (17.31)	52 (100.00)
Women	18 (15.52)	57 (49.14)	11 (9.48)	30 (25.86)	116 (100.00)
Total	31 (18.45)	82 (48.81)	16 (9.52)	39 (23.21)	168 (100.00)

tended to be NLT (69.3%), and BSI only accounted for 4.7% of the total injury cases. However, when Marshall et al further investigated visits per diagnosis type, they still found that individuals with a BSI received only 3.8 ± 1.3 athletic training services over 2.8 ± 4.7 visits.[30]

High school athletes may receive care for their BSIs outside of their school-based ATs, whereas collegiate athletes may seek treatment only from practitioners at their universities, and this may account for the differences. Pryor et al reported that <40% of high school athletic departments employed full-time ATs, often citing budgetary restrictions, hiring power, and misconceptions about the role of ATs in the high school setting as barriers to hiring.[32,33] Limited access to an AT may result in high school athletes seeking care from outside providers, whereas collegiate athletes possibly have daily access to ATs because they are often provided by the university's athletic department.[33] Fewer visits may also reflect a less intensive course of care. High school athletes possibly have less access to care due to staffing issues previously mentioned or an increased demand on high school ATs with the management of NTL injuries, which results in a lower frequency of visits and less treatment provided.[30,31] Even athletes with an overuse-NTL BSI in this sample received 12.2 athletic training services per injury, indicating a high need for treatment despite being able to continue sport participation. Regardless, collegiate cross-country runners with a diagnosis of BSI receive a considerable amount of athletic training services. Athletic trainers should expect to frequently see cross-country athletes with a BSI, and athletic departments at NCAA institutions should provide adequate staffing to support the athletic training needs of these individuals.

Use of other health care resources (physician encounters, prescription medications, tests, etc) was limited in comparison with the use of athletic training services. Specifically, physician encounters and tests were limited to a mean of <1 per BSI. This was surprising, as we expected that each BSI would be accompanied by at least 1 visit to the team physician and diagnostic imaging. *Bone-stress injury* is a general term encompassing both stress-reaction and stress-fracture diagnoses.[21] Many researchers use imaging to confirm the presence of a BSI, and in many cases, this is needed to make a definitive diagnosis of stress reaction versus stress fracture.[9,13,21,34] Although a suspected diagnosis of a low-risk stress fracture can be made based on history and clinical presentation, confirmation of a BSI with imaging, preferably magnetic resonance imaging (MRI) because of its high sensitivity and specificity, is recommended in the early management of this condition.[34] Prognosis, including time frames for bone healing and return to sport participation, has been shown to be associated with MRI grading and should be considered in treatment planning for this population.[9,13,21] The presence of BSI in this population could have been overrepresented or underrepresented based on the limited use of physician follow-up and ordering of diagnostic imaging. The grade of BSI could have affected the frequency of athletic training service use. Knowing the type of BSI may provide greater insight into the health care needs of athletes with a stress reaction or stress fracture. All cases associated with an OSICS code indicating a BSI were kept for analysis despite this limitation to determine rates and health care use associated with all runners classified as having a BSI. In future studies, researchers may consider including only athletes with confirmed BSIs in

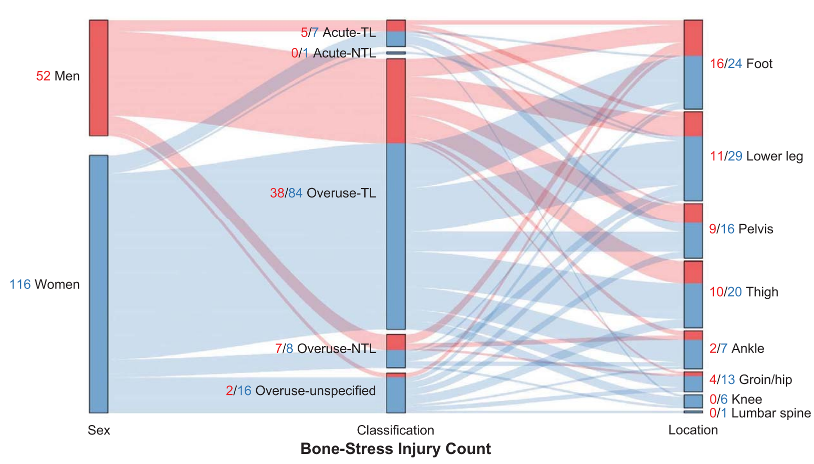

Figure 2. Distribution of bone-stress injuries in Pac-12 cross-country runners by sex (men/women), 2018–2019 through 2021–2022. Injury counts indicated for both classification (acute-time-loss [TL], acute-non–time-loss [NTL], overuse-TL, overuse-NTL, or overuse-unspecified) and location (foot, lower leg, pelvis, thigh, groin/hip, ankle, knee, or lumbar spine). Red represents men's injuries, and blue represents women's injuries.

Table 4. Associated Health Care Use for Collegiate Cross-Country Runners With a Bone-Stress Injury, 2018–2019 Through 2021–2022

	Associated Health Care Use						
	Acute Injury, No.		Overuse Injury, No.				
Associated Health Care	Time-Loss	Non–Time-Loss	Time-Loss	Non–Time-Loss	Unspecified	Total, No.	Mean per Bone-Stress Injury
Athletic training services							
Men	67	0	375	75	6	523	10.06
Women	19	24	954	108	136	1241	10.70
Total	86	24	1329	183	142	1764	10.50
Physician encounters							
Men	4	0	23	5	2	34	0.65
Women	5	1	62	5	10	83	0.72
Total	9	1	85	10	12	117	0.70
Prescription medications							
Men	0	0	3	2	0	5	0.10
Women	0	0	2	0	0	2	0.02
Total	0	0	5	2	0	7	0.04
Tests							
Men	3	0	32	4	1	40	0.77
Women	5	1	64	6	10	86	0.74
Total	8	1	96	10	11	126	0.75
Procedures							
Men	0	0	0	1	0	1	0.02
Women	0	0	0	1	0	1	0.01
Total	0	0	0	2	0	2	0.01
Surgery							
Men	0	0	2	1	0	3	0.06
Women	0	0	1	0	0	1	0.01
Total	0	0	3	1	0	4	0.02

their analysis. In addition, clinicians working with cross-country runners with a history suggestive of BSI should consider follow-up with medical imaging to confirm the diagnosis and plan treatment.[9,21,34,35] Other health care resources may also need to be considered in the management of these athletes. Presence of a BSI may indicate bone-density changes and underlying relative energy-deficiency syndrome and female or male athlete triad syndrome.[8,18,36,37] Individuals with these conditions have been shown to be at greater risk for BSI and may be at greater risk for long-term bone-health issues.[18,36] Clinicians working with individuals with BSI should consider a multidisciplinary approach to diagnosis and management to optimize outcomes.

This study had limitations. Data represented only cross-country athletes from 1 athletic conference and 168 BSIs. This sample may not be representative of the entire population of cross-country athletes, and the rate of BSI may be overrepresented or underrepresented. Injury rates were reported per AS based on an 86% participation rate and not as individual AEs. However, rates of BSI were similar to those found in other investigations of cross-country runners.[2,19,30] As mentioned, not all cases of BSI were associated with diagnostic imaging. Lack of diagnostic imaging may indicate an overrepresentation of BSI. For this study, all cases associated with an OSICS code consistent with a BSI were kept for analysis to investigate health care use for cases treated as BSI. In addition, clinical presentation can be indicative of BSI, and imaging modalities other than MRI, such as plain-film radiographs, have a high false-negative rate and may delay diagnosis.[9] We assumed that competing diagnoses were ruled out, but clinicians should consider obtaining MRI confirmation of suspected BSI. A total of 13 cases were associated with an acute mechanism of injury, which does not fit the classification commonly used to describe BSI.[9] Although the number of cases was limited, the classification of acute injury may represent a lack of consistency in clinician documentation and adherence to surveillance program definitions.[22,38] Athletes presenting with an onset of symptoms within the past 24 hours may have been classified as having an acute injury despite having no clear mechanism of injury. Current information provided by the HAP does not provide data to support this hypothesis, but an analysis completed with the removed 13 acute cases demonstrated similar findings when comparing rates between sexes and years (Supplemental Table). In future injury surveillance programs investigating BSI, researchers should ensure consistent use of injury definitions

Table 5. Mean Athletic Training Services per Bone-Stress Injury by Injury Classification

	Injury Classification				
	Acute		Overuse		
Group	Time-Loss	Non–Time-Loss	Time-Loss	Non–Time-Loss	Unspecified
Men	13.40	0.00	9.87	10.71	3.00
Women	2.71	24.00	11.36	13.50	8.50
Total	7.17	24.00	10.89	12.20	7.89

in addition to obtaining imaging confirmation for this specific diagnosis. Regarding athletic training services used in the management of BSI, we reported only on visits to the AT and not specific interventions used with each case. Therefore, treatment strategies associated with BSI and whether best practices were followed cannot be determined. Future epidemiology studies on health care use for BSI should be done to track treatment codes used in each case.

CONCLUSIONS

We examined the rate of BSIs in collegiate cross-country athletes and are the first to investigate associated health care use in this population. We found a high rate of overuse-TL BSIs in this population that required considerable health care resources. Specifically, the frequency of services provided by ATs was higher than that previously reported in other populations. The need for athletic training services in this population should be considered in the staffing and training of ATs working in collegiate athletic departments. Future research should be done to track treatment codes associated with BSI management to determine whether best-practice patterns are being followed. A suspected BSI should be followed up with diagnostic imaging to confirm diagnosis and grade of injury, and other members of the health care team should be consulted in the management of this condition.

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SUPPLEMENTAL MATERIAL

Supplemental Table. Bone-Stress Injuries Classified as Overuse by Season in Pac-12 Cross-Country Runners, 2018–2019 Through 2021–2022.

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