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Epidemiology of Lower Leg Soft Tissue Injuries in High School Athletes

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Abstract

Background: Annually there are an estimated 4.5 million sports- and recreation-related injuries among children and young adults in the United States. The most common sports-related injuries are to the lower extremities, with two-thirds occurring among children and young adults (age range 5-24 years). The objective is to describe the epidemiology of lower leg injuries across 27 high school (HS) sports over a 3-year period.

Methods: The Datalys Center for Sports Injury Research and Prevention provided lower leg injury data for 27 sports in 147 high schools for 2011-2012 through 2013-2014 academic years from National Athletic Treatment, Injury and Outcomes Network (NATION) HS Surveillance Program.

Results: The overall rate of lower leg injuries over this 3-year period was 1.70 per 10 000 acute events (AEs) (95% CI, 1.59-1.82). In men, the highest number of lower leg injuries was in football (n=181), but indoor track had the highest rate of injury at 2.80 per 10 000 AEs (95% CI, 2.14-3.58). In women, the highest number of lower leg injuries and the highest rate of injury were in cross-country (n=76) at 3.85 per 10 000 AEs (95% CI, 3.03-4.81). The practice injury rate was 0.91 times the competition injury rate (95% CI, 0.78-1.07).

Conclusion: An improved understanding of the most common sports in which lower leg injuries are seen may help direct appropriate resource utilization. Our data would suggest efforts toward prevention of these overuse injuries, especially in football, track, and cross-country may have the greatest impact on the health of student athletes.

Level of Evidence: Level IV, case series.

Keywords: Achilles tendon injuries, high school athletes, epidemiology, soft tissue injuries, non–time-loss injuries

Introduction

High school (HS) sports participation has increased annually for 30 years with 7 795 658 students participating during the 2013 to 2014 academic year.[6] This represents 48% of the 16 million United States (US) HS students.[4] HS sport participation has many benefits, such as improving physical and mental health, self-esteem, teamwork skills, and a reduction in cigarette smoking.[1,14,18,21,22] Although there are benefits, one must also consider the risk of injury. Annually there are an estimated 4.5 million sports- and recreation-related injuries among children and young adults in the United States.[2,3,5] The most common sports-related injuries are to the lower extremities, with two-thirds occurring among children and young adults (age range 5-24 years).[2,5]

In human anatomy, the definition of "leg" refers to the section of the lower limb extending from the knee to the ankle, also known as the crus.[10] The following muscles and tendons are found within the lower leg and are discussed in this study: Achilles tendon (AT), gastrocnemius muscle (GM), peroneal muscle (PM), tibialis anterior muscle (TAM) and tendon (TAT), and tibialis posterior muscle

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Table 1. Comparison of Lower Leg Soft Tissue Injury Rates Among Student-Athletes by Gender.

	Men vs Women Rate Ratio (95% CI)
Sport	Overall
Baseball/softball	0.60
Basketball	0.59
Cross-country	0.67
Rowing	1.79
Soccer	1.02
Indoor track	2.54
Outdoor track	0.74
Total[a,b]	0.79

[a]Baseball/softball, swimming/diving, and tennis are not included because of low reported numbers of Achilles tendon injuries.
[b]Only included sports in which both sexes participated (ie, baseball/softball, basketball, cross-country, rowing, soccer, swimming/diving, and indoor/outdoor track).

(TPM) and tendon (TPT). Tendinitis and tendinosis are typically due to overuse, so they may be seen in endurance runners. Tendinosis refers to degeneration of the tendon without inflammation and is the more common histopathology behind these tendinopathies. This degeneration weakens the tendon and makes it more susceptible to rupture.[12] Tendon ruptures are usually seen in sprinting owing to the rapid stretching and stress placed on the tendon.

Multiple studies have provided estimates of sports-related injuries among adolescents and young adults via data from national administrative databases taken from medical records. Lacking athletic exposure information, such studies are unable to provide data to calculate relative risks among sports or athlete categories.[2,3,5] Although one group has studied the epidemiology of lower extremity injuries among US HS athletes, to our knowledge, no previous studies have specifically described the epidemiology of lower leg injuries in a large sample of the HS student-athlete population using the National Athletic Treatment, Injury and Outcomes Network (NATION) HS Surveillance Program.[5,7,9,11,13,16] The purpose of this study is to describe the epidemiology of lower leg injuries across 27 high school (HS) sports over a 3-year period.

Methods

The Datalys Center for Sports Injury Research and Prevention provided lower leg injury data for 27 sports in 147 high schools for 2011-2012 through 2013-2014 academic years from NATION. R statistical software, version 3.2.5, was used for analysis. This surveillance data set is a convenience sample. To reduce the burden of reporting, non-time-loss (NTL) injuries and injuries that restricted participation for less than 24 hours were recorded as "problems" rather than full injury reports by athletic trainers. As such, the specific diagnosis was not recorded, just the body part injured and the type of injury (ie, lower leg sprain or tear vs Achilles tendinitis). In this study, these types of injuries were labeled as minor lower leg problems (MLPs).

Results

In the 27 HS sports examined during the 2011 through 2014 academic years, there were 877 lower leg injuries. In the analysis of all sex-comparable sports (ie, baseball/softball, basketball, cross-country, rowing, soccer, swimming/diving, and indoor and outdoor track), the rate of all Achilles tendon (AT) injuries in men was 0.79 times that in women (Table 1). The overall rate of lower leg injuries over this 3-year period was 1.70 per 10 000 acute events (AE) (95% CI, 1.59-1.82). In men, the highest number of lower leg injuries was in football (n=181), but indoor track had the highest rate of injury at 2.80 per 10 000 AEs (95% CI, 2.14-3.58). In women, the highest number of lower leg injuries and the highest rate of injury were in cross-country (n = 76) at 3.85 per 10 000 AEs (95% CI, 3.03-4.81). The practice injury rate was 0.91 times competition injury rate (95% CI, 0.78-1.07) (Table 2).

The most common types of lower leg injuries were MLPs (n=668), gastrocnemius muscle tears (GMT)s (n=63), and peroneal tendon tears (PTTs) (n=40) (Figure 1). NTL injuries accounted for 82% of these lower leg injuries (Figure 2). Of these lower leg injuries, 4.3% were classified as recurrent injuries, occurring more frequently in women's sports compared with men's sports (Figure 3). Recurrent injuries included injuries recorded within the same or last academic year.

When MLP injury was excluded from the calculations GMT (30.1% of injuries, with 15.8% of these injuries requiring time loss greater than 13 days), PTT (19.1%, 17.5%), ATT (13.9%, 27.6%), and ATI (13.9%, 32.5%) became the most common injuries with extended amounts of time loss (Figures 4 and 5).

Most of the injuries occurred at practice, but the rate of injury was higher in competition in most sports. In sex-comparable sports, men had a higher total number of injuries, but the rate of injury was higher in women. Exceptions to these trends are noted in sports-specific sections (Table 2).

Discussion

Among the 27 HS sports examined during the 2011-2012 through 2013-2014 academic years, the highest rate of lower leg injuries was observed during competitions, in women's sports, and in runners. This follows similar trends in previous studies showing a higher rate of injury for women compared to men, and in competition compared to practice.[5,15] Although, these other studies included all musculoskeletal injuries during their reporting, which could

Table 2. Number and Rates of Lower Leg/Achilles Injuries among High School Athletes 2011-2014.[a]

Sport	Number of Lower Leg/Achilles Injuries			Rates per 10000 Athletic Exposures[b]			Practice vs Competition Rate Ratio (95% CI)
	Competition	Practice	Total	Competition	Practice	Total	
Men's baseball	4	4	8	0.69 (0.19-1.78)	0.26 (0.07-0.68)	0.38 (0.17-0.76)	0.38 (0.07-2.05)
Men's basketball	20	19	39	2.19 (1.34-3.38)	0.70 (0.42-1.09)	1.07 (0.76-1.46)	0.32 (0.16-0.63)
Men's cross-country	13	54	67	3.57 (1.90-6.10)	2.43 (1.83-3.17)	2.59 (2.01-3.29)	0.68 (0.37-1.36)
Men's football	53	128	181	2.58 1.93-3.37)	1.42 (1.18-1.69)	1.63 (1.41-1.89)	0.55 (0.40-0.77)
Men's lacrosse	7	26	33	1.66 (0.67-3.41)	2.09 (1.36-3.06)	1.98 (1.36-2.78)	1.26 (0.53-3.44)
Men's rowing	0	2	2	0	0.95 (0.12-3.42	0.81 (0.10-2.93)	NA
Men's soccer	17	21	38	3.21 (1.87-5.34)	1.35 (0.84-2.06)	1.82 (1.29-2.5)	0.42 (0.21-0.85)
Men's swimming	0	3	3	0	0.45 (0.09-1.30)	0.37 (0.08—1.08)	NA
Men's indoor track	7	55	62	2.49 (1.00-5.33)	2.84 (2.17-3.70)	2.80 (2.14-3.58)	1.14 (0.52-2.97)
Men's outdoor track	4	47	51	0.82 (0.22-2.11)	2.04 (1.50-2.71)	1.82 (1.36-2.40)	2.48 (0.91-9.47)
Men's wrestling	5	13	18	1.14 (0.37-2.65)	0.67(0.36-1.15)	0.76 (0.45-1.20)	0.59 (0.20-2.12)
Women's basketball	11	41	52	1.43 (0.71-2.56)	1.94 (1.39-2.63)	1.80 (1.35-2.36)	1.36 (0.68-2.93)
Women's cross-country	8	68	76	3.06 (1.32-6.03)	3.97 (3.08-5.03)	3.85 (3.03-4.81)	1.30 (0.62-3.12)
Women's field hockey	4	14	18	1.01 (0.28-2.58)	1.28 (0.70-2.15)	1.21 (0.72-1.91)	1.27 (0.40-5.29)
Women's gymnastics	0	2	2	0	0.76 (0.09-2.74)	0.66 (0.08-2.40)	NA
Women's lacrosse	12	17	29	4.70 (2.43-8.21)	2.25 (1.31-3.60)	2.87 (1.92-4.12)	0.48(0.22-1.10)
Women's rowing	0	1	1	0	0.54 (0.01-2.99)	0.45 (0.01-2.52)	NA
Women's soccer	9	22	31	2.34 (1.07-4.44)	1.63 (1.02-2.47)	1.79 (1.21-2.53)	0.70 (0.31-1.72)
Women's softball	1	8	9	0.26 (0.01-1.47)	0.78 (0.34-1.54)	0.64 (0.29-1.22)	2.97 (0.40-131.72)
Women's swimming	0	1	1	0	0.18 (0.01-0.98)	0.15 (0.01-0.81)	NA
Women's tennis	1	2	3	0.87 (0.02-4.83)	0.62 (0.08-2.25)	0.69 (0.14-2.01)	0.72 (0.04-42.46)
Women's indoor track	9	57	66	3.82 (1.75-7.26)	3.77 (2.86-4.89)	3.78 (2.92-4.81)	0.99 (0.49-2.27)
Women's outdoor track	8	60	68	2.11 (0.91-4.16)	3.30 (2.52-4.24)	3.09 (2.40-3.92)	1.56 (0.74-3.79)
Women's volleyball	2	17	19	0.26 (0.03-0.95	0.77 (0.45-1.24)	0.64 (0.39-1.00)	2.94 (0.70-26.25)
Men's sports total[c]	130	372	502			1.55 (1.42-1.69)	
Women's sports total[c]	65	310	375			1.96 (1.77-2.17)	
Overall total	195	682	877	1.84 (1.59-2.11)	1.67 (1.55-1.80)	1.71 (1.59-1.82)	0.91 (0.78-1.07)

Abbreviations: AT, Achilles tendon; NA, not available.

[a]No AT injuries were reported for men's tennis and men's or women's golf.

[b]An athlete exposure is defined as 1 student-athlete participating in 1 practice or competition.

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

lead to a selection bias when some sports have a higher incidence of participation or are more physical in nature than others, which could skew the injury rates. Because lower leg injuries account for more than two-thirds of these injuries and with the increasing number of foot and ankle specialists in the US helping to treat these problems, we only examined these types of musculoskeletal injuries in our study.[2,5,15] Specifically, the women cohort in which previous studies demonstrate soccer or gymnastics as having the highest rate of injury, our results showed that running sports (both cross-country and track) had the highest injury rate for lower leg injuries.[3,5] This was also true of the men in our study in which the running sports had higher injury rates for lower leg injuries compared with football and basketball in other studies (Table 2).[3,5,13,16]

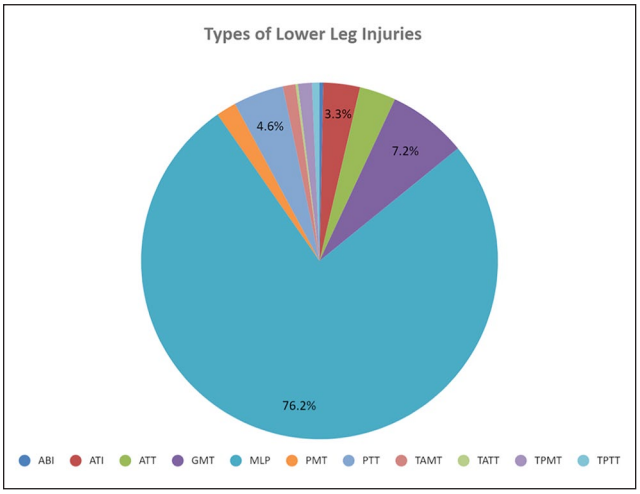

Figure 1. Types of lower leg soft tissue injuries among high school athletes in 27 sports from 2011 to 2012 through 2013 to 2014 academic years. ABI, Achilles bursitis; ATI, Achilles tendinitis; ATT, Achilles tendon tear; GMT, gastrocnemius muscle tear; MLP, minor leg problem; PMT, peroneal muscle tear; PTT, posterior tibial tendonitis; TAMT, tibialis anterior muscle tear; TATT, tibialis anterior tendon tear; TPMT, tibialis posterior muscle tear; TPTT, tibialis posterior tendon tear.

The higher rate of injuries was more likely to occur in competition compared to practice (Table 2). Previous studies have shown basketball to be the highest injury rate for men but did not delineate between competition vs practice and/or did not include the running sports in their comparisons.[3,5,13] Our study did both and showed that the highest lower leg injury rate for competition compared to practice occurred in basketball competition for men, followed by soccer and football. For women in our study, the highest lower leg injury rate for competition compared to practice occurred during lacrosse competition, followed by soccer (Table 2). Some of these differences observed in our study could be attributable to changes in sport participation over time, and the addition of more women's sports as a result of Title IX since these studies were conducted in the late 1990s and early 2000s.[17,19]

When looking at lower leg injuries more likely to occur in practice compared to competition, track and lacrosse were the highest for men whereas softball and volleyball

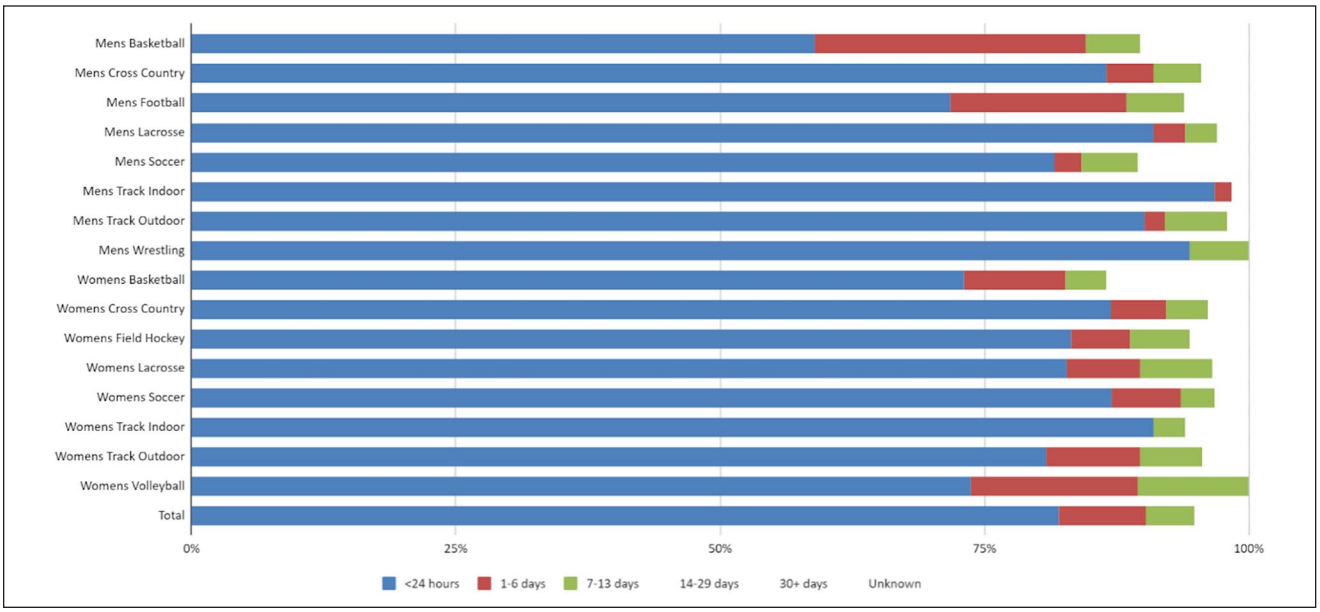

Figure 2. Time loss due to lower leg soft tissue injuries among high school student athletes in different sports from 2011 to 2012 through 2013 to 2014 academic years. Excluded were sports with lower leg soft tissue injury numbers totaling less than 10 (ie, men's basketball, baseball, golf, lacrosse, rowing, swimming, tennis, indoor track, and wrestling and women's field hockey, golf, gymnastics, rowing, soccer, swimming, and tennis).

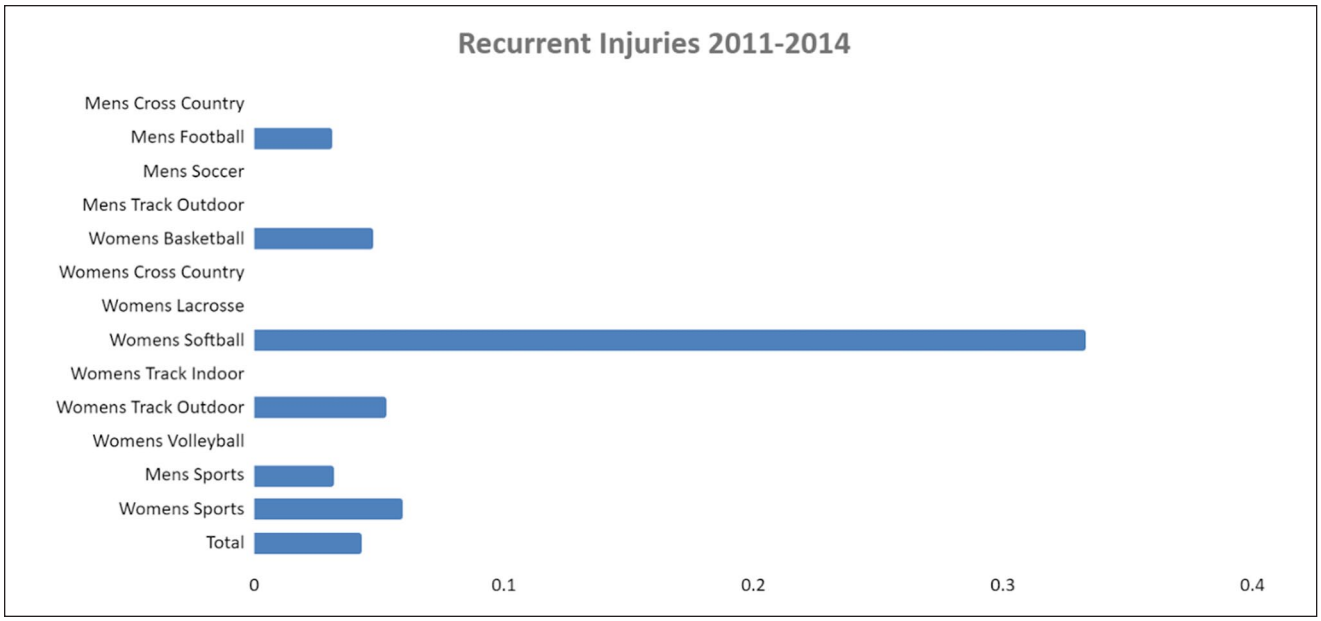

Figure 3. Proportion of lower leg soft tissue injuries that were recurrent among high school student athletes in different sports from 2011 to 2012 through 2013 to 2014 academic years. Excluded were sports with recurrent lower leg soft tissue injury numbers totaling less than 5 (ie, men's basketball, baseball, golf, lacrosse, rowing, swimming, tennis, indoor track, and wrestling and women's field hockey, golf, gymnastics, rowing, soccer, swimming, and tennis).

were the highest for women (Table 2). It is unclear why some of these differences were observed but is important to note that even though softball and volleyball had the higher ratio of practice injuries compared with competition, the overall rate of injuries in these sports were low.

Our study demonstrated an overall higher lower leg injury rate occurring in women compared to men (Table 1). This is consistent with some of the more recent epidemiologic studies looking at high school athletes' injuries and holds true for lower leg injuries in our study, but differs from older studies done before 2007.[3,5,8,15] This is also true when comparing recurrent injuries of the men and women in which women had a higher rate of recurrent and NTL injuries compared with men (Figure 3).[5,8,15] However, our study is limited because baseball/softball and swimming/diving were not included in our analysis of some of these statistics because of low reported numbers, and we only included sports in which both sexes participated.

MLPs were the most common type of lower leg injury, accounting for more than 75% of injuries, but no MLP injury required more than 24 hours of time loss (Figures 1 and 5). The amount of time loss for any lower leg injury by sport and gender was also recorded and showed that basketball and football for men had the highest percentage of time loss per lower leg injury, compared with basketball and volleyball for women (Figure 2). When MLP injury was excluded from the calculations, GMT resulted in the highest percentage of time-loss injuries (30.1%), with ATI having the highest percentage of time loss greater than 13 days

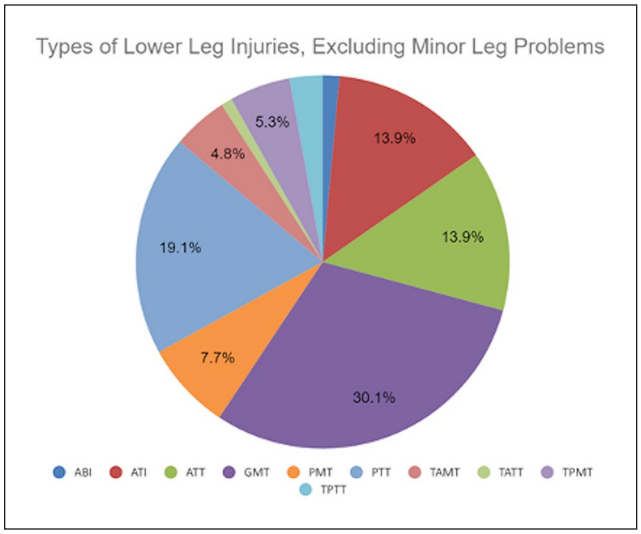

Figure 4. Types of lower leg soft tissue injuries among high school athletes in 27 sports from 2011 to 2012 through 2013 to 2014 academic years excluding minor leg problems. ABI, Achilles bursitis; ATI, Achilles tendinitis; ATT, Achilles tendon tear; GMT, gastrocnemius muscle tear; PMT, peroneal muscle tear; PTT, posterior tibial tendonitis; TAMT, tibialis anterior muscle tear; TATT, tibialis anterior tendon tear; TPMT, tibialis posterior muscle tear; TPTT, tibialis posterior tendon tear.

(32.5%) (Figures 4 and 5). This suggests that if the MLP is suspected, there is likely no more than 24 hours

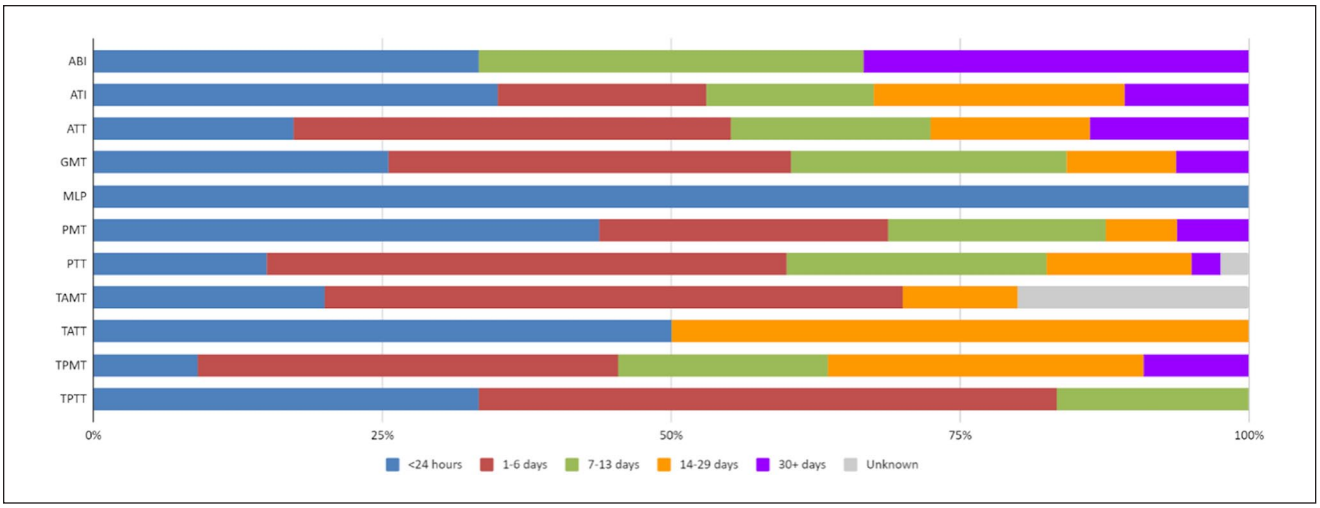

Figure 5. Time loss based on type of lower leg soft tissue injury among both female and male high school student-athletes across all sports from 2011 to 2012 through 2013 to 2014 academic years.

before getting back to activity, compared to excluding it and appreciably increasing chances of needing additional time to recover from an injury.

Our study has many limitations. MLPs greatly increased the power of our study, but it increased the number of NTLs and possibly affected other data such as the total number of injuries and rate per sport. There is also a reporting bias in this study because a database of information was used, and specifically because of how MLPs were recorded. MLPs were all classified as NTLs since they were thought of as minor. Also, to decrease the burden on athletic trainers reporting, they did not include all variables when charting the injury, such as injury mechanism, specific injury location in the lower leg, injury player position, new injury, or chronic injury. Another limitation of our study was that only 147 high schools participated in this reporting and no demographic characteristics of the schools were able to be obtained, making accurate generalization of these data to other high school athletes difficult. Other limitations were lack of reporting on synthetic turf vs nonsynthetic turf and if these differences in field terrains were present in practice vs in competition, which could alter the injury rates.[20] We further do not have information on ligament injuries nor the specific nature of the peroneal injuries (eg, peroneal muscle vs peroneal tendon vs peroneal subluxation vs peroneal dislocation). Lastly, there was no reporting on whether injuries ultimately required a surgery, which would alter the reported time loss variables.

An improved understanding of the most common sports in which lower leg injuries are seen and have higher amounts of time lost may help direct appropriate resource utilization. Our data could help strategize resource allocation for high school athletes in the prevention and/or treatment of lower leg injuries based on gender, practice vs competition situations, and based on sport, especially for running sports that have previously been underreported in the literature when compared to all sports. It may be beneficial to reallocate resources from sports with a higher percentage of NTL injuries to sports that have greater likelihood of more serious injuries, resulting in greater time loss from sport.

Ethical approval

Ethical approval for this study was waived by the University of South Carolina Institutional Review Board because this was determined Non-Human Subjects Research and is exempt from the Protection of Human Subjects Regulations.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article. ICMJE forms for all authors are available online.

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