Journal of Athletic Training 2010;45(1):51–57

www.nata.org/jat

original research

Risk Factors for Self-Reported Exercise-Related Leg Pain in High School Cross-Country Athletes

Mark F. Reinking, PhD, PT, ATC, SCS; Tricia M. Austin, PhD, PT, ATC; Ann M. Hayes, DPT, PT, OCS

Department of Physical Therapy and Athletic Training, Saint Louis University, St Louis, MO

Context: Prevention of exercise-related leg pain (ERLP) has not been successful because ERLP risk factors are not well known.

Objective: To determine the percentage of high school cross-country (XC) athletes who reported a history of ERLP in their running careers, to identify the percentage of athletes who reported an occurrence of ERLP during 1 XC season, and to investigate the association of selected factors (age, high school year, years of high school running, sex, ERLP history, body mass index [BMI], foot type, and training distance) and the occurrence of ERLP.

Design: Prospective cohort study.

Setting: Six local high schools.

Patients or Other Participants: One hundred twenty-five high school XC athletes (62 females, 63 males).

Main Outcome Measure(s): All athletes completed an initial ERLP questionnaire, and foot type was visually assessed. After the season, athletes were asked to complete a Web-based questionnaire regarding the seasonal occurrence of ERLP. Statistical analyses of differences (*t* tests) and associations (χ^2, relative risk) were conducted.

Results: A total of 103 of the 125 athletes (82.4%) reported a history of ERLP, with 81 athletes reporting ERLP occurrence within the month preceding completion of the initial questionnaire. Bilateral medial leg pain was the most common ERLP presentation. More than half of the athletes (58.4%) with an ERLP history reported that the pain had interfered with XC participation. Ninety-three athletes responded to the postseason questionnaire, and 45 (48.0%) reported ERLP seasonal occurrence. Most athletes (97.8%) who experienced the seasonal occurrence of ERLP had a history of ERLP. No associations were noted between ERLP history or seasonal occurrence and age, high school year, years of high school running, sex, BMI, foot type, or training distance.

Conclusions: Both a history of ERLP and the seasonal occurrence of ERLP were common among these XC athletes. The only risk factor identified for ERLP season occurrence was ERLP history.

Key Words: shin splints, overuse injuries, running, injury risks

Key Points

- Exercise-related leg pain was frequent in high school cross-country athletes, affecting more than 80% at some point in their careers and nearly 65% within the month before the season started.
- Postseason, almost half of the athletes reported that exercise-related leg pain had occurred during the season.
- No associations were noted between a history or seasonal occurrence of exercise-related leg pain and age, high school year, years of high school running, sex, body mass index, foot type, or training distance. A history of such pain was the only risk factor identified for seasonal occurrence of pain.

Exercise-related leg pain (ERLP) is a regional pain syndrome occurring in athletes that manifests as pain between the knee and the ankle during exercise.[1–3] Pathoanatomic entities causing this syndrome include medial tibial stress syndrome (MTSS), tibial stress fractures, tendinopathies, and chronic exertional compartment syndrome.[4] The term *shin splints* is also used by both health care professionals and laypersons to describe leg pain. However, the lack of clarity in the diagnostic interpretation of this term has prompted both Brukner[1] and Batt[5] to recommend avoiding it.

The few epidemiologic data that exist regarding ERLP in high school or collegiate cross-country (XC) athletes are further confounded by the labeling of leg pain. Rauh et al[6] reported that "shin injuries" represented the highest rate (per athletic exposure) of new injury and reinjury for all running injuries. Sallis et al[7] conducted a 15-year retrospective study of injury reports in 7 collegiate sports and found that the "lower leg" was the most common site of injury per athlete-years. Overuse injuries were first tracked by the National Collegiate Athletic Association Injury Surveillance System in 2005: the 2005 data[8] for XC athletes indicated that the "lower leg" was among the top 3 body parts injured and was among the top 2 injuries resulting in 7 or more days of restricted participation.

Risk factors for overuse injuries can be categorized as extrinsic and intrinsic[9–13] or as modifiable and nonmodifiable.[14] Extrinsic factors are those outside of the person and include such factors as specific sport activities, training distance, and shoes. Intrinsic factors are those within a person, such as sex, race, and body mass index (BMI). Modifiable risk factors can be altered by prevention strategies. Nonmodifiable risk factors cannot be changed but may be useful in identifying and monitoring at-risk individuals.[14,15] In this study, the potential risk factors of age, high school year, years of high school running, sex, and ERLP history were not modifiable, and BMI and training distance were modifiable. Whether foot type classification is modifiable is debatable; although a person's foot type cannot be changed nonsurgically, the use of foot orthotics can influence the mechanical behavior of the foot and leg.[16–19] In this study, we considered foot type as a modifiable risk factor. In a systematic review regarding prevention of shin splints, Thacker et al[13] reviewed the literature on risk factors for overuse injury in general and for ERLP specifically. They reported that the few authors who have examined risk factors for ERLP suggested that factors including overpronation, increased training volume, hard running surface, and shoe wear may increase ERLP risk. In their conclusion, Thacker et al[13] stated that "Our review yielded little objective evidence to support widespread use of any existing interventions to prevent shin splints."

van Mechelen et al[20] described a 4-step sport injury prevention model. This model begins with identifying the extent of the problem and then focuses on studying the factors associated with the injury. Once risk factors are identified, the third step introduces measures to reduce injury risk and, finally, assesses the effectiveness of the prevention strategies. We believe the lack of effective prevention of ERLP, as described by Thacker et al,[13] is largely the result of a lack of evidence in step 2, the identification of intrinsic and extrinsic factors that predispose an athlete to this pain syndrome.

Therefore, we designed this study based on the first 2 steps described in the injury prevention model of van Mechelen et al.[20] Given the paucity of published information regarding leg pain in high school XC athletes, we established 3 purposes for this study: (1) to determine the percentage of high school XC athletes who reported a history of ERLP in their running careers, (2) to identify the percentage of high school XC athletes who reported an occurrence of ERLP during 1 XC season, and (3) to investigate the association of selected intrinsic factors (age, high school year, years of high school running, sex, ERLP history, BMI, foot type) and 1 extrinsic factor (training distance) on the occurrence of ERLP. Although ERLP can be classified into pathoanatomic entities, we did not focus on these medical diagnostic categories but rather on the athletes' self-reports of ERLP.

METHODS

Design

This study was designed as a prospective cohort design involving high school XC athletes in a Midwestern metropolitan region. Athletes were followed over the course of 1 fall season for an occurrence of ERLP. The study was approved by the Saint Louis University Institutional Review Board.

Participants

We identified 9 public or private high schools with successful XC programs. The high schools' athletic directors and XC coaches were contacted regarding their willingness to allow us to invite participation of their XC athletes, and 6 high schools consented to cooperate. This group included 2 public schools, 2 private coeducational schools, 1 private all-girls high school, and 1 private all-boys high school. A total of 279 high school students were listed on the rosters for the XC teams at these 6 schools.

Initially, we arranged a preseason meeting with athletes and parents at each high school to describe the purpose and methods of the study and to review the construct of ERLP. Because most of the XC athletes were younger than 18 years, the consenting process required both parental or guardian consent and athlete assent.

We then arranged a visit day with the XC coach at each school. At this meeting, we met with the team and reviewed the purpose and methods of the study. Athletes who fulfilled the inclusion criteria (rostered on the XC team, full weight-bearing status) and had completed the consent process with signed consent and assent forms were enrolled in the study. Before they completed the initial questionnaire, we reviewed the definition of leg pain (ie, pain below the knee and above the ankle associated with running) and visually identified the 3 leg pain zones. Athletes were invited to ask questions to clarify their understanding of ERLP, and then specific instructions were provided regarding completion of the initial questionnaire.

Initial Questionnaire

The initial data collection process consisted of completion of a questionnaire and visual assessment of foot type. The questionnaire included self-reported age, height, weight, year in high school, years of competitive running, average training distance per week in the past month, history of ERLP (*ever*, *last year*, *last 30 days*), location of ERLP, whether ERLP had caused the athlete to miss at least 1 day of training, whether ERLP had negatively affected practice or race time, and history of diagnosed stress fracture. Athletes were provided with pictures of right and left legs with the ERLP zones (medial, lateral, posterior) labeled. Each participant's BMI was calculated from self-reported height and weight, and this value was used to categorize the athlete as underweight (BMI less than 18.5 kg/m^2), normal (BMI between 18.5 and 25 kg/m^2), or overweight (BMI greater than 25 kg/m^2).[21]

Visual Assessment of Foot Type

Visual assessment of foot type was based on the method described by Dahle et al.[22] They visually assessed each foot in bilateral stance for 3 factors: calcaneal position (inverted, neutral, or everted), presence or absence of a medial talonavicular bulge, and height of the medial longitudinal arch. According to Dahle et al,[22] for a foot to be classified as either pronatory or supinatory, the foot had to have all 3 criteria for that foot type. If 3 criteria were present—the calcaneus was everted more than 3°, a medial talonavicular bulge was present, and the height of the medial longitudinal arch was low—the foot was classified as pronatory. Conversely, if the calcaneus was inverted more than 3°, a medial talonavicular bulge was not present, and the height of the medial longitudinal arch was high, the foot was classified as supinatory. If the foot did not meet all 3 criteria for either a pronatory or supinatory foot, it was classified as neutral. Dahle et al[22] reported a κ value of 0.724 for intertester reliability of this measure. In our study, a single investigator (A.M.H.) performed all of the visual assessments of foot type.

Postseason Questionnaire

After the high school XC championship event (3.5 months after the initial questionnaire was completed), the athletes were sent e-mail messages asking them to complete the postseason questionnaire using a password-protected Web site. This questionnaire was similar to the initial questionnaire and asked for self-report of average training distance per week, occurrence and location of ERLP during the season, whether ERLP had caused the athlete to miss at least 1 day of training, whether ERLP had negatively affected the athlete's race time, and any diagnosis of stress fracture during the season. The Web-based questionnaire included both the definition of ERLP and the same images of the right and left leg ERLP zones used in the initial questionnaire.

Usability Study

Before data collection with our participants, we assessed usability of the initial and postseason questionnaires with 5 competitive high school distance runners not involved in the study. The athletes reviewed the initial and postseason questionnaires and provided feedback on questionnaire instructions, question clarity, and question routing. Based on the athletes' feedback, minor questionnaire changes were made.

Reliability

A pilot study was conducted to determine the researcher's intratester reliability for the visual assessment of foot type. Seventeen volunteers were measured twice in 1 day and presented in random order, and the investigator was blinded to participant identification. The combined κ statistic for both feet was 0.75.

Data Analysis

Power calculations were made using OpenEpi (version 2.21; Dean AG, Sullivan KM, Soe MM, Atlanta, GA).[23] All other statistical analyses were completed using SPSS for Windows (version 13.0; SPSS Inc, Chicago, IL). Mean and SD values were calculated for continuous demographic characteristics (age, BMI). The *t* tests were used to analyze differences between athletes with or without a history or seasonal occurrence of ERLP for the 2 continuous variables, age and BMI, with significance set at $P < .05$. No Bonferroni adjustment was made for these 4 *t* tests. Frequency distributions were calculated for age, high school year, years of high school running, sex, BMI category, foot type, and weekly training distance. Associations of these categorical measures and ERLP history and ERLP seasonal occurrence were assessed using the χ^2 and Cramer V tests.

Relative risk values were calculated for high school year, years of high school running, training distance, BMI category, and sex using 2 × 2 contingency tables. The measures of high school year, years of high school running, training distance, and BMI were reduced to dichotomous variables based on published literature. For high school year and years of high school running, we dichotomized based on the findings of Goldberg and Pecora[24] that freshmen were at a higher risk for stress fracture injury based on a change in training volume from high school to college. We extended their finding to the possibility of a similar change in training volume from middle school to high school. We chose to dichotomize both by high school year (freshman versus nonfreshman) and years of high school running (first year versus non–first year) to investigate the possibility of an association of ERLP and novice high school runners. For training distance, we used 64.4 km/wk as the threshold for the dichotomy, because Macera et al[25] found that the most important predictor of overuse injury (including leg pain) in a group of adult runners was training 64.4 km (40 mi) or more per week. Based on the work of Plisky et al[26] and Neely,[9] we dichotomized the BMI data into 2 categories: normal BMI and nonnormal BMI (overweight or underweight). Relative risk values were also calculated for ERLP seasonal occurrence based on ERLP history.

Table 1. Rostered and Participant Cross-Country Athletes

Category	Rostered Athletes, No.	Rostered Athletes, %	Participants, No.	Participants, %
High school year				
Freshman	80	28.7	39	31.2
Sophomore	68	24.4	36	28.8
Junior	73	26.2	29	23.2
Senior	58	20.8	21	16.8
Sex				
Female	187	67.0	62	49.6
Male	92	33.0	63	50.4
Total	279		125	

RESULTS

A total of 125 high school athletes (62 females, 63 males) completed the assent and consent process necessary to participate. This represented 44.8% of the potential study participants (279 rostered athletes). The class breakdown and sex of the potential and actual participants are shown in Table 1. The participants' mean age was 15.4 years (range, 13–18 years); 60% of the athletes ($n = 75$) were freshmen or sophomores. A total of 10.4% of the athletes ($n = 13$) reported they were training more than 64.4 km/wk in the month before the season, and 16.1% ($n = 15$) reported training more than 64.4 km/week during the season (Table 2).

Of the 125 athletes, 103 (82.4%) reported a history of ERLP with running; 99 of the 103 (96.1%) had experienced ERLP in the past year and 81 of the 103 (78.6%) had experienced ERLP in the past month. Of the 103 athletes with a history of ERLP, 31 reported that the pain had caused them to miss at least 1 day of practice, and 70 reported that ERLP had adversely affected their performance (ie, race time). The medial leg was the most common site of ERLP, and 61 athletes reported bilateral symptoms.

Of the 125 athletes, 93 (74%) responded to the postseason Web-based questionnaire. The 32 nonresponders were not different than responders for age and BMI, and χ^2

Table 2. High School Cross-Country Athletes by Preseason and In-Season Weekly Training Distance (No., %)

Weekly Distance, km	Preseason ($n = 125$)[a]	In-Season ($n = 93$)
<16	4 (3.2)	1 (1.1)
16–31	19 (15.2)	10 (10.8)
32–47	45 (36.0)	33 (35.5)
48–63	43 (34.4)	34 (36.6)
64–79	9 (7.2)	12 (12.9)
≥80	4 (3.2)	3 (3.2)

[a] One participant did not report training distance.

Table 3. Associations Between Exercise-Related Leg Pain (ERLP) History and Exercise-Related Leg Pain Seasonal Occurrence

Cross-Tabulation	χ^2 Value	*P* Value
ERLP history × age (13, 14, 15, 16, 17, 18 y)	6.45	.17
ERLP season × age (13, 14, 15, 16, 17, 18 y)	4.87	.30
ERLP history × high school year (freshman, sophomore, junior, senior)	5.48	.14
ERLP season × high school year (freshman, sophomore, junior, senior)	7.02	.07
ERLP history × year of high school running (1st, 2nd, 3rd, 4th y)	3.23	.36
ERLP season × year of high school running (1st, 2nd, 3rd, 4th y)	5.63	.13
ERLP history × sex (male, female)	0.96	.33
ERLP season × sex (male, female)	0.11	.74
ERLP history × body mass index category (underweight, normal, overweight)	1.19	.55
ERLP season × body mass index category (underweight, normal, overweight)	0.76	.68
ERLP history × weekly distance (<16.10, 16.10–31.38, 32.19–47.48, 48.28–63.57, 64.37–79.66, ≥80.47 km/wk)	3.92	.56
ERLP season × weekly distance (16.10, 16.10–31.38, 32.19–47.48, 48.28–63.57, 64.37–79.66, ≥80.47 km/wk)	5.05	.41

analyses revealed no difference in distributions between the responders and nonresponders for sex, ERLP history, or training distance. Of the 93 responding athletes, 45 (48%: 20 females, 25 males) reported occurrence of ERLP during the fall XC season. Of the 45 athletes who experienced seasonal occurrence of ERLP, 44 (97.8%) reported an ERLP history. Bilateral medial ERLP was the most common presentation of ERLP during the season, and ERLP interfered with training or race performance in 25 of the 45 athletes (56%). In the initial questionnaire, 6 athletes (2 females, 4 males) reported a history of a diagnosed leg stress fracture. No athletes reported being diagnosed with a stress fracture during the season.

Analyses of differences between groups for the continuous variables of age and BMI were conducted using *t* tests. No difference was noted for mean BMI between those with (19.9 ± 2.2) and without (19.5 ± 1.5) a history of ERLP ($t = .69$, $P = .50$) or those with (19.8 ± 2.1) and without (19.6 ± 2.0) seasonal occurrence of leg pain ($t = .62$, $P = .53$). Similarly, no difference was seen in age between those with (15.5 ± 1.1 years) and without (15.2 ± 1.2 years) a history of ERLP ($t = .98$, $P = .33$) or those with (15.6 ± 1.1 years) and without (15.2 ± 1.1 years) seasonal occurrence of leg pain ($t = 2.00$, $P = .05$). Although post hoc analyses revealed low power for these comparisons (7%–41%), we believe that the differences observed between groups were not clinically meaningful.

Chi-square analyses using nondichotomized data showed no associations ($P > .05$) between the athletes with and without ERLP history or seasonal occurrence with regard to age, high school year, years of high school running, sex, BMI, or weekly training distance (Table 3). An interesting but nonsignificant finding was that all 5 athletes in the overweight BMI category (BMI = 25.0–29.9) had a history of leg pain. However, of the 3 athletes in the overweight category who responded to the postseason questionnaire, only 1 reported occurrence of ERLP during the season. The relative risk values calculated using dichotomized data for high school year, years of high school running, sex, BMI, and training distance were not significant (Table 4). The only significant risk factor for the seasonal occurrence of ERLP was a history of ERLP.

With respect to visual assessment of foot type, most athletes had neutral feet, with pronatory feet the second most common type, and there were very few supinatory feet in the sample. Chi-square analysis of the foot type and ERLP history and seasonal occurrence cross-tabulation (Tables 5 and 6) was not significant but revealed an interesting finding. All athletes with a supinatory foot type reported an ERLP history in the initial questionnaire.

DISCUSSION

A history of ERLP was reported frequently among this group of high school XC athletes (82.4%), and approximately three-quarters of those with an ERLP history reported that the pain had interfered with their XC participation. Nearly one-half of the athletes responding to the postseason questionnaire reported an episode of ERLP during the season, and almost all of those athletes (98%) reported a history of ERLP. More than half of the athletes who reported the seasonal occurrence of ERLP also reported that it interfered with their XC participation.

As this investigation was based on athlete self-reports, the accuracy of injury self-reporting must be addressed. Haugland and Wold[27] stated that adolescents were able to "understand, evaluate, and report subjective health complaints." In the initial questionnaire, we asked the high school athletes to identify if they had ever experienced leg pain with running and if they had experienced leg pain in the past year and in the past month. Of the athletes reporting a history of leg pain at some previous time, 96% reported an episode in the past year and 79% in the past month. Although data from a high school athletic population have not been reported, Gabbe et al[28] reported that in a group of 70 community Australian football players, 100% were able to recall whether or not they were injured during the previous year. More than three-quarters were able to recount the body region that was injured, but only 60% were able to recall a specific diagnosis. No age data were provided in that study. Valuri et al[29] studied a cohort of 1512 community athletes ranging in age from 15 to 56 years (mean age = 23 years) and found that 4-week recall of sport injury was accurate, and recall accuracy was highest for details including the body region injured. Although we were not able to confirm the accuracy of injury reporting in this study, previous authors suggest that the capacity to accurately recall the occurrence of injury and the body region injured may be as high as 75% or higher 1 year after injury.

Two related studies[26,30] on MTSS in high school running athletes have shown this specific manifestation of ERLP to be relatively common among high school runners. The self-report of ERLP had no confirmative medical diagnosis in this study, but the most common self-report of ERLP was bilateral medial leg pain, consistent with the location of MTSS and in agreement with the findings of previous studies.[3,31,32] The percentages of high school athletes with both historical and seasonal occurrence of ERLP exceed the numbers reported in 2 previous studies[3,32] on ERLP in collegiate XC athletes. Both of those studies were also based on self-report and lacked confirmatory diagnostic

Table 4. Proposed Risk Factors for Exercise-Related Leg Pain: Relative Risk Values and 95% Confidence Intervals (CIs)

Factor	History of Exercise-Related Leg Pain? Yes (n = 103), No.	No (n = 22), No.	Relative Risk (95% CI)	Seasonal Occurrence of Exercise-Related Leg Pain? Yes (n = 45), No.	No (n = 48), No.	Relative Risk (95% CI)
High school year						
Freshman	28	11	0.82 (0.66, 1.02)	9	19	0.58 (0.32, 1.04)
Not freshman[a]	75	11		36	29	
Years of high school running						
1st	35	11	0.88 (0.73, 1.06)	12	20	0.69 (0.42, 1.15)
2nd–4th[a]	68	11		33	28	
Sex						
Female	49	13	0.92 (0.78, 1.08)	20	23	0.93 (0.61, 1.42)
Male[a]	54	9		25	25	
History of exercise-related leg pain?[b]						
Yes				44	33	9.14 (1.36, 61.59)
No[a]				1	15	
Body mass index[c]						
Not normal	33	6	1.05 (0.88, 1.24)	15	13	1.11 (0.72, 1.70)
Normal[a]	67	16		30	32	
Training distance, km/wk[d]						
≤64.4	12	1	1.14 (0.95, 1.36)	6	3	1.46 (0.87, 2.44)
>64.4[a]	90	21		38	45	

[a] Referent group.
[b] $\chi^2 = 13.74$, $P < .001$.
[c] Three athletes did not provide information sufficient to permit calculation of body mass index.
[d] One participant did not report training distance.

testing. We speculate that there may be a "natural selection" process occurring, in which high school athletes with a history of repeated ERLP episodes may choose to not pursue collegiate running, effectively lowering the percentage of collegiate athletes with this pain syndrome. Without question, further study in this area is needed.

In a study of stress fractures (a common cause of ERLP) in collegiate athletes, Goldberg and Pecora[24] found that most athletes with stress fractures were freshmen and had increased their training significantly over the 3 months before diagnosis. Although too few self-reported stress fractures occurred to permit data analysis, we were interested in whether the high school freshmen reported a greater occurrence of ERLP during the season based on the same logic used by Goldberg and Pecora.[24] When we conducted a separate 2 × 2 (seasonal occurrence of ERLP [*yes* or *no*] × freshman or not freshman) χ^2 analysis, we found an association ($\chi^2 = 4.23$, $P = .04$), with the freshmen having a lower occurrence than the non-freshmen. The relative risk for this relationship was 0.58, but the 95% confidence interval was 0.32 to 1.04 and the power was 53%. We do believe, though, that these results fail to support the hypothesis that high school freshmen are at greater risk of overuse injury.[24]

Our results also did not show a significant association between training distance and ERLP. Macera et al[25] found that the most important predictor of overuse injury (including leg pain) in a group of adult runners was training 64.4 km (40 miles) or more per week. Among this sample of high school runners, fewer than 15% were training more than 64 km/wk, as compared with our previous study[32] of collegiate XC runners, in which more than 50% were training more than 64 km/wk. Because of this low prevalence of exposure and the small sample size in this study, the power to detect training distance as a significant risk factor for ERLP was low (approximately 22%).

Some investigators[7,9,26,30] have reported a greater occurrence of ERLP in female athletes, whereas others[3,32]

Table 5. Visual Assessment of Foot Type and History of Exercise-Related Leg Pain (No., %)

Foot Type	Right[a] History of Exercise-Related Leg Pain? Yes (n = 103)	Right[a] No (n = 22)	Left[b] Yes (n = 103)	Left[b] No (n = 22)
Pronatory	18 (18)	2 (9)	19 (18)	4 (18)
Neutral	81 (79)	20 (91)	79 (77)	18 (82)
Supinatory	4 (4)	0 (0)	5 (5)	0 (0)

[a] $\chi^2 = 1.99$, $P = .37$.
[b] $\chi^2 = 1.13$, $P = .57$.

Table 6. Visual Assessment of Foot Type and Seasonal Occurrence of Exercise-Related Leg Pain (No., %)

Foot Type	Right[a] Seasonal Occurrence of Exercise-Related Leg Pain? Yes (n = 45)	Right[a] No (n = 48)	Left[b] Yes (n = 45)	Left[b] No (n = 48)
Pronatory	10 (22)	6 (13)	9 (20)	9 (19)
Neutral	35 (78)	40 (83)	35 (78)	37 (77)
Supinatory	0 (0)	2 (4)	1 (2)	2 (4)

[a] $\chi^2 = 3.24$, $P = .20$.
[b] $\chi^2 = 0.292$, $P = .86$.

have not found this relationship. Our results showed no significant sex difference with regard to ERLP history or seasonal occurrence of ERLP. The 2 groups[26,30] reporting a greater occurrence of ERLP in female high school athletes considered only the occurrence of MTSS. Plisky et al[26] reported that being female and having a higher BMI were related to the occurrence of MTSS in high school athletes, but after controlling for use of orthotics, only BMI emerged as a risk factor. Nonnormal categories of BMI (underweight or overweight) were not identified as risk factors for ERLP in this study of high school athletes. However, we found that all athletes in the overweight BMI category reported a history of ERLP. This observation requires further study, as we did not have the data to examine the chronology of their ERLP episodes and their BMI at the onset of ERLP. We had low power to detect differences for both sex (4%) and BMI (7%). The low power for sex was attributable to the fact that we had almost equal numbers exposed (female) as nonexposed (male); the risk of injury was almost the same for exposed and unexposed, and ERLP was a common outcome. However, BMI was likely low in power because the risk of injury was almost the same in the normal and not-normal BMI groups after we collapsed underweight and overweight together as "not normal."

No association was found between visual assessment of foot type (pronatory, neutral, or supinatory) and historical or seasonal ERLP in these high school XC athletes (Tables 5 and 6). Evidence regarding the association between foot type (pronatory, neutral, or supinatory) and the occurrence of ERLP is conflicting. Some authors[30,33–37] have shown an association between a pronatory foot and ERLP, whereas 2 groups[38,39] have reported an association between a supinatory foot and lower extremity overuse injury. However, other investigators[3,32,40] have reported no association between foot type and ERLP. Although ERLP is commonly attributed to characteristics such as a pronatory foot, our data do not support this association. One interesting finding is that all 5 athletes with a supinatory foot had a history of ERLP; this is consistent with our collegiate XC study results,[32] in that 8 athletes had a supinatory foot type and 7 of those had a history of ERLP. This trend supports the research[38,39] indicating that a supinatory foot may be a risk factor for ERLP conditions and justifies the need for further investigation in this area.

It must be noted, though, that visual assessment of foot type is a static measure, and no direct measure of foot function during walking or running was assessed in this study. Willems et al[33] used instrumented motion analysis to measure dynamic gait characteristics in a group of 400 collegiate freshmen physical education students. Based on kinematic variables and plantar pressures, the authors found that those students with ERLP had greater foot pronation than those without ERLP. Consequently, they concluded that "altered biomechanics play a role in the genesis of ERLLP [exercise related lower leg pain] and thus should be considered in prevention and rehabilitation."[33(p91)] The difference in our findings may be related to differences in participant characteristics (high school XC athletes versus physical education students) or in assessment of foot type (static versus dynamic measures). Further research is necessary to elucidate these differences.

Athletes were asked to report any diagnosis of stress fractures in the initial questionnaire and in the postseason questionnaire. Based on our collective clinical experience, we did not anticipate the low number of stress fractures reported in this sample of high school XC runners. Only 6 of the 125 athletes reported a history of stress fracture (2 females, 4 males) in the initial questionnaire, and none of the 93 athletes responding to the postseason questionnaire reported a diagnosed stress fracture during the season. Considerable research[41–45] has shown a greater incidence of stress fractures in females than in males, but our results did not agree with this finding.

The only risk relationship identified in this study was between a history of ERLP and the seasonal occurrence of ERLP. A history of ERLP is an intrinsic, nonmodifiable risk factor. The relative risk for development of ERLP during the season for those who had a history of ERLP was 9.14 (95% confidence interval = 1.36, 61.59). Authors[3,32,35] of 3 previous studies suggested that a history of ERLP is a risk factor for recurrence of ERLP.

Effective prevention of athletic injuries requires an understanding of the risk factors associated with the injury. Given the very common occurrence of ERLP in these high school XC runners, the percentage of athletes who reported its interference with training and performance, and the high likelihood of recurrence of ERLP, further research is needed to identify contributing factors. Identifying risk factors can lead to more sensitive preseason screening strategies. After risk factors are identified, investigators can then focus on developing appropriate preventive measures and, as needed, intervention approaches for this condition.

Limitations of this study may affect the validity and generalizability of this research. First, we relied on self-report of ERLP and stress fractures as our primary outcome measures. With the exception of foot type, the data for this study were derived from the initial and postseason questionnaires, and we do not have psychometric properties for those instruments. No confirmatory physical examination was conducted on those who reported ERLP seasonal occurrence, nor was there any medical diagnostic testing. Second, our definition of ERLP was pain occurring between the knee and the ankle and associated with exercise. Although we intentionally spent time explaining this to athletes, demonstrating the regions of pain, providing pictures outlining the pain zones, and answering questions, we recognize that their self-reports were based on their interpretation of ERLP. Third, this study included 6 high schools in a single major metropolitan area and is not generalizable across all high schools in all regions. Fourth, we have no data on the athletes who were listed on the roster but did not participate in the study, and therefore we recognize that these missing data may have biased our results. Also, we have only limited information on the participating athletes who did not complete the postseason questionnaire. Finally, we do not have athletic exposure data that would allow us to calculate incidence rates in this population.

CONCLUSIONS

In this group of high school XC runners, ERLP was common. Bilateral medial leg pain was the most frequent presentation of ERLP, and most athletes reported that ERLP negatively affected their XC participation. Foot type, as assessed visually, was not associated with either a history of ERLP or the seasonal occurrence of ERLP. Age, years of high school running, sex, BMI, and training distance were not risk factors for ERLP. The only identified risk factor for the occurrence of ERLP was a history of ERLP. Further investigation is warranted to identify factors that may, either singularly or in combination, increase an athlete's risk of developing ERLP.

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Address correspondence to Mark F. Reinking, PhD, PT, ATC, SCS, Department of Physical Therapy and Athletic Training, Saint Louis University, 3437 Caroline Mall, St Louis, MO 63104. Address e-mail to reinking@slu.edu.