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ORIGINAL RESEARCH

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Running-related injuries in middle school cross-country runners: Prevalence and characteristics of common injuries

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Abstract

Background: Understanding the prevalence and factors associated with running-related injuries in middle school runners may guide injury prevention.

Objective: To determine the prevalence of running-related injuries and describe factors related to a history of injury.

Design: Retrospective cross-sectional study.

Setting: Survey distributed online to middle school runners.

Methods: Participants completed a web-based survey regarding prior running-related injuries, training, sleep, diet, and sport participation.

Main Outcome Measurements: Prevalence and characteristics differentiating girls and boys with and without running-related injury history adjusted for age.

Participants: Youth runners (total: 2113, average age, 13.2 years; boys: $n = 1255$, girls: $n = 858$).

Results: Running-related injuries were more prevalent in girls (56% vs. 50%, $p = .01$). Ankle sprain was the most common injury (girls: 22.5%, boys: 21.6%), followed by patellofemoral pain (20.4% vs. 7.8%) and shin splints (13.6% vs. 5.9%); both were more prevalent in girls ($p < .001$). Boys more frequently reported plantar fasciitis (5.6% vs. 3.3%, $p = .01$), iliotibial band syndrome (4.1% vs. 1.4%, $p = .001$) and Osgood-Schlatter disease (3.8% vs. 1.2%, $p = .001$). Runners with history of running-related injuries were older, ran greater average weekly mileage, ran faster, had fewer average hours of sleep on weekends, skipped more meals, missed breakfast, and consumed less milk (all $p < .05$). Girls with history of running-related injuries reported higher dietary restraint scores, later age of menarche, more menstrual cycle disturbances, and higher likelihood of following vegetarian diets and an eating disorder diagnosis (all $p < .05$). Runners with no history of running-related injuries were more likely to have participated in ≥2 years of soccer or basketball ($p < .001$).

Conclusions: Most middle school runners reported a history of running-related injuries and certain injuries differing by gender. Modifiable factors with the greatest association with running-related injuries included training volume, dietary restraint, skipping meals, and less sleep. Sport sampling, including participation in ball sports, may reduce running-related injury risk in this population.

INTRODUCTION

Running participation has increased across all ages, including in middle school and high school athletes. In the National Federation of State High School Associations' 2018-2019 Annual High School Athletics Participation Survey, 488,640 individuals participated in cross-country.[1] The rising popularity of running can be partially attributed to the convenience, low cost, social environment, and cardiovascular benefits.[2,3] The U.S. Government initiative in 2008 to develop competitive running programs for middle and high school students to address high rates of obesity may have also contributed to this growth.[4-6]

The risk of running-related injuries may be associated with longer participation in the sport of running, and children may be uniquely vulnerable to injuries.[7,8] Running-related injuries have been estimated to affect up to 79% of adult runners annually.[9] A cross-sectional retrospective study in 748 high school runners found that 68% of girls and 59% of boys sustained one or more running-related injuries by mean age of 15 years,[10] expanding on earlier prospective cohort studies that showed 29% to 38.5% of high school cross-country runners incurred at least one prior running-related injury.[11,12] A 15-year prospective cohort study of 3233 high school boy and girl runners reported an injury rate of 13.1 per 1000 athletic exposures (AEs).[11] The incidence, injury rate, and severity of running-related injuries was greater in girls than boys,[11,12] and the running-related injury rates were higher during practices than in competitive events for girls.

The type of running-related injury may differ between girls and boys based on studies of youth runners. Whereas patellofemoral pain and bone stress injuries may be more common in girls,[13-15] Osgood-Schlatter and Sever's disease are more prevalent among boys.[16,17] The literature is inconclusive for differences in medial tibial stress syndrome or Achilles tendinopathy.[10,11,18,19]

The epidemiology of running-related injuries has primarily focused on adult, elite, and high school runners, so our understanding of running-related injuries in younger runners has remained limited. In a 20-year prospective longitudinal study of middle school athletes, Beachy and Rauh reported rates of 10.9/1000 AEs and 8.0/1000 AEs for girl and boy middle school cross-country runners.[20] In a retrospective study of children and adolescents treated in emergency departments, the overall incidence of running-related injuries for ages 6 to 18 years was 30.7/100,000 children with a reported increase in injury rate of 34% in 2007 compared to 1994.[21]

Risk factors for running-related injuries have been described in high school age runners. Extrinsic factors include eating behaviors and training errors. Intrinsic risk factors include prior injuries, anatomic variations (limb length discrepancy, Q angle, muscle imbalance, body mass index [BMI], foot pronation/supination), bone mineral density, and gender-specific differences related to hormones.[22-31] Higher running volume may be a risk factor for boys, and more competitive girls appear at greater risk for injury.[13-15]

Although running-related injuries are common and well described in older running populations, the incidence, prevalence, and risk factors for running-related injuries in middle school runners are poorly understood. This age group has enhanced needs of growth and development, requiring appropriate nutrition, sleep, and training. Although errors in the approach to these factors have been suggested to predispose this population to overuse running-related injuries,[5,6,25] reports on these factors in this population are scarce. This knowledge gap limits our ability to optimize injury treatment and prevention and make recommendations regarding sports specialization for young runners.[32-34] This study aims to characterize the prevalence of running-related injuries and factors associated with running-related-injuries in middle school runners.

METHODS

Study design and participants

A retrospective cross-sectional online survey was distributed to middle school cross-country runners (grades 6-9) in May 2020 through a database of over 900 coaches, runners, and parents of middle school runners primarily residing in the state of Massachusetts, inviting athletes to complete an online survey. Cross-country coaches also sent letters of invitation via email to the parents of their athletes. Participants received a $5 gift card following survey completion. The Partners Institutional Review Board approved the study with a waiver of written parental consent. Assent was obtained from each participant prior to completing the survey.

Online survey

The online survey tool was administered using secure, web-based REDCap electronic data capture tools hosted at Partners HealthCare Research Computing, Enterprise Research Infrastructure & Services group.[35,36] REDCap (Research Electronic Data Capture) is a secure, web-based software platform designed to support data capture for research studies, providing (1) an intuitive interface for validated data capture, (2) audit trails for tracking data manipulation and export procedures, (3) automated export procedures for seamless data downloads to common

statistical packages; and (4) procedures for data integration and interoperability with external sources.

The survey was adapted from a prior study of high school long distance runners and included demographic information, weight, height, training variables, daily dietary patterns, sleep patterns, and injury history.[10]

Running-related injury

Running-related injury was gathered using self-report with instructions to "please indicate any types of injury you have had in the past diagnosed by a doctor that were result of running training or running in a race." Injury options were expanded from a prior high school survey[10] to include possible running-related injuries in this cohort: Achilles tendonitis, shin splints, runner's knee/patellofemoral pain, iliotibial band syndrome, knee injury/anterior cruciate ligament tear, plantar fasciitis, sprained ankle, hamstring strain, Osgood-Schlatter disease, Sever's disease, "other tendon/bone/joint injury" (free text box included to add injury details), or none.[37,38]

Demographic and sport history

Each participant reported current age, age at start of race participation, gender, height, weight, and race/ethnicity. All reported previous training patterns and average weekly mileage in the summer and fall and recorded their best time for the one-mile distance.

Participants were queried to record all other sports or training in the past 2 years. Participation in basketball and soccer was delineated with additional detailed questions. Regular participation in plyometrics, weightlifting, lower body core-strengthening, abdominal exercises, and calf strengthening exercises was also elicited (answer for each response: yes, no).

Dietary pattern

Dietary questions included number of meals and snacks usually eaten per day (options 1 through 7 or more than 7). Yes or no responses were obtained for questions "Do you regularly skip meals," "Do you usually eat breakfast (at least 5 times per week)," "Do you drink at least 1 cup of milk or other calcium fortified beverage (eg, calcium fortified soy milk or orange juice) each day," "Do you eat at least one serving of cheese or yogurt each day," "Do you eat at least one serving of calcium fortified soy food products (eg, soy cheese or soy yogurt) each day," "Do you currently follow a vegetarian diet (meaning that you never eat fish, chicken, or meat, but you do eat eggs and dairy)," and "Have you previously followed a vegetarian diet." The use of calcium and vitamin D supplement two or more days/week over past year and doses were surveyed. The Eating Disorder Examination Questionnaire dietary restraint subscale was used to measure of dietary restraint.[39] An elevated score was defined as mean value ≥3 based on report marker of low energy availability (EA) as described previously.[40] Information regarding the diagnosis of eating disorder was requested along a more specific diagnosis of anorexia nervosa, bulimia nervosa, or eating disorder not otherwise specified.

Menstrual history

Each girl participant completed a menstrual history including her age of menarche. For girls who had reached menarche, detailed questions were asked about number of menstrual periods per year during the previous and current grade levels (answer choices: 0, 1-3, 4-9, 10-12, >12), if they had missed three or more menstrual periods in a row (answers: yes, no), the number of menstrual periods in past 12 months (free response), and the use of prescription pills or hormones to regulate menstrual periods.

Sleep

Each participant was asked to record average hours of sleep per day on the weekday (defined as Sunday through Thursday) and weekend (Friday and Saturday). Additionally, participants provided a numeric value to the question "in the past 30 days, how many days did you feel that you did not get enough rest or sleep?"

Statistical analyses

We conducted univariate and bivariate analyses of each response while stratifying for gender. Free entry responses for height, weight, and best mile time were reviewed, and implausible responses were removed from the study analyses. Because age was associated with running-related injuries in our dataset, we calculated age-adjusted p values for girls versus boys for the prevalence of each running-related injury using a Wald test statistic from a logistic regression model by including age as a covariate in the model. For continuous variables, values were presented as mean $\pm$ SD. Student t-tests were used to calculate mean differences between groups and chi-square tests were used to compare percentage differences where the dependent variable was categorical. Statistical significance was set at $p < .05$. All analyses were conducted in SAS Studio 3.7 (SAS Institute Inc., Cary, NC, USA).

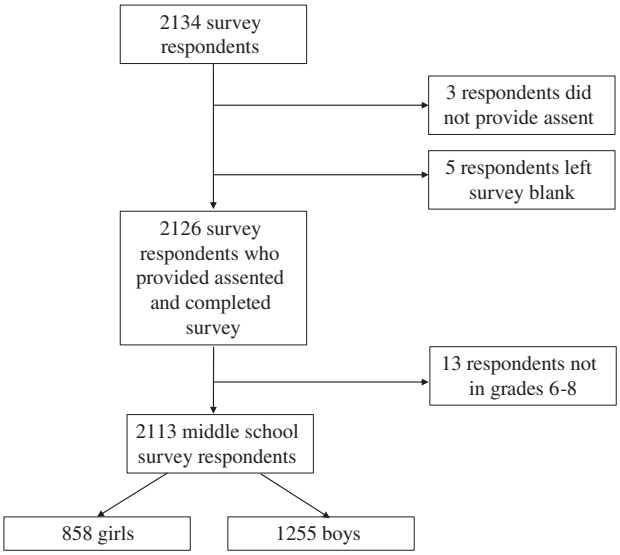

FIGURE 1 Flowchart of survey respondents

RESULTS

Participants

Of the 2134 runners who completed the survey, 2113 (1255 boys, 858 girls) met the inclusion criteria for analysis (Figure 1). The average age was 13.2 years and BMI 19.1 kg/m^2 (see Table 1 for characteristics of the cohort). Most participants who completed the survey were in the seventh or eighth grade.

History, anatomic distribution, and factors associated with running-related injury

Adjusting for age, more than half (56%) of the girls and 50% of boys ($p = .01$) reported a history of one or more running-related injuries (Table 2). Overall, the most common running-related injury was an ankle sprain (girls: 22.5%; boys: 21.6%, $p = .78$). The second and third most common running-related injuries were higher in girls than boys and were patellofemoral pain (girls: 20.4%; boys: 7.8%, $p < .001$) and shin splints (girls: 13.6%, boys: 5.9%, $p < .001$). Boys were more likely than girls to develop Osgood-Schlatter disease (3.8% vs. 1.2%, $p = <.001$), iliotibial band syndrome (4.1% vs. 1.4%, $p = <.001$), and plantar fasciitis (5.6% vs. 3.3%, $p = .01$).

Training variables, performance data, sleep volume, nutrition parameters, additional sports participation, and strength training were compared between runners with and without history of running-related injury in Table 3. Average weekly volume of training during the fall season was statistically higher in participants with running-related injuries (girls: 27.8 ± 6.9 km vs. 26.6 ± 10.0 km, $p = .04$; boys: 27.4 ± 8.0 km vs. 26.3 ± 8.4 km, $p = .01$). Kilometers run per week in the summer before the start of the cross-country season were similar between participants with and without injuries (girls: 17.1 ± 8.9 km vs. 17.7 ± 13.7 km, $p = .56$; boys: 16.7 ± 9.3 km vs. 16.1 ± 10.8, $p = .39$). Faster mile performances were in runners with a history of running-related injuries for both girls ($6{:}18 \pm 0{:}36$ vs. $6{:}30 \pm 0{:}42$, $p < .001$) and boys ($6{:}00 \pm 0{:}36$ vs. $6{:}06 \pm 0{:}36$, $p = .02$).

DISCUSSION

The purpose of this study is to characterize the prevalence of and factors related to running-related injuries in a large cohort of middle school runners. We observed that most middle school runners had sustained one or more running-related injury by average age 13 years, and more girls reported prior injury compared to boys. Runners with and without a history of running-related injuries had differentiating factors related to training, nutrition, and sleeping behaviors. A history of running-related injuries was more common in runners with higher average weekly mileage and faster running performances. Runners with a history of running-related injuries reported skipping more meals, not eating breakfast at least 5 days per week, not consuming at least one cup of milk daily, and having fewer hours of sleep during the weekend. More girls with a history of running-related injuries reported a vegetarian diet, dietary intake restraint, and an eating disorder. In contrast, runners without a history of running-related injuries were more likely to report playing basketball and/or soccer for at least 2 years. It is important to note that the observed differences between injured and non-injured runners may be confounded by behaviors of the

TABLE 1 Characteristics of study sample of middle school distance runners

Variable	All ($n = 2113$) Mean ± SD or *n* (%)	Girl ($n = 858$) Mean ± SD or *n* (%)	Boy ($n = 1255$) Mean ± SD or *n* (%)	*p* value
Age (year)	13.2 ± 0.95	13.3 ± 0.9	13.2 ± 1.0	.26
Grade				.009
Sixth	502 (23.8%)	185 (21.6%)	317 (25.3%)	
Seventh	637 (30.2%)	258 (30.1%)	379 (30.2%)	
Eighth	809 (38.3%)	360 (42.0%)	449 (35.8%)	
Ninth	165 (7.8%)	55 (6.4%)	110 (8.8%)	
Weight (kg)	50.3 ± 6.4	49.3 ± 5.7	51.1 ± 6.7	<.001
Height (cm)	162.1 ± 7.6	161.3 ± 6.4	162.6 ± 8.4	<.001
BMI (kg/m^2)	19.1 ± 1.4	19.0 ± 1.4	19.2 ± 1.4	<.001
BMI Z-score	−0.12 ± 0.57	−0.2 ± 0.5	−0.1 ± 0.6	<.001
Ethnicity				.16
White	1688 (80%)	695 (81.0%)	993 (79.2%)	
Latino	169 (8.0%)	67 (7.8%)	102 (8.1%)	
Black	100 (4.7%)	30 (3.5%)	70 (5.6%)	
Asian	151 (7.1%)	64 (7.5%)	87 (6.9%)	
Other	5 (0.2%)	2 (0.2%)	3 (0.2%)	
Menstrual history				
Reached menarche		138 (17.1%)		
Age of menarche (year)		11.6 ± 1.1		
Number menses past 12 months		9.9 ± 2.6		
History of 3 or more missed periods		18 (13.0%)		

Abbreviation: BMI, body mass index.

TABLE 2 Prevalence of running-related injuries among middle school runners[a]

Injury type	All ($n = 2113$)[b]	Girl ($n = 858$)[b]	Boy ($n = 1255$)[b]	*p* value[c]
One or more overuse injury	1110 (52.5%)	481 (56.0%)	629 (50.0%)	.01
Achilles tendonitis	116 (5.5%)	38 (4.4%)	78 (6.2%)	.07
Shin splints/tibial stress	191 (9.0%)	117 (13.6%)	74 (5.9%)	<.001
Patellofemoral pain	273 (12.9%)	175 (20.4%)	98 (7.8%)	<.001
Iliotibial band syndrome	63 (3.0%)	12 (1.4%)	51 (4.1%)	<.001
Knee injury/ACL tear	33 (1.6%)	9 (1.1%)	24 (1.9%)	.12
Plantar fasciitis	98 (4.6%)	28 (3.3%)	70 (5.6%)	.01
Ankle sprain	464 (22.0%)	193 (22.5%)	271 (21.6%)	.78
Hamstring strain	163 (7.7%)	73 (8.5%)	90 (7.2%)	.28
Osgood-Schlatter disease	57 (2.7%)	10 (1.2%)	47 (3.8%)	<.001
Sever's disease	89 (4.2%)	42 (4.9%)	47 (3.8%)	.19
Other[d]	22 (1.0%)	14 (1.6%)	8 (0.64%)	.03

Abbreviation: ACL, anterior cruciate ligament.
[a]Participants could report having more than one running-related injury.
[b]Report values for each injury *n* (%).
[c]*p* values adjusted for age.
[d]Other included groin strain, tendonitis, pelvis avulsion.

runners. For example, girls and boys who primarily focus on youth running may differ from those who continue to sport sample, influencing behaviors including volume of training, performance, nutrition, and participation in ball sports. Nonetheless, the high prevalence of running-related injuries and the associated factors suggest an opportunity to address injury in these young runners.

TABLE 3 Characteristics associated with running-related injuries among middle school runners

Variable[a]	Girl participants			Boy participants		
	≥1 running-related injury ($N = 481$)	No running-related injury ($N = 377$)	*p* value	≥1 running-related injury ($N = 629$)	No running-related injury ($N = 626$)	*p* value
Demographics						
Age (year)	13.4 ± 0.9	13.1 ± 1.0	<.001	13.4 ± 0.9	13.0 ± 1.0	<.001
BMI (kg/m^2)	19.0 ± 1.4	18.9 ± 1.4	.28	19.2 ± 1.5	19.1 ± 1.4	.17
BMI Z-score	−0.22 ± 0.77	−0.24 ± 0.66	.79	−0.04 ± 0.76	−0.12 ± 0.74	.07
Training variables						
Age started endurance races (years)	13.7 ± 1.5	13.3 ± 1.9	<.001	13.6 ± 1.6	13.6 ± 1.9	.65
Age started sprint races (years)	9.9 ± 1.4	9.5 ± 1.4	<.001	9.6 ± 1.6	9.5 ± 1.6	.13
Summer mileage (km/week)	17.1 ± 8.9	17.7 ± 13.7	.56	16.7 ± 9.3	16.1 ± 10.8	.39
Fall mileage (km/week)	27.8 ± 6.9	26.6 ± 10.0	.04	27.4 ± 8.0	26.3 ± 8.4	.01
Mile time (minutes: seconds)	6:18 ± 0:36	6:30 ± 0:42	<.001	6:00 ± 0:36	6:06 ± 0:36	.02
Basketball for ≥2 years	58 (12.1%)	119 (31.6%)	<.001	162 (25.8%)	262 (41.9%)	<.001
Soccer for ≥2 years	62 (12.9%)	110 (29.2%)	<.001	118 (18.8%)	224 (25.8%)	<.001
Sleep variables						
Hours sleep per night on weekdays	7.8 ± 0.8	8.0 ± 0.7	.002	8.0 ± 0.9	8.1 ± 0.8	.34
Hours sleep per night on weekends	8.7 ± 1.1	9.2 ± 1.0	<.001	8.7 ± 1.2	9.1 ± 1.2	<.001
Days felt not enough sleep in last month	3.0 ± 3.5	2.7 ± 2.7	.16	3.4 ± 3.1	3.0 ± 2.9	.04
Daily dietary patterns						
History of skipping meals	75 (15.6%)	10 (2.7%)	<.001	46 (7.3%)	19 (3.0%)	<.001
Eats breakfast 5 days per week	370 (76.9%)	354 (93.9%)	<.001	524 (83.8%)	591 (94.6%)	<.001
Diagnosis of eating disorder	22 (4.5%)	1 (0.3%)	<.001	0 (0%)	0 (0%)	N/A
Drinks at least 1 cup of milk per day	302 (62.8%)	319 (84.6%)	<.001	476 (75.9%)	566 (90.4%)	<.001
Vegetarian diet	75 (15.6%)	39 (10.3%)	.02	70 (11.2%)	101 (16.2%)	.009
EDEQ, mean	0.33 ± 0.76	0.25 ± 0.47	.04	0.10 ± 0.43	0.14 ± 0.50	.18
Conditioning						
Plyometrics or weight-lifting	65 (13.5%)	22 (5.8%)	<.001	167 (26.6%)	95 (15.2%)	<.001
Lower body core-strengthening on a regular basis	272 (56.7%)	237 (62.9%)	.08	365 (58.0%)	393 (62.8%)	.09
Abdominal exercises on a regular basis	296 (61.7%)	253 (67.1%)	.109	395 (62.8%)	411 (65.7%)	.29
Calf strengthening exercises	289 (60.2%)	247 (65.5%)	.11	367 (58.4%)	413 (66.5%)	.003
Menstrual history						
Reached menarche	75 (16.6%)	63 (17.9%)	.65			
Age of menarche	11.8 ± 1.2	11.4 ± 0.9	.01			
No. menses past 12 months	9.5 ± 2.8	10.4 ± 2.3	.04			
History of 3 or more missed periods	16 (21.3%)	2 (3.2%)	.002			

Abbreviations: BMI, body mass index; EDEQ, Eating Disorder Examination Questionnaire.
[a]Values presented as Mean ± SD or *n* (%).

Few studies have described running-related injuries in middle school runners. Our findings are similar to those reported in a 20-year longitudinal study of middle school athletes showing girls participating in cross-country or track and field had a higher incidence of injury than boys who competed in the same sport.[20] Our findings that ankle sprains and patellofemoral pain were the most common running-related injuries during middle school is consistent with a prior report that the knee and ankle are common locations for running-related injuries in high school runners.[20]

Most of the reported running-related injuries would be classified as an overuse injury, especially among the girls. A study of school-aged children reported similar results with an overuse sport-related injury 1.5 times more likely in girls than boys.[20] One explanation may be that boys and girls experience their peak height velocities at different ages and may be more vulnerable to overuse injury during this developmental stage.[6,41] Furthermore, during and after periods of accelerated growth, girls and boys develop muscle imbalances that may also contribute to the increased risk of overuse injuries, although future studies are needed to assess definitive causality.[42]

Runners in our study with a history of running-related injuries reported running faster and at a higher weekly volume than those without a history of running-related injuries, which is consistent with prior studies of high school runners.[10] However, the difference in average weekly mileage was relatively small.[10,43] These variables may not be easy to modify given prior reports that higher running volume was associated with faster running performances,[10] and our findings do not delineate a weekly running volume that will reduce injury risk. Further, differences in running volume and performance measures may reflect other behaviors such as focus on youth running specialization. Sports sampling may help partially address these concerns by providing alternative activity than solely running.

Both nutritional and sleep factors influence running-related injuries and may be modifiable risk factors. Many studies suggest that athletes should focus on nutrition to prevent injuries,[44] and our findings support that inadequate diet increases the likelihood for a running-related injuries.[44] Poor nutrition contributes to low energy availability and deprives the body of nutrients needed for recovery, healing, and growth.[45] Middle school runners who reported less sleep on weekends also had a history of more running-related injuries, which is consistent with findings in collegiate cross-country runners that found poor sleep quality was significantly associated with higher risk of injury.[46] Thus, diet and sleep are important for recovery from training even at the middle school ages and should be addressed as injury reduction strategies.

Female middle school athletes are subject to the effects of low energy availability as demonstrated by more running-related injuries in girls with poor nutrition habits and described by the Female Athlete Triad[47] and Relative Energy Deficiency in Sport.[48] In female athletes, eating disorders, delayed menarche, and secondary menstrual disturbances are key markers for energy availability. Although BMI was not different between injured and noninjured runners, this is an imperfect marker for the low energy availability state and should be considered among other risk factors.[47] The average age of menarche in the United States is around age 12, yet about one in six girls reported menarche in this cohort of girls with an average age of 13 years.[49] Our findings suggest that girls who participate in the sport of running might involuntarily delay their age of menarche. Girls with history of running-related injuries had a history of eating disorder, later age of menarche, fewer periods in the past year, and greater percentage of missing three of more periods. Our findings are consistent with prior work in high school athletes that identified Triad risk factors associated with overuse musculoskeletal injuries.[50] Healthy eating behaviors and ensuring proper nutrition and menstrual status to support growth and attain peak bone mass are critical issues for young girls. Promoting adequate energy availability may reduce injuries and promote long-term health.

We found that more runners without a history of running-related injuries reported playing basketball or soccer for at least 2 years during middle school. A previous study showed male high school distance runners who participated in basketball were less likely to sustain stress fractures.[54] Studies of track and field athletes in late adolescence and military personnel have suggested that early participation in ball sports has a protective effect against future stress fracture.[51] The protective effect of ball sports may be due to the multidirectional loading and high ground reaction forces that result in subsequent bone remodeling and increased strength, particularly at regions most stressed in the respective sport.[51] Our study suggests that both basketball and soccer may be associated with fewer running-related injuries of all types in middle school runners. These findings are consistent with recommendations from major sports medicine organizations that encourage sports sampling at young ages, owing to crossover benefits in participation in other forms of sport and reducing risk of burnout and discontinuation of sport from youth sport specialization.[52,53]

Limitations

Several limitations in this study are worth noting. The retrospective cross-sectional study design is appropriate for describing prevalence of running-related injuries; however, this design is limited to examining associations and cannot establish causality for running-related injuries. Self-report surveys are prone to recall bias or errors in reporting details of injury; future

prospective studies may help minimize these limitations. Although we provided a list of common running-related injuries to help the runners remember the running-related injury they incurred, the diagnoses were not clinically verified and relied on accurate recall from middle schoolers. Thus, some misclassification of running-related injuries was likely in this study and because the surveys were conducted anonymously, we were unable to verify names or other clinical information. Moreover, we did not ask about hyperlaxity or paramorphism (eg, scoliosis) and were unable to assess potential contributing role in running-related injuries. The middle school runners were primarily Caucasian and lived in geography around Massachusetts; our findings may not be generalizable to middle school populations in other parts of the country. We were unable to report a response rate because we do not know the total population who received the survey invitation. The large sample size may reduce risk that this population is not generalizable.

CONCLUSIONS

More than half of middle school cross-country runners sustain a running-related injury by the average age 13 years. Ankle sprains, patellofemoral pain, and shin splints/medial tibial stress syndrome are the most common injuries in this population. Girls reported a higher percentage of running-related injuries than boys, and some injuries were more common in female compared to male runners. Nutrition, sleep, and training volume are factors associated with running-related injuries in middle school. Participation in ball sports was associated with fewer running-related injuries. Sport sampling, including participation in ball sports and strengthening programs may be protective against running-related injuries. Our findings may be further substantiated with prospective studies to evaluate risk factors for running-related injuries and to test interventions focused on strength training and other exercise programs to address the high prevalence of running-related injuries identified in our population.

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DISCLOSURES

Dr. Heiderscheit is the owner of Science of Running Medicine, LLC, outside the submitted work. Dr. Tenforde has no disclosures related to this work. He serves as senior editor for PM&R Journal. He gives professional talks such as grand rounds and medical conference plenary lectures and receives honoraria from conference organizers. He has participated in research funded by The Arnold P. Gold Foundation (physician and patient care disparities), Football Player Health Study at Harvard (health in American-Style Football players), and American Medical Society for Sports Medicine (bone density research).

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