

Prevalence, Anatomic Distribution, and Risk Factors Associated with Bone Stress Injury in Middle School Runners



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Introduction

Background

- Bone stress injury (BSI) is a common overuse injury in which the epidemiology has been described in high school and young adult athletes, predominately runners.
- Biological risk factors for females include the Female Athlete Triad (low energy availability, low bone mineral density (BMD), and menstrual dysfunction).^{1,2}
- For both sexes, triad risk factors associated with low energy availability include disordered eating, low body mass index (BMI), prior fracture, and low BMD.³⁻⁵
- BSIs are not well understood in middle school runners.
- Identifying potential risk factors and interventions for BSIs can optimize bone health in the middle school population.

Purpose

- To evaluate the prevalence, anatomical distribution, and factors associated with BSIs in male and female middle school runners.

Hypotheses

- Higher prevalence of BSIs in girl compared to boy runners.
- Risk factors associated with BSIs vary by sex and anatomical site.

Methods

Participant Demographics

- 2134 participants completed the survey. After evaluation of responses for inconsistencies and/or missing data, 2107 (857 girls, 1250 boys) participants were included in the study.
- Predominately 7th/8th graders of white race, mean age 13.2 ± 0.9 yrs, avg BMI 19.2 ± 1.7 kg/m².

Study Design

- Retrospective cross-sectional study.
- Online survey to assess BSI history, sex, age, grade, height, weight, dietary patterns, disordered eating and eating disorder history, menstrual history, exercise training, and other health-related characteristics.
- To assess bone health, participants were asked if they received a diagnosis of osteopenia, osteoporosis, or low BMD confirmed by a bone density test. They were also asked about prior history of fractures and family history of osteopenia or osteoporosis. Subjects also indicated whether they played soccer or basketball in the previous 2 years.
- Self-report of prior imaging was mandated to confirm BSI and identify anatomical location.

Data Analyses

- ANOVA evaluated group differences for continuous variables (sex, BMI)
- Chi-square analyses evaluated group differences for categorical variables (menstrual status, history of eating disorder, ball sports participation).
- Independent samples t-tests evaluated mean differences between 2 groups (male versus female, runners with BSI at a cortical versus trabecular-rich site).
- Univariate logistic regression assessed association of individual factors with BSI.
- Multivariate logistic regression evaluated factors with an increased likelihood of BSI.
- Univariate and multivariate logistic regression models evaluated factors associated with increased risk for BSI at cortical-rich compared to trabecular-rich sites.
- Statistical significance set at P < .05. For continuous variables, values were expressed as means +/- standard deviation. Categorical variables were represented as N(%).

Results

- BSIs were higher in girls than boys (6.7% v 3.8%).
- The most common site of injury was the tibia.
- Cortical-rich sites of BSI were 5.5 times more common than trabecular-rich sites of BSI, with almost all trabecular-rich BSIs in girls.
- Trabecular-rich BSI were more common in runners with lower BMI, lower BMD, higher weekly mileage, greater dietary restraint, skipping meals, vegetarian diet and consuming fewer daily meals.
- Common factors associated with BSI in girls and boys included lower BMI, higher weekly mileage, higher dietary restraint, and skipping meals. Both girls and boys reporting a prior BSI were more likely to have a family history of osteoporosis.
- Unique factors associated with a greater likelihood of BSI in girl runners included prior diagnosis of eating disorder, following a vegetarian diet, skipping meals, dietary restraint, and history of missing 3 or more menstrual periods.
- Participation in basketball and soccer for 2 or more years was shown to be protective from BSI.

Distribution of injury site for the 132 BSI sustained by 105 middle school runners.

	Bone Stress Injuries		Total
	Girls (n= 57)	Boys (n= 48)	
Cortical-rich			
Tibia	27	24	51
Metatarsals	11	18	29
Fibula	5	20	25
Femoral Shaft	4	0	4
Sesamoid	3	1	4
Navicular	0	1	1
Total	50	64	114
Trabecular-rich			
Pelvis	6	1	7
Femoral Neck	6	0	6
Sacrum	4	0	4
Total	16	1	17

*Site of one BSI not reported.

Individual factors associated with BSI as assessed by univariate logistic regression analyses.

	Girls			Boys			Total		
	OR	95%CI	p-value	OR	95%CI	p-value	OR	95%CI	p-value
Age	2.5	1.3, 3.6	<0.001	1.2	0.9, 1.7	0.15	1.7	1.4, 2.2	<0.001
Female	--	--	--	--	--	--	1.8	1.2, 2.6	0.004
BMI Z score < -1.0	11.2	4.6, 28.6	<0.001	1.4	0.5, 6.3	0.61	4.9	2.4, 10.0	<0.001
Running mileage	1.1	1.1, 1.2	<0.001	1.1	1.1, 1.2	<0.001	1.1	1.1, 1.2	<0.001
Mile time	0.98	0.97, 0.99	<0.001	0.99	0.98, 1.0	0.01	0.99	0.99, 0.99	<0.001
Basketball (2 years)	0.1	0.0, 0.5	0.006	0.4	0.2, 0.8	0.01	0.2	0.1, 0.4	<0.001
Soccer (2 years)	0.2	0.1, 0.7	0.009	0.3	0.1, 0.8	0.01	0.2	0.1, 0.5	<0.001
Ball sports (2 years)	0.1	0.0, 0.5	0.001	0.4	0.2, 0.8	0.01	0.3	0.2, 0.5	<0.001
Low BMD	18.6	10.3, 33.6	<0.001	7.7	3.4, 17.0	<0.001	14.1	9.1, 21.9	<0.001
Family Hx osteoporosis	10.4	5.4, 19.8	<0.001	4.3	1.9, 9.8	<0.001	7.5	4.6, 12.3	<0.001
Prior fracture (non-BSI)	5.1	2.5, 9.2	<0.001	3.3	1.8, 6.0	<0.001	3.6	2.4, 5.5	<0.001
Elevated dietary restraint	30.1	5.4, 168.2	<0.001	5.1	0.6, 44.5	0.14	14.3	4.4, 45.7	<0.001
Vegetarian	9.5	5.4, 16.7	<0.001	1.5	0.7, 3.1	0.29	4.2	2.8, 6.4	<0.001
Skip meals	13.8	7.7, 24.7	<0.001	3.4	1.4, 7.8	0.005	8.6	5.5, 13.5	<0.001
Calcium food (1 serving/d)	2.5	1.3, 5.1	0.01	2.4	0.9, 6.2	0.08	2.7	1.5, 4.7	0.001
Female-specific*									
Missed 23 cycles	14.5	3.6, 58.7	<0.001	--	--	--	--	--	--
BMI for age <5%	38.8	9.8, 153.4	<0.001	--	--	--	--	--	--
Eating disorder dx	31.8	39.7, 284.4	<0.001	--	--	--	--	--	--

*Factors only reported or exhibited by female runners.

Multivariate logistic regression model evaluating factors associated with BSI in middle school runners.

	Girls			Boys			Total		
	AOR	95%CI	p-value	AOR	95%CI	p-value	AOR	95%CI	p-value
Family history osteoporosis	5.2	2.0, 13.1	0.001	3.7	1.5, 9.3	0.005	3.9	2.0, 7.5	<0.001
Skip meals	5.0	2.0, 12.4	0.001	--	--	--	3.6	1.8, 7.0	<0.001
Prior fracture (non-BSI)	--	--	--	3.4	1.6, 6.8	0.001	2.3	1.3, 4.1	0.003
Dietary restraint score	2.2	1.4, 3.3	<0.001	--	--	--	1.9	1.4, 2.5	<0.001
Age	1.5	1.0, 2.4	0.06	--	--	--	--	--	--
Running mileage	--	--	--	1.1	1.0, 1.1	0.006	1.0	1.0, 1.1	0.03
Two years ball sports	0.2	0.04, 0.9	0.04	0.4	0.2, 1.0	0.04	0.3	0.1, 0.6	0.002

Nagelkerke R Square, Female= 0.44; Male= 0.14; Total= 0.29.
 Female (n= 857); Male (n= 1,250); Total (n= 1,651).
 AOR, adjusted odds ratio

Discussion

- This is the first report on BSI in a large cohort of middle school runners.
- Anatomical location for BSI may guide next steps in evaluation and management for risk factors. BSIs at trabecular-rich sites tend to be associated with biological risk factors^{4,6,7}.
- Common factors related to suboptimal nutrition are associated with increased likelihood of BSI in girl and boy middle school runners.
- Basketball and soccer were shown to be protective of BSI, consistent with prior data on high school/adult runners and the military^{2, 8-9}. 2 years of participation before puberty has been proposed as minimum dose for protection.
- Promotion of adequate intake of energy and bone-building nutrients, encouragement of sport sampling, in either basketball or soccer, and avoidance of sport specialization may reduce risk for BSI.
- Association of low BMD more commonly reported in middle school runners with BSI must be interpreted within context of bias; reporting errors from runners on diagnosis of low BMD and BSI prompting evaluation for eating disorder and bone density may explain such findings. Potential need for further work of impaired skeletal health in athletes who sustain BSIs.
- Limitations include recall bias, sample size and population, self-report of BSI, inability to prove causality with respect to the factors associated with BSI.

Conclusion

- Prevalence of BSIs in middle school runners was higher in girls versus boys.
- Behaviors related to low energy availability such as skipping meals and dietary restraint emerged as independent factors related to BSI for both girls and boys.
- Factors associated with greater odds of BSI in both girl and boy runners included lower BMI, higher weekly mileage, faster running performances, higher dietary restraint, and skipping meals.
- Participation in ball sports for 2 or more years appears to be protective and may reduce the risk for BSI in both girl and boy runners.

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