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# Overuse Injuries in High School Athletes

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## Abstract

**Purpose.** To evaluate relationships between seasonal patterns of athletic participation and overuse injuries in high school athletes. **Methods.** Self-reported survey of sports played and injuries sustained during the preceding 12 months administered anonymously to 9th-12th graders in school. **Results.** Females suffered more overuse injuries than males. Overuse injuries increased slightly with age and with seasons of sports played per calendar year. Students who played sports all year long had 42% increased risk of overuse injury compared to those who played fewer than 4 seasons. **Conclusions.** Reducing the number of sport seasons played by high school athletes could decrease their rate of overuse injuries, with the greatest gains potentially achieved by taking at least one season off from sports entirely each calendar year.

## Keywords

overuse injury, adolescents, athletes

## Introduction

Overuse injuries are a common cause of missed time and decreased performance among athletes. They are estimated to comprise 50% of all athletic injuries,<sup>1</sup> accounting for twice as many visits to sports medicine physicians as acute trauma.<sup>2</sup> Resulting from repetitive stresses imparted on tissues at levels below physiological failure thresholds, these injuries can be attributed to activity overload with insufficient time to heal.<sup>3</sup> While training errors are most frequently cited as a risk factor,<sup>4</sup> anatomical, environmental, nutritional, and psychological factors have also been implicated. In younger athletes, areas of growth cartilage found throughout the immature skeleton may be more susceptible to injury than the more stable articular cartilage in adults,<sup>5</sup> especially during periods of rapid growth.<sup>6</sup>

Experienced clinicians have observed an increasing incidence of overuse injuries in the pediatric age group. This trend has been attributed, in part, to an earlier introduction to sports at higher levels of intensity than has been seen in the past. It is not uncommon for children as young as 6 years old to begin playing on "travel" or "select" teams in sports such as soccer or hockey.<sup>7</sup>

As children participate in organized sports at younger ages and higher levels of competition, they potentially expose themselves to more repetitive forces and therefore may place themselves at greater risk of developing overuse injuries.

But how much is too much? Previous studies have documented injury rates by sport based on the number of exposures (games and practices) in a given period of time (season or year)<sup>7-11</sup> but have neglected to account for the effects of playing multiple sports during the same season, playing the same sport in multiple consecutive seasons, or playing multiple sports in consecutive seasons. The purpose of this study therefore was to evaluate relationships between seasonal patterns of athletic participation and overuse injuries in high school athletes.

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**Table 1.** Population Characteristics

	Overall	School 1	School 2	School 3	School 4	School 5
Age (years) <sup>a</sup>	16 (14-19)	16 (14-18)	16 (14-18)	16 (14-19)	16 (14-18)	16 (14-18)
Male, n (%)	1784 (54%)	156 (53%)	379 (49%)	461 (54%)	404 (57%)	384 (59%)
No. of sports seasons <sup>a</sup>	4 (1-24)	4 (1-18)	4 (1-18)	4 (1-24)	4 (1-13)	4 (1-16)
No. of different sports <sup>a</sup>	2 (1-8)	2 (1-6)	2 (1-8)	2 (1-8)	2 (1-6)	2 (1-5)
4-Season participation, n (%)						
Same sport	1271 (37.3)	107 (36.3)	322 (42.0)	343 (40.4)	256 (36.0)	243 (37.3)
Different sports	644 (19.7)	64 (21.7)	132 (17.2)	158 (18.6)	160 (22.5)	130 (19.9)

<sup>a</sup>Median (range).**Table 2.** Popularity of Sports

Sport	Total No. of Seasons Played	Sport	Total No. of Students Participating
Weightlifting	1747	Basketball	872
Basketball	1708	Running	769
Soccer	1519	Weightlifting	687
Running	1392	Football	569
(track & CC)			
Baseball	1294	Baseball	554
Football	1086	Soccer	552

NOTE: CC= cross country.

## Methods

An anonymous survey (Appendix A) was hand delivered to 5 high schools in northeast Ohio between the spring of 2006 and spring of 2007. The schools were asked to distribute the survey to all students in homeroom or an equivalent period. Students were read an information sheet detailing the purpose and goals of the study before being asked to complete the survey. Completion of the survey implied consent. All surveys were collected by school staff and returned to the main office where they were picked up and securely stored by the principal investigator. Study methodology was approved by the institutional review boards at University Hospitals of Cleveland and Children's Hospital Medical Center of Akron, Ohio.

The survey consisted of 9 questions. Students were asked to circle their age, gender, and each of the sports in which they had participated for at least 1 practice, training event, or game per week during the previous 4 calendar seasons (winter, fall, summer, spring). They were asked if they suffered any injuries that caused them to miss at least 1 week of games or practice or to seek the attention of a doctor, or that decreased their performance. If they did suffer an injury, they were asked to circle both the body part that was injured and the type of injury sustained from a list of names, including both common lay and clinical terms. There was also space to write in any body part or injury type that was not listed. Finally, if more than 1 injury occurred, students were asked to draw a line between each

body part and the corresponding injury. Injuries were classified as "acute" or "overuse" by the principal investigator before statistical analysis was performed (Appendix B). Any student who did not report participating in at least 1 season of sports was excluded from the study.

## Statistical Analysis

The demographics of the study population were described overall and by school. The continuous measure of age is described by the median and the range. Nominal variables are described with frequencies and percentages. "Seasonal pattern" was defined in several ways to distinguish the difference between the effects of continuous participation and repetitive participation on the probability of having an overuse injury. "Number of sports seasons" was defined as the sum of the number of all sports played each season over the 4 seasons in the study period, which could therefore be greater than 4. The dichotomous classification of "all 4 seasons" versus fewer than 4 seasons was adopted, regardless of the number of sports played each season. This was further divided into 4 seasons of the same sport, 4 seasons of different sports, and fewer than 4 seasons.

Logistic regression analyses were carried out in 2 steps. First, unadjusted odds ratios (ORs) with 95% confidence intervals (CIs) were calculated for each of these variables separately, followed by a multivariable model. The 3-level variable was designed to determine if there was a difference between 4 seasons of the same sport and 4 seasons of different sports when compared with fewer than 4 seasons. If these 2 unadjusted ORs were different, then the 3-level variable would be included in the multivariate step; if not, the 2-level variable would be used, along with age, gender, total sports seasons, and number of seasons of the same sport. Analyses were performed using SAS v 9.2 (the SAS Institute, Cary, NC).

## Results

A total of 7492 surveys were distributed to the schools. 4182 (56%) were completed, and 3276 (44%) met

**Table 3.** Injury Outcomes

	Overall	School 1	School 2	School 3	School 4	School 5
None	1591 (48%)	149 (50%)	412 (54%)	417 (49%)	303 (42%)	310 (48%)
Any overuse <sup>a</sup>	584 (18%)	41 (14%)	107 (14%)	162 (19%)	162 (23%)	112 (17%)
Acute only	949 (29%)	91 (31%)	210 (27%)	225 (27%)	218 (31%)	205 (31%)
Unknown	152 (5%)	14 (5%)	38 (5%)	46 (5%)	29 (4%)	25 (4%)

<sup>a</sup>Any overuse means the athlete could also have sustained an acute injury.

**Table 4.** Injury Breakdown by Type

Overuse Injuries (685)	Acute Injuries (1668)
Tendonitis (238) 35%	Muscle strain (467) 28%
Shin splints (214) 31%	Joint sprain (432) 26%
Lower-extremity stress fracture (75) 11%	Fracture (313) 19%
Spondylolysis (57) 8%	Ligament tear (128) 8%
Apophysitis (44) 6%	Concussion (124) 7%
Patellofemoral syndrome (34) 5%	Dislocation (106) 6%
Other (23) 4%	Other (98) 6%

**Table 5.** Regression Results for Overuse Injury

	Unadjusted OR (CI)	Adjusted OR (CI)
Female versus male	1.55 (1.29, 1.86)	1.65 (1.37, 1.98)
Age	1.07 (0.99, 1.016)	1.11 (1.02, 1.20)
Total sports seasons	1.10 (1.06, 1.13)	1.06 (1.02, 1.10)
No. of seasons of same sport	1.32 (1.22, 1.44)	1.07 (0.94, 1.23)
Any 4 seasons versus <4	1.89 (1.56, 2.30)	1.42 (1.05, 1.92)
4 Different, 4 the same versus <4		
4 The same versus <4	1.89 (1.53, 2.34)	
4 Different versus <4	1.90 (1.48, 2.43)	

NOTE: OR = odds ratio; CI = confidence interval.

inclusion criteria. Characteristics of the participants are listed overall and by school (Table 1); 1784 (55%) of the athletes were male. The median age was 16 years, with a range of 14 to 19. The median number of sports seasons was 4 (range 1-24), and the median number of different sports was 2 (range 1-8). In all, 1915 (57%) athletes played sports in all 4 seasons of the year, and 1271 (37%) athletes played the same sport all year long. Weightlifting was the most popular sport as measured by total seasons played, whereas basketball was the sport played by the largest number of students (Table 2). Overall, 36 sports were represented in our study.

We found that 1685 (51%) athletes reported some type of injury (Table 3): 584 respondents (18%) suffered an overuse injury, whereas 152 (5%) experienced an injury that was unable to be classified. The most common

overuse injuries reported were tendonitis (238), shin splints (214), and lower-extremity stress fracture (75; Table 4). The most common acute injuries were muscle strain (467), joint sprain (432), and fracture (313).

### Factors Associated With Overuse Injury

In all, 316 (21%) female participants suffered overuse injury as compared with 268 (15%) male participants (Table 5). Overuse injuries increased slightly with each year of age, but the increase was not statistically significant. Overuse injuries also increased with increasing number of total sports seasons played per calendar year and increasing number of seasons of the same sport; 414 (22%) athletes who played sports all year long suffered overuse injury compared with 170 (13%) athletes who took at least 1 season off from sports during the year. Of those who played sports all year long, 274 (22%) athletes who played the same sport for all 4 seasons experienced overuse injury. Similarly, 140 (22%) of those who played a combination of sports throughout the year had an overuse injury.

In a multivariate model, female gender remained significantly associated with overuse injury (adjusted OR [aOR] = 1.65; 95% CI = 1.37-1.98) as did total sports seasons (aOR = 1.06; 95% CI = 1.02-1.10). Controlling for total number of sports seasons rendered the "same sport" variable nonsignificant (aOR = 1.07; 95% CI = 0.94-1.23). Because the unadjusted ORs for 4 seasons of the same sport versus fewer than 4, and 4 seasons of different sports versus fewer than 4 were not significantly different, only the 2-level variable (4 seasons of participation vs taking at least 1 season off) was used in the multivariable model. Playing sports all year round without taking a season off remained highly significant after adjusting for the other variables (aOR = 1.42; 95% CI = 1.05-1.92).

### Discussion

Participation in sports for all 4 seasons of the year appears to be the greatest modifiable risk factor for overuse injury in this study. High school athletes who played year round had a 42% increased risk of overuse injury than those who took at least 1 season off from sports, even taking into account the other variables. It does not

seem to matter if one plays the same sport all year or a combination of different sports throughout the year, however, because both groups demonstrated similarly increased risk of overuse injury when compared with those taking a season off.

We also analyzed injuries with respect to total sports seasons played during the year. This takes into account the higher volume of sports to which multisport athletes are exposed at one time. In the multivariate model, the risk of overuse injury increased by 6% for each total sports season played. It could be argued that athletes who play sports all 4 seasons of the year may suffer more injuries of all types because they have more injury exposures. However, the increased risk for overuse injury persisted even when controlling for total seasons played, which we consider a reasonable proxy for exposures.

Repetitive microtrauma to normal tissues can cause overuse injuries if the tissues are not given adequate time to heal and repair damage. It is plausible, therefore, that year-round athletes could suffer more overuse injuries by not allowing for adequate recuperative time. Additionally, repetitive stresses can also lead to muscle fatigue, weakness, and biomechanical abnormalities that predispose athletes to both acute and overuse injury.

Female participants were at higher risk of sustaining overuse injury than male participants in this study, consistent with previous research showing higher rates of overuse injury in women. Multiple studies have shown a

higher incidence of stress fracture in female compared with male participants in various populations,<sup>12</sup> including division I college athletes<sup>13</sup> and military cadets.<sup>14</sup> Female participants have also been shown to have higher rates of patellofemoral syndrome,<sup>15,16</sup> and some believe that they are more likely have multidirectional instability of the shoulder.<sup>17</sup> Possible anatomical explanations for these differences include increased ligamentous and joint laxity, relatively weaker upper body and vastus medialis obliquus strength, increased Q angle and genu varum, and excessive pronation and external tibial torsion.<sup>18</sup>

Overuse injuries increased slightly with increasing age in our study. Previous research has been mixed in regard to an association between increasing age and risk of injury and seems to be somewhat sport specific. Higher rates of injury have been reported in older male youth football<sup>19</sup> and soccer<sup>20</sup> players compared with their younger counterparts as well as in higher-level gymnasts.<sup>8,21</sup> It is possible that the increased risk of overuse injury is a result of more intense, frequent, and longer training sessions as athletes progress through high school.

There are limitations to our study. Because of the retrospective design, we relied on self-reporting of injuries by our participants, necessitating the following assumptions: First of all, the proper diagnosis must have been made; second, the athlete had to have a proper understanding of this diagnosis and then had to be able to adequately report the correct diagnosis on the

## Appendix A

1. **Age:** 14 15 16 17 18 19

2. **Gender:** male female

3. **Which sport(s) did you play this winter? (On average, at least 1 practice, training event or game per week)**

Baseball	Basketball	Cheerleading	Cross-Country	Dance	Field Hockey	Figure Skating
Football	Golf	Hockey	Lacrosse	Soccer	Softball	Swimming
Tennis	Track	Volleyball	Weightlifting	Wrestling	None	Other _____

4. **Which sport(s) did you play last fall? (On average, at least 1 practice, training event or game per week)**

Baseball	Basketball	Cheerleading	Cross-Country	Dance	Field Hockey	Figure Skating
Football	Golf	Hockey	Lacrosse	Soccer	Softball	Swimming
Tennis	Track	Volleyball	Weightlifting	Wrestling	None	Other _____

5. **Which sport(s) did you play last summer? (On average, at least 1 practice, training event or game per week)**

Baseball	Basketball	Cheerleading	Cross-Country	Dance	Field Hockey	Figure Skating
Football	Golf	Hockey	Lacrosse	Soccer	Softball	Swimming
Tennis	Track	Volleyball	Weightlifting	Wrestling	None	Other _____

(continued)

## Appendix A (continued)

### 6. Which sport(s) did you play last spring? (On average, at least 1 practice, training event or game per week)

Baseball	Basketball	Cheerleading	Cross-Country	Dance	Field Hockey	Figure Skating
Football	Golf	Hockey	Lacrosse	Soccer	Softball	Swimming
Tennis	Track	Volleyball	Weightlifting	Wrestling	None	Other _____

### 7. During the past 12 months did you suffer any injury that made you play worse, caused you to miss at least one week of practice or games, or required you to see a doctor? Yes No

#### 7a. If so, what did you injure?

Head Neck	Shoulder	Arm	Elbow	Wrist	Hand	Finger	
Chest	Stomach	Back	Hip	Leg	Knee	Foot	Other

#### 7b. What was the injury, to the best of your knowledge?

Dislocation	Fracture (broken bone)	Ligament Tear	Muscle Strain/Pull/Tear	Shin Splints
Sprain	Stinger	Stress Fracture	Tendonitis	
Concussion	Golfer's Elbow	Jumper's Knee	Osgood-Schlatter	Patello-Femoral Pain
Plantar Fasciitis	Sever's disease	Spondylolysis	Tennis Elbow	Turf Toe
Other _____		Don't Know		

If you had more than one injury, draw a line between each injury in 7b and the body part in 7a

questionnaire. Overall, 152 (4.6%) athletes suffered an injury that we were unable to classify based on the information provided. However, this small proportion of "unknown" injuries would have been unlikely to affect our overall results given the large sample population.

Future research of this type should have a prospective design to make diagnosis and classification of injuries more precise. It would be interesting to study individual sports to determine if findings of overuse injury differed by sport. Also, it would be helpful to study a younger population to find out if our conclusions are also applicable to the preadolescent age group.

## Conclusions

Overuse injuries appear to "live up to their name," with the risk of sustaining such an injury increasing with age and number of total sports seasons played per year. Varying the sports played from season to season does not appear to have as much impact as taking a season off from all athletic activities because participation in sports year round was associated with a markedly increased risk for self-reported overuse injury in high school students. Reducing the number of sport seasons played by high school athletes could decrease their rate of overuse injuries, with the greatest gains potentially achieved by taking at least 1 season off from sports entirely each calendar year.

## Appendix B

Acute	Overuse
Bone bruise	Exertional compartment syndrome
Bursitis—elbow	Hip apophysitis
Bursitis—knee	IT band syndrome
Concussion	Little league elbow
Dislocation—elbow	Little league shoulder
Dislocation—finger	Osteochondritis dissecans
Dislocation—hip	Osgood-Schlatter's disease
Dislocation—jaw	Patellofemoral syndrome
Dislocation—patella	Plantar fasciitis
Dislocation—shoulder	Sever's disease
Fracture—arm/wrist	Shin splints
Fracture—back	Spondylolysis
Fracture—clavicle	Stress fracture—arm
Fracture—facial	Stress fracture—leg/pelvis
Fracture—foot	Stress fracture—foot
Fracture—hand/finger	Swimmer's shoulder
Fracture—hip	Tendonitis—ankle
Fracture—leg	Tendonitis—elbow
Fracture—neck	Tendonitis—hip
Fracture—rib	Tendonitis—knee
Hematoma/Bruise	Tendonitis—shoulder
Herniated disc	Tendonitis—wrist
Laceration	
Muscle strain—arm	

(continued)



Acute	Overuse
Muscle strain—back	
Muscle strain—chest	
Muscle strain—groin	
Muscle strain—leg/hip	
Muscle strain—neck	
Muscle strain—stomach	
Nerve irritation	
Pneumothorax	
Sprain—ankle	
Sprain—back/neck	
Sprain—elbow	
Sprain—finger	
Sprain—foot	
Sprain—knee	
Sprain—shoulder	
Sprain—toe	
Sprain—wrist	
Stinger/Burner	
Torn ligament—ankle	
Torn ligament—elbow	
Torn ligament—finger	
Torn ligament—knee	
Torn ligament—shoulder	
Torn ligament—wrist	

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### References

- Herring SA, Nilson KL. Introduction to overuse injuries. *Clin Sports Med.* 1987;6:225-239.
- Baquié P, Brukner P. Injuries presenting to an Australian sports medicine centre: a 12-month study. *Clin J Sport Med.* 1997;7:28-31.
- Hogan KA, Gross RH. Overuse injuries in pediatric athletes. *Orthop Clin North Am.* 2003;34:405-415.
- Rooks DS, Micheli LJ. Musculoskeletal assessment and training: the young athlete. *Clin Sports Med.* 1988;7: 641-677.
- Flachsmann R, Broom ND, Hardy AE, Moltschaniwskyj G. Why is the adolescent joint particularly susceptible to osteochondral shear fracture? *Clin Orthop Relat Res.* 2000;(381):212-221.
- Caine D, DiFiori J, Maffulli N. Physeal injuries in children's and youth sports: reasons for concern? *Br J Sports Med.* 2006;40:749-760.
- Caine D, Maffulli N, Caine C. Epidemiology of injury in child and adolescent sports: injury rates, risk factors, and prevention. *Clin Sports Med.* 2008;27:19-50, vii.
- Caine D, Caine C, Maffulli N. Incidence and distribution of pediatric sport-related injuries. *Clin J Sport Med.* 2006;16:500-513.
- Emery CA, Meeuwisse WH, McAllister JR. Survey of sport participation and sport injury in Calgary and area high schools. *Clin J Sport Med.* 2006;16:20-26.
- Powell JW, Barber-Foss KD. Injury patterns in selected high school sports: a review of the 1995-1997 seasons. *J Athl Train.* 1999;34:277-284.
- Radelet MA, Lephart SM, Rubinstein EN, Myers JB. Survey of the injury rate for children in community sports. *Pediatrics.* 2002;110:e28.
- Ivkovic A, Franic M, Bojanic I, Pecina M. Overuse injuries in female athletes. *Croat Med J.* 2007;48:767-778.
- Hame SL, LaFemina JM, McAllister DR, Schaadt GW, Dorey FJ. Fractures in the collegiate athlete. *Am J Sports Med.* 2004;32:446-451.
- Bijur PE, Horodyski M, Egerton W, Kurzon M, Lifrak S, Friedman S. Comparison of injury during cadet basic training by gender. *Arch Pediatr Adolesc Med.* 1997; 151:456-461.
- DeHaven KE, Lintner DM. Athletic injuries: comparison by age, sport, and gender. *Am J Sports Med.* 1986;14: 218-224.
- Ireland ML, Ott SM. Special concerns of the female athlete. *Clin Sports Med.* 2004;23:281-298, vii.
- Templeton KJ, Hame SL, Hannafin JA, Griffin LY, Tosi LL, Shields NN. Sports injuries in women: sex- and gender-based differences in etiology and prevention. *Instr Course Lect.* 2008;57:539-552.
- Holschen JC. The female athlete. *South Med J.* 2004;97: 852-858.
- Malina RM, Morano PJ, Barron M, Miller SJ, Cumming SP, Kontos AP. Incidence and player risk factors for injury in youth football. *Clin J Sport Med.* 2006;16: 214-222.
- Kucera KL, Marshall SW, Kirkendall DT, Marchak PM, Garrett WE Jr. Injury history as a risk factor for incident injury in youth soccer. *Br J Sports Med.* 2005;39:462.
- Caine D, Cochrane B, Caine C, Zemper E. An epidemiologic investigation of injuries affecting young competitive female gymnasts. *Am J Sports Med.* 1989;17: 811-820.