



Epidemiology of Overuse Injuries among High-School Athletes in the United States

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Objective To examine high school overuse injury rates and patterns by sex and sport.

Study design High school athletes participating in the High School Reporting Information Online study were examined in a descriptive epidemiologic study. Overuse injury data for the 2006/2007-2011/2012 academic years collected via High School Reporting Information Online from a large national sample of US high schools where certified athletic trainers completed detailed injury reports were evaluated.

Results From 2006/2007 to 2011/2012, a total of 2834 overuse injuries were reported during 18 889 141 athletic exposures (1.50 per 10 000 athletic exposures). Girls had greater rates of overuse injury (1.88) than boys (1.26) (rate ratio 1.50, 95% CI 1.39-1.61). The greatest rates were in girls' track and field (3.82) and girls' field hockey (2.93). Overuse injuries represented 7.7% of all injuries, ranging from a low of 1.4% of all boys' ice hockey injuries to a high of 55.7% of all boys' swimming and diving injuries. Overall, overuse injuries were evenly distributed across athletes in each year of high school (freshman, 25.6%; sophomore, 25.3%; junior, 24.9%; senior, 24.3%). However, there were distinct differences by sex. The most frequent site of injury was the lower leg (21.8%). Injuries most frequently resulted in time loss of less than 1 week (50.0%), with only 7.6% resulting in time loss greater than 3 weeks.

Conclusions Overuse injury patterns differed by sex and sport. A better understanding of overuse injury patterns and criteria for return to play may help direct preventative measures and injury management. (*J Pediatr* 2015;166:600-6).

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Overuse injuries are more prevalent in older (13-17 years) rather than younger (5-12 years) children.¹⁻³ To date, detailed analysis of the epidemiology of overuse injury among young athletes has been lacking.³ Overuse injuries result from repetitive microtrauma without a single responsible event.⁴ Young athletes may be at greater risk of developing overuse injury than older athletes for several reasons: bone mineralization can lag behind linear bone growth,^{5,6} growing cartilage can be more susceptible to injury than stable articular cartilage,⁷ increased muscle and tendon tightness that results from growth spurts during adolescence,⁷ and a lack of awareness from the young athlete of the signs of overuse injuries.⁶ Therefore, conclusions drawn about overuse injury in adults cannot always be equated to children.

Participation and intensity in high school athletics has increased steadily during the past decade.^{8,9} An increase in the incidence of overuse injuries in children has been observed.^{5,10} As the popularity and intensity of high school sports continues to increase,² so too will the risk of overuse injuries unless effective prevention programs can be developed.

Few epidemiologic studies have looked solely at overuse injuries, especially among high school athletes, as most have focused on a specific injury type or body region,¹¹ a specific sport,^{12,13} or have been limited to one¹⁴ or a few⁵ athletic programs. The epidemiology of overuse injuries has been analyzed in collegiate athletes,¹⁴ but this may not be generalizable to high school athletes.^{5,15} One study, in which investigators looked specifically at overuse injuries in high school

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AE	Athletic exposure
AT	Athletic trainer
FR	Freshman
JR	Junior
RIO	Reporting Information Online
RR	Rate ratio
SO	Sophomore
SR	Senior

athletes, was limited to 5 high schools in northeast Ohio.⁵ Large-scale research on overuse injuries in high school athletes with a prospective design that evaluated overuse injuries by sport, sex, and year in school is lacking.

The purpose of this study was to examine overuse injuries in a large national sample of US high school athletes. Specifically, the aims were to: (1) calculate overuse injury rates; (2) describe patterns of overuse injury; and (3) compare differences by sex, sport, and type of exposure (competition vs practice). Understanding the epidemiology of overuse injury among young athletes is the first step toward the development of effective, targeted prevention efforts.

Methods

A retrospective cohort study of data collected using the National High School Sports-Related Injury Surveillance System, High School RIO (ie, Reporting Information Online). The methods of the High School RIO study have been previously reported.^{16,17} In brief, high schools with one or more National Athletic Trainers' Association-affiliated certified athletic trainers (ATs) with a valid e-mail address were invited to participate. High School RIO used 2 concurrent surveillance cohorts during the study period. In the original study cohort, willing participants were categorized into 8 strata based on US census geographic region (Northeast, Midwest, South, and West) and school population (enrollment ≤ 1000 or >1000).¹⁸ One hundred high schools were chosen randomly from the 8 strata to report for each of the 9 sports included in the original High School RIO Study (boys' football, boys' and girls' soccer, girls' volleyball, boys' and girls' basketball, boys' wrestling, boys' baseball, and girls' softball). If a school dropped out of the study, a replacement was selected from the same stratum to maintain this nationally representative sample for this 100 school study.

For the additional 11 sports added as part of the expanded study cohort since 2008/2009, schools not selected to participate in the nationally representative sample of 100 schools reporting the original 9 sports but that offered any of the other 11 sports (girls' field hockey, girls' gymnastics, boys' ice hockey, boys' and girls' lacrosse, boys' and girls' track and field, boys' and girls' swimming and diving, boys' volleyball, and cheerleading) were included in the expansion of the High School RIO Study as a convenience sample. Combined, these dual sampling methodologies resulted in a large, nationally disperse convenience sample of US high schools providing data for the 20 sports.

Although the National High School Sports-Related Injury Surveillance study began in the 2005/2006 academic year, an option to select "overuse/chronic" as an injury mechanism was not added until the 2006/2007 academic year. Therefore, data analyzed in this study includes the 2006/2007 through 2011/2012 academic years. During the 2005/2006 through 2007/2008 academic years, ATs from participating high schools would log on to the High School

RIO website weekly throughout the academic year to report injury incidence and athletic exposure (AE) for the original 9 sports. Beginning in the 2008/2009 academic year, data were collected for 9 additional sports: girls' field hockey, girls' gymnastics, boys' ice hockey, boys' and girls' lacrosse, boys' and girls' track and field, and boys' and girls' swimming and diving. Beginning in the 2009/2010 academic year, data were collected for boys' volleyball and cheerleading. The total number of schools reporting data for each sport varied annually.

Definition of Injury and AE

An AE was defined as one athlete participating in one practice or competition. A reportable injury was defined as one which: (1) occurred as a result of participation in an organized high school practice or competition; (2) required medical attention by an AT or physician; and (3) resulted in restriction of the student-athlete's participation for at least 1 day beyond the day of injury. More specifically, for this study, overuse injury was defined as any injury reported by the AT as having an "overuse" or "chronic" basic injury mechanism (ie, the mechanism was not "acute"). ATs are trained sports medicine clinicians who used pertinent information such as discussions with other clinicians who treated the injured athlete, their own knowledge, and their relationship with the athlete and the athlete's coach to make the decision on overuse status.

For each reported injury, the ATs completed detailed injury reports, including athlete demographics (eg, sex, age, weight, year in school), injury information (eg, site, diagnosis, severity, new vs recurrent), and injury event information (eg, sport in which the athlete was participating, mechanism). ATs were able to view previously submitted information and update reports as needed.

Statistical Analyses

Data were analyzed using SPSS software, version 20.0 (SPSS, Chicago, Illinois). Frequencies were calculated and missing data was reported as "unknown." All rates and rate comparisons were calculated using unweighted case counts. Overuse injury rates were calculated as the number of overuse injuries per 10 000 AEs. Injury rate ratios (RRs) were calculated with 95% CIs provided as a measure of effect. This study was approved by the Human Subjects Research Board at Nationwide Children's Hospital.

Results

Overall Injury Rates by Exposure Type

From 2006/2007–2011/2012, ATs reported 2834 overuse injuries during 18 889 141 AEs, a rate of 1.50 per 10 000 AEs (Table 1). The greatest overuse injury rates occurred in girls' track and field and girls' field hockey. The lowest overuse injury rates occurred in boys' volleyball and boys' ice hockey. The greatest percentage of all injuries that were overuse injuries occurred in boys' and girls' swimming and

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