

# Subsequent Injury Patterns in Girls' High School Sports

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**Context:** Girls' participation in high school sports has increased 79.5% since 1975–1976. The incidence of injury among boys in high school sports has been well documented, but information regarding the incidence, severity, and type of injury among girls in high school sports is limited.

**Objective:** To examine the effects of subsequent injuries among high school girls in 5 sports.

**Design:** Observational cohort.

**Setting:** Existing data from the 1995–1997 National Athletic Trainers' Association High School Injury Surveillance database.

**Patients or Other Participants:** Girl athletes ( $n = 25\,187$  player-seasons) participating in 5 varsity high school sports: basketball, field hockey, soccer, softball, and volleyball.

**Main Outcome Measure(s):** Injury status, body location, injury type, time lost from injury, and number of players at risk for injury as recorded by athletic trainers and submitted to the Sports Injury Monitoring System.

**Results:** Overall, 23.3% of the athletes had 2 or more injuries within a sport; basketball and soccer athletes were most vulnerable. Overall, the probability of an athlete sustaining 3 or

more injuries was 38.6%, and the risk was highest for field hockey players (61.9%). The risk of subsequent injury at a new body location was almost 2 times higher than reinjury at the same body location (risk ratio = 1.7, 95% confidence interval = 1.6, 1.8) and was similar for all sports except volleyball. Only in softball was the proportion of reinjuries causing 8 or more days lost from participation greater than the proportion of new injuries causing similar time loss. Softball and volleyball had the highest proportion of reinjuries at the shoulder, especially rotator cuff strains. The proportion of knee reinjuries was significantly higher than new injuries for all sports except soccer. The proportion of anterior cruciate ligament injuries was significantly higher for volleyball players only. Overall, the proportion of reinjuries was significantly higher for stress fractures and musculoskeletal condition injuries.

**Conclusions:** Patterns of subsequent injury risk appear to vary among these 5 sports. Almost one quarter of the athletes incurred 2 or more injuries over a 3-year period, so the effects of subsequent injuries deserve more consideration.

**Key Words:** epidemiology, surveillance, sports injuries, reinjuries, female athletes

## Key Points

- High school girls in basketball, field hockey, soccer, softball, and volleyball were more likely to sustain an additional injury to a new body part than a reinjury to the same body part.
- It may be that the actual initial injury risk across these sports is similar and that a small percentage of athletes is responsible for the differences in overall injury rates.
- As we continue to determine and understand the risk factors associated with initial injury, minimizing and controlling the effects of reinjury through proper management deserve similar attention.

In 1991, an estimated 2 million school sports injuries, 500 000 doctor visits, and 30 000 hospitalizations were related to high school sports in the United States.<sup>1</sup> Participation in interscholastic sports in the United States has risen annually from 5.3 million in 1991 to more than 7 million high school athletes during the 2005–2006 school year.<sup>2</sup> Recent estimates suggest that 1.4 million injuries occurred in 9 sports during the 2005–2006 school year, a rate of 2.4 injuries per 1000 athlete-exposures.<sup>3</sup> Given the more than 40 sports associated with the National Federation of State High School Associations, the actual number of injured athletes is likely larger.<sup>2</sup> Although the incidence of injury among boys' high school sports has been well documented,<sup>4</sup> information regarding the incidence, severity, and types of injury among girls' high school sports is limited. This is of concern because of

the large increase in the number of participants and diversity of sports offered for girls at the high school level during the past 30 years. More than 2.95 million girls participated in high school sports nationally during the 2005–2006 school year.<sup>2</sup> This number represents a 79.5% increase in participation since 1975–1976, compared with a 2.0% increase for boys during the same time. Thus, with the growing popularity of girls' sports, additional consideration must be given to the occurrence of injuries in light of recent authors' reports of higher injury rates among girl athletes than boy athletes in similar sports.<sup>5–9</sup>

Although an important aspect of injury prevention is to minimize the risk of an athlete's initial (first) injury, an equal goal is to minimize the occurrence of subsequent injuries (reinjury to the same body location or additional injuries to new body

locations).<sup>5,6,8,10-13</sup> However, few investigators have addressed the distinction between initial and subsequent injury specifically for girls' high school athletes. Of these, the reports have varied with sport type.<sup>6,8,10,11</sup> Similarly, few authors have specifically assessed the effect of subsequent injury types, that is, the difference between reinjury to the same body location and injuries to a new body location.<sup>6,8</sup> Further, few have assessed the effect of reinjury by specific body location, injury type, and time lost from injury (severity), which may provide important information for determining those injuries needing greater attention. Finally, a limited number of researchers have examined the effect of injury proneness (ie, athletes who incur multiple injuries),<sup>14,15</sup> especially in high school sports.<sup>7,8</sup>

We anticipate that the popularity of girls' high school sports on a recreational and competitive basis will continue. Thus, efforts should be focused on examining the effect of the athlete's first and subsequent injuries in girls' sports. Our purpose was to conduct an in-depth analysis of the 1995–1997 National Athletic Trainers' Association (NATA) High School Injury Surveillance database to determine patterns of new and subsequent injuries among female athletes participating in interscholastic sports.

## METHODS

We acquired existing data on all female athletes on the rosters of the following girls' varsity sports: basketball, field hockey, soccer, softball, and volleyball, included in the 1995–1997 NATA High School Injury database. The original NATA database included 5 boys' and 5 girls' varsity sports from 235 selected schools among the 50 states in the United States. The database represented 10 different geographic regions with school enrollment sizes from less than 500 to more than 2000 students.<sup>10</sup> Our study was approved by the university institutional review board.

### Injury Definitions and Data Reporting

In the original data collection phase, each certified athletic trainer recorded all study data using the standard operational definitions for all reported injuries in a surveillance protocol created by the NATA to report daily participation and injuries within the sports program.<sup>10</sup> When a reported injury occurred, the following types of data were recorded and collected: date of and return from injury, clinical impression, body location, time of injury, and nature of injury (new injury versus reinjury). The injuries were identified according to a detailed clinical impression code that allowed for accurate description of the injury.<sup>10</sup> Two data recording procedures were used: (1) a customized version of the Sports Injury Monitoring System (SIMS) (Med Sports Systems, Iowa City, IA) for those athletic trainers with computer capability, and (2) a parallel system of paper forms for those athletic trainers without computer capability.<sup>10</sup> All certified athletic trainers were instructed in the study procedures through several methods: instructor's manual, videotape, and a central data collection office for answering questions. All data included in the NATA study were monitored and verified by the central data collection system.<sup>10</sup>

A reportable injury in the 1995–1997 NATA surveillance study included (1) any injury that caused cessation of participation in the current game or practice and prevented the player's return to that session, (2) any injury that caused cessation of a player's customary participation on the day following the

day of onset, (3) any fracture that occurred, even though the athlete did not miss any regularly scheduled session, (4) any dental injury, including fillings, luxations, and fractures, and (5) any mild brain injury that required cessation of a player's participation for observation before returning, either in the current session or next session.<sup>10</sup>

## Data Analysis

The data presented represent the findings on the combined data for the 3 study years.

**Risk of Multiple Injuries.** Initially, we provided distributions of the number of injuries per athlete by sport. We then assessed the probability of single and subsequent injuries. The probability and 95% confidence intervals (CIs) of a girl athlete sustaining at least 1 injury were calculated by dividing the number of injured athletes by the number of athletes at risk. The probability or risk of an athlete sustaining 2 injuries was calculated by dividing the number of athletes who sustained 2 injuries by the number of athletes who sustained at least 1 injury.<sup>11</sup> The probability of an athlete sustaining 3 or more injuries was also calculated by dividing the number of athletes who sustained 3 or more injuries by the number of athletes who sustained 2 injuries.

**Initial Versus Subsequent Injury Risk.** To assess the effect of initial versus subsequent injury and the effect of reinjury at the same body location versus a new body location, we calculated several types of individual injury risks. The *initial injury risk* was defined as the number of initial injuries (first injuries) per number of players participating per 100 athletes at risk. The *subsequent injury risk* was defined as the number of injuries occurring after the initial injury per number of players who were initially injured.<sup>6,8</sup> We also calculated 2 types of subsequent injury risk: reinjury to same body location and additional injury to a new body location.<sup>6,8</sup> The reinjury risk to same body location was defined as the number of injuries to the same body location after the initial injury per number of players who were initially injured.<sup>6,8</sup> The additional new injury risk was defined as the number of new injuries to different body locations after the initial injury per number of players who were initially injured.<sup>6,8</sup> Risk ratios and 95% CIs were estimated to compare subsequent injury rates among sports.

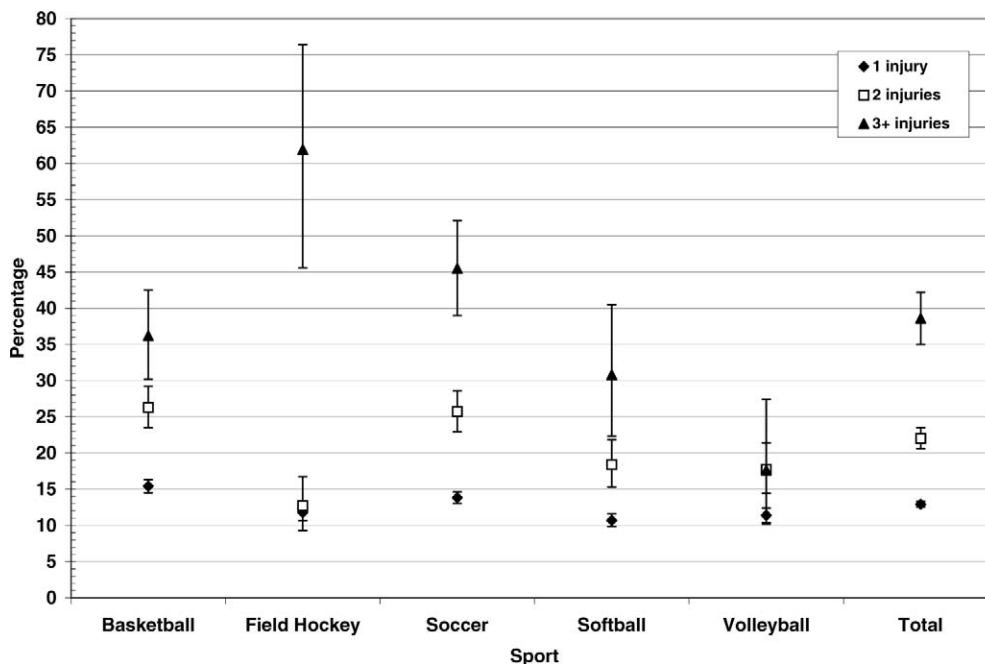
**Effect of Reinjury.** We examined the effect of reinjury by calculating reinjury to new injury ratios as the percentage of reinjuries divided by the percentage of new injuries. Ratios greater than 1.0 indicated that the occurrence of reinjury was higher than the occurrence of new injury. Ratios were calculated for severity of injury (time lost), body location, injury type, and selected injury classifications. For severity of injury, 2 time-loss categories were compared: minor (less than 8 days lost) and moderate/major: (8 or more days lost).<sup>16</sup> The significance of all ratios was tested with  $\chi^2$  tests.<sup>17</sup> All analyses were conducted with SPSS (version 14.0; SPSS Inc, Chicago, IL) and STATA (version 5.0; STATA Corp, College Station, TX) software.

## RESULTS

The total number of player-seasons from 5 girls' sports during the 3-year period was 25 187. Soccer had the largest number of player-seasons ( $n = 6642$  player-seasons), followed by basketball ( $n = 6083$ ), softball ( $n = 5435$ ), volleyball ( $n =$

**Table 1. Athletes With 1 or More Injuries (n = 4696) Among 5 High School Girls' Sports, National Athletic Trainers' Association High School Injury Surveillance Database, 1995–1997**

No. of Injuries	Basketball		Field Hockey		Soccer		Softball		Volleyball		Total	
	n	%	n	%	n	%	n	%	n	%	n	%
1	936	73.6	332	83.0	916	72.8	582	80.6	480	82.8	3246	76.7
≥2	335	26.4	68	17.0	342	27.2	140	19.4	100	17.2	985	23.3
2	246	19.4	42	10.4	235	18.7	107	14.8	85	14.7	715	16.9
3	55	4.3	17	4.3	66	5.2	21	2.9	12	2.1	171	4.1
≥4	34	2.7	9	2.3	41	3.3	12	1.7	3	0.5	99	2.3



**Probability of multiple injuries in 5 high school girls' sports, National Athletic Trainers' Association High School Injury Surveillance Database, 1995–1997.**

4222), and field hockey (n = 2805). A total of 4696 injured players suffered 5640 injuries. The total reported injuries by sport were soccer (n = 1771), basketball (n = 1748), softball (n = 910), volleyball (n = 701), and field hockey (n = 510).

### Multiple Injuries

The number of athletes who incurred 1 or more injuries is presented in Table 1. Overall, 23.3% (985 of 4231) of the injured athletes reported 2 or more injuries. Soccer (27.2%) and basketball (26.4%) had the most athletes reporting multiple injuries, whereas field hockey (17.0%) had the fewest number of players reporting multiple injuries. Soccer had the greatest number of athletes reporting 4 or more injuries (3.3%). Overall, the probability of an athlete incurring a single injury was 12.9% (Figure). The probability of sustaining a subsequent injury increased to 22.0% for at least 2 injuries and 38.6% for sustaining 3 or more injuries. By sport, the probability of sustaining a single injury only was highest for basketball (15.4%) and lowest for volleyball (11.4%). The probability of incurring 3 or more injuries was highest for field hockey (61.9%) and lowest for volleyball (17.6%).

### Initial and Subsequent Injury Risks

Overall, the risk of subsequent injury was almost 3 times higher than the risk of initial injury (risk ratio [RR] = 2.8, 95% CI = 2.6, 2.9) (Table 2). By sport, field hockey and soccer had the highest subsequent injury risks (RR = 2.8, 95% CI = 2.3, 3.4; RR = 2.8, 95% CI = 2.5, 3.1, respectively), while volleyball had the lowest subsequent injury risk (RR = 2.3, 95% CI = 1.9, 2.7). Overall, regarding subsequent injury, the risk for an injury to a new body location was higher (RR = 1.7, 95% CI = 1.6, 1.8) than reinjury to the same body location (RR = 1.1, 95% CI = 0.9, 1.1). The risk for subsequent injury to a new body location was significantly higher for 4 sports: basketball, field hockey, soccer, and softball ( $P < .0001$ ). For reinjury to the same body location, the risk was similar and statistically nonsignificant for all 5 sports.

### Reinjury Versus New Injury by Severity

Overall, a higher proportion of moderate/major injuries (8 or more days lost) occurred among reinjuries than new injuries ( $P = .02$ ) (Table 3). By sport, softball had a higher proportion

**Table 2. Risk of Initial and Subsequent Injury Among 5 High School Girls' Sports, National Athletic Trainers' Association High School Injury Surveillance Database, 1995–1997**

	Basketball		Field Hockey		Soccer		Softball		Volleyball		Total	
	n	Rate	n	Rate	n	Rate	n	Rate	n	Rate	n	Rate
Initial injury*	1164	19.1	372	13.3	1184	17.8	678	12.5	542	12.8	3940	15.6
Subsequent injury†	584	50.2	138	37.1	587	49.6	232	34.2	159	29.3	1700	43.2
Risk ratio		2.6		2.8		2.8		2.7		2.3		2.8
95% Confidence interval		2.4, 2.9		2.3, 3.4		2.5, 3.1		2.4, 3.2		1.9, 2.7		2.6, 2.9
Reinjury to same body location‡	238	20.5	54	14.5	184	15.6	88	13.0	74	13.6	638	16.2
Risk ratio		1.1		1.1		0.9		1.1		1.1		1.1
95% Confidence interval		0.9, 1.2		0.8, 1.5		0.7, 1.0		0.8, 1.3		0.8, 1.4		0.9, 1.1
Injury to new body location§	346	29.7	84	22.6	403	34.0	144	21.2	85	15.7	1062	27.0
Risk ratio		1.6		1.7		1.9		1.7		1.2		1.7
95% Confidence interval		1.4, 1.8		1.3, 2.2		1.7, 2.1		1.4, 2.0		1.0, 1.5		1.6, 1.8

\*Initial injury risk: risk defined as the number of initial injuries per number of players participating without limitation of injury, thus being exposed to the risk of injury. Denominators: basketball = 6083, field hockey = 2805, soccer = 6642, softball = 5435, volleyball 4222, total = 25 187.

†Subsequent injury risk: risk defined as the number of injuries occurring after the initial injury per number of players who were initially injured. Denominators: basketball = 1164, field hockey = 372, soccer = 1184, softball = 678, volleyball = 542, total = 3940.

‡Reinjury to same body location risk: risk defined as the number of injuries occurring to the same body location after the initial injury per number of players who were initially injured. Denominators: basketball = 1164, field hockey = 372, soccer = 1184, softball = 678, volleyball = 542, total = 3940.

§Injury to new body location risk: risk defined as the number of injuries occurring to new different body locations after the initial injury per number of players who were initially injured. Denominators: basketball = 1164, field hockey = 372, soccer = 1184, softball = 678, volleyball = 542, total = 3940.

**Table 3. Comparison of Reinjuries and New Injuries Resulting in 8 or More Days Lost From Sport Participation Among 5 High School Girls' Sports, National Athletic Trainers' Association High School Injury Surveillance Database, 1995–1997**

Injury Nature	Basketball		Field Hockey		Soccer		Softball		Volleyball		Total	
	%*	Ratio†	%	Ratio	%	Ratio	%	Ratio	%	Ratio	%	Ratio
Reinjury‡	31.5	1.18	14.8	0.73	31.0	1.15	30.7	1.46§	25.7	1.04	29.2	1.17§
New injury	26.7		20.2		27.0		21.0		24.7		25.0	

\*Percentage of injuries for which 8 or more days of participation were lost.

†Severity ratio: injuries that caused 8 or more days of lost participation compared with injuries that caused 7 or fewer days of lost participation.

‡Reinjury: injury occurring to the same body location after the initial injury to that body location (basketball = 238, field hockey = 54, soccer = 184, softball = 88, volleyball = 74, total = 638).

§P value < .05,  $\chi^2$  test.

||New injury: first injury occurrence to a new body location (basketball = 1510, field hockey = 456, soccer = 1587, softball = 822, volleyball = 627, total = 5002).

of moderate/major reinjuries due to practice or games than new injuries ( $P = .03$ ).

### Reinjury Versus New Injury by Body Location

Overall, compared with new injury, a higher proportion of reinjuries (to the same body location) occurred at the shoulder ( $P < .0001$ ), knee ( $P < .0001$ ), and lower leg ( $P < .0001$ ) (Table 4). A higher proportion of shoulder reinjury than new injury occurred in softball ( $P < .0001$ ) and volleyball ( $P = .007$ ). A higher proportion of knee reinjuries than new injuries was found in basketball ( $P = .003$ ), field hockey ( $P = .004$ ), softball ( $P = .02$ ), and volleyball ( $P = .005$ ). A significantly higher proportion of lower leg reinjuries than new injuries occurred in basketball ( $P < .0001$ ) and volleyball ( $P = .003$ ). Other body regions had a significantly higher proportion of reinjury than new injury: spine (basketball [ $P = .02$ ]), hip/groin/thigh (field hockey [ $P = .05$ ]), and ankle (soccer [ $P = .02$ ]).

### Reinjury Versus New Injury by Injury Type

Overall, the proportion of reinjury than new injury was higher for stress fractures ( $P = .0001$ ) and other musculo-

skeletal condition injuries only ( $P < .0001$ ) (Table 5). A significantly higher proportion of stress fracture reinjuries than new injuries occurred among basketball ( $P = .004$ ) and soccer ( $P = .003$ ) players. The proportion of musculoskeletal condition injuries was higher for reinjuries than new injuries in all 5 sports ( $P < .0001$ ). Only volleyball players had a higher proportion of reinjuries considered “general traumatic” than new injuries ( $P = .02$ ).

### Reinjury Versus New Injury by Selected Injuries

Overall, a higher proportion of reinjuries than new injuries was noted for rotator cuff strain ( $P = .02$ ) and shin splint injuries ( $P < .0001$ ) (Table 6). The proportion of rotator cuff strain reinjuries was higher than new injuries in softball ( $P = .04$ ) and volleyball players ( $P = .02$ ) only. The proportion of shin splint reinjuries was higher than new injuries in basketball ( $P < .0001$ ), soccer ( $P = .04$ ), and volleyball ( $P = .002$ ). A significantly higher proportion of hamstring strains and anterior cruciate ligament reinjuries than new injuries was found in field hockey ( $P = .04$ ) and volleyball ( $P = .04$ ), respectively.

**Table 4. Proportion of Reinjuries and New Injuries by Body Location Among Girls' High School Sports, National Athletic Trainers' Association High School Injury Surveillance Database, 1995–1997**

Body Location	Basketball		Field Hockey		Soccer		Softball		Volleyball		Total	
	%	Ratio*	%	Ratio	%	Ratio	%	Ratio	%	Ratio	%	Ratio
<b>Head/face</b>												
Reinjury†	3.4	0.30‡	1.9	0.10‡	1.6	0.17‡	4.5	0.42	1.4	0.47	2.7	0.26‡
New injury§	11.1		17.8		9.6		10.9		2.9		10.2	
<b>Spine</b>												
Reinjury	9.7	1.70‡	1.9	0.34	5.4	1.29	4.5	0.93	12.2	1.11	7.4	1.28
New injury	5.7		5.5		4.2		4.9		11.0		5.7	
<b>Chest/abdomen</b>												
Reinjury	0.4	0.32	0.0	0.0	1.6	1.52	1.1	0.72	2.7	1.13	1.1	0.80
New injury	1.3		0.9		1.1		1.6		2.4		1.4	
<b>Shoulder</b>												
Reinjury	2.9	1.27	3.7	1.53	1.6	0.89	34.1	3.05‡	17.6	2.30‡	8.6	2.01‡
New injury	2.3		2.4		1.8		11.2		7.7		4.3	
<b>Upper arm/elbow</b>												
Reinjury	0.0	0.0	0.0	0.0	0.0	0.0	10.2	1.50	2.7	0.84	1.7	0.78
New injury	1.1		1.5		0.5		7.1		3.2		2.2	
<b>Forearm/wrist/hand</b>												
Reinjury	2.5	0.24‡	1.9	0.14‡	0.0	0.0	9.1	0.47‡	1.4	0.14‡	2.5	0.25‡
New injury	10.5		13.2		4.6		19.3		9.9		10.2	
<b>Hip/groin/thigh</b>												
Reinjury	5.9	0.53‡	24.1	1.83‡	16.3	0.90	8.0	0.56	1.4	0.22	10.2	0.76‡
New injury	11.1		13.2		18.1		14.1		6.2		13.4	
<b>Knee</b>												
Reinjury	24.4	1.70‡	27.8	2.30‡	22.3	1.17	18.2	1.82‡	21.6	2.19‡	22.9	1.60‡
New injury	14.4		12.1		19.0		10.0		9.9		14.4	
<b>Lower leg</b>												
Reinjury	12.6	2.57‡	13.0	1.91	9.8	1.28	2.3	0.48	10.8	3.57‡	10.2	1.80‡
New injury	4.9		6.8		7.6		4.7		3.0		5.7	
<b>Ankle</b>												
Reinjury	31.5	0.98	20.4	1.03	36.4	1.32‡	5.7	0.42‡	24.3	0.60‡	27.6	1.0
New injury	32.3		19.7		27.7		13.6		40.8		27.7	
<b>Foot</b>												
Reinjury	2.9	0.64	1.9	0.50	4.9	1.0	2.3	1.17	2.7	1.0	3.3	0.84
New injury	4.6		3.7		4.9		1.9		2.7		3.9	

\*Ratio: reinjury/new injury.

†Reinjury: injury occurring to the same body location after the initial injury to that body location (basketball = 238, field hockey = 54, soccer = 184, softball = 88, volleyball = 74, total = 638).

‡P value < .05,  $\chi^2$  test (Fisher exact test when expected values in cells <5).

§New injury: first injury occurrence to a new body location (basketball = 1510, field hockey = 456, soccer = 1587, softball = 822, volleyball = 627, total = 5002).

## DISCUSSION

### Main Findings

The results of this study indicate that (1) almost one quarter of the athletes reported multiple injuries, with soccer and basketball players reporting the most multiple injuries per athlete, (2) the injury risk for subsequent injury was high, (3) the proportion of moderate/major injury was higher for reinjury than new injury, (4) the proportion of shoulder, knee, and lower leg reinjuries was higher than for new injuries, (5) the proportion of stress fracture and other musculoskeletal conditions was higher for reinjuries than new injuries, and (6) the proportion of rotator cuff strains and shin splints reinjuries was higher than for new injuries.

### Multiple Injuries and Subsequent Injury Effect

Although several authors<sup>8,9,18,19</sup> have found self-reported previous sports injury to be a strong predictor for future sports injury, only a few<sup>14,15</sup> have examined the reinjury or injury proneness of athletes participating in high school sports.<sup>7,8</sup> Traditionally, authors of most high school sport injury studies have reported injury risk as the total number of injured players per total number of athletes,<sup>7,10,20–22</sup> the total number of injuries per total number of athletes,<sup>5,7,9,10,20–26</sup> the number of players injured per number of players,<sup>7,9,10,23–26</sup> or the total number of injuries per total athletic time/exposures.<sup>6,8,10,22</sup> Although these injury rates provide valuable information, they do not tell us how the injury rates might be partially skewed by a percentage of individual athletes who are injured repeat-

**Table 5. Proportion of Reinjuries and New Injuries by Injury Type Among Girls' High School Sports, National Athletic Trainers' Association High School Injury Surveillance Database, 1995–1997**

Injury Type	Basketball		Field Hockey		Soccer		Softball		Volleyball		Total	
	%	Ratio*	%	Ratio	%	Ratio	%	Ratio	%	Ratio	%	Ratio
Sprains†												
Reinjury‡	38.2	0.82	27.8	1.10	40.2	1.04	25.0	1.05	41.9	0.80	36.5	0.94
New injury	46.2		25.2		38.6		23.7		52.6		39.0	
Strains§												
Reinjury	16.4	0.91	27.8	1.44	25.5	1.16	37.5	1.19	18.9	0.69	23.2	1.02
New injury	17.9		19.3		22.0		31.6		27.3		22.8	
General trauma¶												
Reinjury	18.5	0.89	18.5	0.48#	19.0	0.74	15.9	0.55#	20.3	1.90#	18.5	0.77#
New injury	20.6		39.0		25.6		28.8		10.7		24.0	
Stress fractures												
Reinjury	3.8	3.36#	1.9	1.41	3.3	4.71#	0.0	0.0	1.4	1.70	2.7	3.17#
New injury	1.1		1.3		0.7		0.4		0.8		0.8	
Fractures**												
Reinjury	1.7	0.29#	0.0	0.0	0.5	0.10#	1.1	0.13#	0.0	0.0	0.9	0.16#
New injury	5.8		5.0		5.4		8.8		3.2		5.8	
Neurotrauma††												
Reinjury	1.7	0.43	1.9	0.56	3.8	0.81	5.7	1.95	1.4	1.06	2.8	0.78
New injury	3.9		3.3		4.7		2.9		1.3		3.6	
Musculoskeletal conditions‡‡												
Reinjury	13.9	5.66#	18.5	7.68#	6.5	3.57#	13.6	4.87#	14.9	5.18#	12.2	5.18#
New injury	2.5		2.4		1.8		2.8		2.9		2.4	

\*Ratio: reinjury/new injury.

†Sprains: injuries to the connective ligamentous structures about the joint.

‡Reinjury: injury occurring to the same body location after the initial injury to that body location (basketball = 238, field hockey = 54, soccer = 184, softball = 88, volleyball = 74, total = 638).

§Strains: injuries to the muscle-tendon complex.

||New injury: first injury occurrence to a new body location (basketball = 1510, field hockey = 456, soccer = 1587, softball = 822, volleyball = 627, total = 5002).

¶General trauma: contusions, wounds, cramps, and acute inflammations.

#P value < .05,  $\chi^2$  (Fisher exact test when expected values in cells <5).

\*\*Fractures: includes all fracture types other than stress fractures.

††Neurotrauma: injuries to the nervous system (eg, mild traumatic brain injury).

‡‡Musculoskeletal conditions: includes conditions that affect the musculoskeletal system (eg, inflammations or tumors).

edly. Thus, how an athlete's first injury increases the risk for future injury has not been measured.

**Multiple Injuries.** In our study, 23% of the injured athletes reported 2 or more injuries, with a range of 1 to 8 individual injuries. This finding is lower than that reported by Beachy et al<sup>7</sup> for girl athletes incurring 2 or more injuries (63%) during their high school career. The difference in findings may be due to several factors. First, we assessed athletes from high school varsity sports over a 3-year period, whereas Beachy et al<sup>7</sup> followed athletes in grades 7–12 over an 8-year period. Thus, they were able to follow athletes for at least 6 years, compared with our 3. A total of 5.2% of their injured female athletes reported 10 or more injuries per individual athlete, with a range from 1 to more than 26 injuries. In our study, girls' soccer (3.3%) and basketball (2.7%) players had the greatest percentage of athletes with 4 or more injuries per athlete, with basketball and field hockey players reporting the largest range of multiple injuries per individual athlete (1 to 8 injuries). However, we could not compare our findings with theirs, because they did not report multiple individual injuries by specific sport. Second, our study sample was based on reports from multiple schools across the United States. Further, not all schools reported injuries to the SIMS for all 3 years. In contrast, Beachy et al's<sup>7</sup> findings were based on 1 school using a

consistent reporting mechanism over an 8-year period. Despite these differences, both studies indicate that some athletes may be prone to multiple injuries.

Most high school sport injury studies have reported the probability of sustaining at least 1 injury. However, reporting this probability does not provide a true picture of the individual athlete's risk.<sup>11</sup> Although we found that the probability of a single injury was similar across all 5 girls' sports, the probability of incurring 2 or more injuries varied. The probability of incurring 3 or more injuries was most apparent for field hockey players. The reasons are not clear for the increased injury proneness among some athletes or sports, but we suggest that the findings could be due to (1) some sport positions having a higher risk for multiple injuries, (2) some players being at greater risk for injury time (athlete-exposure) due to player skill or smaller team size, (3) some sports increasing the risk of injury for all body regions, (4) the contact/noncontact nature of the sport, or (5) inadequate rehabilitation, that is, sending the athlete back to practice or game before the injury is appropriately healed. Future authors should examine these factors to help explain this finding.

**Initial Versus Subsequent Injury.** The difference between initial and subsequent injuries has been examined in several studies of girls' high school cross-country runners<sup>6,8</sup> but has

**Table 6. Proportion of Reinjuries and New Injuries by Selected Injury Types Among Girls' High School Sports, National Athletic Trainers' Association High School Injury Surveillance Database, 1995–1997**

Selected Injury Type	Basketball		Field Hockey		Soccer		Softball		Volleyball		Total	
	%	Ratio*	%	Ratio	%	Ratio	%	Ratio	%	Ratio	%	Ratio
<b>Concussion</b>												
Reinjury†	1.7	0.47	1.9	0.77	1.6	0.38	3.4	1.56	0.0	0.0	1.7	0.55
New injury‡	3.6		2.4		4.3		2.2		1.0		3.1	
<b>Rotator cuff strain</b>												
Reinjury	0.0	0.0	0.0	0.0	0.0	0.0	10.2	2.00§	8.1	2.99§	2.4	1.84§
New injury	0.2		0.2		0.1		5.1		2.7		1.3	
<b>Hamstring strain</b>												
Reinjury	0.8	0.44	11.1	2.98§	3.8	0.76	5.7	1.11	1.4	1.06	3.3	0.94
New injury	1.9		3.7		5.0		5.1		1.3		3.5	
<b>Anterior cruciate ligament sprain</b>												
Reinjury	2.9	0.74	0.0	0.0	3.3	0.81	3.4	3.11	8.1	2.82§	3.4	1.08
New injury	4.0		2.0		4.0		1.1		2.9		3.2	
<b>Shin splints</b>												
Reinjury	6.3	5.01§	5.6	1.96	3.3	2.46§	0.0	0.0	6.8	7.06§	4.5	3.73§
New Injury	1.3		2.9		1.3		0.2		1.0		1.2	
<b>Ankle sprain</b>												
Reinjury	27.7	0.93	18.5	1.21	27.7	1.19	5.7	0.51	23.0	0.62§	23.4	0.96
New Injury	29.7		15.4		23.4		11.1		37.3		24.3	

\*Ratio: reinjury/new injury.

†Reinjury: injury occurring to the same body location after the initial injury to that body location (basketball = 238, field hockey = 54, soccer = 184, softball = 88, volleyball = 74, total = 638).

‡New injury: first injury occurrence to a new body location (basketball = 1510, field hockey = 456, soccer = 1587, softball = 822, volleyball = 627, total = 5002).

§P value < .05,  $\chi^2$  test (Fisher exact test when expected values in cells <5).

not been studied in other girls' interscholastic sports. Our purposes for reporting injury rates in this manner were (1) the incidence of initial injury estimates the rate at which previously healthy high school female athletes experienced a first injury during a practice or game, and (2) the occurrence of an injury may be a risk factor for a subsequent injury at the same site or a new body location.<sup>6,8,27,28</sup> With the exception of volleyball, we found that female athletes were 2 times more likely to incur a subsequent new injury to a different body location, whereas the risk for reinjury to the same body location was essentially the same as the initial (first) injury. These findings are opposite those reported among girls' high school cross-country runners, for whom the risk of reinjury to the same body location was 4 to 5 times greater, while the risk of an injury to a new body location was less than 0.5.<sup>6,8</sup> The differences may be due to the mechanisms of injury in each sport. In the 5 sports studied, the risk of injury likely comprised contact and noncontact injury mechanisms, thus exposing the athlete to a higher risk of acute traumatic injuries to different body regions, whereas in cross-country running, the mechanism of injury is largely chronic, repetitive use of the lower extremities only. Comparisons with these cross-country studies, however, are limited. In our study, data to determine athletic exposures up to the athletes' first injury were not available. Thus, we were unable to examine the risk of initial versus subsequent injury by actual daily sport participation. In any case, the multiple injury and injury risk findings suggest that the severity of the primary injury may be underestimated. For the high school female athlete, we suggest early recognition of symptoms of overuse and subsequent reduction and/or change in the training load and complete rehabilitation (that is, a high school female athlete should only return to sports if

she is free from pain and has regained full range of motion of joint(s) involved in the injury and muscle strength at a level of at least 90% of the preinjured strength. However, to our knowledge, the preventive effect of these factors in minimizing high school sports injuries is not conclusive.<sup>29,30</sup>

### Effects of Reinjury to Same Body Location

Although the overall prevalence of reinjury to the same body location for these 5 girls' sports was smaller (11.3%) than that reported in high school cross-country runners,<sup>5,7</sup> the observed effects of reinjury reflect the need to minimize recurrence.

**Reinjury and Severity.** Except for softball, we found that the proportions of both reinjury and new injuries causing 8 or more participation days lost were similar. As most new injuries were minor (less than 8 days lost) for all 5 sports, increased efforts to appropriately manage the original injury may reduce the occurrence or severity of a reinjury.

**Reinjury and Body Location.** To our knowledge, no authors have reported on reinjury by body location specifically for these 5 girls' high school sports. Our finding that higher proportions of reinjury by body region varied by sport seems reasonable because of the nature of activities occurring in each sport. The proportion of lower extremity reinjuries, especially at the knee, was highest in sports that require a large percentage of lower extremity use, that is, running back and forth on a fairly continuous basis. The proportion of lower leg reinjury was highest in basketball and volleyball, 2 sports that are played on a hard surface. This result suggests that surface type may play a role in subsequent lower leg injuries. Softball and volleyball, sports that require active use of the upper extremity,

had the highest proportion of upper extremity reinjury, particularly at the shoulder. Further, basketball, soccer, and volleyball, sports that require a good deal of forward trunk-flexion activities, had the highest proportion of reinjury of the lower back, although the proportion was only significantly different for basketball.

**Reinjury and Injury Type.** Although sprains and strains comprised the most injuries, the proportion of reinjuries was significantly higher than that of new injuries only for stress fracture and musculoskeletal condition injuries. Most musculoskeletal condition reinjuries were those classified as overuse or chronic, including tendinitis, fasciitis, patellofemoral pain syndrome, and knee chondromalacia. The proportion of musculoskeletal condition reinjury was significantly higher for all sports. This finding coincides with the results of other reports, in which these injuries have a high recurrence rate in girls' high school or competitive sports that involve a large amount of repetitive strain activities in practices and games.<sup>6,8,31,32</sup> Although the proportion of stress fracture reinjuries was only significantly higher for basketball and soccer, trends were also found for field hockey and volleyball. The overall number of these injuries may be small, but this finding merits further investigation, as these injuries typically have a longer healing period that may end a female athlete's season prematurely.

**Reinjury and Selected Injuries.** We also examined selected injuries by body region that have been known to have significant effects on an athlete's performance and time lost from sport. The proportion of rotator cuff reinjuries was higher in softball and volleyball, sports that typically involve a high volume of repetitive shoulder use. Similarly, the proportion of shin splint reinjuries was higher for the 4 sports that require a large amount of repetitive back-and-forth or jumping activity of the lower leg. In terms of prevention, our findings suggest that better prevention and rehabilitation management is needed for these types of injuries. We noted that only volleyball had a significantly greater proportion of anterior cruciate ligament reinjuries. This result suggests that proper management after the initial injury may have been partially responsible for the decrease in subsequent anterior cruciate ligament injury for most of the 5 sports. We are unaware of any authors who have specifically reported anterior cruciate ligament reinjuries in girls' volleyball. Thus, more investigation is needed to determine the reasons for recurrence in this sport. Although Schulz et al<sup>33</sup> reported that a previous history of concussion was a risk factor for recurrence in 12 high school sports, they did not report specific values for girls' sports. We did not observe any significantly higher recurrence for concussion in these 5 girls' sports. The low number of reinjuries suggests that appropriate steps to minimize their recurrence may have been instituted. This is important because concussion injuries can significantly affect an athlete's performance.<sup>34-36</sup>

## Strengths

Several strengths of this study are noted. First, the large sample size and substantial number of injuries provided sufficient power to examine differences between new and subsequent injury (reinjury and subsequent new injury) for severity (time loss), body location, and injury type. Second, a standard injury definition and systematic method of collecting and reporting data were employed in 235 schools. Third, the data were collected over a 3-year period and found to be homogeneous.<sup>10</sup> Thus, the collection period minimized yearly

fluctuations that can lead to faulty conclusions when only 1 to 2 years of data are used.<sup>6,37</sup>

## Limitations

In addition to some of the limitations previously stated, we encountered several other limitations in our study. First, because the data were collected for only 3 years, and not all schools participated in each year of the data collection period, we were unable to determine the true subsequent risk or number of multiple injuries that an individual female athlete might incur over a 4-year interscholastic sport career. Therefore, the true subsequent injury and multiple injury risks were likely underestimated. Second, we were only able to determine an individual athlete's multiple injury risk within a single sport. Thus, we were unable to determine the athlete's true overall multiple injury risk if she played more than 1 sport.

## CONCLUSIONS

The comparisons of subsequent injury among the 5 sports should not be viewed as a means of deciding whether 1 or more of these sports is too risky for participation but as an initial attempt to compare and identify subsequent injury patterns for which special focus and attempts to decrease additional injuries to athletes might be better targeted. Our early findings suggest that most of these 5 sports had a higher injury risk of an additional injury to a new body location than a reinjury to the same body location. This result seems logical, as the skills and sport mechanisms of injury vary with the activities involved in each respective sport.

The effects of subsequent injury and multiple injury warrant further attention. We recommend that future authors prospectively follow a cohort for at least 4 years to determine the true initial injury, reinjury, and overall multiple injury risk. We also strongly recommend that each athlete's injuries and athlete-exposures are collected in a manner so that the true initial injury and subsequent injury risks can be determined for appropriate comparison purposes across all sports.<sup>6,8,11</sup> It may be that the actual initial injury risk is similar and that a small percentage of the athletes are responsible for the difference in overall injury rates.

As current researchers continue to determine and understand the risk factors associated with initial injury, minimizing and controlling the effects of reinjury through proper management deserve similar attention. Our findings of reinjury by body location and severity of injury provide information to help direct future research and prevention efforts in these 5 sports. Further, our results suggest that some athletes may be more injury prone than other athletes. Ongoing efforts are needed to look at the injury and reinjury problem in these and other girls' high school sports, so that these athletes may continue accruing the immediate and long-term benefits of physical activity.<sup>38</sup>

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