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Epidemiology of Overuse and Acute Injuries Among Competitive Collegiate Athletes

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Context: Although overuse injuries are gaining attention, epidemiologic studies on overuse injuries in male and female collegiate athletes are lacking.

Objective: To report the epidemiology of overuse injuries sustained by collegiate athletes and to compare the rates of overuse and acute injuries.

Design: Descriptive epidemiology study.

Setting: A National Collegiate Athletic Association Division I university.

Patients or Other Participants: A total of 1317 reported injuries sustained by 573 male and female athletes in 16 collegiate sports teams during the 2005–2008 seasons.

Main Outcome Measure(s): The injury and athlete-exposure (AE) data were obtained from the Sports Injury Monitoring System. An injury was coded as either overuse or acute based on the nature of injury. Injury rate was calculated as the total number of overuse (or acute) injuries during the study period divided by the total number of AEs during the same period.

Results: A total of 386 (29.3%) overuse injuries and 931 (70.7%) acute injuries were reported. The overall injury rate was 63.1 per 10000 AEs. The rate ratio (RR) of acute versus overuse injuries was 2.34 (95% confidence interval [CI] = 2.05, 2.67). Football had the highest RR (RR = 8.35, 95% CI = 5.38, 12.97), and women's rowing had the lowest (RR = 0.75, 95% CI = 0.51, 1.10). Men had a higher acute injury rate than women (49.8 versus 38.6 per 10000 AEs). Female athletes had a higher rate of overuse injury than male athletes (24.6 versus 13.2 per 10000 AEs). More than half of the overuse injuries (50.8%) resulted in no time loss from sport.

Conclusions: Additional studies are needed to examine why female athletes are at greater risk for overuse injuries and identify the best practices for prevention and rehabilitation of overuse injuries.

Key Words: injury surveillance, athlete-exposures

Key Points

- More than one-quarter of all injuries were overuse injuries.
- Compared with acute injuries, more overuse injuries involved no time lost from participation.
- Female athletes had a higher rate of overuse injuries than did male athletes.

Overuse injuries, also called chronic injuries, are a category of sport-related injuries that result from cumulative trauma or repetitive use and stress. Unlike acute injuries, which are typically caused by a single traumatic event, overuse injuries often are the result of many repetitive minor insults.[1,2] Moreover, overuse injuries occur when inadequate time is provided for the injured area of the body to heal properly. Typical examples of overuse injuries include tendinitis, bursitis, medial tibial stress syndrome, and stress fractures.[3]

Although most injuries in sports involving high speed (eg, soccer) or full-body contact (eg, football, wrestling) are acute, overuse injuries are often found in low-contact sports that involve long training sessions or the same movement repeated numerous times (eg, long-distance running, rowing, swimming).[4–7] Consequences of overuse injuries include loss of playing time, reduced function, psychological exhaustion, and significant pain.[3,8–10] Because overuse injuries are associated with a gradual increase in symptoms, athletes may be unaware that they are seriously injured.[8] Thus, overuse injuries may present not only physical but also psychological challenges that could significantly affect an athlete's recovery and performance. Furthermore, undiagnosed and untreated overuse injuries can produce long-term residual symptoms and health consequences, including deformities and arthritis.[11,12]

In recent years, increased research has focused on overuse injuries among athletes involved in various competitive sports.[4,9–14] One group[13] compared the frequencies of overuse injuries among National Collegiate Athletic Association (NCAA) Division I teams of women's field hockey, soccer, and basketball but found no significant differences in the injury incidence rates for these sports. In another study[4] of professional volleyball athletes, both male and female players reported a

high prevalence of overuse injuries of the lower back, knee, and shoulder. Most authors of published studies on overuse injuries have focused either on a specific sport team[4,9,10,14] or a specific injury type or injured body region,[13,15] but there are few epidemiologic studies on overuse injury. In particular, a significant gap exists in the relative rates of overuse and acute injuries in male and female Division I collegiate athletes.

The purpose of our study was to report the epidemiology of overuse injuries sustained by Division I collegiate athletes and to compare the rates of overuse and acute injuries. Understanding the frequency, rate, and severity of overuse injuries is an important first step for designing effective injury-prevention programs, intervention strategies, and treatment protocols to prevent and rehabilitate athletes with these injuries.[16]

METHODS

Study Population

The study sample consisted of male and female collegiate athletes from 1 NCAA Division I institution in the Big Ten Athletic Conference. The athletes participated in 16 teams: men's baseball, basketball, cross-country and track and field, football, gymnastics, swimming and diving, and wrestling and women's basketball, cross-country and track and field, field hockey, gymnastics, rowing, soccer, softball, swimming and diving, and volleyball.

From these 16 teams, we compiled injury and athlete-exposure (AE) data over a 3-year period (August 1, 2005, through July 31, 2008). These data were reported through the Sports Injury Monitoring System (SIMS), an ongoing injury-surveillance system established by the Big Ten Athletic Conference in the early 1980s.[17] The SIMS database includes a roster of all team members, a daily log for all team practices and games, and a detailed record of all reportable injuries, including type and location of injury and the medical attention and rehabilitation received. Certified athletic trainers are responsible for entering data from their teams into SIMS. The study was approved by the Institutional Review Board of the University of Iowa.

Case Definition

An *overuse injury* was defined as a gradual-onset injury caused by repeated microtrauma without a single, identifiable event responsible for the injury.[1,2,9] An *acute injury* was defined as trauma resulting from a specific and identifiable event.[1,2,9] All injuries included in this study met the following 2 criteria: clinical signs of tissue damage determined by team athletic trainers or team physicians and inability of the player to return to practice or game the same day.[17] Two trained research assistants manually coded the injuries reported through SIMS as either overuse or acute injury based on the case definitions. Inter-rater reliability was calculated as a kappa coefficient of 0.94. When the coding was inconsistent, we reviewed a detailed description of the injury available through the SIMS database for clarification before the final categorization. Thus, we included a total of 1317 injury cases in the data analysis.

Main Measures

Type of Overuse Injury. Using a combination of injury descriptions and conditions, we categorized overuse injuries as follows: bursitis, deformity or weakness, general stress, impingement, inflammation, joint laxity, loose bodies or debris, stress fracture, tendinitis, or other.[9,12]

Type of Acute Injury. Based on the nature of the injury and injury diagnosis, we described acute injuries as follows: blood vessels, dislocation, fracture, internal organ, nerves, open wound, sprain or strain, superficial or contusion, or other.[9,12]

Injury Severity. Each injury was classified as *no time lost* if an athlete lost no participation time, *minor* if the athlete lost less than 1 week, *moderate* if the athlete lost 1 to 3 weeks, or *major* if the athlete lost more than 3 weeks.[9,12,18]

Athlete-Exposure. We defined *1 AE* as attending 1 coach-directed session of either a game or practice as reported in SIMS. The total number of AEs for a sport team was calculated as the sum of the total number of coach-directed games and practices attended by athletes on that team.

Statistical Analysis

We calculated descriptive statistics for the occurrence and proportion of overuse and acute injuries during the study period. Differences across subgroups were compared using Pearson chi-square tests. To compare sex differences, additional analysis was conducted for 10 sex-comparable sports: men's and women's basketball, baseball and softball, cross-country and track and field, gymnastics, and swimming and diving. The characteristics of overuse and acute injuries were analyzed and compared by injury type, body region, and injury severity. *Injury rate* was calculated as the total number of overuse (or acute) injuries during the study period divided by the total number of AEs during the same period, multiplied by 10000. Generalized linear models were constructed to estimate the injury rate ratio with the generalized estimation equation method, using the overuse injury rate as a denominator. The binomial distribution with the log link function was used. A working exchangeable correlation structure was specified to account for correlations of the injuries sustained by the same athlete. Analyses were conducted using SAS (version 9.2; SAS Institute Inc, Cary, NC).[19] Statistical significance was set at $\alpha = .05$.

RESULTS

Numbers of Overuse and Acute Injuries

A total of 573 injured athletes reported 1317 injuries during the 3-year study period, with 288 athletes (50.3%) reporting more than 1 injury. A total of 319 male athletes sustained 705 injuries, and 254 female athletes sustained 612 injuries (Table 1). Of all included injuries, 386 (29.3%) were overuse injuries, whereas 931 (70.7%) were acute injuries. Women's rowing and men's cross-country and track and field athletes had the greatest number of overuse injuries, and football players and wrestlers reported the highest number of acute injuries. The number of reported overuse injuries was less than the number of acute injuries during the same time period across almost all subgroups. Although male athletes had a higher proportion of acute injuries (59.8% versus 40.2%, $P < .0001$), female athletes had a higher proportion of overuse injuries (61.7% versus 38.3%, $P < .0001$). However, when sex differences were compared across 10 sex-comparable sports, the difference became statistically insignificant, with 48.3% versus 51.7% for overuse injuries and 54.0% versus 46.0% for acute injuries in men and women, respectively ($P = .1840$).

Table 1. Overuse and Acute Injuries by Year, Sex, and Sport

Variable	Number of Injured Athletes[a]	Number of Injuries			*P* Value[b]
		Total	Overuse	Acute	
		N (%)	n (%)	n (%)	
All	573	1317	386 (29.3)	931 (70.7)	
Year					.5867
2005–2006	300	501 (38.0)	155 (40.2)	346 (37.2)	
2006–2007	254	434 (33.0)	124 (32.1)	310 (33.3)	
2007–2008	248	382 (29.0)	107 (27.7)	275 (29.5)	
Sex					<.0001
Male	319	705 (53.5)	148 (38.3)	557 (59.8)	
Female	254	612 (46.5)	238 (61.7)	374 (40.2)	
Sex (comparable sports[c])					.1840
Male	152	310 (52.0)	102 (48.3)	208 (54.0)	
Female	115	286 (48.0)	109 (51.7)	177 (46.0)	
Men's sports					<.0001
Baseball	42	55 (4.2)	17 (4.4)	38 (4.1)	
Basketball	23	64 (4.9)	8 (2.1)	56 (6.0)	
Cross-country and track and field	46	95 (7.2)	40 (10.4)	55 (5.9)	
Football	109	186 (14.1)	20 (5.2)	166 (17.8)	
Gymnastics	22	65 (4.9)	26 (6.7)	39 (4.2)	
Swimming and diving	19	31 (2.4)	11 (2.8)	20 (2.1)	
Wrestling	58	209 (15.9)	26 (6.7)	183 (19.7)	
Women's sports					
Basketball	16	59 (4.5)	14 (3.6)	45 (4.8)	
Cross-country and track and field	32	47 (3.6)	15 (3.9)	32 (3.4)	
Field hockey	23	105 (8.0)	35 (9.1)	70 (7.5)	
Gymnastics	21	65 (4.9)	22 (5.7)	43 (4.6)	
Rowing	64	98 (7.4)	56 (14.5)	42 (4.5)	
Soccer	35	74 (5.6)	15 (3.9)	59 (6.3)	
Softball	19	70 (5.3)	34 (8.8)	36 (3.9)	
Swimming and diving	27	45 (3.4)	24 (6.2)	21 (2.3)	
Volleyball	17	49 (3.7)	23 (6.0)	26 (2.8)	

[a] Athletes may be on the same team for more than 1 year.
[b] Based on χ^2 tests.
[c] Includes men's and women's basketball, cross-country and track and field, gymnastics, swimming and diving, and men's baseball and women's softball.

Rates of Overuse and Acute Injuries

A total of 208666 AEs (32256 game AEs and 176410 practice AEs) were accumulated for 16 teams during the 3 study years (Table 2). The overall injury rate was 63.1 per 10000 AEs. Further breakdown revealed that the rate for overuse injuries was 18.5 per 10000 AEs (95% CI=16.7, 20.4), and the rate for acute injuries was 44.6 per 10000 AEs (95% CI=41.8, 47.6). The rate ratio (RR) of acute versus overuse injury was 2.34 (95% CI=2.05, 2.67). Compared with male athletes, female athletes had a higher rate of overuse injuries, with 24.6 per 10000 AEs (95% CI=21.6, 27.9) versus 13.2 per 10000 AEs (95% CI=11.2, 15.5), respectively. However, the difference between sexes was less in 10 sex-comparable sports (16.8 per 10000 AEs [95% CI=13.8, 20.3] for women versus 14.9 per 10000 AEs [95% CI=12.1, 18.1] for men). The RR of acute versus overuse injury was higher among men (3.67 [95% CI=3.02, 4.46]) than women (1.53 [95% CI=1.28, 1.83]).

The highest overuse injury rates were observed in 4 women's teams: field hockey, soccer, softball, and volleyball (Table 2). Specifically, the overuse injury rate for women's field hockey was the highest, with 70.5 per 10000 AEs. The highest acute injury rate across sports was in women's soccer, with 190.0 per 10000 AEs, followed by wrestling and women's field hockey. Although the rate in football was 51.4 per 10000 AEs for acute injuries and 6.2 per 10000 AEs for overuse injuries, football had the highest injury RR for acute versus overuse injury (8.35 [95% CI=5.38, 12.97]), followed by men's basketball (7.04, 95% CI=3.02, 16.43) and wrestling (6.99, 95% CI=4.57, 10.68). The lowest RRs were found in women's rowing (0.75, 95% CI=0.51, 1.10) and women's swimming and diving (0.87, 95% CI=0.51, 1.51).

Type and Body Region of Overuse and Acute Injuries

The most common overuse injuries were general stress (n=103, 26.7%), followed by inflammation (n=80, 20.7%) and tendinitis (n=60, 15.5%) (Table 3). No difference was found between male and female athletes in types of overuse injuries in 10 sex-comparable sports. The most common acute injuries were sprains and strains, which constituted almost two-thirds of all acute injuries (n=584, 62.7%). Compared with female athletes, male athletes had a lower proportion of sprains and strains (60.1% versus 66.6%, $P=.0465$) and a higher proportion of open wounds (8.1% versus 3.5%, $P=.0044$).

Injuries to the lower extremities were most common (Table 4). Nearly half of the total documented injuries occurred to the

Table 2. Injury Rates and Rate Ratios of Acute Versus Overuse Injuries

Variable	AEs	Overuse Injuries		Acute Injuries		Injury Rate Ratio (95% CI)[a]
		Number	Rate per 10000 AEs (95% CI)	Number	Rate per 10000 AEs (95% CI)	
All	208666	386	18.5 (16.7, 20.4)	931	44.6 (41.8, 47.6)	2.34 (2.05, 2.67)
Year						
2005–2006	70574	155	22.0 (18.6, 25.7)	346	49.0 (44.0, 54.5)	2.22 (1.83, 2.71)
2006–2007	69553	124	17.8 (14.8, 21.3)	310	44.6 (39.8, 49.8)	2.39 (1.93, 2.97)
2007–2008	68539	107	15.6 (12.8, 18.9)	275	40.1 (35.5, 45.2)	2.46 (1.95, 3.10)
Sex						
Male	111814	148	13.2 (11.2, 15.5)	557	49.8 (45.8, 54.1)	3.67 (3.02, 4.46)
Female	96852	238	24.6 (21.6, 27.9)	374	38.6 (34.8, 42.7)	1.53 (1.28, 1.83)
Sex (comparable sports[b])						
Male	68525	102	14.9 (12.1, 18.1)	208	30.4 (26.4, 34.8)	2.01 (1.56, 2.58)
Female	64842	109	16.8 (13.8, 20.3)	177	27.3 (23.4, 31.6)	1.59 (1.23, 2.06)
Men's sports						
Baseball	7040	17	24.1 (14.1, 38.6)	38	54.0 (38.2, 74.1)	2.23 (1.31, 3.79)
Basketball	6768	8	11.8 (5.1, 23.1)	56	82.7 (62.5, 107.4)	7.04 (3.02, 16.43)
Cross-country and track and field	22770	40	17.6 (12.6, 23.9)	55	24.2 (18.2, 31.4)	1.37 (0.9, 2.08)
Football	32300	20	6.2 (3.8, 9.6)	166	51.4 (43.9, 59.8)	8.35 (5.38, 12.97)
Gymnastics	11472	26	22.7 (14.8, 33.2)	39	34.0 (24.2, 46.5)	1.50 (0.86, 2.6)
Swimming and diving	20475	11	5.4 (2.7, 9.6)	20	9.8 (6.0, 15.1)	1.81 (1.02, 3.23)
Wrestling	10989	26	23.7 (15.5, 34.7)	183	166.5 (143.3, 192.5)	6.99 (4.57, 10.68)
Women's sports						
Basketball	4950	14	28.3 (15.5, 47.3)	45	90.9 (66.4, 121.7)	3.19 (1.65, 6.15)
Cross-country and track and field	18150	15	8.3 (4.6, 13.6)	32	17.6 (12.1, 24.9)	2.13 (1.16, 3.93)
Field hockey	4965	35	70.5 (49.2, 98.1)	70	141.0 (110.0, 178.0)	2.02 (1.39, 2.92)
Gymnastics	10962	22	20.1 (12.6, 30.4)	43	39.2 (28.4, 52.9)	1.95 (1.07, 3.55)
Rowing	18540	56	30.2 (22.8, 39.2)	42	22.7 (16.3, 30.6)	0.75 (0.51, 1.10)
Soccer	3105	15	48.3 (27.1, 79.5)	59	190.0 (144.8, 244.9)	3.90 (1.91, 7.96)
Softball	6000	34	56.7 (39.3, 79.2)	36	60.0 (42.1, 83.1)	1.05 (0.72, 1.54)
Swimming and diving	24780	24	9.7 (6.2, 14.4)	21	8.5 (5.3, 12.9)	0.87 (0.51, 1.51)
Volleyball	5400	23	42.6 (27.0, 63.9)	26	48.1 (31.5, 70.5)	1.12 (0.63, 2.01)

Abbreviations: AEs, athlete-exposures; CI, confidence interval.

[a] Generalized linear models were constructed to estimate injury rate ratio accounting for the correlations of the injuries from the same athlete. The overuse injury rate is the reference group for the injury rate ratio.

[b] Includes men's and women's basketball, cross-country and track and field, gymnastics, and swimming and diving and men's baseball and women's softball.

lower extremity: 49.0% of overuse injuries and 49.7% of acute injuries. Overuse injuries also occurred frequently to the upper extremity and torso, whereas injuries to the head, face, and neck were more likely to be acute.

Severity of Overuse and Acute Injuries

The severity patterns for overuse injuries and acute injuries were quite different (Table 4). Half of the overuse injuries (50.8%) were associated with no time loss, compared with less than one-third (29.8%) of acute injuries. About 40% of acute injuries were minor or moderate, whereas only about 18% of overuse injuries fell into this category. Compared with female athletes, male athletes sustained more major injuries (34.0% versus 26.8%) and fewer no–time-loss injuries (27.2% versus 45.9%) ($P = .0021$). The sex discrepancy in injury severity was particularly large for overuse injuries, with the proportion of major injuries incurred by male athletes almost twice that of females (45.9% versus 23.1%, $P < .0001$) in 16 study sports and 10 sex-comparable sports (49.0% versus 29.4%, respectively, $P = .0002$).

The knee joint was the most severely injured body region for both acute and overuse injuries, accounting for 27.7% of all major injuries (n = 112, data not shown). For major acute injuries, fractures were among the most severe (44.8%), followed by sprains and strains (34.9%) and dislocations (31.0%). The majority of overuse injuries involved no time loss. However, 82.4% (n = 14) of stress fractures required the injured athlete to miss participation for more than 3 weeks.

DISCUSSION

Our study provides epidemiologic data on the numbers and rates of overuse and acute injuries sustained by collegiate athletes. Although the exposure and injury rates for 16 Division I collegiate sport teams were collected at a single university, differences between acute and overuse injuries varied by sex, sport, and severity. Male athletes had a higher acute injury rate than female athletes; however, the overuse injury rate was higher among female athletes. Football had the highest injury rate ratio of acute versus overuse injury, whereas women's rowing had the lowest. Half of all overuse injuries were associated

Table 3. Overuse and Acute Injuries by Injury Type and Sex

	Total	Men	Women	
Injury	N (%)	n (%)	n (%)	*P* Value[a]
Overuse	386 (100.0)	148 (38.3)	238 (61.7)	.1754
General stress	103 (26.7)	36 (24.3)	67 (28.2)	.4085
Inflammation	80 (20.7)	26 (17.6)	54 (22.7)	.2274
Tendinitis	60 (15.5)	25 (16.9)	35 (14.7)	.5644
Deformity or weakness	52 (13.5)	16 (10.8)	36 (15.1)	.2273
Loose bodies or debris	20 (5.2)	11 (7.4)	9 (3.8)	.1156
Impingement	19 (4.9)	8 (5.4)	11 (4.6)	.7293
Bursitis	19 (4.9)	9 (6.1)	10 (4.2)	.4066
Stress fracture	17 (4.4)	6 (4.1)	11 (4.6)	.7915
Joint laxity[b]	12 (3.1)	8 (5.4)	4 (1.7)	.0659
Other[b]	4 (1.0)	3 (2.0)	1 (0.4)	.1296
Acute	931 (100.0)	557 (59.8)	374 (40.2)	.0015
Sprain or strain	584 (62.7)	335 (60.1)	249 (66.6)	.0465
Superficial or contusion	94 (10.1)	56 (10.1)	38 (10.2)	.9578
Internal organ	77 (8.3)	59 (10.6)	18 (4.8)	.0017
Fracture	67 (7.2)	36 (6.5)	31 (8.3)	.2907
Open wound	58 (6.2)	45 (8.1)	13 (3.5)	.0044
Dislocation	29 (3.1)	18 (3.2)	11 (2.9)	.8025
Unspecified	17 (1.8)	6 (1.1)	11 (2.9)	.0373
Nerve	4 (0.4)	2 (0.4)	2 (0.5)	.6878
Blood vessel[b]	1 (0.1)	0 (0)	1 (0.3)	.4017

[a] Based on Pearson χ^2 tests.
[b] Two-sided Fisher exact test used.

Table 4. Overuse and Acute Injuries by Sex, Injured Body Region, and Severity[a]

	Time Lost to Overuse Injuries					Time Lost to Acute Injuries				
Variable	Total	No Time Lost	Minor	Moderate	Major	Total	No Time Lost	Minor	Moderate	Major
	N (%)	n (%)	n (%)	n (%)	n (%)	N (%)	n (%)	n (%)	n (%)	n (%)
Total	386 (100.0)	196 (50.8)	41 (10.6)	26 (6.7)	123 (31.9)	931 (100.0)	277 (29.8)	235 (25.2)	138 (14.8)	281 (30.2)
Sex[b]										
Male	148 (38.3)	49 (33.1)	17 (11.5)	14 (9.5)	68 (45.9)	557 (59.8)	143 (25.7)	140 (25.1)	102 (18.3)	172 (30.9)
Female	238 (61.7)	147 (61.8)	24 (10.1)	12 (5.0)	55 (23.1)	374 (40.2)	134 (35.8)	95 (25.4)	36 (9.6)	109 (29.1)
Sex (comparable sports[c])										
Male	102 (48.3)	30 (29.4)	10 (9.8)	12 (11.8)	50 (49)	208 (54)	54 (26)	51 (24.5)	28 (13.5)	75 (36.1)
Female	109 (51.7)	57 (52.3)	17 (15.6)	3 (2.8)	32 (29.4)	177 (46)	53 (29.9)	49 (27.7)	18 (10.2)	57 (32.2)
Injured body region										
Head, face, neck	14 (3.6)	8 (57.1)	4 (28.6)	1 (7.1)	1 (7.1)	197 (21.2)	92 (46.7)	65 (33.0)	18 (9.1)	22 (11.2)
Torso	75 (19.4)	46 (61.3)	5 (6.7)	6 (8.0)	18 (24.0)	83 (8.9)	33 (39.8)	12 (14.5)	14 (16.9)	24 (28.9)
Upper extremity	108 (28.0)	62 (57.4)	7 (6.5)	7 (6.5)	32 (29.6)	187 (20.1)	57 (30.5)	43 (23.0)	27 (14.4)	60 (32.1)
Shoulder, upper arm	68 (17.6)	37 (54.4)	5 (7.4)	4 (5.9)	22 (32.4)	73 (7.8)	18 (24.7)	16 (21.9)	12 (16.4)	27 (37.0)
Forearm, elbow	15 (3.9)	8 (53.3)	0 (0)	1 (6.7)	6 (40.0)	43 (4.6)	8 (18.6)	12 (27.9)	6 (14.0)	17 (39.5)
Hand, wrist, fingers	25 (6.5)	17 (68.0)	2 (8.0)	2 (8.0)	4 (16.0)	71 (7.6)	31 (43.7)	15 (21.1)	9 (12.7)	16 (22.5)
Lower extremity	189 (49.0)	80 (42.3)	25 (13.2)	12 (6.3)	72 (38.1)	463 (49.7)	95 (20.5)	115 (24.8)	79 (17.1)	174 (37.6)
Hip	10 (2.6)	6 (60.0)	1 (10.0)	1 (10.0)	2 (20.0)	48 (5.2)	18 (37.5)	12 (25.0)	8 (16.7)	10 (20.8)
Upper leg, thigh	7 (1.8)	5 (71.4)	1 (14.3)	0 (0)	1 (14.3)	74 (7.9)	11 (14.9)	21 (28.4)	16 (21.6)	26 (35.1)
Knee	83 (21.5)	30 (36.1)	10 (12.0)	8 (9.6)	35 (42.2)	139 (14.9)	20 (14.4)	21 (15.1)	21 (15.1)	77 (55.4)
Lower leg, ankle	65 (16.8)	32 (49.2)	9 (13.8)	2 (3.1)	22 (33.8)	156 (16.8)	36 (23.1)	47 (30.1)	28 (17.9)	45 (28.8)
Foot, toe	24 (6.2)	7 (29.2)	4 (16.7)	1 (4.2)	12 (50.0)	46 (4.9)	10 (21.7)	14 (30.4)	6 (13.0)	16 (34.8)
Other, unspecified	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.1)	0 (0)	0 (0)	0 (0)	1 (100)

[a] Injury severity was defined as *no time lost* if an athlete lost no time, *minor* if <1 wk lost, *moderate* if 1–3 wk lost, or *major* if >3 wk lost.
[b] Based on Pearson χ^2 tests: sex difference in all injuries ($P < .0001$), overuse injuries ($P < .0001$), and acute injuries ($P = .0002$).
[c] Consists of men's and women's basketball, cross-country and track and field, gymnastics, and swimming and diving and men's baseball and women's softball. *P* values based on Pearson χ^2 tests: sex difference in all injuries ($P = .0021$), overuse injuries ($P = .0002$), and acute injuries ($P = .5327$).

with no time loss, and the proportion of no–time-loss injuries for female athletes was almost twice that of male athletes. These findings have implications for future research and for interventions in the area of overuse injury prevention.

Previous researchers have suggested that high-contact sports are commonly associated with a higher incidence of acute injuries,[5,7,17,20] and low-contact sports typically lead to more chronic, overuse injuries.[4,7,9,10,21] In concordance, we found that contact sports such as wrestling and women's soccer were associated with a higher acute injury risk; overuse injuries were associated with low-contact sports such as women's rowing, softball, and volleyball and men's and women's cross-country and track and field. However, we found that 4 women's teams (ie, field hockey, soccer, softball, and volleyball) had the highest rates of overuse injury rates among the 16 sports. Football ranked second highest among the 16 sport teams in total number of injuries and had the highest injury RR for acute versus overuse injury. Yet the high frequency of injuries in football does not automatically translate to the highest injury rate. When we factored in the number of AEs for games and practices, the rate of acute injury in football was no longer the highest, and the rate of overuse injury was among the lowest. Our findings that football injury rates were lower than those of other sports are inconsistent with the prior literature.[5,6] This discrepancy may be due to the large number of athletes on the football team, resulting in a larger number of AEs in the denominator when calculating the injury rate. Therefore, caution is necessary when interpreting our finding on football injury rates. Our findings, along with those of others, suggest the importance of accounting for the number of AEs when quantifying the risk of injury.[22,23] We noted that female athletes had a higher incidence of overuse injuries compared with male athletes, although the difference was less when the results were compared between men and women in comparable sports. Previous researchers[9,15] have found that female athletes sustained more overuse injuries than did male athletes. For example, female rowers reported a significantly greater number of chest overuse injuries (ie, rib stress fractures) than did male rowers,[9] and female military recruits reported more stress fractures than did male military recruits during basic training.[15] The exact reasons for the higher rate of overuse injuries in female athletes in our study are unknown. A possible partial explanation may be the structural and biomechanical differences between male and female athletes, which may increase the likelihood of an overuse injury in female athletes in comparison with their male counterparts.[13,24] More investigation is warranted to determine why female athletes may be at a greater risk for overuse injuries than are male athletes. Further study is also needed on preseason screening procedures for identifying collegiate athletes who may be at greater risk of overuse injuries.[13]

We found that more than one-quarter of all injuries were overuse injuries. Similar findings were reported by Junge et al,[25] who observed that 22% of all reported injuries during the 2008 Summer Olympic Games were overuse injuries. We also noted that the time-loss patterns for overuse and acute injuries were quite different, with more overuse injuries involving no time loss. This probably indicates that athletes are returning to play before being fully recovered or playing through overuse injuries. Youth athletes may be particularly vulnerable to repetitive biomechanical stress because of immature musculoskeletal systems.[12] With an increasing number of young people becoming involved in competitive sports and more athletes being exposed to high-intensity training from an earlier age, it is important to educate athletes, coaches, parents, pediatricians, and sport governing bodies about overuse injury risks and potential prevention strategies, including increasing activity gradually, minimizing training error, and allowing adequate time for recovery within training programs.[11]

Although overuse injuries are well known among collegiate athletes and other sports participants, few published studies on overuse injuries are available. Clearly defining and quantifying overuse injuries present researchers with several challenges. Overuse injuries are not often the result of a single macrotraumatic event; instead, they develop through repetitive microtrauma.[12] Athletes may be asymptomatic or may not report their signs and symptoms when they first experience them. The participation status of an athlete with an overuse injury can also vary on a day-to-day basis, making time-loss calculations difficult.[9,15] As a result, time loss due to overuse injuries may not be accurately reported. It is also sometimes hard for athletic trainers and other medical professionals to diagnose overuse injuries because of their inconsistent injury patterns. These injuries have a gradual onset with no specific mechanism, and symptoms can vary based on the frequency and intensity of activity.[9,15] Last, even though athletes with acute, traumatic injuries often have detailed rehabilitation protocols to follow and are monitored during recovery, athletes with overuse injuries often modify their workout routines depending on the level of pain they are experiencing.[15] As a result, acute and overuse injuries present athletes and sports medicine professionals with very different rehabilitation scenarios.[12,21] It is imperative to provide an accurate and comprehensive diagnosis for an overuse injury and to treat each symptomatic athlete on a case-by-case basis. This may include tailored treatment plans, workout modifications, preventive exercises, strength and conditioning protocols, and evaluation for underlying maladaptations that might precipitate reinjury.

Our study had several limitations. First, it is possible that athletes who suffered from overuse injuries did not report their symptoms to an athletic trainer or other health care professional or attempted to self-treat until their symptoms became too debilitating. Therefore, the number of overuse injuries reported in this study might be underestimated. Second, data on injured athletes' functional and performance limitations were lacking. Using the duration of time loss to measure severity of overuse injuries is potentially problematic because a large number of overuse injuries involved no time loss. To better measure overuse injury severity, more data may be collected on injured athletes, including the level of medical attention received, functional and performance limitations, and cost of treatment. Furthermore, use of *general stress* as a category of overuse injury in the existing data set limited our ability to clearly define a specific type of overuse injury. Finally, this study was limited to a single NCAA Big Ten institution. A national sample is needed to determine the true incidence and prevalence of overuse injuries.

CONCLUSIONS

Despite the limitations, this study revealed that more than one-quarter of all injuries sustained by collegiate athletes were overuse injuries, with female athletes having a higher rate of overuse injuries than did male athletes. Our results warrant more research on overuse injuries and associated risk factors, in particular, developing better measures to properly define and quantify overuse injuries. Future researchers also should

investigate why female athletes are at greater risk for overuse injuries. Strategies for prevention of and early intervention with overuse injuries are needed to reduce the number and severity of overuse injuries.

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