

# Descriptive Epidemiology of Collegiate Women's Volleyball Injuries: National Collegiate Athletic Association Injury Surveillance System, 1988–1989 Through 2003–2004

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**Objective:** To review 16 years of NCAA injury surveillance data for women's volleyball and to identify potential areas for injury prevention initiatives.

**Background:** Participation in NCAA women's volleyball has increased greatly over the past 16 years. As with all sports, women participating in volleyball assume an inherent risk of injury each time they practice or participate in a game. In order for clinicians to better understand the risks associated with volleyball, it is critical to gather data that illustrates injury rates and patterns among volleyball athletes. Furthermore, with knowledge of injury mechanisms and risk factors comes the ability to initiate prevention strategies to minimize future injury.

**Main Results:** Over the past 16 years, the rate of injury in a game situation was slightly higher than in practice (4.58 versus 4.10 game injuries per 1000 athlete-exposures, rate ratio = 1.1, 95% confidence interval = -1.0, 1.2,  $P < .01$ ). A total of 2216

injuries from more than 50 000 games and 4725 injuries from more than 90 000 practices were reported. The lower extremity accounted for more than 55% of all game and practice injuries, with ankle ligament sprains representing 44.1% of game injuries and 29.4% of practice injuries. Approximately 20% of all game injuries involved the upper extremity. The majority of injuries during a game situation occurred while athletes were in one of the front 3 positions. A player landing on another player and contact with the floor each accounted for 21% of game injuries.

**Recommendations:** Ankle injuries appear to be the most common injuries in women's volleyball. Future preventive efforts should focus on preventing first-time ankle sprains and acute traumatic knee injuries, as well as reducing the risk of ankle sprain recurrence.

**Key Words:** athletic injuries, injury prevention, lower extremity injuries, ankle injuries, knee injuries

The NCAA conducted its first women's volleyball championship in 1981. In the 1988–1989 academic year, 721 schools were sponsoring varsity women's volleyball teams, with 9486 participants. By 2003–2004, the number of varsity teams had increased 36% to 982, involving 13 310 participants.<sup>1</sup> Participation growth during this time has been apparent in all 3 divisions but particularly in Divisions II and III.

## SAMPLING AND METHODS

Over the 16-year period from 1988–1989 through 2003–2004, an average of 12.5% of schools sponsoring varsity women's volleyball programs participated in the annual Injury Surveillance System (ISS) data collection (Table 1). The sampling process data collection methods, injury and exposure definitions, inclusion criteria, and data analysis method are described in detail in the "Introduction and Methods" article in this special issue.<sup>2</sup>

## RESULTS

### Game and Practice Athlete-Exposures

The average annual number of games and practices and average number of participating athletes for each division con-

densed over the years are shown in Table 2. Division I annually averaged 8 practices more than Division II and 22 more than Division III. Divisions I and II annually played 1 more game than Division III. Average game and practice participants were similar in all divisions.

### Injury Rate by Activity, Division, and Season

Game and practice injury rates over years combined across divisions, with 95% confidence intervals (CIs), are shown in Figure 1. Over the 16 years, the risk of injury in a game situation was slightly higher than in practice (4.58 versus 4.10 injuries per 1000 athlete-exposures [A-Es], rate ratio = 1.1, 95% CI = 1.0, 1.2,  $P < .01$ ). Nonsignificant average annual decreases in game (-1.1%,  $P = .23$ ) and practice (-0.8%,  $P = .53$ ) injury rates occurred over the sample period.

The total number of games and practices and associated injury rates condensed over years by division and season (preseason, in season, and postseason) are displayed in Table 3. Over the 16-year period, 2216 injuries from more than 50 000 games and 4725 injuries from more than 90 000 practices were reported. Game and practice injury rates did not differ significantly among divisions. Combining divisions, preseason practice injury rates were more than twice as high as in the regular season (6.19 versus 2.82 injuries per 1000 A-Es, rate ratio =

**Table 1. School Participation Frequency (in Total Numbers) by Year and National Collegiate Athletic Association (NCAA) Division, Women's Volleyball, 1988–1989 Through 2003–2004\***

Academic Year	Division I Schools		Division II Schools		Division III Schools		All Divisions		
	Participating	Sponsoring	Participating	Sponsoring	Participating	Sponsoring	Participating	Sponsoring	Percentage
1988–1989	20	266	11	180	23	273	54	721	7.5
1989–1990	39	266	26	183	38	273	103	722	14.3
1990–1991	33	270	23	193	35	278	91	742	12.3
1991–1992	49	273	33	201	39	288	121	763	15.9
1992–1993	41	274	31	207	31	303	103	784	13.1
1993–1994	36	279	29	227	33	304	98	810	12.1
1994–1995	38	282	37	228	44	318	119	830	14.3
1995–1996	43	287	29	256	40	360	112	904	12.4
1996–1997	46	292	38	258	49	365	133	915	14.5
1997–1998	36	293	17	256	30	366	83	915	9.1
1998–1999	27	299	24	270	37	391	88	960	9.2
1999–2000	47	307	32	267	45	393	124	967	12.8
2000–2001	38	308	28	271	28	396	94	975	9.6
2001–2002	42	312	44	266	55	396	141	974	14.5
2002–2003	56	312	38	259	61	402	155	973	15.9
2003–2004	39	312	36	260	52	406	127	982	12.9
Average	39	290	30	236	40	345	109	871	12.5

\*"Participating" refers to schools that provided appropriate data to the NCAA Injury Surveillance System; "Sponsoring" refers to the total number of schools offering the sport within the NCAA divisions.

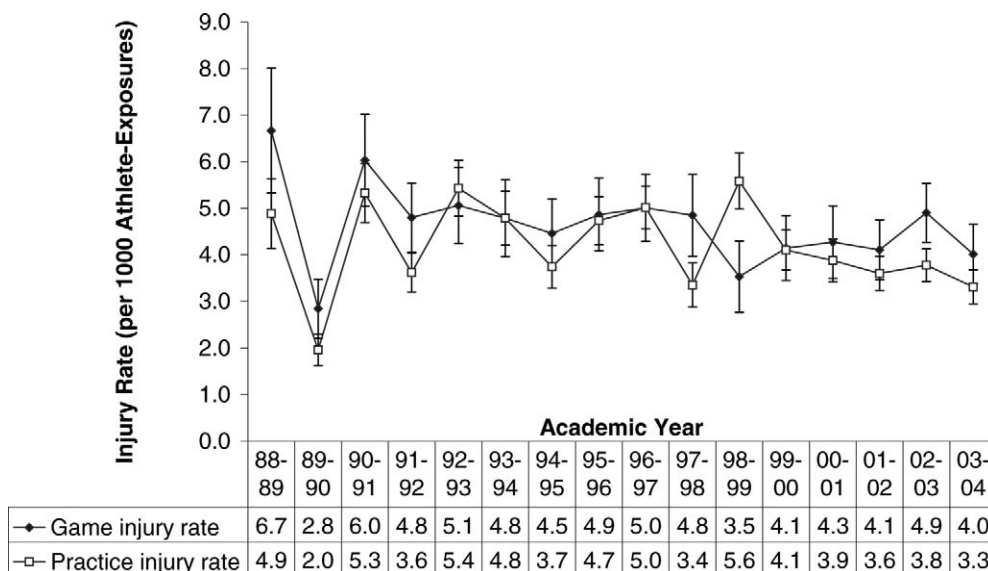
**Table 2. Average Annual Games, Practices, and Athletes Participating by National Collegiate Athletic Association Division per School, Women's Volleyball, 1988–1989 Through 2003–2004**

Division	Games	Athletes per Game	Practices	Athletes per Practice
I	31	10	66	12
II	31	10	58	12
III	30	9	44	13

2.2, 95% CI = 2.1, 2.3,  $P < .01$ ), whereas regular-season game injury rates were significantly higher than in the post-season (4.52 versus 2.67 injuries per 1000 A-Es, rate ratio = 1.7, 95% CI = 1.3, 2.2,  $P < .01$ ).

**Body Areas Injured Most Often and Specific Injuries**

The frequency of injury to 5 general body areas (head/neck, upper extremity, trunk/back, lower extremity, and other/system) for games and practices with years and divisions combined is shown in Table 4. More than 55% of all game and



**Figure 1. Injury rates and 95% confidence intervals per 1000 athlete-exposures by games, practices, and academic year, women's volleyball, 1988–1989 through 2003–2004 (n = 2216 game and 4725 practice injuries). Game average annual change = -1.1%; time trend,  $P = .23$ ; 95% confidence interval = -2.8, 0.7. Practice average annual change = -0.80%; time trend,  $P = .53$ ; 95% confidence interval = -3.1, 1.7.**

**Table 3. Games and Practices With Associated Injury Rates by National Collegiate Athletic Association Division and Season, Women's Volleyball, 1988–1989 Through 2003–2004\***

	Total Number of Games Reported	Game Injury Rate per 1000 Athlete-Exposures	95% Confidence Interval	Total Number of Practices Reported	Practice Injury Rate per 1000 Athlete-Exposures	95% Confidence Interval
<b>Division I</b>						
Preseason	837	4.23	2.83, 5.63	13845	6.30	5.93, 6.68
In season	17214	5.30	4.94, 5.65	24413	3.09	2.89, 3.29
Postseason	787	2.45	1.32, 3.58	1501	1.50	0.93, 2.06
Total Division I	18843	5.35	5.01, 5.69	39759	4.33	4.14, 4.52
<b>Division II</b>						
Preseason	707	3.27	1.94, 4.61	8876	6.47	6.00, 6.94
In season	13125	4.13	3.77, 4.48	14252	2.65	2.41, 2.89
Postseason	470	3.20	1.52, 4.87	939	0.87	0.33, 1.40
Total Division II	14307	4.25	3.90, 4.59	24074	4.19	3.96, 4.42
<b>Division III</b>						
Preseason	885	2.28	1.26, 3.31	8666	5.79	5.36, 6.21
In season	15784	4.00	3.68, 4.32	17608	2.60	2.39, 2.80
Postseason	796	2.57	1.42, 3.73	1189	1.00	0.49, 1.51
Total Division III	17476	4.01	3.70, 4.31	27463	3.70	3.50, 3.89
<b>All Divisions</b>						
Preseason	2429	3.26	2.53, 3.99	31387	6.19	5.95, 6.43
In season	46123	4.52	4.32, 4.72	56273	2.82	2.69, 2.94
Postseason	2053	2.67	1.94, 3.40	3629	1.17	0.85, 1.48
Total	50626	4.58	4.39, 4.77	91296	4.10	3.98, 4.21

\*Wald  $\chi^2$  statistics from negative binomial model: game injury rates did not differ among divisions ( $P = .28$ ) but did differ within season ( $P < .01$ ); practice injury rates did not differ among divisions ( $P = .08$ ) but did differ within season ( $P < .01$ ). Postseason sample sizes were much smaller and had higher variability than preseason and in season sample sizes because only a small percentage of schools participated in the postseason tournaments in any sport, and not all of those were a part of the Injury Surveillance System (ISS) database. Numbers do not always sum to totals because of missing division or season information.

**Table 4. Percentage of Game and Practice Injuries by Major Body Part, Women's Volleyball, 1988–1989 Through 2003–2004**

Body Part	Games	Practices
Head/neck	6.7	3.1
Upper extremity	21.4	18.7
Trunk/back	10.8	17.4
Lower extremity	58.7	55.9
Other/system	2.4	4.9

practice injuries were to the lower extremity. Approximately 20% of all game and practice injuries involved the upper extremity.

The most common body part and injury type combinations for games and practices with years and divisions combined are shown in Table 5. All injuries that accounted for at least 1% of reported injuries over the 16-year sampling period were included. In games, ankle ligament sprains (44.1%), knee internal derangements (14.1%), shoulder muscle strains (5.2%), and low back muscle strains (4.8%) accounted for the majority of injuries. In practices, ankle ligament sprains accounted for 29.4% of all reported injuries, whereas other common injuries were upper leg muscle-tendon strains (12.3%), low back muscle-tendon strains (7.9%), and knee internal derangements (7.8%). A participant had twice the risk of sustaining a knee internal derangement in a game (0.46 versus 0.22 per 1000 A-Es, rate ratio = 2.1, 95% CI = 1.8, 2.5) than in a practice. Furthermore, female volleyball players also had almost twice the risk of sustaining an ankle sprain in a game compared with a practice (1.44 versus 0.83 per 1000 A-Es, rate ratio = 1.7,

95% CI = 1.6, 1.9). Of interest, over the 16 years of this study, the rate of ankle sprains has decreased on average per year by 1.8% ( $P = .15$ ) in games and 3.0% ( $P = .04$ ) in practices. The specific structures injured among the knee internal derangement injuries during games and practices combined are identified in Figure 2; menisci and collateral ligament injuries had the highest proportion.

### Mechanism of Injury

The 3 primary injury mechanisms—player contact, other contact (eg, balls, standards, floor), and no contact—in games and practices with division and years combined are displayed in Figure 3. Game injuries were distributed relatively equally across the 3 categories. Most practice injuries (more than 50%) did not involve direct external contact to the injured body part.

### Severe Injuries: 10+ Days of Activity Time Loss

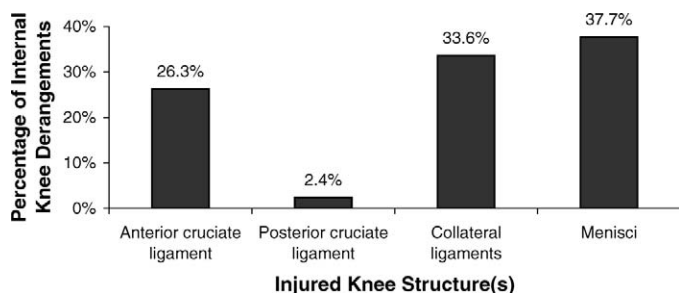
The most common injuries that resulted in at least 10 consecutive days of restricted or total loss of participation and their primary injury mechanisms combined across divisions and years are demonstrated in Table 6. Time loss of 10+ days was, for this analysis, considered a measure of severe injury. Approximately 23% of game injuries and 19% of practice injuries restricted participation for at least 10 days. Although the number of combined game and practice injuries resulting in 10+ days of activity time loss has increased over the 16-year period from 55 in 1989–1990 to 132 in 2003–2004, the overall rates have remained relatively stable (Figure 4). In both games and practices, ankle (games = 29.1%, practices = 18.4%) and

**Table 5. Most Common Game and Practice Injuries Resulting in 10+ Days of Activity Time Loss, Women's Volleyball, 1988–1989 Through 2003–2004\***

Body Part	Injury Type	Frequency	Percentage of Injuries	Injury Rate per 1000 Athlete-Exposures	95% Confidence Interval
<b>Games</b>					
Ankle	Ligament sprain	696	44.1	1.44	1.33, 1.54
Knee	Internal derangement	222	14.1	0.46	0.40, 0.52
Shoulder	Muscle-tendon strain	82	5.2	0.17	0.13, 0.21
Lower back	Muscle-tendon strain	76	4.8	0.16	0.12, 0.19
Head	Concussion	75	4.7	0.15	0.12, 0.19
Patella	Patella or patella tendon injury	49	3.1	0.10	0.07, 0.13
Unspecified†	Unspecified	44	2.8	0.09	0.06, 0.12
Thumb	Ligament sprain	41	2.6	0.08	0.06, 0.11
Pelvis, hip	Muscle-tendon strain	39	2.5	0.08	0.06, 0.11
Shoulder	Subluxation	38	2.4	0.08	0.05, 0.10
Shoulder	Tendinitis	36	2.3	0.07	0.05, 0.10
Foot	Ligament sprain	35	2.2	0.07	0.05, 0.10
Upper leg	Muscle-tendon strain	33	2.1	0.07	0.04, 0.09
Finger(s)	Fracture	27	1.7	0.06	0.03, 0.08
Finger(s)	Ligament sprain	23	1.5	0.05	0.03, 0.07
Knee	Muscle-tendon strain	22	1.4	0.05	0.03, 0.06
Abdomen	Muscle-tendon strain	21	1.3	0.04	0.02, 0.06
Wrist	Ligament sprain	21	1.3	0.04	0.02, 0.06
<b>Practices</b>					
Ankle	Ligament sprain	955	29.4	0.83	0.78, 0.88
Upper leg	Muscle-tendon strain	401	12.3	0.35	0.31, 0.38
Lower back	Muscle-tendon strain	258	7.9	0.22	0.20, 0.25
Knee	Internal derangement	252	7.8	0.22	0.19, 0.25
Shoulder	Muscle-tendon strain	181	5.6	0.16	0.13, 0.18
Patella	Patella or patella tendon injury	174	5.4	0.15	0.13, 0.17
Unspecified†	Unspecified	173	5.3	0.15	0.13, 0.17
Pelvis, hip	Muscle-tendon strain	164	5.0	0.14	0.12, 0.16
Shoulder	Tendinitis	154	4.7	0.13	0.11, 0.15
Abdomen	Muscle-tendon strain	96	3.0	0.08	0.07, 0.10
Thumb	Ligament sprain	75	2.3	0.07	0.05, 0.08
Heel/Achilles tendon	Tendinitis	69	2.1	0.06	0.05, 0.07
Lower leg	Stress fracture	68	2.1	0.06	0.04, 0.07
Head	Concussion	66	2.0	0.06	0.04, 0.07
Lower back	Ligament sprain	60	1.8	0.05	0.04, 0.07
Lower leg	Muscle-tendon strain	54	1.7	0.05	0.03, 0.06
Shoulder	Subluxation	48	1.5	0.04	0.03, 0.05

\*Only injuries that accounted for at least 1% of all injuries are included.

†“Unspecified” indicates injuries that could not be grouped into existing categories but that were believed to constitute reportable injuries.



**Figure 2. Game and practice internal knee derangements by injured structure, women's volleyball, 1988–1989 through 2003–2004 (n = 486).**

knee problems (games = 25.7%, practices = 14.6%) accounted for most of these severe injuries. Severe ankle injuries were associated primarily with player contact, whereas severe knee injuries primarily involved noncontact mechanisms. Stress

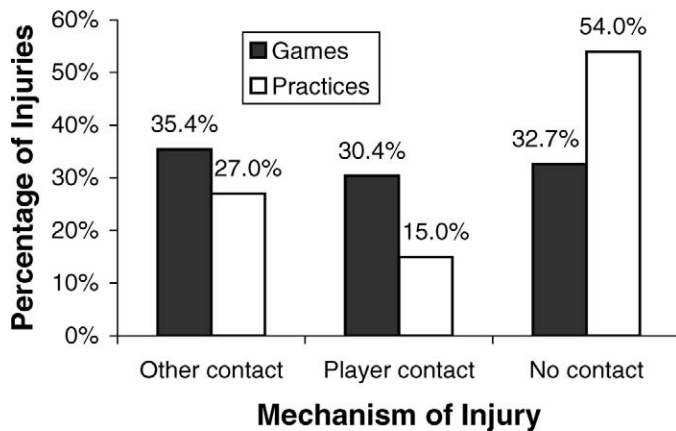
fractures associated with the foot and lower leg accounted for 7% of severe practice injuries (data not shown).

### Game Injuries

Game injury mechanisms are shown in more detail in Figure 5 for the 2216 game injuries recorded. No apparent contact accounted for 25.8% of injury mechanisms in games, whereas 21.1% involved a player landing on another player and 20.6% were the result of contact with the floor. Injuries associated with contact with the net standard or out-of-bounds objects were minimal (1.9%). The game position played at the time of injury is shown in Figure 6. Most injuries (67.3%) occurred to athletes in the front 3 positions (left front, right front, center front).

### COMMENTARY

These data suggest that injury rates in women's collegiate volleyball have remained relatively stable over the 16 years



**Figure 3. Game and practice injury mechanisms, all injuries, women's volleyball, 1988–1989 through 2003–2004 (n = 2216 game injuries and 4725 practice injuries). "Other contact" refers to contact with items such as balls, standards, or the floor. Injury mechanism was unavailable for 1% of game injuries and 4% of practice injuries.**

covered in this analysis. Not surprisingly, more than half of all injuries affected the lower extremity, with most affecting the ankle and knee. During practices, ankle ligament sprains, knee internal derangement, and upper leg muscle strains were the most common injuries, whereas in games, ankle ligament sprains, knee internal derangement, and muscle strains of the shoulder and low back were most frequent. Women had almost twice the rate of ankle ligament sprains in games than in practices and just over twice the rate of sustaining knee injuries in

games versus practices. The frequencies of 3 types of injury mechanisms (player contact, other contact, and no contact) were relatively similar during games; however, more than half of the practice injuries did not involve direct external contact to the injured body part. More than two thirds of injuries occurring in a game situation were sustained by athletes playing a front-line position.

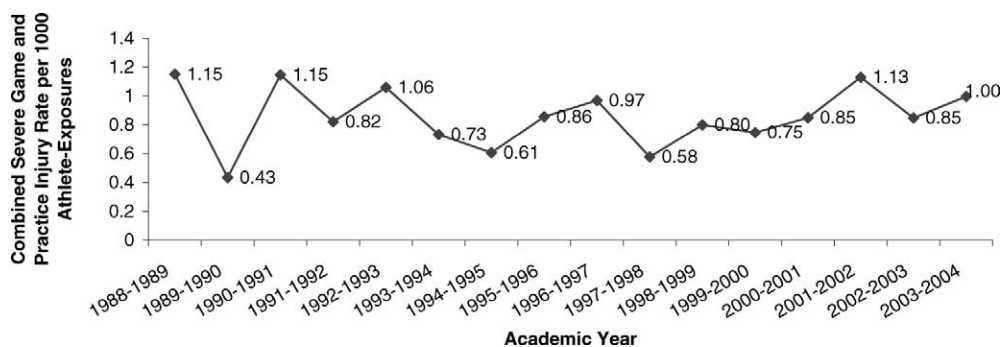
For the most part, the reported results are in agreement with those of previous investigators<sup>3–6</sup> examining the epidemiology of volleyball injuries, showing similar trends in the types, rates, and mechanisms of injury. However, a notable exception is that the frequency of patellar injuries was lower than previously reported.<sup>7</sup>

Ankle ligament sprains are extremely common in volleyball, most often occurring when a player lands from an attack or a block and comes in contact with another player's foot. This injury mechanism is consistent with the player-to-player contact injury mechanism reported. Although ankle sprains often are considered mild in comparison with other injuries (eg, knee ligament tears), the data presented here suggest that ankle sprains are a significant problem for volleyball players in terms of both frequency and severity, accounting for approximately 23% of all injuries resulting in 10+ days away from activity. Thus, many of the ankle ligament sprains sustained may have been grade II or grade III.

Knee injuries accounted for 14% of women's collegiate volleyball game injuries and, according to the current data, they typically occur via a noncontact injury mechanism. This result agrees with previous findings indicating that knee ligament and meniscal injuries often did not involve direct external contact to the injured body part (eg, landing from a jump on a

**Table 6. Most Common Game and Practice Injuries Resulting in 10+ Days of Activity Time Loss, Women's Volleyball, 1988–1989 Through 2003–2004**

Body Part	Injury Type	Frequency	Percentage of Severe Injuries	Most Common Injury Mechanism
Games (23.0% of all injuries required 10+ days of time loss)				
Ankle	Ligament sprain	148	29.1	Player contact
Knee	Internal derangement	131	25.7	No contact
Other		230	45.2	
Total		509		
Practice (19.0% of all injuries required 10+ days of time loss)				
Ankle	Ligament sprain	165	18.4	Player contact
Knee	Internal derangement	131	14.6	No contact
Other		601	67.0	
Total		897		



**Figure 4. Game and practice injury rates for injuries resulting in 10+ days of activity time loss, women's volleyball, 1988–1989 through 2003–2004 (n = 1406).**



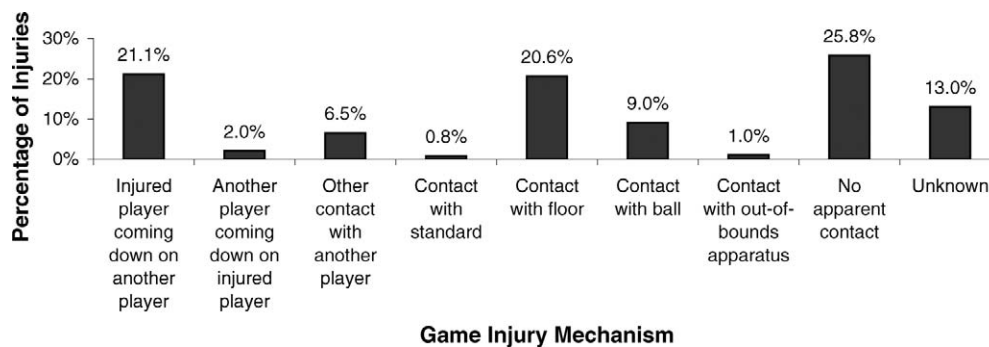


Figure 5. Sport-specific game injury mechanisms, women's volleyball, 1988–1989 through 2003–2004 (n = 2216).

single leg, which occurs often when landing after spiking a ball).<sup>8,9</sup> Although these injury types were relatively frequent, only 55% of the internal knee injuries resulted in 10 or more days lost from sport and are likely to represent chronic or overuse injuries. This number seems rather low if the women had suffered collateral ligament tears, anterior cruciate ligament ruptures, or meniscal tears. Further research on the types and severity of knee injuries incurred by volleyball athletes is needed to be able to design potential prevention interventions.

The data illustrate that the risk of sustaining a lower extremity injury, in particular to the ankle or knee, is much higher in a game than in a practice. A previous group<sup>10</sup> has shown this to be true in men's volleyball players, but this is the first time results of this nature have been reported in women's volleyball players. In general, the literature suggests that injury incidence in volleyball is greater during games than in practices.<sup>11</sup> We believe this finding indicates that US female collegiate volleyball athletes may be more aggressive during games or subjected to more situations (eg, player-to-player contact) that may increase the injury risk.

As would be expected, the majority of injuries sustained in games occurred when the female athletes were playing a front-line position, which is where jumping and landing occur most often. Findings of previous authors<sup>4,6</sup> suggested that about 63% of the musculoskeletal injuries in volleyball result from jumping or landing movements. Most of these injuries occurred to the lower extremity, primarily the ankle. Ankle sprains occurred most often at the net due to contact between the attacker and the opposing team's blocker.<sup>4,6</sup> Approximately half of these sprains occurred when a blocker landed on the foot of an opposing attacker who had crossed the center line,<sup>12</sup> and another fourth of ankle sprains in indoor volleyball occurred when a blocker landed on a teammate's foot during a multi-person block. Thus, middle and outside hitters and blockers are at greatest risk for sustaining an ankle sprain and should be targeted aggressively for ankle ligament sprain prevention interventions.

Several injury-prevention strategies have been suggested to reduce the risk of ankle sprains in volleyball: (1) modifying the center line rule, (2) improving spike and landing techniques, (3) participating in proprioceptive training, and (4) requiring the use of external ankle supports.<sup>13</sup> Because most ankle sprains occur at the net as the result of players crossing the center line, Bahr et al<sup>14</sup> proposed a rule change that would prevent players from contacting the center line. The rule change was tested in a single tournament and was found to greatly increase center line violations, which interrupted the flow of play, and, thus, this rule change was not recommended or further studied. A more liberal center line rule was intro-

duced in 1998 for all NCAA divisions, permitting complete penetration of the center line (as long as such penetration does not interfere with the opponent's play on the opposite court); the incidence of ankle sprains in women's collegiate volleyball has not changed significantly over the last several years, suggesting that changing the center line rule may have little effect on ankle injury incidence.<sup>15</sup>

Knee injuries occurred most frequently to the meniscus (37.7%), followed by the collateral ligaments (33.6%), the anterior cruciate ligament (26.3%), and the posterior cruciate ligament (2.3%). These percentages differ in some instances from a recent report by Majewski et al,<sup>16</sup> who found that anterior cruciate ligament injuries accounted for approximately 60% of volleyball-related internal knee injuries, whereas collateral ligament injuries only accounted for about 3% in men, women, boys, and girls. Differences in methods make it difficult to speculate as to the reasons for the disparities between these studies and ours. Men and boys accounted for more than 66% of the anterior cruciate ligament injuries (across all sports) in the Majewski et al<sup>16</sup> study and, thus, it may be that such injuries are more common in male volleyball athletes than in female volleyball athletes. However, we cannot be definitive because data are not available from the Majewski et al<sup>16</sup> work to determine the occurrence of anterior cruciate ligament injuries in male and female volleyball players. The incidence of traumatic knee injuries in volleyball players must be studied further so that we can better understand the effects of these injuries on these athletes.

In this large cohort of women's volleyball players, knee injuries accounted for a larger proportion of injuries than patellar injuries, which contradicts previously published reports on volleyball injuries.<sup>6</sup> Patellar tendinopathy (jumper's knee) has consistently been reported to afflict about 40% to 50% of male indoor volleyball players,<sup>7,17</sup> but the evidence has been mixed as to whether knee internal derangement is a frequent occurrence.<sup>18,19</sup> The incidence of patellar tendinopathies is likely more frequent than what we describe here. The NCAA ISS records only injuries that result in time loss, which may cause overuse-type injuries to be underreported, because these symptoms may not be severe enough to cause an athlete to miss a game or a practice. Recent changes to the ISS reporting structure allow for the reporting of all injuries, regardless of the amount of time lost. This modification to the ISS will assist us in determining whether patellar tendinopathies are more common in female volleyball athletes than has been described here using the current ISS data.

Given the many risk factors that might contribute to patellar tendinopathy, it is often difficult to prescribe effective treatment or to intervene prophylactically. Eccentric quadriceps

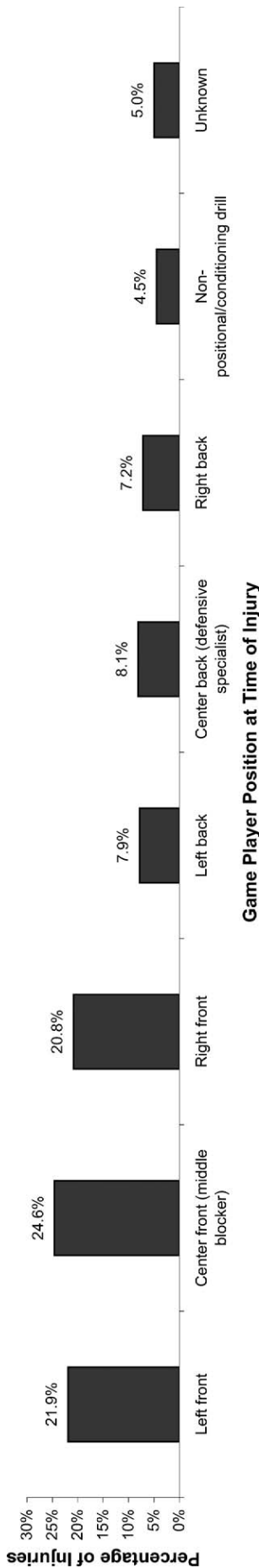


Figure 6. Game injuries by player position, women's volleyball, 1988–1989 through 2003–2004 (n = 2216).

training, in a small cohort of patients with painful jumper's knee, has been shown to reduce pain and improve function for more than 2 years.<sup>26</sup> Pain-producing eccentric decline squat exercises and a traditional pain-free eccentric leg squat (on a 10-cm step) protocol were both effective for treating pain and improving functional outcomes in volleyball players.<sup>12</sup> The amount of jump training performed may be a risk factor for jumper's knee, so monitoring and controlling the amount of jumping may reduce risk, although this would be difficult due to the inherent need to jump in the sport. Furthermore, minimizing jump training on hard surfaces also may decrease injury risk but would be difficult to enforce due to the competition surface. Reeser et al<sup>12</sup> suggested that volleyball athletes may benefit from changes in landing technique. Specifically, they suggested that more research should be done to determine if athletes taught to land in positions that minimize knee flexion and valgus strain, so as to reduce load on the patellar tendon, have a lower incidence of jumper's knee. Although we agree that reducing the amount of valgus loading would be beneficial, we caution clinicians about instructing athletes to land with less knee flexion, because this could increase the risk for other knee injuries (eg, anterior cruciate ligament ruptures). More research is needed to determine the mechanisms leading to patellar tendinopathy in volleyball players and to identify programs to prevent this chronic injury from occurring.

Although the current data suggest that patellar tendinopathy is less common than knee injuries, the former injury may afflict female volleyball athletes. Several epidemiologic investigations<sup>19–21</sup> have shown that jumper's knee afflicts approximately 45% to 50% of male volleyball players, but we could not locate any data illustrating its incidence in female volleyball athletes. Several risk factors for patellar tendinopathy have been identified; the available research suggests that its onset is associated with biomechanical factors that increase loads on the patellar tendon, but it is not clear why some athletes are prone to developing symptoms and others, given equivalent training and competition histories, are not. A higher incidence of jumper's knee was noted in athletes who jump the highest and land from a spike with the deepest knee flexion angle.<sup>20</sup> Further, valgus strain about the knee during the eccentric loading phase of the spike-approach takeoff,<sup>22</sup> reduced dorsiflexion range of motion,<sup>23</sup> diminished quadriceps and hamstrings flexibility,<sup>24</sup> and high ankle inversion-eversion moments during landing<sup>7</sup> have been associated with patellar tendinopathy. Players who train on hard surfaces and with increased frequency also are thought to be predisposed to jumper's knee.<sup>25</sup>

Musculotendinous strains about the shoulder, low back, and thigh appear to be other injuries that frequently plague female volleyball athletes. Most of these injuries likely occurred from twisting, landing, and pivoting (thigh strains) and repetitive overhead swinging (shoulder strains). Low back and shoulder injuries have been reported previously as frequently occurring injuries in volleyball players. Bahr et al<sup>27</sup> noted that low back pain (19%) and shoulder problems (10%) were 2 of the most common overuse injuries reported by professional male and female beach volleyball athletes. The causes of shoulder pain, low back pain, and thigh muscle strains have not been well studied in the female volleyball athlete and, given the frequency of these injuries, more research is needed.

In conclusion, injury rates have remained fairly steady over the course of the 16 years. Ankle sprains and knee injuries remain the most common injuries in women's volleyball. Fu-

ture efforts should focus on preventing first-time ankle sprains, reducing the risk of ankle sprain recurrence and anterior cruciate ligament tears, and identifying the causes of patellar tendinopathy so that preventive measures can be implemented.

## DISCLAIMER

The conclusions in the Commentary section of this article are those of the Commentary authors and do not necessarily represent the views of the National Collegiate Athletic Association.

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