Injuries Affecting Intercollegiate Water Polo Athletes

A Descriptive Epidemiologic Study

Grant G. Schroeder,* MD, Daniel J. McClintick,* MD, Rishi Trikha,† MD, and Thomas J. Kremen Jr,†‡ MD

Investigation performed at David Geffen School of Medicine at UCLA, Los Angeles, California, USA

Background: There are few data on injuries suffered by collegiate water polo athletes.

Purpose: To describe the epidemiology of injuries suffered by National College Athletic Association (NCAA) male and female water polo players by using injury surveillance data over a 5-year period.

Study Design: Descriptive epidemiology study.

Methods: Deidentified data on all water polo injuries and illnesses recorded in the Pac-12 Sports Injury Research Archive from July 2016 through June 2021 were obtained and analyzed. Three men's and 4 women's teams were observed for the entire 5-year period, and 1 men's and 1 women's team was observed from July 2018 through June 2021.

Results: During the observation period, 729 injuries were recorded in the database, with no differences in overall injury rates between male and female athletes (relative risk [RR] = 1.0; 95% CI, 0.9-1.2); 33.7% of injuries required a physician encounter, and 3.6% required surgery. The shoulder was the most injured body part, making up 20.6% of all injuries, followed by the head/face (18.8%) and hand/wrist/forearm (11.7%). Shoulder tendinopathy was the most common shoulder injury diagnosis (4.5% of all injuries). Concussion was the most common injury diagnosis overall, making up 11.4% of injuries, and 81.9% of concussions occurred outside of competition. Male athletes were significantly more likely than female athletes to have a concussion in an off-season practice (RR, 3.25; 95% CI, 1.2-8.8) and via contact with another player (RR, 2.9; 95% CI, 1.3-6.4). Half of the 26 surgical procedures occurring over the observation period were for chronic joint trauma of the groin/hip/pelvis/buttock, with 9 of those 13 being for femoroacetabular impingement specifically.

Conclusion: Among NCAA water polo athletes, the shoulder was the most injured body part; however, shoulder injuries rarely required missed time from sport or necessitated surgical intervention. Concussions were the most common injury diagnosis, had the worst return-to-play outcomes among common diagnoses, and were mostly sustained outside of competition. Femoroacetabular impingement was found to be the dominant diagnosis for which surgical intervention was required.

Keywords: collegiate athletics; concussions; femoroacetabular impingement; injuries; NCAA; shoulder; water polo

Water polo is the longest running team competition in the modern Olympic Games, first introduced in Paris in 1900.[25] Although the sport has traditionally been most popular in European countries such as Hungary, Spain, Italy, Croatia, Greece, and Serbia, its popularity is growing in several areas of the world, including the United States.[8,29] Outside the Olympic team, National College Athletic Association (NCAA) water polo is the highest level of competitive play in the United States, with over 2300 participating athletes in the year 2020.[21] NCAA water polo has been dominated by teams from the Pacific-12 (Pac-12) Conference[20,22]; the Pac-12 is made up of 12 member universities located across the western United States, 4 of which host men's water polo teams and 5 of which host women's water polo teams.

The combination of swimming, throwing, and wrestling during play, along with unique sporting rules including unlimited player fouls and freedom to hold, sink, and pull a player holding the ball, make water polo players prone to unique injuries that athletic trainers and physicians must be prepared to address.[26] There are relatively limited data on the epidemiology of injuries suffered by water polo players. Shoulder injuries have traditionally been the major focus of water polo injury research, with increased shoulder mobility, rotator cuff imbalances, and repeated

The Orthopaedic Journal of Sports Medicine, 10(7), 23259671221110208
DOI: 10.1177/23259671221110208

throwing often cited as causes of pain and dysfunction.[18,30] The high prevalence of shoulder injuries has been shown in previous studies of water polo players in Australia and Korea.[12,16] In addition, in-competition head injuries are relatively common based on a study of injuries suffered by elite water polo players during matches from the Olympic Games and World Championships.[19] Concussions have also emerged as an important topic in the sport;[2-4] however, data on their overall incidence from an NCAA injury surveillance study are absent.[31]

The longitudinal nature of an injury surveillance program has been emphasized as a critical need for understanding injuries in the sport.[5,19] To date, there has been no study to our knowledge that captures multiple years of both in-competition and out-of-competition injuries for multiple men's and women's collegiate water polo teams. This study aimed to characterize the injuries sustained by a large cohort of male and female water polo athletes from the Pac-12 Conference over a period of 5 years. Illness data were also included as an important component of the injury surveillance program, with rates of COVID-19 being particularly relevant at present.

METHODS

Data Collection

The study population was made up of Pac-12 athletes from 4 men's and 5 women's water polo teams during the observation period. The observation period was July 2016 through June 2021 for 3 men's and 4 women's teams and July 2018 through June 2021 for 1 men's and 1 women's team. All athletes who consented to having their deidentified injury and illness data used for research were included in the study population regardless of how long they remained in the sport; none were excluded. This study was considered exempt from institutional review board approval.

The following data are collected into the Pac-12 Sports Injury Research Archive for each health event (injury or illness) sustained by an athlete: deidentified athlete ID, sex, event year, body part affected, injury/illness type, mechanism of injury, season timing (in season vs off season), event setting, requirement for physician encounter, requirement for surgery, and return-to-play data. Information for each event is maintained in the database by athletic trainers and/or physicians over the course of the injury or illness; for example, the event year is recorded at the time when an athlete is first evaluated, whereas return-to-play outcome information is determined at the time of injury or illness resolution or when the outcome can be prospectively determined with confidence. Data from the Pac-12 Sports Injury Research Archive were extracted and transferred for analysis.

Definitions

A health event was defined as a player's first presenting to his or her athletic trainer or physician with a health complaint. Health events were classified as either illnesses or injuries. Illness was defined as a health event that was nonmusculoskeletal, nontraumatic, and labeled as "illness," "infection," "condition," or "disease" in the event type; and injury was defined as any health event that was not an illness, including all musculoskeletal conditions (such as fractures, arthritis, and bursitis) and nonmusculoskeletal conditions that resulted from a distinct traumatic event (such as concussions, lacerations, and hematomas). Athletes affected was defined as the number of athletes suffering from at least 1 of the specified health events during the observation period.

Statistical Analysis

Statistical analysis was performed using Microsoft Excel Version 16.49 in consultation with the biostatistics core facility at our institution. The percentage of health events was calculated as the number of the specific injury/illness divided by the total number of injuries/illnesses. The percentage of athletes affected was calculated as the number of athletes affected at least once by the specific injury/illness divided by the total number of athletes observed. Relative risk (RR) was used to compare the percentage of athletes affected between sexes, with statistical significance defined by a 95% CI, that does not include 1.0 ($P < .05$).

RESULTS

Overall, 729 injury events and 188 illness events (917 total health events) occurred from July 2016 through June 2021. Table 1 summarizes the injury data for the included participants. There were 406 injuries among 92 of 142 male athletes observed, and 323 injuries among 105 of 165 female athletes observed. Of the injuries, 405 (55.6%) occurred during the off season, and 324 (44.4%) while in season; 419 of the injuries (57.5%) occurred during practice,

‡Address correspondence to Thomas J. Kremen Jr, MD, 1225 15th Street, Suite 2100, Santa Monica, CA 90404, USA (email: tjkremen@mednet.ucla.edu) (Twitter: @ThomasKremenMD).
*David Geffen School of Medicine at UCLA, Los Angeles, California, USA.
†Department of Orthopaedic Surgery, David Geffen School of Medicine at UCLA, Los Angeles, California, USA.
Final revision submitted February 8, 2022; accepted March 23, 2022.
One or more of the authors has declared the following potential conflict of interest or source of funding: Sponsorship of this study was provided by the University of California, Los Angeles, Department of Orthopaedic Surgery. Research support for T.J.K. was provided by the US Department of Veterans Affairs (project No. 2020-000059). T.J.K. has received education payments from Micromed, consulting fees from Heron Therapeutics, honoraria from Fidia Pharma and Musculoskeletal Transplant Foundation, and hospitality payments from RTI Surgical. AOSSM checks author disclosures against the Open Payments Database (OPD). AOSSM has not conducted an independent investigation on the OPD and disclaims any liability or responsibility relating thereto.
Ethical approval for this study was waived by the University of California, Los Angeles.

TABLE 1
Injury Data for Male and Female Water Polo Players in the Pac-12 Conference, 2016 to 2021[a]

	Overall (N = 307 athletes)		Men (n = 142 athletes)		Women (n = 165 athletes)		
	Events	Athletes Affected	Events	Athletes Affected	Events	Athletes Affected	RR (95% CI)
Year							
2016 (6 mo)	31 (4.25)	20 (6.51)	14 (3.45)	10 (7.04)	17 (5.26)	10 (6.06)	1.16 (0.5-2.71)
2017	118 (16.19)	47 (15.31)	61 (15.02)	22 (15.49)	57 (17.65)	25 (15.15)	1.02 (0.6-1.73)
2018	156 (21.4)	78 (25.41)	74 (18.23)	35 (24.65)	82 (25.39)	43 (26.06)	0.95 (0.64-1.39)
2019	205 (28.12)	101 (32.9)	140 (34.48)	53 (37.32)	65 (20.12)	48 (29.09)	1.28 (0.93-1.77)
2020	103 (14.13)	62 (20.2)	63 (15.52)	32 (22.54)	40 (12.38)	30 (18.18)	1.24 (0.79-1.93)
2021 (6 mo)	116 (15.91)	77 (25.08)	54 (13.3)	31 (21.83)	62 (19.2)	46 (27.88)	0.78 (0.53-1.16)
Season timing							
Off season	405 (55.56)	164 (53.42)	259 (63.79)	82 (57.75)	146 (45.2)	82 (49.7)	1.16 (0.94-1.43)
In season	324 (44.44)	138 (44.95)	147 (36.21)	64 (45.07)	177 (54.8)	74 (44.85)	1 (0.78-1.29)
Setting							
Practice	419 (57.48)	165 (53.75)	223 (54.93)	77 (54.23)	196 (60.68)	88 (53.33)	1.02 (0.83-1.25)
Competition	78 (10.7)	55 (17.92)	42 (10.34)	28 (19.72)	36 (11.15)	27 (16.36)	1.21 (0.75-1.94)
Weight room	42 (5.76)	32 (10.42)	26 (6.4)	22 (15.49)	16 (4.95)	10 (6.06)	2.56 (1.25-5.22)[b]
Nonsport team activity	31 (4.25)	25 (8.14)	16 (3.94)	13 (9.15)	15 (4.64)	12 (7.27)	1.26 (0.59-2.67)
Not specified/other	159 (21.81)	88 (28.66)	99 (24.38)	41 (28.87)	60 (18.58)	47 (28.48)	1.01 (0.71-1.44)
Required physician encounter?							
Yes	246 (33.74)	137 (44.63)	130 (32.02)	65 (45.77)	116 (35.91)	72 (43.64)	1.05 (0.82-1.35)
No	483 (66.26)	141 (45.93)	276 (67.98)	66 (46.48)	207 (64.09)	75 (45.45)	1.02 (0.8-1.3)
Required surgery?							
Yes	26 (3.57)	23 (7.49)	17 (4.19)	14 (9.86)	9 (2.79)	9 (5.45)	1.81 (0.81-4.05)
No	703 (96.43)	193 (62.87)	389 (95.81)	89 (62.68)	314 (97.21)	104 (63.03)	0.99 (0.84-1.18)
Total	729 (100)	197 (64.17)	406 (100)	92 (64.79)	323 (100)	105 (63.64)	1.02 (0.86-1.2)

[a]Data are reported as n (%) unless otherwise indicated. RR, relative risk, men vs women.
[b]Statistical significance ($P < .05$).

and 78 (10.7%) occurred during competition. A total of 246 (33.7%) injuries required a physician encounter, and 26 injuries (3.6%) required surgical intervention. Men had a 2.6 times higher risk of being injured in the weight room, which was significantly different compared with women (95% CI, 1.3-5.2), although overall injury risk was not significantly different between men and women (RR, 1.0; 95% CI, 0.9-1.2).

The shoulder was the most injured body part, with a total of 150 injuries (20.6% of all injuries) affecting 93 athletes (Table 2). This was followed by the head/face (137 injuries; 18.8%), hand/wrist/forearm (85 injuries; 11.7%), and groin/hip/pelvis/buttock (83 injuries; 11.4%). Men had a 2.1 times higher risk of spine/neck injury compared with women (95% CI, 1.2-3.5).

When stratified by injury type, ligament sprain was most common, with 103 events (14.1% of all injuries) affecting 66 athletes (Appendix Table A1). This was followed by muscle spasm/cramp/soreness (96 events; 13.2%), concussion (83 events; 11.4%), and tendinopathy/bursitis (73 events; 10.0%). Men had a significantly higher risk of muscle spasm/cramp/soreness (RR, 2.3; 95% CI, 1.4-4.0), fracture (RR, 3.1; 95% CI, 1.3-7.7), and visceral damage/trauma (RR, 3.8; 95% CI, 1.3-11.3) compared with women.

Concussions were the most common injury diagnosis, with 83 events accounting for 11.4% of all injuries and affecting a total of 63 athletes (Table 3), followed by shoulder tendinopathy (33 events; 4.5%), shoulder synovitis (26 events; 3.6%), and elbow ligament sprain (24 events; 3.3%). Men had a significantly higher risk of shoulder tendinopathy (RR, 3.0; 95% CI, 1.3-7.0) and lumbar spine muscle spasm/cramps/soreness (RR, 3.7; 95% CI, 1.4-9.9) compared with women.

Among the most common diagnoses, concussion, shoulder tendinopathy, elbow ligament sprain, femoroacetabular impingement (FAI), thumb ligament sprain, and groin/hip muscle strain were associated with <50% immediate return to play with no restrictions (Table 4). For other common diagnoses, many of the injuries resulted in immediate return to play with no restrictions.

Overall, 83 concussions were recorded in 63 athletes (Table 5). A total of 41 events (49.4%) occurred in season and 42 events (50.6%) occurred in the off season. Practice was the most common setting for concussions, with 54 events (65.1%), and 15 concussions occurred during competition, making up 18.1% of the injuries. For men, the most common mechanism was contact with another player (26 events; 57.8%), followed by contact with a playing device (13 events; 28.9%). In contrast, for women the most common mechanism was contact with a playing device (16 events; 42.1%), followed by contact with another player

TABLE 2
Injuries According to Body Part[a]

	Overall		Men		Women		
	Events	Athletes Affected	Events	Athletes Affected	Events	Athletes Affected	RR (95% CI)
Shoulder	150 (20.58)	93 (30.29)	92 (22.66)	50 (35.21)	58 (17.96)	43 (26.06)	1.35 (0.96-1.9)
Head/face	137 (18.79)	87 (28.34)	75 (18.47)	44 (30.99)	62 (19.2)	43 (26.06)	1.19 (0.83-1.7)
Hand/wrist/forearm	85 (11.66)	57 (18.57)	45 (11.08)	31 (21.83)	40 (12.38)	26 (15.76)	1.39 (0.87-2.22)
Groin/hip/pelvis/buttock	83 (11.39)	61 (19.87)	42 (10.34)	29 (20.42)	41 (12.69)	32 (19.39)	1.05 (0.67-1.65)
Spine/neck	81 (11.11)	53 (17.26)	48 (11.82)	34 (23.94)	33 (10.22)	19 (11.52)	2.08 (1.24-3.48)[b]
Elbow/arm	65 (8.92)	49 (15.96)	35 (8.62)	25 (17.61)	30 (9.29)	24 (14.55)	1.21 (0.72-2.02)
Knee/thigh	57 (7.82)	43 (14.01)	32 (7.88)	21 (14.79)	25 (7.74)	22 (13.33)	1.11 (0.64-1.93)
Foot/ankle/lower leg	50 (6.86)	40 (13.03)	23 (5.67)	19 (13.38)	27 (8.36)	21 (12.73)	1.05 (0.59-1.88)
Chest/abdomen	18 (2.47)	16 (5.21)	13 (3.2)	11 (7.75)	5 (1.55)	5 (3.03)	2.56 (0.91-7.18)
Unclassified	3 (0.41)	3 (0.98)	1 (0.25)	1 (0.7)	2 (0.62)	2 (1.21)	0.58 (0.05-6.34)
Total	729 (100)	197 (64.17)	406 (100)	92 (64.79)	323 (100)	105 (63.64)	1.02 (0.86-1.2)

[a]Data are reported as n (% of total) unless otherwise indicated. RR, relative risk, men vs women.
[b]Statistical significance ($P < .05$).

TABLE 3
Injuries by Most Common Diagnoses[a]

	Overall		Men		Women		
	Events	Athletes Affected	Events	Athletes Affected	Events	Athletes Affected	RR (95% CI)
Concussion	83 (11.39)	63 (20.52)	45 (11.08)	32 (22.54)	38 (11.76)	31 (18.79)	1.2 (0.77-1.86)
Shoulder tendinopathy	33 (4.53)	25 (8.14)	26 (6.4)	18 (12.68)	7 (2.17)	7 (4.24)	2.99 (1.29-6.95)[b]
Shoulder synovitis	26 (3.57)	22 (7.17)	15 (3.69)	11 (7.75)	11 (3.41)	11 (6.67)	1.16 (0.52-2.6)
Elbow ligament sprain	24 (3.29)	23 (7.49)	8 (1.97)	8 (5.63)	16 (4.95)	15 (9.09)	0.62 (0.27-1.42)
Lumbar spine muscle spasm/cramps/soreness	22 (3.02)	21 (6.84)	17 (4.19)	16 (11.27)	5 (1.55)	5 (3.03)	3.72 (1.4-9.9)[b]
Femoroacetabular impingement	21 (2.88)	16 (5.21)	12 (2.96)	8 (5.63)	9 (2.79)	8 (4.85)	1.16 (0.45-3.02)
Thumb ligament sprain	20 (2.74)	16 (5.21)	8 (1.97)	5 (3.52)	12 (3.72)	11 (6.67)	0.53 (0.19-1.48)
Shoulder muscle strain	18 (2.47)	18 (5.86)	12 (2.96)	12 (8.45)	6 (1.86)	6 (3.64)	2.32 (0.9-6.03)
Shoulder muscle spasm/cramps/soreness	17 (2.33)	15 (4.89)	12 (2.96)	10 (7.04)	5 (1.55)	5 (3.03)	2.32 (0.81-6.64)
Hand/finger ligament sprain	17 (2.33)	15 (4.89)	10 (2.46)	10 (7.04)	7 (2.17)	5 (3.03)	2.32 (0.81-6.64)
Groin/hip muscle strain	14 (1.92)	11 (3.58)	9 (2.22)	6 (4.23)	5 (1.55)	5 (3.03)	1.39 (0.43-4.47)
Groin/hip muscle spasm/cramps/soreness	12 (1.65)	12 (3.91)	7 (1.72)	7 (4.93)	5 (1.55)	5 (3.03)	1.63 (0.53-5.01)
Thoracic spine muscle spasm/cramps/soreness	12 (1.65)	9 (2.93)	7 (1.72)	5 (3.52)	5 (1.55)	4 (2.42)	1.45 (0.4-5.31)

[a]Data are reported as n (%) unless otherwise indicated. RR, relative risk, men vs women.
[b]Statistical significance ($P < .05$).

(9 events; 23.7%). Compared with women, men had a 3.3 times higher risk of concussion occurring in off-season practice (95% CI, 1.2-8.8) and a 2.9 times higher risk of concussion via contact with another player (95% CI, 1.3-6.4).

A total of 26 injuries in 23 athletes (Table 6) were treated with surgical procedures. Of these surgical procedures, 18 (69.2%) were for chronic injuries, compared with 8 (30.8%) for acute injuries such as fractures, dislocations, and lacerations. Half of the injuries (13 of 26, 50%) treated with a surgical procedure were due to groin/hip/pelvis/buttock chronic joint trauma, with 9 of these groin/hip/pelvis injuries being specifically attributed to FAI. The next most common injured body parts treated with a surgical procedure were the hand/wrist/forearm (4 injuries; 15.4%) and the shoulder (3 injuries; 11.5%).

There were 84 illnesses in 58 of 142 men, and there were 104 illnesses in 55 of 165 women (Table 7). Non-COVID-19 respiratory infection was the most common diagnosis, making up 32.5% of illnesses, followed by symptomatic

TABLE 4
Return-to-Play Data by Most Common Diagnoses[a]

	Returned to Play						
	With No Restrictions	With Restricted Activity	Later in Same Season	In Following Season	Unable to Return	Left Campus/ Not Specified	Total, N
Concussion	6 (7.23)	1 (1.2)	62 (74.7)	2 (2.41)	2 (2.41)	10 (12.05)	83
Shoulder tendinopathy	16 (48.48)	0 (0)	14 (42.42)	2 (6.06)	0 (0)	1 (3.03)	33
Shoulder synovitis	18 (69.23)	1 (3.85)	7 (26.92)	0 (0)	0 (0)	0 (0)	26
Elbow ligament sprain	9 (37.5)	1 (4.17)	10 (41.67)	3 (12.5)	0 (0)	1 (4.17)	24
Lumbar spine muscle spasm/ cramps/soreness	16 (72.73)	0 (0)	5 (22.73)	0 (0)	0 (0)	1 (4.55)	22
Femoroacetabular impingement	3 (14.29)	3 (14.29)	7 (33.33)	2 (9.52)	1 (4.76)	5 (23.81)	21
Thumb ligament sprain	8 (40)	0 (0)	9 (45)	1 (5)	0 (0)	2 (10)	20
Shoulder muscle strain	10 (55.56)	0 (0)	7 (38.89)	0 (0)	0 (0)	1 (5.56)	18
Shoulder muscle spasm/ cramps/soreness	16 (94.12)	0 (0)	1 (5.88)	0 (0)	0 (0)	0 (0)	17
Hand/finger ligament sprain	16 (94.12)	0 (0)	1 (5.88)	0 (0)	0 (0)	0 (0)	17
Groin/hip muscle strain	5 (35.71)	0 (0)	6 (42.86)	0 (0)	0 (0)	3 (21.43)	14
Groin/hip muscle spasm/ cramps/soreness	12 (100)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	12
Thoracic spine muscle spasm/ cramps/soreness	6 (50)	0 (0)	4 (33.33)	1 (8.33)	0 (0)	1 (8.33)	12

[a]Data are reported as n (%) unless otherwise indicated.

TABLE 5
Concussion Data by Season Timing, Setting, and Mechanism for Male and Female Water Polo Players[a]

	Overall		Men		Women		
	Events	Athletes Affected	Events	Athletes Affected	Events	Athletes Affected	RR (95% CI)
In season							
Practice	32 (38.55)	27 (8.79)	13 (28.89)	12 (8.45)	19 (50)	15 (9.09)	0.93 (0.45-1.92)
Competition	6 (7.23)	6 (1.95)	3 (6.67)	3 (2.11)	3 (7.89)	3 (1.82)	1.16 (0.24-5.67)
Weight room	1 (1.2)	1 (0.33)	0 (0)	0 (0)	1 (2.63)	1 (0.61)	—
Nonsport team activity	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	—
Not specified/other	2 (2.41)	2 (0.65)	1 (2.22)	1 (0.7)	1 (2.63)	1 (0.61)	1.16 (0.07-18.41)
Off season							
Practice	22 (26.51)	19 (6.19)	17 (37.78)	14 (9.86)	5 (13.16)	5 (3.03)	3.25 (1.2-8.81)[b]
Competition	9 (10.84)	9 (2.93)	7 (15.56)	7 (4.93)	2 (5.26)	2 (1.21)	4.07 (0.86-19.26)
Weight room	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	—
Nonsport team activity	3 (3.61)	3 (0.98)	2 (4.44)	2 (1.41)	1 (2.63)	1 (0.61)	2.32 (0.21-25.36)
Not specified/other	8 (9.64)	8 (2.61)	2 (4.44)	2 (1.41)	6 (15.79)	6 (3.64)	0.39 (0.08-1.89)
Mechanism							
Contact with another player	35 (42.17)	28 (9.12)	26 (57.78)	20 (14.08)	9 (23.68)	8 (4.85)	2.9 (1.32-6.39)[b]
Contact with playing device	29 (34.94)	24 (7.82)	13 (28.89)	11 (7.75)	16 (42.11)	13 (7.88)	0.98 (0.45-2.13)
Contact with apparatus	12 (14.46)	12 (3.91)	5 (11.11)	5 (3.52)	7 (18.42)	7 (4.24)	0.83 (0.27-2.56)
Contact with ground	1 (1.2)	1 (0.33)	1 (2.22)	1 (0.7)	0 (0)	0 (0)	—
Not specified/other	6 (7.23)	6 (1.95)	0 (0)	0 (0)	6 (15.79)	6 (3.64)	—
Total	83 (100)	63 (20.52)	45 (100)	32 (22.54)	38 (100)	31 (18.79)	1.2 (0.77-1.86)

[a]Data are reported as n (%) unless otherwise indicated. Dashes indicate a zero or undefined RR. RR, relative risk, men vs women.
[b]Statistical significance ($P < .05$).

COVID-19 (9.0%) and skin/soft tissue infection (6.9%). Men had a 2.8 times higher risk of symptomatic COVID-19 compared with women (95% CI, 1.01-7.7).

DISCUSSION

Given highly limited data in the literature, the objective of our study was to present information on injuries in men's

TABLE 6
Injuries Requiring Surgery According to Body Part and Injury Type[a]

	Overall		Men		Women		
	Events	Athletes Affected	Events	Athletes Affected	Events	Athletes Affected	RR (95% CI)
Groin/hip/pelvis/buttock							
Chronic joint trauma	13 (50)	10 (3.26)	8 (47.06)	5 (3.52)	5 (55.56)	5 (3.03)	1.16 (0.34-3.93)
Hand/wrist/forearm							
Fracture	2 (7.69)	2 (0.65)	2 (11.76)	2 (1.41)	0 (0)	0 (0)	—
Dislocation	1 (3.85)	1 (0.33)	0 (0)	0 (0)	1 (11.11)	1 (0.61)	—
Articular/chondral damage	1 (3.85)	1 (0.33)	0 (0)	0 (0)	1 (11.11)	1 (0.61)	—
Shoulder							
Dislocation	1 (3.85)	1 (0.33)	1 (5.88)	1 (0.7)	0 (0)	0 (0)	—
Instability	2 (7.69)	2 (0.65)	2 (11.76)	2 (1.41)	0 (0)	0 (0)	—
Foot/ankle/lower leg							
Fracture	1 (3.85)	1 (0.33)	0 (0)	0 (0)	1 (11.11)	1 (0.61)	—
Dislocation	1 (3.85)	1 (0.33)	1 (5.88)	1 (0.7)	0 (0)	0 (0)	—
Head/face							
Fracture	1 (3.85)	1 (0.33)	1 (5.88)	1 (0.7)	0 (0)	0 (0)	—
Laceration	1 (3.85)	1 (0.33)	0 (0)	0 (0)	1 (11.11)	1 (0.61)	—
Elbow/arm							
Articular/chondral damage	1 (3.85)	1 (0.33)	1 (5.88)	1 (0.7)	0 (0)	0 (0)	—
Knee/thigh							
Visceral damage/trauma	1 (3.85)	1 (0.33)	1 (5.88)	1 (0.7)	0 (0)	0 (0)	—
Total	26 (100)	23 (7.49)	17 (100)	14 (9.86)	9 (100)	9 (5.45)	1.81 (0.81-4.05)

[a]Data are reported as n (%) unless otherwise indicated. Dashes indicate a zero or undefined RR. RR, relative risk, men vs women.

TABLE 7
Illness Data by Diagnosis for Male and Female Water Polo Players[a]

	Overall		Men		Women		
	Events	Athletes Affected	Events	Athletes Affected	Events	Athletes Affected	RR (95% CI)
Non-COVID-19 respiratory infection	61 (32.45)	44 (14.33)	20 (23.81)	17 (11.97)	41 (39.42)	27 (16.36)	0.73 (0.42 -1.29)
COVID-19, symptomatic	17 (9.04)	17 (5.54)	12 (14.29)	12 (8.45)	5 (4.81)	5 (3.03)	2.79 (1.01-7.73)[b]
Skin/soft tissue infection	13 (6.91)	12 (3.91)	9 (10.71)	8 (5.63)	4 (3.85)	4 (2.42)	2.32 (0.71-7.56)
COVID-19, asymptomatic	12 (6.38)	12 (3.91)	6 (7.14)	6 (4.23)	6 (5.77)	6 (3.64)	1.16 (0.38-3.52)
Gastrointestinal illness	8 (4.26)	8 (2.61)	4 (4.76)	4 (2.82)	4 (3.85)	4 (2.42)	1.16 (0.3-4.56)
Respiratory illness	8 (4.26)	8 (2.61)	2 (2.38)	2 (1.41)	6 (5.77)	6 (3.64)	0.39 (0.08 -1.89)
Pharyngitis	7 (3.72)	6 (1.95)	2 (2.38)	2 (1.41)	5 (4.81)	4 (2.42)	0.58 (0.11-3.13)
Sinusitis	7 (3.72)	7 (2.28)	1 (1.19)	1 (0.7)	6 (5.77)	6 (3.64)	0.19 (0.02-1.59)
Ear infection	7 (3.72)	7 (2.28)	3 (3.57)	3 (2.11)	4 (3.85)	4 (2.42)	0.87 (0.2-3.83)
Systemic viral infection	5 (2.66)	5 (1.63)	5 (5.95)	5 (3.52)	0 (0)	0 (0)	—
Mononucleosis	4 (2.13)	4 (1.3)	2 (2.38)	2 (1.41)	2 (1.92)	2 (1.21)	1.16 (0.17-8.14)
Cardiovascular illness	4 (2.13)	4 (1.3)	2 (2.38)	2 (1.41)	2 (1.92)	2 (1.21)	1.16 (0.17-8.14)
Dermatological illness	4 (2.13)	4 (1.3)	1 (1.19)	1 (0.7)	3 (2.88)	3 (1.82)	0.39 (0.04-3.68)
Eye infection	2 (1.06)	2 (0.65)	0 (0)	0 (0)	2 (1.92)	2 (1.21)	—
Allergic reaction	2 (1.06)	2 (0.65)	1 (1.19)	1 (0.7)	1 (0.96)	1 (0.61)	1.16 (0.07-18.41)
Urinary infection	1 (0.53)	1 (0.33)	0 (0)	0 (0)	1 (0.96)	1 (0.61)	—
Neurological illness	1 (0.53)	1 (0.33)	0 (0)	0 (0)	1 (0.96)	1 (0.61)	—
Influenza	1 (0.53)	1 (0.33)	0 (0)	0 (0)	1 (0.96)	1 (0.61)	—
Other	24 (12.77)	22 (7.17)	14 (16.67)	12 (8.45)	10 (9.62)	10 (6.06)	1.39 (0.62-3.13)
Total	188 (100)	113 (36.81)	84 (100)	58 (40.85)	104 (100)	55 (33.33)	1.23 (0.91-1.64)

[a]Data are reported as n (%) unless otherwise indicated. Dashes indicate a zero or undefined RR. RR, relative risk, men vs women.
[b]Statistical significance ($P < .05$).

and women's water polo as the first epidemiology study to our knowledge involving both in-competition and out-of-competition injury surveillance data from multiple teams. In addition to providing general information such as injury rates and return-to-play data, our results are particularly relevant to several key areas of discussion.

Shoulder Injuries

Previous studies on water polo injuries have mostly focused on shoulder pathology, proposing increased shoulder mobility, rotator cuff imbalances, and repeated throwing as major causes of pain.[18,30] The present study found the shoulder to be the most common injury site for water polo players; however, for common shoulder injuries including synovitis, muscle strain, and muscle spasm/cramps/soreness, more than 50% of athletes returned with no missed time or restrictions. In addition, only a total of 3 shoulder injuries required surgery, 1 for an acute dislocation and 2 for chronic instability. Operative shoulder injuries in water polo are not well studied; however, data from other NCAA sports suggest labral tears and shoulder dislocations to be the most common injuries requiring surgery.[10] Findings from this study suggest that although shoulder injuries are the most common injuries among water polo players, their clinical significance appears relatively minor compared with other injuries such as concussions and FAI.

Concussions

Despite being widely studied in a variety of collegiate sports, concussion data on water polo players from an NCAA injury surveillance study have been absent to date.[31] Concussions were found to make up 1.9% of injuries in 8904 matches from the Olympic Games and World Championships,[19] similar to the 2.1% rate of concussions sustained in competition in the present study. However, the importance of out-of-competition injury surveillance data is underscored by the 81.9% of concussions that occurred outside of competition in the present study, resulting in concussions being 11.4% of all injuries and by far the most common single injury diagnosis overall. In addition, concussions had the worst return-to-play outcomes compared with other common diagnoses, with 91.6% of concussions resulting in the athlete missing playing time, 2.4% resulting in the athlete having to return the following season, and 2.4% resulting in the athlete being unable to return because of the injury. These findings highlight the critical need for concussion-reduction strategies, which may benefit from different approaches for men and women; whereas the highest percentage of male concussions occurred via contact with another player, the highest percentage of female concussions occurred via contact with a playing device (ie, the ball). As several studies have shown position-specific differences in head impacts/concussions during play,[2-4] concussion-prevention strategies would be enhanced by more detailed injury surveillance data that include player-position information and a more thorough description of the injury mechanism.

Femoroacetabular Impingement

The irregular "eggbeater" or treading-water motion used during water polo play is recognized to contribute to lower extremity injuries, with knee pathology often emphasized.[8,26] Although less traditionally discussed, groin/hip pathology is becoming increasingly recognized as important in water polo.[5,11] Strikingly, this study found pathology of the groin/hip/pelvis/buttock to make up 50% of injuries requiring surgery, which was considerably more than the second most common site, the hand/wrist/forearm (15.4%). A total of 9 of the 13 groin/hip/pelvis/buttock injuries had the specific diagnosis of FAI, and the other 4 were described more generally as chronic joint trauma and may or may not have been FAI. Some 8 of the 13 surgical procedures resulted in athletes returning to play, 4 resulted in an indeterminate outcome with either athletes leaving campus or the outcome not specified, and 1 resulted in the athlete unable to return from the injury. Overall, FAI was diagnosed in 16 athletes for a total of 21 events (2.9% of injuries), although this is likely to be an underestimate because radiographic evidence of FAI has been found in around 2 of 3 water polo players and synchronized swimmers,[17] and many athletes remain asymptomatic.

FAI is thought to arise from repetitive hip loading at extreme ranges of motion, especially hip flexion and internal rotation, which is seen during water treading, in skeletally immature individuals, causing bony remodeling.[28] Despite previous reports showing great surgical outcomes for both water polo and swimming athletes,[9,23] the high burden of surgery and missed playing time associated with FAI makes this injury a critical subject of future research. For example, such research could focus on how early sport specialization and high training volume, which have been shown to increase injury rates and missed time among NCAA athletes,[1] may influence rates of FAI.

Injury Comparisons With Other Sports

Across NCAA sports, upper extremity injuries account for approximately 20% of all injuries,[10] which is notably lower than the 41.2% value for water polo seen in the present study. This is somewhat unsurprising for a sport that relies heavily on the upper extremities for throwing, wrestling, and swimming and has comparable rates of upper extremity injuries with NCAA swimming, which is also above 40%.[15] Elbow sprains, the fourth most common injury diagnosis overall for water polo players, are also particularly prevalent in football, baseball, and wrestling,[13] which share some of the same throwing and contact requirements. The relatively low percentage of lower extremity injuries (26.1%) in water polo was mostly anticipated, compared with NCAA land sports such as basketball in which lower extremity injuries make up about 60% of injuries, with ankle sprains being the most common diagnosis.[7]

Sex-Based Differences

Several significant differences were seen between various male and female injury rates, although the overall risk of

injury was not different between the sexes. Men were found to be at significantly higher risk of being injured in the weight room; injuring the spine/neck; having muscle spasm/cramp/soreness, fracture, and visceral damage/trauma/surgery injury types; being diagnosed with shoulder tendinopathy and lumbar spine muscle spasm/cramps/soreness; suffering a concussion in off-season practice or via contact with another player; and having symptomatic COVID-19. Although these differences could be due to chance, several of these corroborate previously published sex differences that warrant mentioning. For example, in a study of comparable NCAA sports, men were found to be more likely than women to sustain a neck or cervical spine injury.[6] Another study of 25 NCAA sports found male athletes to have higher rates of lumbar injuries compared with female athletes.[14] In addition, although men having a significantly higher risk of symptomatic COVID-19 is likely to be multifactorial, it is notably in line with evidence that different immune responses to SARS-CoV-2 between men and women result in greater COVID-19 symptoms among men.[27] Finally, an earlier study comparing sex-based differences in water polo injuries at one NCAA institution found women to suffer from significantly more shoulder injuries compared with men; however, this was hypothesized to be because of team-specific training differences[24] and was not seen in the present study.

Limitations

This study is not without limitations. One limitation of this study was the use of a relatively new injury surveillance database that began collecting data on water polo in 2016; the relatively lower number of events in the earlier years of the database is probably owing to lower reporting during the injury surveillance program rollout. However, the addition of 1 men's and 1 women's team in July 2018 does account for some of the increased number of injuries seen in 2018 and 2019. The drop in injury rates in 2020 is likely to be the result of play suspension secondary to the COVID-19 pandemic, and therefore is unlikely to be reflective of injury rates during a normal season. Thus, these both probably contribute to an underestimation of true injury rates. In addition, the database has no athlete exposure or observation period data for individual athletes, making us unable to report injury rates per athlete exposure. However, if desired, one could estimate the number of water polo "athletic exposures," defined as an athlete participating in an NCAA-sanctioned practice or competition, based on data from other sports; for example, an NCAA swimmer has an average of 155 to 160 athletic exposures per year.[15] One would also need to estimate the average number of years observed per athlete, which would likely be between 2 and 3 years in the present study depending on chosen assumptions. An unavoidable limitation of this study is that it includes data only on athletes who consented to having their injury and illness data used for research. In addition, there were likely to be injuries and illnesses that were never brought to the attention of athletic trainers and physicians and thus were not included in the database. Finally, this study assumed complete diagnostic accuracy by athletic trainers and physicians during documentation, because diagnostic criteria for injuries were not specified.

CONCLUSION

Among NCAA water polo athletes, the shoulder was the most common body part injured; however, shoulder injuries rarely required missed time from sport or necessitated surgical intervention. Concussions were the most common injury diagnosis, had the worst return-to-play outcomes among common diagnoses, and were sustained mostly outside of competition. FAI was found to be the dominant diagnosis for which surgical intervention was required. These data help to guide care and injury-prevention strategies for these unique athletes.

ACKNOWLEDGMENT

Special thanks go to Jeffrey Gornbein, DrPH, in the UCLA Department of Biomathematics for his assistance with the statistical analysis included in this manuscript. The authors also thank the athletic trainers and physicians who continually contribute data to the Pac-12 Sports Injury Research Archive as well as the database managers for their service in providing an invaluable research tool for improving student athlete health and well-being.

REFERENCES

1. Ahlquist S, Cash BM, Hame SL. Associations of early sport specialization and high training volume with injury rates in National Collegiate Athletic Association Division I athletes. *Orthop J Sports Med*. 2020;8(3):2325967120906825. doi:10.1177/2325967120906825
2. Blumenfeld RS, Winsell JC, Hicks JW, et al. The epidemiology of sports-related head injury and concussion in water polo. *Front Neurol*. 2016;7:1-11. doi:10.3389/fneur.2016.00098
3. Cecchi NJ, Monroe DC, Fote GM, et al. Head impacts sustained by male collegiate water polo athletes. *PLoS One*. 2019;14(5):1-9. doi:10.1371/journal.pone.0216369
4. Cecchi NJ, Monroe DC, Phreaner JJ, et al. Patterns of head impact exposure in men's and women's collegiate club water polo. *J Sci Med Sport*. 2020;23(10):927-931. doi:10.1016/j.jsams.2020.03.008
5. Croteau F, Brown H, Pearsall D, et al. Prevalence and mechanisms of injuries in water polo: a systematic review. *BMJ Open Sport Exerc Med*. 2021;7(2):1-12. doi:10.1136/bmjsem-2021-001081
6. Deckey DG, Makovicka JL, Chung AS, et al. Neck and cervical spine injuries in National College Athletic Association athletes: a 5-year epidemiologic study. *Spine (Phila Pa 1976)*. 2020;45(1):55-64. doi:10.1097/BRS.0000000000003220
7. Dick R, Hertel J, Agel J, et al. Descriptive epidemiology of collegiate men's basketball injuries: National Collegiate Athletic Association Injury Surveillance System, 1988-1989 through 2003-2004. *J Athl Train*. 2007;42(2):194-201.
8. Franić M, Ivković A, Rudić R. Injuries in water polo. *Croat Med J*. 2007;48(3):281-288.
9. Frank RM, Ukwuani G, Chahla J, et al. High rate of return to swimming after hip arthroscopy for femoroacetabular impingement. *Arthroscopy*. 2018;34(5):1471-1477. doi:10.1016/j.arthro.2017.11.030
10. Gil JA, Goodman AD, DeFroda SF, et al. Characteristics of operative shoulder injuries in the National Collegiate Athletic Association, 2009-2010 through 2013-2014. *Orthop J Sports Med*. 2018;6(8):2325967118790764. doi:10.1177/2325967118790764

11. Girdwood M, Webster M. Quantifying the burden of shoulder and hip pain in water polo players across different playing levels. *Int J Sports Phys Ther*. 2021;16(1):57-63. doi:10.26603/001c.18801
12. Hams A, Evans K, Adams R, et al. Epidemiology of shoulder injury in sub-elite level water polo players. *Phys Ther Sport*. 2019;35:127-132. doi:10.1016/j.ptsp.2018.12.001
13. Hassebrock JD, Patel KA, Makovicka JL, et al. Elbow injuries in National Collegiate Athletic Association athletes: a 5-season epidemiological study. *Orthop J Sports Med*. 2019;7(8):1-10. doi:10.1177/2325967119861959
14. Hassebrock JD, Patel KA, Makovicka JL, et al. Lumbar spine injuries in National Collegiate Athletic Association athletes: a 6-season epidemiological study. *Orthop J Sports Med*. 2019;7(1):1-10. doi:10.1177/2325967118820046
15. Kerr ZY, Baugh CM, Hibberd EE, et al. Epidemiology of National Collegiate Athletic Association men's and women's swimming and diving injuries from 2009/2010 to 2013/2014. *Br J Sports Med*. 2015;49(7):465-471. doi:10.1136/bjsports-2014-094423
16. Kim HC, Park KJ. Injuries in male and female elite aquatic sports athletes: an 8-year prospective, epidemiological study. *J Sport Sci Med*. 2020;19(2):390-396.
17. Langner JL, Black MS, MacKay JW, et al. The prevalence of femoroacetabular impingement anatomy in Division 1 aquatic athletes who tread water. *J Hip Preserv Surg*. 2020;7(2):233-241. doi:10.1093/jhps/hnaa009
18. Miller AH, Evans K, Adams R, et al. Shoulder injury in water polo: a systematic review of incidence and intrinsic risk factors. *J Sci Med Sport*. 2018;21(4):368-377. doi:10.1016/j.jsams.2017.08.015
19. Mountjoy M, Miller J, Junge A. Analysis of water polo injuries during 8904 player matches at FINA World Championships and Olympic Games to make the sport safer. *Br J Sports Med*. 2019;53(1):25-31. doi:10.1136/bjsports-2018-099349
20. *NCAA Men's Water Polo Championship History*. Published 2021. https://www.ncaa.com/history/waterpolo-men/nc
21. *NCAA Sports Sponsorship and Participation Rates Database [Data Visualization Dashboard]*, 2020-2021 academic year. Published 2021. https://www.ncaa.org/about/resources/research/ncaa-sports-sponsorship-and-participation-rates-database
22. *NCAA Women's Water Polo Championship History*. Published 2021. https://www.ncaa.com/history/waterpolo-women/nc
23. Ramos N, Youssefzadeh K, Gerhardt M, et al. Results of hip arthroscopy in elite level water polo players with femoroacetabular impingement: return to play and patient satisfaction. *J Hip Preserv Surg*. 2020;7(1):116-121. doi:10.1093/jhps/hnz069
24. Sallis RE, Jones K, Sunshine S, et al. Comparing sports injuries in men and women. *Int J Sports Med*. 2001;22(6):420-423. doi:10.1055/s-2001-16246
25. Smith HK. Applied physiology of water polo. *Sports Med*.1998;26(5):317-334.
26. Stromberg JD. Care of water polo players. *Curr Sports Med Rep*. 2017;16(5):363-369. doi:10.1249/JSR.0000000000000409
27. Takahashi T, Ellingson MK, Wong P, et al. Sex differences in immune responses that underlie COVID-19 disease outcomes. *Nature*. 2020;588(7837):315-320. doi:10.1038/s41586-020-2700-3
28. Trigg SD, Schroeder JD, Hulsopple C. Femoroacetabular impingement syndrome. *Curr Sports Med Rep*. 2020;19(9):360-366. doi:10.1249/JSR.0000000000000748
29. *Water Polo: One of America's Fastest Growing Sports!* USAWaterPolo.org. Published 2020. https://usawaterpolo.org/news/2020/4/8/general-water-polo-one-of-americas-fastest-growing-sports.aspx
30. Webster MJ, Morris ME, Galna B. Shoulder pain in water polo: a systematic review of the literature. *J Sci Med Sport*. 2009;12(1):3-11. doi:10.1016/j.jsams.2007.05.014
31. Zuckerman SL, Kerr ZY, Yengo-Kahn A, et al. Epidemiology of sports-related concussion in NCAA athletes from 2009-2010 to 2013-2014. *Am J Sports Med*. 2015;43(11):2654-2662. doi:10.1177/0363546515599634

APPENDIX

APPENDIX TABLE A1
Injury Data by Injury Type for Men's and Women's Water Polo Players in the Pac-12 Conference, 2016 to 2021[a]

	Overall (N = 307 athletes)		Men (n = 142 athletes)		Women (n = 165 athletes)		
Affected	Events	Athletes Affected	Events	Athletes Affected	Events	Athletes Affected	RR (95% CI)
Ligament sprain	103 (14.13)	66 (21.5)	45 (11.08)	28 (19.72)	58 (17.96)	38 (23.03)	0.86 (0.55 -1.32)
Muscle spasm/cramp/soreness	96 (13.17)	51 (16.61)	64 (15.76)	34 (23.94)	32 (9.91)	17 (10.3)	2.32 (1.36-3.98)[b]
Concussion	83 (11.39)	63 (20.52)	45 (11.08)	32 (22.54)	38 (11.76)	31 (18.79)	1.2 (0.77 -1.86)
Tendinopathy/bursitis	73 (10.01)	53 (17.26)	45 (11.08)	30 (21.13)	28 (8.67)	23 (13.94)	1.52 (0.92-2.49)
Muscle strain	62 (8.5)	47 (15.31)	39 (9.61)	27 (19.01)	23 (7.12)	20 (12.12)	1.57 (0.92-2.67)
Hematoma/contusion	29 (3.98)	22 (7.17)	15 (3.69)	14 (9.86)	14 (4.33)	8 (4.85)	2.03 (0.88-4.71)
Synovitis	29 (3.98)	25 (8.14)	17 (4.19)	13 (9.15)	12 (3.72)	12 (7.27)	1.26 (0.59-2.67)
Chronic joint trauma	25 (3.43)	22 (7.17)	11 (2.71)	9 (6.34)	14 (4.33)	13 (7.88)	0.8 (0.35 -1.83)
Fracture	23 (3.16)	22 (7.17)	17 (4.19)	16 (11.27)	6 (1.86)	6 (3.64)	3.1 (1.25-7.71)[b]
Visceral damage/trauma	21 (2.88)	17 (5.54)	17 (4.19)	13 (9.15)	4 (1.24)	4 (2.42)	3.78 (1.26-11.32)[b]
Inflammation	18 (2.47)	15 (4.89)	4 (0.99)	4 (2.82)	14 (4.33)	11 (6.67)	0.42 (0.14 -1.3)
Laceration/abrasion	16 (2.19)	14 (4.56)	9 (2.22)	7 (4.93)	7 (2.17)	7 (4.24)	1.16 (0.42-3.23)
Neural condition/nerve damage	11 (1.51)	11 (3.58)	6 (1.48)	6 (4.23)	5 (1.55)	5 (3.03)	1.39 (0.43-4.47)
Atraumatic arthritis/effusion/joint pain	10 (1.37)	9 (2.93)	5 (1.23)	4 (2.82)	5 (1.55)	5 (3.03)	0.93 (0.25-3.4)
Articular/chondral damage	8 (1.1)	6 (1.95)	2 (0.49)	2 (1.41)	6 (1.86)	4 (2.42)	0.58 (0.11-3.13)
Instability	8 (1.1)	8 (2.61)	6 (1.48)	6 (4.23)	2 (0.62)	2 (1.21)	3.49 (0.71-17)
Dislocation	6 (0.82)	6 (1.95)	4 (0.99)	4 (2.82)	2 (0.62)	2 (1.21)	2.32 (0.43-12.5)

(continued)

Appendix Table A1 (continued)

	Overall (N = 307 athletes)		Men (n = 142 athletes)		Women (n = 165 athletes)		
Affected	Events	Athletes Affected	Events	Athletes Affected	Events	Athletes Affected	RR (95% CI)
Subluxation	5 (0.69)	5 (1.63)	3 (0.74)	3 (2.11)	2 (0.62)	2 (1.21)	1.74 (0.3-10.29)
Stress fracture	3 (0.41)	3 (0.98)	0 (0)	0 (0)	3 (0.93)	3 (1.82)	—
Disc degeneration	2 (0.27)	2 (0.65)	0 (0)	0 (0)	2 (0.62)	2 (1.21)	—
Complete tendon rupture	2 (0.27)	2 (0.65)	0 (0)	0 (0)	2 (0.62)	2 (1.21)	—
Chronic degenerative arthritis	2 (0.27)	2 (0.65)	1 (0.25)	1 (0.7)	1 (0.31)	1 (0.61)	1.16 (0.07-18.41)
Ligament tear	1 (0.14)	1 (0.33)	1 (0.25)	1 (0.7)	0 (0)	0 (0)	—
Bone stress injury	1 (0.14)	1 (0.33)	1 (0.25)	1 (0.7)	0 (0)	0 (0)	—
Unclassified	92 (12.62)	62 (20.2)	49 (12.07)	29 (20.42)	43 (13.31)	33 (20)	1.02 (0.65-1.59)
Total	729 (100)	197 (64.17)	406 (100)	92 (64.79)	323 (100)	105 (63.64)	1.02 (0.86-1.2)

[a]Data are reported as n (%) unless otherwise indicated. Dashes indicate a zero or undefined RR. RR, relative risk, men vs women.
[b]Statistical significance, $P < .05$.