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Epidemiology of Acromioclavicular Joint Injury in Young Athletes

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Background: Acromioclavicular (AC) joint injuries, particularly sprains, are common in athletic populations and may result in significant time lost to injury. However, surprisingly, little is known of the epidemiology of this injury.

Purpose: To define the incidence of AC joint injuries and to determine the risk factors for injury.

Study Design: Descriptive epidemiological study.

Methods: A longitudinal cohort study was performed to determine the incidence and characteristics of AC joint injury at the United States Military Academy between 2005 and 2009. All suspected AC joint injuries were reviewed by an independent orthopaedic surgeon using both chart reviews as well as assessments of radiological imaging studies. Injuries were graded according to the modified Rockwood classification system as well as dichotomized into low-grade (Rockwood types I and II) and high-grade (Rockwood types III, IV, V, and VI) injuries for analysis. Injury mechanisms, return-to-play timing, and athlete-exposures were documented and analyzed. χ^2 and Poisson regression analyses were performed, with statistical significance set at $P < .05$.

Results: During the study period, 162 new AC joint injuries and 17,606 person-years at risk were documented, for an overall incidence rate of 9.2 per 1000 person-years. The majority of the AC joint injuries were low-grade (145 sprains, 89%) injuries, with 17 high-grade injuries. Overall, male patients experienced a significantly higher incidence rate for AC joint injuries than female patients (incidence rate ratio [IRR], 2.18; 95% confidence interval [CI], 1.21-4.31). An AC joint injury occurred most commonly during athletics (91%). The incidence rate of AC joint injury was significantly higher in intercollegiate athletes than intramural athletics when using athlete-exposure as a measure of person-time at risk (IRR, 2.11; 95% CI, 1.31-3.56). Similarly, the incidence rate of AC injury was significantly higher among male intercollegiate athletes when compared to female athletes (IRR, 3.56; 95% CI, 1.74-8.49) when using athlete-exposure as the denominator. The intercollegiate sports of men's rugby, wrestling, and hockey had the highest incidence rate of AC joint injury. Acromioclavicular injuries resulted in at least 1359 total days lost to injury and an average of 18.4 days lost per athlete. The average time lost to injury for low-grade sprains was 10.4 days compared with high-grade injuries at 63.7 days. Of the patients with high-grade injuries, 71% elected to undergo coracoclavicular/AC reconstructions. The rate of surgical intervention was 19 times higher for high-grade AC joint injuries than for low-grade injuries (IRR, 19.2; 95% CI, 7.64-48.23; $P < .0001$).

Conclusion: Acromioclavicular separations are relatively common in young athletes. Most injuries occur during contact sports such as rugby, wrestling, and hockey. Male athletes are at greater risk than female athletes. Intercollegiate athletes are at greater risk than intramural athletes. The average time lost to sport due to AC joint injury was 18 days, with low-grade injuries averaging 10 days lost. High-grade injuries averaged 64 days lost to sport, and 71% elected to undergo surgical repair/reconstruction.

Keywords: acromioclavicular; sprain; epidemiology; risk factor

Acromioclavicular (AC) joint injury is common in young athletes.[7] Most AC joint injuries occur in the third decade of life, and published reports suggest that they occur 5 times as often in male patients as female patients.[9] These injuries are commonly categorized according to the Rockwood classification system,[9] with types I and II typically treated nonoperatively; types IV, V, and VI treated with surgical stabilization; and the treatment of type III injuries remaining controversial within the orthopaedic and sports medicine communities.[7]

While there are several descriptive studies that have examined the incidence of AC joint injury in selected populations,[2-5,10] there are little data from large-scale population-based studies with corresponding athlete-exposure data used in calculating incidence rates for AC joint injuries and the associated risk factors.[2] The purpose of this study was to determine the epidemiology of AC joint

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injury within the physically active cadet population at the United States Military Academy (USMA). Additionally, we intended to examine the relationship among gender, type of sport, level of competition, and incidence of AC joint injuries in a homogeneous cohort and to determine the effect of these injuries by evaluating the rate of surgical repair and time lost to injury. We hypothesized that male sex and participation in collision sports would be associated with higher rates of AC joint injury.

MATERIALS AND METHODS

Study Design and Setting

A longitudinal cohort study was performed to examine the epidemiology of AC joint injuries over a 4-year period between 2005 and 2009 within the cadet population at the USMA utilizing the Cadet Illness and Injury Tracking System (CIITS). This study was approved by the Institutional Review Board at Keller Army Hospital. The population for this study included all cadets in attendance during the study period. All cadets entering the USMA undergo a comprehensive medical evaluation and are required to meet the US Army's physical induction standards when joining the military.[1] During their 4 years at the USMA, cadets are required to participate in intramural, club, or intercollegiate sports in at least 6 semesters of their USMA attendance. Cadets also participate in Department of Physical Education courses and activities, some of which may be gender specific, as well as a biannual Army Physical Fitness Test (APFT). Mandatory military training occurs throughout the cadets' attendance at the USMA. Cadets participate in intensive physical training programs and field-training exercises in addition to mandatory participation in either intramural or intercollegiate athletics. Because of the USMA requirements, documented attendance is required for cadets at all places of duty to include athletics. Attendance is taken and reported for all sporting events, games, and practices. Exposure data are based on daily attendance data documented for every practice and game at the intramural, club, or varsity sport level. The data are reported online through the USMA student information system, which then provides athlete-exposure data for the CIITS. All cadets receive medical care through the closed health care system at the USMA, and all injuries are evaluated through its associated sports medicine and orthopaedic clinics. All injuries resulting in time lost to sports or activity and requiring presentation at a receiving clinic are documented in the CIITS.

Injury Surveillance

Diagnoses were made by an orthopaedic surgeon trained in sports medicine based on patient history, physical examination, and plain radiographs. Radiographs included standard shoulder anteroposterior and axillary views as well as Zanca views. All injuries were traumatic in nature. The Rockwood classification[9] was used for diagnosing the type and severity of AC joint injury. Our grading of injuries was performed using a standardized measurement technique on the anteroposterior radiograph in the injured shoulder assessing the superior cortex of the clavicle and the superior cortex of the acromion. Minimal displacement (<50%) was graded as type II, moderate displacement (50%-100%) was graded type III, and severe displacement (>100%) was graded type V. A type IV injury was assessed on axillary view with posterior displacement. Rockwood type I and II AC injuries were considered low-grade injuries, and types III through VI were considered high-grade injuries. Time lost to injury was the period of disability calculated from start and end dates on the cadet medical excusal in the CIITS, which determines physical limitations imposed by health care providers for cadets during athletics and other physical training activities. When the physical profile is discontinued, this marks the full, unrestricted return to athletics and/or physical training irrespective of sport or level of activity. Patients were offered surgical intervention for AC instability or posttraumatic AC arthrosis.

Data Collection

Injury data were extracted from the CIITS database, and all AC joint and clavicle injuries were identified. Radiographic images and electronic medical records were reviewed, and only new AC joint injuries were included in incidence rate calculations. New AC joint injuries were defined as a primary injury resulting in time lost to sport and activity that occurred within the study period. Injuries sustained before the study period were not included as new AC joint injuries in this study. The primary outcomes of interest were the incidence rate of AC joint injury per 1000 person-years at risk and the incidence rate of AC joint injury per 1000 athlete-exposures. Person-years were calculated from the beginning of the study period until (1) the patient sustained an incidence of AC joint injury, (2) the patient graduated or left the USMA, or (3) the administrative end of the study period on May 23, 2009. Athlete-exposures were defined as one cadet participating in one activity session (eg, game or practice). Recurrent AC joint injuries were not included in incidence rate calculations. Incidence rates are calculated by dividing the total number of injuries observed in a population by a measure of person-time at risk to injury. While athlete-exposure to injury has commonly been used as a measure of person-time at risk in sports injury research, person-years at risk is a more widely used measure of exposure in population-based epidemiological studies. In our population, athlete-exposure is a more precise measure of person-time in the calculation of incidence rates for AC joint injury, and Knowles et al[6] recommended collecting data for person-time at risk to injury as precisely as possible.

Data Analysis

Using data extracted from the CIITS database, incidence rates with 95% confidence intervals were calculated per 1000 person-years at risk by gender, sport, and level of competition for the entire cadet population. Among athletes, incidence rates with 95% confidence intervals were

TABLE 1
Incidence Rates of Acromioclavicular Injury[a]

	Person-Years	Injuries	IR per 1000 Person-Years	IRR	95% CI	Athlete-Exposures	IR per 1000 Athlete-Exposures	IRR	95% CI
Total patients	17,606	162	9.20						
Male	14,995	150	10.00	2.18	1.21-4.31				
Female	2611	12	4.60	—[b]					
Intramural athletes	21,805	21	0.96			225,683	0.09	—[b]	
Intercollegiate athletes	5820	104	17.87			528,523	0.20	2.11	1.31-3.56
Male	4392	96	21.86	3.90	1.90-9.30	407,475	0.24	3.56	1.74-8.49
Female	1428	8	5.60	—[b]		121,048	0.07	—[b]	

[a]IR, incidence rate; IRR, incidence rate ratio; CI, confidence interval.
[b]Not applicable because this category was used as the referent value.

also calculated per 1000 athlete-exposures by gender, sport, and level of competition. Level of competition categories included involvement on an intercollegiate or an intramural level. Intercollegiate sport categories included sports with both men's and women's athletic teams (basketball, rugby, lacrosse, tennis, soccer, track sports) as well as single-gender athletic teams (men's baseball, football, hockey, and wrestling; women's softball and gymnastics). Intramural sport categories include basketball, flag football, combat grappling, football, orienteering, pass n go, soccer, Sandhurst, team handball, ultimate frisbee, and wrestling. Pass n go is similar to ultimate frisbee but uses a football. Sandhurst is a team adventure racing competition involving running in full combat gear and obstacle maneuvering. Incidence rate ratios and respective confidence intervals were calculated between male and female cadets, intercollegiate and intramural athletes, and men's and women's intercollegiate rugby. χ^2 and Poisson regression analyses were used to examine the relationship between the variables of interest and the incidence of AC joint injury. All analyses were carried out using STATA (version 10.1, StataCorp, College Station, Texas), with statistical significance set at $P < .05$ for all comparisons.

RESULTS

Between 2005 and 2009, there were 187 incident injuries to the clavicle or its articulations. Acromioclavicular joint sprains were the most common presenting injury (n = 162, 87% of injuries), followed by fractures (n = 13, 7%), sternoclavicular joint sprains (n = 6, 3%), and inflammation/osteolysis (n = 5, 3%). During the study period, 162 incident AC joint injuries and 17,606 person-years at risk were documented, for an overall incidence rate of 9.2 per 1000 person-years (Table 1).

Of these 162 incident injuries, a similar proportion of patients sustained an injury of the right (89 sprains, 55%) and left (73 sprains, 45%) AC joints. The majority of the AC joint injuries were low grade (145 sprains, 89%), while there were 17 high-grade injuries. The overall distribution of injuries was as follows: type I, 109 (67%); type II, 36 (22%); type III, 16 (10%); and type IV, 1 (1%).

Gender

During the study period, 150 male patients (1.0% of male cadets) sustained an AC joint injury, for an incidence rate of 10.0 sprains per 1000 male person-years. Among female patients, 12 athletes (0.46% of female cadets) sustained an AC injury, for an incidence rate of 4.6 sprains per 1000 female person-years. Male patients, when compared with female patients, had a significantly higher incidence rate for AC joint injury (incidence rate ratio [IRR], 2.18; 95% confidence interval [CI], 1.21-4.31) (Table 1). Male intercollegiate athletes were at greater than 3 times the risk of AC injury compared with female intercollegiate athletes using either the population data (IRR, 3.90; 95% CI, 1.90-9.30) or athlete-exposure–adjusted data (IRR, 3.56; 95% CI, 1.74-8.49) (Table 1).

Level of Competition

Of 5820 at-risk intercollegiate athletes, 104 athletes (96 male, 8 female) sustained AC joint injuries during 528,523 (407,475 male, 121,048 female) athlete-exposures of follow-up, for an overall incidence rate of 0.20 AC joint injuries per 1000 athlete-exposures. The overall incidence rate of AC joint injury among this population was 17.87 AC joint injuries per 1000 person-years. Of the 21,805 at-risk intramural athletes, 21 athletes (20 male, 1 female) sustained AC joint injuries during a total 225,683 athlete-exposures, for an overall incidence of 0.09 injuries per 1000 athlete-exposures. The overall incidence rate of AC joint injury using person-years as a measure to time at risk was 0.96 injuries per 1000 person-years among intramural athletes. The incidence rate of AC joint injuries was significantly higher among intercollegiate athletes when compared with intramural athletes (IRR, 2.11; 95% CI, 1.31-3.56) (Table 1).

Incidence by Sport

The incidence of AC joint injury in selected intercollegiate sports is presented in Table 2. In intercollegiate sports, rugby (incidence rate, 1.16/1000 athlete-exposures), wrestling (incidence rate, 0.43/1000 athlete-exposures), and

TABLE 2
Incidence Rates of Acromioclavicular Injury in Intercollegiate Sports[a]

	Athletes	Injuries	%	High Grade	Athlete-Exposures	IR per 1000 Person-Years	IR per 1000 Athlete-Exposures	IRR	95% CI	P Value
Male sports	2655	96	100	10	299,924	36.16	0.32			
Rugby	289	21	21.88	2	18,115	72.66	1.16	18.73	3.01-774.58	.001[c]
Wrestling	179	6	6.25	1	14,092	33.52	0.43	6.88	0.83-316.43	.048[c]
Hockey	111	6	6.25	3	14,547	54.05	0.41	6.66	0.81-306.53	.052[c]
Judo	133	3	3.13	0	8443	22.56	0.36	5.74	0.46-301.39	.134
Lacrosse	327	8	8.33	1	23,631	24.46	0.34	5.47	0.73-242.71	.075
Tennis	61	2	2.08	0	6227	32.79	0.32	5.19	0.27-306.16	.211
Football	1298	46	47.92	3	181,622	35.44	0.25	4.09	0.70-165.10	.113
Nordic skiing	72	2	2.08	0	8809	27.78	0.23	3.67	0.19-216.42	.330
Power lifting	92	1	1.04	0	8281	10.87	0.12	1.95	0.02-153.15	.678
Basketball	93	1	1.04	0	16,157	10.75	0.06	—[b]		
Female sports	408	8	100	0	24,795	19.61	0.32			
Rugby	211	6	75	0	17,155	28.44	0.35	1.34	0.24-13.54	.771
Track	197	2	25	0	7640	10.15	0.26	—[b]		

[a]IR, incidence rate; IRR, incidence rate ratio; CI, confidence interval.
[b]Not applicable because this category was used as the referent value.
[c]The relative risks of acromioclavicular injury in men's rugby, wrestling, and hockey are statistically greater than in men's basketball.

TABLE 3
Incidence Rates of Acromioclavicular Injury in Intramural Sports[a]

	Athletes	Injuries	%	High Grade	Athlete Exposures	IR per 1000 Person-Years	IR per 1000 Athlete-Exposures	IRR	95% CI	P Value
Sandhurst	508	2	10	0	3100	3.94	0.65	6.14	0.45-84.76	.107
Rugby	878	4	20	1	6976	4.56	0.57	5.46	0.78-60.36	.054
Football	1918	8	40	0	22,466	4.17	0.36	3.39	0.68-32.78	.111
Ultimate frisbee	1099	2	10	1	10,441	1.82	0.19	1.82	0.13-25.17	.575
Grappling	1475	2	10	0	13,367	1.36	0.15	1.42	0.10-19.66	.740
Wrestling	1637	2	10	0	19,046	1.22	0.11	—[b]		
Pass n go	900	1	5	0	8791	1.11	0.11	1.08	0.02-20.81	.916
Total	7907	21	100	2	81,087	2.66	0.26			

[a]IR, incidence rate; IRR, incidence rate ratio (per 1000 athlete-exposures); CI, confidence interval.
[b]Not applicable because this category was used as the referent value.

hockey (incidence rate, 0.41/1000 athlete-exposures) had the highest incidence rates by athlete-exposures. Among women's intercollegiate sports, the majority of AC joint injuries occurred in rugby (75%), with the remaining injuries occurring in track (25%).

The incidence of AC joint injury in selected intramural sports is listed in Table 3. In intramural sports, Sandhurst (0.65), rugby (0.57), and football (0.36) had the highest incidence rates per 1000 athlete-exposures. Gender differences were not available for intramural sports, as both male and female athletes compete together on many sports teams with the exception of rugby and football.

Time Lost to Sport

Of the 125 intercollegiate and intramural athletes with AC injuries, 74 patients (59.2%) had reportable time lost information. Acromioclavicular injuries resulted in at least 1359 total days lost to injury and an average of 18.4 days lost per athlete. The average time lost to injury for low-grade sprains was 10.4 days compared with high-grade injuries at 63.7 days. This did not reach statistical significance likely because of the low numbers of high-grade injuries (P = .18).

Subsequent Surgeries

Of the 145 low-grade injuries, 6 patients (4%) underwent subsequent distal clavicle resection, and an additional 12 (8%) underwent ipsilateral shoulder surgery for a glenohumeral condition (labral repair). Of the 17 high-grade injuries, 12 patients (71%) underwent AC/coracoclavicular reconstruction. The rate of surgical intervention in the AC joint after injury (AC/coracoclavicular reconstruction or distal clavicle resection) was significantly higher for high-grade AC joint injuries compared with low-grade injuries (IRR, 19.2; 95% CI, 7.64-48.23; $P < .0001$).

DISCUSSION

Our study determined that AC joint injuries are common in young athletes, with an incidence rate of 9.2 per 1000 person-years in our population. The study by Nordqvist and Petersson[8] reported that AC joint injury represents 4% of all shoulder injuries in a Swedish urban population of 250,000; however, they did not estimate incidence rates for AC joint injury. It was not a cohort study and only included those persons who presented for treatment. The strength of the present study is that it examines incident injuries in a young athletic cohort participating in multiple sports and includes athlete-exposure data.

Male patients were twice as likely to sustain an AC joint injury as their female counterparts in our population. This finding differs from that previously reported by Rockwood et al[9] and Nordqvist and Petersson,[8] who noted that male patients were 5 and 8 times more likely to experience an AC joint injury than female patients, respectively. This may be because our cohort was much younger and highly active, with female athletes participating in more potentially injurious activities.

Male intercollegiate athletes are over 3.5 times more likely to sustain AC joint injuries when compared with their female counterparts. This is certainly a result of the higher proportion of contact sports in which male athletes participate. However, the rate was fairly consistent when comparing the same sport with similar athlete-exposures, as male rugby players were 3 times more likely to sustain an AC joint injury than were female rugby players. This may be explained by the overall larger size and potentially more aggressive play of male athletes. In addition, very few female injuries were observed from a limited number of sports, so rates might be different in a larger population of female athletes.

To our knowledge, this is the first study to document the incidence rate of AC joint injury incurred by participation in over 20 different intercollegiate sports within a single cohort. Male intercollegiate athletes in rugby, wrestling, hockey, judo, and lacrosse had the highest rates of AC joint injury, whereas the female sport that had the highest rate of AC joint injury was rugby. Traditionally, an increased rate of AC joint injury has been observed in football, rugby, and hockey.[2-5] In these high-risk sports, athletes frequently encounter forceful contact with other players and the playing surface, which exposes the shoulder to increased risk of AC joint injury. In our analysis, the incidence rate of AC joint injury was less than 1.2 per 1000 athlete-exposures in all sports combined. With the exception of football, these results have no comparison in the literature. In intercollegiate football, the incidence rate of AC joint injury in the current study was 0.25 per 1000 athlete-exposures, which was within the range reported by Dick et al.[2] They reported that the incidence rate of AC joint injury was 0.98 and 0.07 per 1000 athlete-exposures, in games and practices, respectively, across all National Collegiate Athletic Association Division I, II, and III teams during a 16-year period.

Intercollegiate athletes were twice as likely to sustain an AC joint injury when compared with intramural athletes based on measures of incidence that used athlete-exposure as a measure of person-time at risk for injury. This can be explained by the higher level of play in intercollegiate sports. Interestingly, football accounted for approximately 40% of both intercollegiate and intramural injuries, with rugby also accounting for roughly 20% of each.

Clearly, these 2 sports are among the most collision-heavy contact sports. Football uses protective shoulder pads, while rugby does not, although methods of tackling technique are different. These data may have some implications for preventive study focusing on shoulder pad wear.

Nearly 90% of all AC joint injuries were low-grade separations consistent with Rockwood type I and II injuries. In a review of 520 AC joint injuries treated at their institution, Rockwood et al noted a ratio of low-grade to high-grade injuries of 2:1.[9] This difference is likely because many patients with type I and II injuries never seek care. The current study provides a more accurate indication of the true incidence of injury in an athletic population, as nearly all injuries were included in this study, regardless of whether they were originally seen by a physician for treatment. As expected, the overall majority of injuries were relatively minor.

Time lost to injury was markedly higher for high-grade AC joint injuries than for low-grade injuries. Although the difference in time loss by injury severity was not statistically significant, it is important to note that athletes sustaining a high-grade AC joint injury were lost to sports for an average of 2.5 months versus 2 weeks for low-grade injuries, which is clearly of clinical importance. It is likely that the lack of a statistical difference between these groups is because of the limited number of high-grade injuries observed in our cohort.

Athletes with high-grade injuries were far more likely to undergo surgery. Nearly three quarters of all patients with a high-grade injury ultimately underwent coracoclavicular ligament reconstruction to return to their previous level of activity. Of those who sustained a low-grade injury, only 12% ultimately underwent surgical repair. In a review of 336 elite collegiate football players invited to the National Football League Combine, Kaplan et al[5] noted 93 players with a history of AC joint injury, of which 11.8% underwent surgery (8 distal clavicle resections and 3 Weaver-Dunn procedures). They did not indicate the severity of injury in their study. The high proportion of cadets undergoing surgery in the current study may be explained by the physical demands placed on the cadets both in athletics and military training while at the USMA. In addition to common overhead activity (eg, push, pull, climb, crawl), the cadets are required to complete combative training, complete a demanding indoor obstacle course, wear body armor for extended periods, and carry heavy rucksacks (backpacks), which place excessive strain on an unstable AC joint, over long distances in order to graduate. As a result, this latter requirement of wearing a rucksack and carrying a heavy load is particularly problematic with any residual AC joint instability or pain.

The authors acknowledge the limitations inherent to any large database study. First, because of limited patient history, we could not fully exclude all patients with AC injury sustained before matriculation at the USMA. Recurrent sprains during the study period were not included in the calculation of incidence, and any patients with a prior recorded sprain during attendance at the USMA were excluded at the onset of this study. Second, multiple providers evaluated and coded the patient encounters, which may decrease the accuracy of the diagnosis of AC joint injury. In addition, the lack of standardization of treatment protocols and timing considerations for surgical intervention may influence the interpretation of the time loss data. This study was not designed to be a natural history study of AC sprain and should not be interpreted as such. The variability and subjectivity of surgical indications may have influenced our high rate of surgery in the high-grade injuries. Despite these limitations, the data from this closed longitudinal cohort study represent the first estimates of the incidence of AC joint injury in a young and athletic population and can guide future research as well as strategies for risk reduction and injury prevention in at-risk groups. The greatest strength of this study is the large number of athletes (greater than 10,000 person-years at risk) and the corresponding athlete-exposure data that were captured within the closed health care system and annotated in the CIITS database. As a result of this closed cohort, our study can more adequately assess the true incidence of AC joint injury in a collegiate athletic population.

CONCLUSION

Overall, the incidence of AC joint injury in a young athletic cohort was 9.2 injuries per 1000 person-years. Male athletes were twice as likely as female athletes to experience an AC joint injury in our cohort. Among male intercollegiate athletes, the incidence rate of AC joint injury was even higher, with male athletes being over 3.5 times more likely than female athletes to sustain an AC injury. Intercollegiate athletes were twice as likely to sustain an AC joint injury when compared to intramural athletes. The intercollegiate sports of rugby, wrestling, hockey, judo, and men's lacrosse had the highest incidence rates of AC joint injury. Nearly 90% of all AC joint injuries were low-grade (types I and II) injuries, and those sustaining a high-grade (types III-VI) injury were far more likely to undergo surgery compared with those with low-grade injuries.

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