The Incidence and Characteristics of Shoulder Instability at the United States Military Academy

MAJ Brett D. Owens,[*†] MD, Michele L. Duffey,[†] MS, LTC Bradley J. Nelson,[‡] MD, LTC Thomas M. DeBerardino,[†] MD, COL (ret) Dean C. Taylor,[§] MD, and Sally B. Mountcastle,[†] PhD

From the [†]Orthopaedic Surgery Service, Keller Army Hospital, US Military Academy, West Point, New York, [‡]Department of Orthopaedic Surgery, University of Minnesota, Minneapolis, Minnesota, and the [§]Division of Orthopaedic Surgery, Duke University Medical Center, Durham, North Carolina

Background: The literature provides little information detailing the incidence of traumatic shoulder instability in young, healthy athletes.

Hypothesis: Shoulder instability is common in young athletes.

Study Design: Descriptive epidemiologic study.

Methods: We prospectively captured all traumatic shoulder instability events at the United States Military Academy between September 1, 2004, and May 31, 2005. Throughout this period, all new traumatic shoulder instability events were evaluated with physical examination, plain radiographs, and magnetic resonance imaging. Instability events were classified according to direction, chronicity, and type (subluxation or dislocation). Subject demographics, mechanism of injury, and sport were evaluated.

Results: Among 4141 students, 117 experienced new traumatic shoulder instability events during the study period; 11 experienced multiple events. The mean age of these 117 subjects was 20.0 years; 101 students were men (86.3%), and 16 were women (13.7%). The 1-year incidence proportion was 2.8%. The male incidence proportion was 2.9% and the female incidence proportion was 2.5%. Eighteen events were dislocations (15.4%), and 99 were subluxations (84.6%). Of the 99 subluxations, 45 (45.5%) were primary events, while 54 (54.5%) were recurrent. Of the 18 dislocations, 12 (66.7%) were primary events, while 6 (33.3%) were recurrent. The majority of the 117 events were anterior in nature (80.3%), while 12 (10.3%) were posterior, and 11 (9.4%) were multidirectional. Forty-four percent (43.6%) of the instability events experienced were as a result of contact injuries, while 41.0% were a result of noncontact injuries, including 9 subluxations caused by missed punches during boxing; information was unavailable for the remaining 15%.

Conclusion: Glenohumeral instability is a common injury in this population, with subluxations comprising 85% of instability events.

Keywords: shoulder; instability; dislocation; subluxation; epidemiology; incidence; mechanism

The glenohumeral joint has the greatest range of motion of all joints in the human body. Unfortunately, glenohumeral instability is a common musculoskeletal problem that leads to pain, decreased ability to participate in high-level activities, and a decrease in overall health.[2,3]

There are few reports detailing the incidence of shoulder instability. Simonet et al[14] reviewed patients treated at a facility for more than 10 years and estimated the incidence rate of primary anterior shoulder dislocation in the general population in Olmstead County, Minnesota, to be 8.2 per 100 000 person-years. Kroner et al[7] estimated 17 dislocations per 100 000 person-years for the total population of Aarhus, Denmark, which is an urban population of 250 000. In 1995, Nordqvist and Petersson[10] reported a shoulder dislocation incidence of 23.9 per 100 000 person-years among an urban population in Malmo, Sweden. Despite the efforts of these studies, it is often difficult to determine the true incidence of instability in an open population

*Address correspondence to MAJ Brett D. Owens, MD, Keller Army Hospital, US Military Academy, West Point, NY 10996 (e-mail: b.owens@us.army.mil).

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because of the number of people entering and leaving a population at any one time, and due to the fact that all events in a population are not captured by 1 facility.

There are also few reports detailing the incidence of shoulder subluxation as most studies include only dislocations. It is important to understand both the populations at risk for shoulder instability and risk factors associated with injury so that preventive strategies can be developed and implemented. Thus, we sought to determine the incidence and characteristics of shoulder instability events in a closed cohort of young, active, college-aged men and women during an academic year. Our hypothesis was that shoulder instability events were not only common injuries in this population but even more common than previously reported.

METHODS

This study, approved by our Institutional Review Board, investigated the cases of new traumatic shoulder instability events at our institution between September 1, 2004, and May 31, 2005 (1 academic year).

Study Definitions

Traumatic shoulder instability events were defined as instability events that resulted in a consequent diagnosis of glenohumeral instability by an orthopaedic surgeon, based on history as well as physical examination consistent with instability: anterior/posterior apprehension sign, relocation sign, sulcus sign, and the load-shift test. Subluxations were defined as instability events that did not require manual reduction by a health care provider; dislocations were defined as those instability events that required a manual reduction by a health care provider. New events were defined as events that occurred within the study time period; only the first instability events per shoulder per patient during the study period were considered new and were included in this analysis. Therefore, a shoulder may have subluxated or dislocated before the study initiation, but if a patient was seen during the study period for the first time with this injury, it would be counted as a "new" event in this study.

The chronicity of instability events was also defined. Primary subluxations or dislocations occurred if the patient experienced an instability event but had no history of any instability (dislocation or subluxation) in the involved shoulder. Events were classified as recurrent subluxations or dislocations if the patient had a history of at least 1 of either type of instability event in the involved shoulder either before the study time period or during the study time period.

Anterior instability was defined as a subluxation or dislocation in an anterior or anteroinferior direction. Posterior instability was defined as an instability event in any posterior direction (ie, posterosuperior, posteroinferior, posterior). Instability events were classified as multidirectional instability when an individual experienced an instability event of unknown direction and on physical examination was determined to have excessive glenohumeral translation in an inferior as well as anterior or posterior direction.[9]

Data Collection

We prospectively tracked all shoulder instability events that occurred in our population during the study period. All students at our institution were required to participate in organized physical activities, and if they were injured, they required an evaluation by a physician to be excused from these activities. Therefore, any significant musculoskeletal injuries among students in our closed population presented for evaluation and were documented shortly after injury. During the study period, all subjects with a shoulder complaint were referred to the orthopedic surgery service within 72 hours of initial care. An orthopedic surgeon evaluated the subject with a focused history and physical examination. A diagnosis of glenohumeral instability was made based on a history of a traumatic event and physical examination consistent with instability: anterior and posterior apprehension sign, relocation sign, sulcus sign, and the load-shift test (anterior, inferior, and posterior directions). Once the diagnosis of an instability event was made, our instability imaging protocol was ordered: anteroposterior radiograph, West Point axillary radiograph, and standard noncontrast magnetic resonance imaging (MRI) study.

To ensure that all eligible subjects were captured in our cohort, a database of International Classification Diagnosis (ICD-9) codes for all student-body health care visits was queried monthly for all ICD-9 codes related to shoulder instability to cross-check the study list.

Data Analysis

For this analysis, we included only new events, and therefore only the first instability event per shoulder per patient during the specified study period was included. We determined the incidence proportion (IP) of shoulder instability events, which is the proportion of an at-risk closed population that becomes injured within a given time period.[12] The unit of analysis is the student, and the IP provides the average probability—across all students—that the student will be injured during a 1-year period at our institution.[6] Therefore, the numerator is the number of injured students, and the denominator is the number of students at risk.[6] We present descriptive data for several different epidemiologic variables of interest, such as gender, sport, mechanism of injury, year group, type of injury, for example, contact versus noncontact, and the mean number of prior instability events. All events were included in the analysis irrespective of whether plain radiographs or MRIs were obtained. Magnetic resonance imaging results are presented for those events for which they were available. Statistical calculations were performed with SAS (Cary, NC) with a significant P value set at .05.

RESULTS

Among 4 141 students (3 509 men and 632 women), 117 subjects sustained a new traumatic instability event during the

TABLE 1
Direction and Chronicity of Shoulder Dislocations and Subluxations

	Dislocation (n = 18)		Subluxation (n = 99)		Total
Direction	First Time	Recurrent	First Time	Recurrent	(% of total)
Anterior	12	5	38	39	94 (80)
Posterior	0	1	5	6	12 (10)
MDI[a]	0	0	2	9	11 (10)
Total	12	6	45	54	117 (100)

[a]Multidirectional instability.

TABLE 2
Sport Activity During Which Shoulder Instability Occurred

Sport	Total Number With Injury (% of total)	Participants	Estimated Exposures
Boxing	19 (16.2)	1,354	26 118
Football	18 (15.4)	871	280 954
Military movement gymnastics course	13 (11.1)	1,157	21 638
Indoor obstacle course test	10 (8.5)	2 898	2 898
Rugby	8 (6.8)	529	8 983
Wrestling/ martial arts	7 (5.9)	2 287	40 780
Skiing/ snowboarding	7 (5.9)	80	5 439
Weight lifting	6 (5.1)	N/A	N/A
Army physical fitness test	5 (4.2)	3 976	3 976
Military training	5 (4.2)	N/A	N/A
Hockey	4 (3.4)	30	3 003
Soccer	2 (1.7)	579	12 140
Swimming	2 (1.7)	1 299	31 270
Handball	1 (0.9)	336	7 515
Cheerleading	1 (0.9)	22	3 170
Surfing	1 (0.9)	N/A	N/A
Track (hammer throw)	1 (0.9)	N/A	N/A
Waterskiing	1 (0.9)	N/A	N/A
Data missing	5 (4.2)	N/A	N/A
Total	116	15 418	447 884

time period and compose the study population. Eleven of these individuals sustained more than 1 instability injury during the time period.

Ninety-seven percent (n = 114) of the subjects during the time period were evaluated by an orthopaedic surgeon. Three subjects were not evaluated by an orthopaedic surgeon but were evaluated by another health care provider and identified by the monthly ICD-9 query. A review of these medical records revealed adequate documentation of the injuries to ensure a diagnosis of instability. Therefore, we are confident that all new traumatic instability events during the time period were captured and identified. The incidence proportion for 1 academic year is 0.028. Thus, the probability that any student at the institution will sustain at least 1 shoulder instability event during the course of 1 academic year is 2.8%.

Study Population and Injury History

In the study population, 101 students were men (86.3%) and 16 were women (13.7%) with a mean age of 20.0 years. This gender difference is proportional to the entire student population at our institution, of which approximately 15% is women. The male incidence proportion was 2.9%, and the female incidence proportion was 2.5%. The incidence proportion ratio of these values was 0.89 (confidence interval [CI], 0.52, 1.47), $P = .70$.

The majority of the instability events were anterior in nature (80.3%), while 12 (10.3%) were posterior events, and 11 (9.4%) were multidirectional (Table 1). Five of the 11 multidirectional events occurred in female subjects, and these events comprised 31% of all female instability events. The female incidence proportion for multidirectional instability (MDI) events was 0.008, and the male incidence proportion was 0.002 ($P = .02$).

More freshmen (37.6%) and sophomores (25.6%) were injured than juniors (17.9%) and seniors (16.2%). This predilection toward instability in younger students occurred at a greater rate than would be expected from the respective class sizes: freshman 1144 (27.6%), sophomore 1136 (27.4%), junior 908 (21.9%), and senior 953 (23.0%).

Of the 117 new traumatic instability events, 18 were dislocation events (15.4%), and 99 were subluxation events (84.6%) (Table 1). Of the 99 subluxation events, 45 (45.5%) were primary events, while 54 (54.5%) were recurrent. Among the 54 patients with recurrent subluxations, 36 (66.7%) experienced only prior subluxations, 7 (13.0%) experienced only prior dislocations, 5 (9.3%) experienced prior subluxations and dislocations, and 6 (11.1%) subjects were missing specific information on history of instability although prior instability was documented. Among those with prior subluxations for whom instability history was documented (n = 41), 7 (17.1%) had 1 to 2 prior subluxations, 12 (29.3%) had 3 to 4 prior subluxations, 5 (12.2%) had 5 to 7 prior subluxations, 14 (34.1%) had ≥10 subluxations, and the data on the number of prior subluxations were missing in 3 (7.3%) patients.

Of the 18 dislocations, 12 (66.7%) were primary events, while 6 (33.3%) were recurrent. Among the 6 recurrent dislocations, 3 (50.0%) had prior dislocations only, 2 (33.3%) had a prior subluxation only, and 1 (16.7%) had a history of both. Among those with prior dislocations (n = 4) 2 (50.0%) had 1 prior dislocation, and 1 each (25.0%) had 2 and 3 prior dislocations.

All injuries occurred in athletics except for one, which occurred during a motor vehicle accident. The most common sport causing an event was boxing (16.2%), followed by football (15.4%) (Table 2). For 5 subjects, the activity at time of injury was missing. Forty-four percent (43.6%) of the instability events experienced were a result of contact

TABLE 3
Mechanism of Injury for Traumatic, Shoulder Instability Events

Mechanism of Injury	Total Number With Injury (% of total)
Thrown or missed punch	17 (14.5)
Collision	17 (14.5)
Fall	18 (15.4)
Weight bearing overhead arm	12 (10.3)
Pull-ups	8 (6.8)
Push-ups	6 (5.1)
Military low-crawl	6 (5.1)
Throwing an object	2 (1.7)
Other, specified	10 (8.5)
Unspecified	21 (17.9)
Total	117

injuries, 41.0% were as a result of noncontact injuries, and 15.4% were missing the type of injury. Mechanism of injury (MOI) was specified for 96 (82.1%) of the 117 injuries during the time period (Table 3). The most common specified MOI was from a fall (15.4%), followed by a collision (14.5%). The most common noncontact injury occurred during boxing as the result of a missed punch (14.5%).

Radiographic Results

Plain radiographs were obtained in 108 of the 117 subjects (92.3%). Fourteen (13.0%) subjects had radiographic evidence of a Hill-Sachs lesion, while none had reverse Hill-Sachs lesions. Eighteen (16.7%) subjects had radiographic evidence of a bony Bankart lesion, while 1 subject had a reverse Bankart lesion.

MRI Results

Magnetic resonance images were obtained on 94 of 117 subjects in the cohort (80.3%) and revealed labral tears in 53 (56.4%) and humeral head osteochondral lesions in 48 (51.1%) (Table 4). Specifically, among subjects with subluxations and MRI results, there were 39 (49.4%) with labral tears and 36 (45.6%) with humeral head osteochondral lesions. Among subjects with dislocations and MRI results, there were 14 (93.3%) with labral tears and 12 (80.0%) with humeral head osteochondral lesions. Considering only those with a primary instability event with MRI results (n = 48), 28 (58.3%) experienced labral tears and 28 (58.3%) displayed humeral head osteochondral lesions.

DISCUSSION

While shoulder instability is a common athletic injury, little is known of the incidence of this condition. As with any musculoskeletal injury or disease, an improved understanding of the risk factors and populations at risk are essential before any preventive strategies can be developed and employed. The experience at our institution suggested a high incidence of traumatic shoulder instability.[1,2,18] We sought to formally determine the incidence and characteristics of this injury in this young, active population.

In our closed cohort we found the probability that a student will sustain at least 1 shoulder instability event during the course of the academic year to be 2.8%. This includes subluxation events and dislocations. If only considering the 18 dislocations among 4175 students during 1 academic year, the probability drops to 0.43%. This value is 1 order of magnitude greater than that reported in the literature.[7,10,14] This can be explained by both the age and activity level of our cohort, as well as excellent capture of all injury events in our closed system. However, complete athletic exposure time was not available for this analysis and, therefore, the instantaneous rate of development of injury in the population is not available.

The activities that were associated with the greatest number of instability events reflect those sports that involve throwing punches, collisions, and falls. Nineteen injuries (16%) were associated with boxing, which is a mandatory physical education class for all male students and therefore occurred only in males. Interestingly, 9 of these injuries occurred during a missed punch, and all resulted in an anterior shoulder subluxation. The mechanism of a missed punch causing a shoulder subluxation has not been previously reported to our knowledge. This is a common mechanism for shoulder instability in our population and seems to result from the unexpected unopposed anterior momentum of the upper extremity causing subluxation or dislocation of the shoulder.

The football injuries (n = 18, 15%) occurred in the intramural football program and 2 intercollegiate programs (Division IA and lightweight/sprint football). All but 3 of the injuries with specified mechanisms of injury occurred during a fall or tackle. The gymnastics injuries occurred during a mandatory physical education class that incorporates both gymnastic events and a challenging obstacle course test. Yeap et al[19] reported sports as the injury event in only 5.3% of dislocations in Malaysia. However, each of the other shoulder instability epidemiologic studies performed in Western populations found that between 25% and 37% of events were associated with sports.[5,7,10,14] We found that 96.6% of the injuries were associated with a sporting event, but our results are difficult to compare because of the inclusion in the other reports of many different age groups. In addition, the unique demands placed on our population in regard to athletic and military training exposures make comparisons difficult.

The male predominance in our instability population (male to female ratio of 6.3:1) was not surprising. The cohort that was studied consisted of 4141 students, of which 632 are women (male to female ratio, 6.5:1). A male predominance has been reported to be from 2:1 to 4.25:1 in studies evaluating a general population.[5,7,10,14,19] Of note, our female population sustained a higher proportion of multidirectional events than did the male population.

The direction of instability in our study was primarily anterior (88%) in nature. Of our 18 dislocation events, 17 (94%) were anterior. This is very consistent with previous

TABLE 4
Pathologic Abnormalities Demonstrated on Magnetic Resonance Imaging by Direction of Instability, Type of Instability, and Chronicity of Instability Experienced in the Cohort

Direction	Type of Instability	Chronicity	Number of Events	Number of MRI Obtained	Number of Labral Tears on MRI (% of total)	Number of Hill-Sachs on MRI (% of total)
Anterior	Dislocation	1st Time	12	10	9 (90)	8 (80)
		Recurrent	5	4	4 (100)	4 (100)
	Subluxation	1st Time	38	34	18 (53)	18 (53)
		Recurrent	39	29	14 (48)	13 (45)
Posterior	Dislocation	1st Time	0	0	0	0
		Recurrent	1	1	1 (100)	0 (0)
	Subluxation	1st Time	5	4	1 (25)	2 (50)
		Recurrent	6	6	4 (67)	1 (17)
MDI[a]	Dislocation	1st Time	0	0	0	0
		Recurrent	0	0	0	0
	Subluxation	1st Time	2	0	0	0
		Recurrent	9	6	2 (33)	2 (33)
Total			117	94	53 (56%)	48 (51%)

[a]Multidirectional instability.

reports. Kroner et al[7] and Yeap et al[19] reported 97% and 98% anterior dislocations, respectively. One unexpected finding in our study was the large proportion (85%) of shoulder instability events that were subluxations. Subluxations have received relatively little attention in the literature.[4,8,13,17] However, in our population, subluxation comprised the majority of instability events and was associated with MRI findings of labral tears in 49.4%.

The instability events seen in this study were associated with a high rate of pathologic lesions. Eighty percent of the injuries were evaluated with plain radiographs and MRI, the latter of which demonstrated labral tears in 56% and Hill-Sachs lesions in 51%. That the anterior dislocations showed Bankart lesions in 93% and Hill-Sachs lesions in 86% is hardly surprising. While the true incidence of Bankart and Hill-Sachs lesions among a cohort of patients sustaining glenohumeral dislocations has not been determined, the presence of pathologic changes noted via arthroscopy in those patients who elect surgical intervention has been documented at 97% for Bankart lesions and 90% for Hill-Sachs lesion.[15] Our patients who had sustained anterior subluxations had Bankart lesions noted in 49% and Hill-Sachs lesion noted in 48%. There are no known reports of the pathologic changes associated with this injury for comparison. This finding warrants further study, specifically into the labral injuries of patients with first-time subluxations as well as the natural history of this injury.

CONCLUSION

Traumatic shoulder instability is a common entity in young athletes. The majority of these events are anterior subluxation events. The mechanism of a missed punch during boxing causing shoulder subluxation is interesting. This study highlights the large relative number of subluxations, which our results suggest are associated with a significant amount of articular injuries.

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