Non-modifiable Risk Factors Associated with Sternoclavicular Joint Dislocations in the U.S. Military

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ABSTRACT INTRODUCTION: Sternoclavicular joint (SCJ) dislocations, although uncommon, are observed in patients with ligamentous laxity as well as those who experience traumatic injuries. The incidence and epidemiology of this costly and debilitating injury to our relatively young and active military population have not previously been reported. The purpose of this study is to consider and quantify the non-modifiable risk factors associated with this injury. METHODS: Using Defense Medical Epidemiological Database, first-time occurrences, from 2006 to 2015 for the ICD-9-CM code 839.61 (closed dislocation of the SCJ), were obtained and further categorized by gender, race, age, rank, and branch of service. Race was classified based on self-reporting of patients into White, Black, or other categories. Age was divided into the categories of less than 20 yr, 20–24 yr, 25–29 yr, 30–34 yr, 35–39 yr, and greater than 40 yr. Rank was categorized as junior enlisted (E-1 to E-4), senior enlisted (E-5 to E-9), junior officer (O-1 to O-3), and senior officer (O-4 to O-10). Branch of service includes Army, Navy, Air Force, and Marines. Multivariate data analysis was performed to obtain rate per 1,000 person-years as well as adjusted rate (adjusted for age group, gender, race, rank, and service) to isolate risk factors. RESULTS: Between 2006 and 2015, 427 cases of closed SCJ dislocations occurred among an at-risk population of 13,772,342 person-years for an unadjusted incidence rate (IR) of 0.031 per 1,000 person-years. The annual unadjusted IR ranged from 0.017 in 2006 to 0.059 in 2014 with the greatest increase occurring between 2006 and 2007 representing 61% increase in the rate of injuries. Males were almost twice as likely to sustain these injuries compared with females (adjusted rate ratio 1.73; 95% confidence interval [CI] 1.23, 2.43). Age was not found to be a risk factor for the development of these injuries with IRs for each age group overlapping with 95% CI for all other age groups. Similarly, the other category for race was also not found to be a statistically significant risk factor. Junior Officers (adjusted rate 0.017; 95% CI 0.011, 0.025) were found least likely to suffer from these injuries with Junior Enlisted (0.034; 95% CI 0.030, 0.040) and Senior Enlisted (0.032; 95% CI 0.028, 0.037) most at risk. Being in the Navy (0.019; 95% CI 0.015, 0.025) was found to be most protective compared with Air Force (0.032; 95% CI 0.026, 0.039), Army (0.036; 95% CI 0.031, 0.041), and Marines (0.036; 95% CI 0.028, 0.045). DISCUSSION and CONCLUSION: Annual unadjusted IR of SCJ dislocations readily increased from 2006 to 2014. Statistically significant risk factors, for suffering a closed SCJ dislocation, identified by our study, were male sex, enlisted rank, and branch of service other than Navy. Age and race were not found to have a statistically significant risk. These results can shed light on non-modifiable risk factors for dislocations of the SCJ and can be used in other studies to aid in reducing injury burden on the U.S. Military.

INTRODUCTION

The sternoclavicular joint (SCJ) is a diarthrodial saddle joint that connects the upper extremity to the axial skeleton.[1,2] Although relatively rare, dislocations of the SCJ account for 3% of all shoulder girdle dislocations. These injuries can have significant complications including compression of major neurovascular structures and tracheal obstruction, with reported mortality rates of 0.4% associated in these injuries.[1–4] With minimal direct contact between the clavicular head and the manubrial notch, integrity of the SCJ is maintained primarily by the strong anterior and posterior ligamentous/capsular complex and costoclavicular ligaments.[5] Damage to either of these ligaments predisposes individuals to SCJ dislocation.

Typically, SCJ dislocations result from high-energy, traumatic injuries such as sports collisions, motor vehicle accidents, or falls from heights.[6] Thus, the exhaustive demands and increased risk for trauma experienced by a military population suggest that this cohort may be at a heightened risk for SCJ dislocation.[7–9] Atraumatic dislocation can also be clinically observed in patients with hypermobility syndromes, clavicular deformity, abnormal muscular patterns, infection, or generalized ligamentous laxity.[10–12]

Anterior dislocation is the most common type of dislocation to the SCJ, with a reported incidence up to nine times that of posterior dislocation.[13–15] This injury is often caused by indirect force to the shoulder through an abducted arm and is typically treated nonoperatively with conservative management.[16] Because the posterior capsule has 50% more

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strength than the anterior capsule, posterior SCJ dislocations are significantly less common as their mechanism of injury requires a greater force.[17–19] Posterior dislocations present a more immediate problem due to complications related to the local anatomy of the mediastinum. Such complications can include brachiocephalic and subclavian venous obstruction, dysphagia, esophageal compromise, tracheoesophageal fistula, neurologic damage, major laceration of the great vessels, and thoracic outlet syndrome.[1,2,20–23]

This study aims to determine the primary intrinsic risk factors for SCJ dislocation within a military population. By identifying individuals at an elevated risk for this injury, future patients can be identified and treated before their symptoms become life-threatening. Based on the previous literature, the authors of this study hypothesized that there will be an increased incidence of SCJ dislocations among the younger, male populations of enlisted rank and in branches of service that are typically exposed to more intensive training and operational experience such as the Army and Marines.[1,2,24] This study is particularly important because of the significant risks and complications associated with an SCJ dislocation and because this is the first study designed to consider these non-modifiable risk factors associated with this injury in a military population.

MATERIALS AND METHODS

After obtaining Institutional Review Board approval, the Defense Medical Epidemiology Database (DMED) was retrospectively queried for epidemiology and incidence rates (IRs) of injury among ambulatory and active duty service members. DMED was selected due to its extensive reporting of demographic and military service information, which is obtained from the Armed Forces Health Longitudinal Technology Application and its predecessor Composite Health Care System II. DMED was queried for first-time occurrences from 2006 to 2015 for the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) code 839.61 (closed dislocation of the SCJ). Results were further categorized by age, sex, race, rank, and branch of service. Age was classified into the following categories: less than 20 yr, 20–24 yr, 25–29 yr, 30–34 yr, 35–39 yr, and greater than 40 yr. Race was stratified based on self-reported categories of White, Black, and other categories. Rank was categorized as Junior Enlisted (grade E-1 to E-4), Senior Enlisted (grade E-5 to E-9), Junior Officer (grade O-1 to O-3), and Senior Officers (grade O-4 to O-10). Branches of service included Army, Navy, Air Force, and Marines.

Statistical Methods

SAS software, version 9.2 (SAS Institute, Cary, NC) was utilized for data analysis in order to capture unadjusted IR per 1,000 person-years with 95% confidence intervals (CI) for SCJ dislocations. One exposure year was considered as 1 yr that the members served in the U.S. Armed Forces. These statistics were then adjusted to control for age group, sex, race, rank, and service in order to isolate any risk factors, using a multivariate Poisson regression to determine the adjusted IRs, 95% CI and adjusted incidence rate ratios (IRR). The lowest IR was chosen as the referent category, which the other IRs were based upon.

RESULTS

Between 2006 and 2015, 427 cases of closed SCJ occurred among an at-risk population of 13,772,342 person-years for an unadjusted IR of 0.031 per 1,000 person-years. The annual unadjusted IR ranged from 0.017 in 2006 to 0.059 in 2014. The greatest increase occurred between 2006 and 2007, with 61% increase in the rate of SCJ dislocations (Fig. 1).

Age

Age was not found to be a significant risk factor for sustaining a SCJ dislocation injury. Service members under 20 yr suffered from 5.6% (IRR 0.027) of the dislocations, 20–24 from 38.6% (IRR 0.037), 25–29 from 22.0% (IRR 0.029), 30–34 from 12.2% (IRR 0.025), 35–39 from 10.1% (IRR 0.027), and over 40 yr from 11.5% (IRR 0.033). Although there was a trend for increased incidence in the age group of 20–24 yr (IRR 1.38; 95% CI 0.90, 2.12) and greater than 40 yr (IRR 1.42; 95% CI 0.79, 2.53), this difference was not statistically significant (Table I).

Sex

Males were almost twice as likely to sustain SCJ dislocation injuries compared with females (IRR 1.73; 95% CI 1.23, 2.43) (Table I).

Race

Race was not found to be a statistically significant risk factor sustaining SCJ dislocations. Black service members (IR 0.030; CI 95% 0.024, 0.038) had a similar unadjusted IR to White service members (IR 0.033; CI 95% 0.029, 0.037) (Table I).

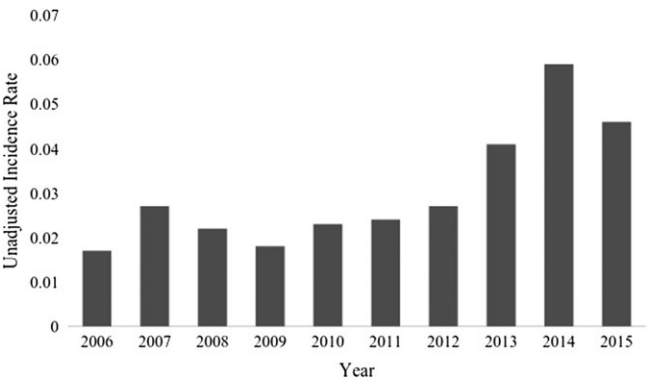

FIGURE 1. Unadjusted IRs of closed dislocation of the SCJ.

TABLE I. Unadjusted and Adjusted IRs from Risk Factors

	Total Number of Cases of Closed Dislocations of SCJ (*n*)	Person-Years	Unadjusted IR (95% CI)	Adjusted Rate Ratio[a] (95% CI)	*p*-Value
Age (yr)					
<20	24	882,632	0.027 (0.018, 0.041)	1	—
20–24	165	4,518,363	0.037 (0.031, 0.043)	1.38 (0.90, 2.12)	0.1451
25–29	94	3,211,408	0.029 (0.024, 0.036)	1.16 (0.71, 1.87)	0.5571
30–34	52	2,081,075	0.025 (0.019, 0.033)	0.99 (0.57, 1.70)	0.9685
35–39	43	1,605,387	0.027 (0.020, 0.036)	1.10 (0.62, 1.94)	0.7474
≥40	49	1,473,477	0.033 (0.025, 0.044)	1.42 (0.79, 2.53)	0.2395
Gender					
Male	390	11,764,533	0.033 (0.030, 0.037)	1.73 (1.23, 2.43)	0.0017
Female	37	2,007,809	0.018 (0.013, 0.025)	1	—
Race					
White	312	9,540,535	0.033 (0.029, 0.037)	1.07 (0.82, 1.39)	0.6389
Other	45	1,890,147	0.024 (0.018, 0.032)	0.85 (0.58, 1.24)	0.4037
Black	70	2,341,660	0.030 (0.024, 0.038)	1	—
Rank					
Junior Enlisted	207	6,000,903	0.034 (0.030, 0.040)	1.86 (1.18,2.93)	0.0075
Senior Enlisted	174	5,439,967	0.032 (0.028, 0.037)	1.93 (1.25,2.96)	0.0028
Junior Officer	24	1,414,230	0.017 (0.011, 0.025)	1	—
Senior Officer	22	917,242	0.024 (0.016, 0.036)	1.25 (0.67,2.33)	0.4816
Service					
Army	189	5,265,345	0.036 (0.031, 0.041)	1.84 (1.38, 2.45)	<0.0001
Navy	63	3,272,132	0.019 (0.015, 0.025)	1	—
Marines	71	1,976,826	0.036 (0.028, 0.045)	1.68 (1.19, 2.37)	0.0033
Air Force	104	3,258,039	0.032 (0.026, 0.039)	1.69 (1.24, 2.32)	0.001

Rate: per 1,000 person-years.
[a]Adjusted rate: adjusted for age group, gender, race, rank, service, and year.

Rank

Junior Officers were least likely to suffer from SCJ dislocations (IR 0.017; 95% CI 0.011, 0.025), whereas Senior Officers also did not significantly experience SCJ dislocations (IRR 1.25; 95% CI 0.67, 2.33). Junior Enlisted (IRR 1.86; 95% CI 1.18, 2.93) and Senior Enlisted (IRR 1.93; 95% CI 1.25, 2.96) were most at risk for suffering from these injuries (Table I).

Branch of Service

The Navy was found to have the lowest unadjusted IR (0.019; 95% CI 0.015, 0.025) among the four branches of service. In contrast, the Army had the highest adjusted IR (IRR 1.84; 95% CI 1.38, 2.45), followed by the Air Force (IRR 1.69; 95% CI 1.24, 2.32) and the Marines (IRR 1.68; 95% CI 1.19, 2.37) (Table I).

DISCUSSION

SCJ dislocations are associated with patients with hypermobility as well as those who experience traumatic events; although uncommon, the risk factors for SCJ dislocations and the epidemiology of this debilitating injury have not previously been reported. The purpose of this study sought to calculate the IR and demographic risk factors of SCJ dislocations within a relatively young, active U.S. Military population. Across this cohort, male sex, enlisted rank, and branch of service other than Navy were found to be significantly associated with the incidence of SCJ dislocation. Additionally, the annual unadjusted IR increased significantly between 2006 and 2007, representing a 61% increase in the rate of injuries.

Traumatic injuries in the military, such as SCJ dislocations, can be caused by a myriad of events both in training and in real-world scenarios including falling from height, demanding physical training, among countless other situations that can be compounded with the use of body armor such as the Improved Outer Tactical Vest.[24] An understanding of the non-modifiable risk factors for dislocations of the SCJ can inform other studies and encourage the recognition of these injuries in those patients who are most susceptible. Additionally, this information can be used to develop and employ preventative strategies such as continued improvements in manpower protection like the Improved Outer Tactical Vest up-armored vehicles both in garrison and in deployed settings.[25] Contemporary armor research to determine the best way to spread the kinetic force of a bullet without causing a traumatic event in the terrestrial military branches will be valuable for the prevention of SCJ dislocations, as well as other traumatic injuries, caused by bullet impact into bulletproof vests.

Given the elevated risk of traumatic injury associated with physically active patients, military cohorts have been ideal for previous investigations of the demographic risk factors of these injuries.[26] A previous study by Amako et al reported that 4.1

individuals will sustain a traumatic shoulder injury for every 1,000 service members each year.[27] This investigation reflects an at-risk population of over 13,000,000 person-years for an unadjusted IR of 0.031 per 1,000 person-years examining 427 cases across an 11-yr time frame. Cameron et al reported an incidence of 126 individuals out of 1,420 shoulders in the U.S. Military Academy that experienced a history of shoulder instability – out of these cases, 46 acute instability events occurred during the documented follow-up time.[28] Further, Hsiao et al reported that an IR, for U.S. Military service members, of 0.91 per 1,000 person-years suffered a clavicle fracture.[29] Although SCJ dislocations are less common than the aforementioned shoulder injuries, the increasing number of observed cases in young, active populations, and the potential consequences of such injury, merits increased focus for practicing military clinicians.

Males were found to be two-fold more likely to experience a SCJ dislocation than their female counterparts. Although the demographics of each Military Occupation Specialty code continue to change, males still make up a greater proportion of units more likely to be exposed to trauma relative to the rest of the military. Kirby et al conducted a retrospective medical review on patients admitted to a level 1 trauma center where they identified 22 SCJ dislocation patients who sustained an SCJ dislocation. This study similarly showed males to be 4.5 times as likely to suffer a SCJ dislocation compared with females, consistent with our findings.[30]

This study further determined an increased unadjusted IR for enlisted servicemen compared with officers regardless of seniority status. Junior and Senior Enlisted service members may encounter more physically rigorous and taxing situations than their officers, thus leading to a greater incidence of injury and dislocation. In a similar study conducted by Waterman et al, it was discovered that lower extremity stress fractures occurred almost two-fold greater in the Junior Enlisted group than in any other rank.[31] Although stress fractures result from repeated cyclic loading, the increased exposure to such physical demands, they are also associated with the high-amplitude traumas that can cause SCJ dislocations.[1] The Navy (IR 0.019, 95% CI 0.015, 0.025) experienced the lowest unadjusted IR of the four military branches, with the Army, Marines, and Air Force presenting significantly higher adjusted rate ratios. The Army (IR 0.036, 95% CI 0.031, 0.041) and Marines (IR 0.036, 95% CI 0.028, 0.045) had similar unadjusted IRs, with the Air Force with a slightly decreased rate (IR 0.032, 95% CI 0.026, 0.039). We speculate that the elevated IR observed in the Army and Marines can be attributed to the greater physical training demands of the terrestrial forces, increased exposure to ground-based combat, and blast injuries, whereas Air Force may be due to relative increased incidence of aviation-related trauma.

Although we hypothesized that younger age would be associated with an increased risk for SCJ dislocation, age was not found to be a risk factor for service members. Although SCJ dislocations are traditionally observed among younger, physically active individuals engaging in high-risk behavior, no significance was found when comparing different age group. The majority of SCJ dislocations occurred in the 20–24 age range (38.6% of all injuries), with the next highest presentation in the 25–29 age range, suggesting a slight trend of injury in younger patients. However, because SCJ dislocations are still prevalent in older service members, clinical precaution is required as missed injuries can lead to significant consequences and disability. Previous case series and retrospective studies have reported average ages ranging from 21 yr to 39.2 yr when discussing SCJ dislocations.[32,33]

Although previous literature demonstrates excellent short- and long-term outcomes, our study helps elucidate current risk factors and epidemiology seen in military populations. A recent study conducted by Kusnezov et al determined functional outcomes and recovery after SCJ reconstruction in 14 military servicemen. With the majority (85%) of patients undergoing an augmented figure-of-eight tendon reconstruction, outcomes were measured using self-reported pain scores and shoulder range of motion; the authors demonstrated significant improvement postoperatively at 3 mo and 6 mo. They found that 71% were able to return to active duty at an average of 6.5 mo postoperatively. Long-term, 43% of the servicemen completed their service at an average of 15.6 mo, whereas six are still involved in full active duty.[34] A retrospective review and consequent follow-up completed by Boesmueller et al studied clinical outcomes of all SCJ injuries. They found that seven of the 92 had true SCJ dislocations, presenting an average American Shoulder And Elbow Surgeons score of 88.57, University of California, Los Angeles shoulder scale score of 31.43, and visual analog scale score of 1.43 over a median of 14.5 yr follow-up.[33]

The primary strength of this study is the large number of active service members who had injuries, treatment, and demographics registered in DMED, allowing us to sample almost 14 million person-years. Due to the high physical demands and inherently dangerous missions that this population may encounter, our study is also well positioned to capture this relatively rare, but potentially morbid injury through the use of such a large database. Studying the IRs within this at-risk population can help reduce the economic burden and improve the medical care for young, active athletes who can experience similar physical demands and injuries.

However, there are several limitations that must be addressed. Primarily, the database registry does not include imaging data or other diagnostic tools to confirm the diagnosis of the injury. Although radiographs provide an initial assessment of the joint, computerized tomography and magnetic resonance angiography have been shown to provide a more complete evaluation of the injury.[5,35] This may be a potential limitation with DMED studies where the pathology is difficult to diagnose, as the database relies solely on the ICD-9-CM code entered by the provider. Such a limitation could cause unintentional inclusion of misdiagnosed injuries

such as physeal fractures of the medial clavicle; this potential limitation could possibly contribute to an increased IR of SCJ dislocations for the 20–24 age group reported in this study.[36,37] Another limitation is the classification of demographic identity in DMED. Lastly, this research study was conducted by searching ICD-9-CM code 839.61 (closed dislocation of the SCJ) in DMED. This ICD-9-CM code encapsulates both anterior and posterior SCJ dislocations and unfortunately does not differentiate between the two injuries. Anterior SCJ dislocations are reportedly more common, whereas posterior dislocations are potentially more concerning due to the relative proximity of important, vital structures.[1,4,14] Due to varying rates of presentation and potential outcomes, distinct ICD-9 codes would allow for a more accurate correlation of risk factors and injury.

This study was successful in describing demographic risk factors in this at-risk, active population. This study determined that male sex, enlisted rank, and branches of service other than Air Force are significant risk factors for sustaining SCJ dislocations in the military. Race and age were not found to have statistically significant increase in risk. Future studies may evaluate the effect of SCJ dislocations on return to military training, retention, and health care costs. Although a few studies cite the short- and long-term impact, to the best of our knowledge, there is no literature on determining the economic burden of these injuries. As we seek to implement quality care for our armed forces, understanding risk factors for these high-energy injuries and establishing preventative measures remain of paramount importance.

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