Chapter 7
Shoulder Injuries

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Introduction

In January 1994, the Armed Forces Epidemiological Board (AFEB) formed the Injury Prevention and Control Work Group to provide guidance and recommendations to the Army Surgeon General on the surveillance, prevention, and control of injuries in the military population [1]. The main objectives of the work group were to determine the magnitude of the injury problems across the military services, identify the causes, risk factors, and prevention strategies for injuries, assess the value of medical databases, and make recommendations with regard to research and prevention. The executive summary of this work group's report revealed several significant conclusions with regard to injuries in the military. They identified that injuries have a greater continual negative impact on the health and readiness of the US Armed Forces than any other category of medical complaint during both peacetime and combat. They also reported that training-related injuries treated on an outpatient basis contribute to a significant percentage of the overall morbidity in the military population, and subsequent disability results in significant compensation costs—exceeding $750 million per year [1].

Sports injuries, motor vehicle crashes, and falls are the leading causes of injuries across all military services [2]. The military mantra that every soldier is an athlete holds true, in the sense that the military is a unique organization which requires every member to maintain physical fitness standards and evaluates each member with a biannual physical evaluation test. Physical training (PT) programs are crucial to maintaining the physical readiness of the Armed Forces, yet also result in high rates

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of musculoskeletal injury overall. Injury rates in recruits range from 10 to 15 per 100 per month for males, 15 to 25 per 100 per month for females, and 30 to 35 per month for Navy special warfare candidates [3, 4].

While training and occupational injuries contribute to significant disability, a substantial number of injuries also occur while military service members participate in recreational and competitive athletics. Over a 6-year surveillance period, Lauder et al. identified that the rates of sports injuries were 38 and 18 per 10,000 person -years for military men and women, respectively [5]. These injuries accounted for an average of 29,435 lost-duty days per year, with men losing an average 13 days per injury and women averaging 11 days per injury. While the knee was the most injured body part in both genders (more than 25 % of all injuries), the shoulder was eighth in males and sixth in females (less than 5 % of injuries in both genders) ([5], Fig. 7.1). Among joint dislocations, the shoulder was the most common in males with an overall injury rate of 0.44 per 10,000 person-years, occurring most commonly while participating in football, and second most common in females with an injury rate of 0.11 per 10,000 person-years, occurring most commonly in basketball [5].

Orthopedic injuries are the leading cause of disability for the Army, Navy, Air Force, and Marine Corps, resulting in between 22 and 63 % of all Physical Evaluation Board (PEB) cases in various services [2, 6]. Overall, between 1 and 2 % of all service members are evaluated annually for injury, with approximately 60 % of these resulting in discharge or permanent retirement from service [2]. Musculoskeletal disorders are on the rise in the Army specifically, with initial data from 1992 showing that they accounted for 30 % of all hospital admissions (28,000) and 40 % of all soldier noneffective days (over 500,000 days). Based on US Naval Medical Evaluation Board data between 1989 and 1993, of the top 10 diagnoses of injury leading to disability, shoulder dislocation was eighth overall, and was the top diagnosis not involving the lower extremity, accounting for 2.9 % of cases overall [6].

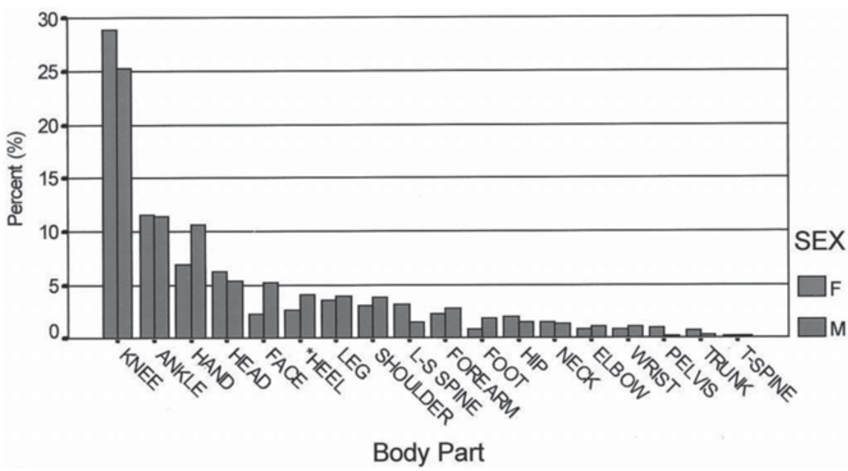

Fig. 7.1 Percent distribution of body areas injured in sports by gender [5]

Shoulder problems are common among US military service members and shoulder pain is a frequent complaint among service members who present to healthcare professionals, both in the primary care and tertiary specialty clinic settings. Walsworth et al. conducted a prospective descriptive analysis of patients presenting to a tertiary military medical treatment facility to better characterize the diagnoses of those who presented with a chief complaint of shoulder pain [7]. Of those who eventually underwent surgery, 84 % had more than one pathologic condition identified, with the three most common diagnoses including glenoid labrum injuries (80 %), impingement with rotator cuff disease (49 %), and instability (29 %) [7]. Seventy-six percent of patients were able to recall a specific mechanism of injury, with the top 3 mechanisms of injury reported, in order of prevalence, including overuse related to physical training/sports, trauma related to physical training/sports, and fall [7].

This study highlights the complexity of shoulder conditions encountered in US military service members, which commonly involve multiple structures (84 %), often have a prolonged duration of symptoms prior to presentation (average 33.75 months), and frequently have failed prolonged courses of nonoperative management prior to surgery (96 %) [7]. The frequency with which military patients attribute their conditions to a specific injury (76 %) is significantly higher than what has been described in civilian patients presenting to primary care settings, who have a reported mechanism of injury between 12 and 33 % of the time [8]. The increased rate of known injury further suggests the inherent occupational risks associated with the military profession and its associated upper extremity physical demands and requirements.

Provencher et al. further examined the young, active military population who presented to orthopedic surgeons with a complaint of shoulder dysfunction [9]. Two hundred seventy-five consecutive patients, with a mean age of 36.5 years, completed a battery of validated outcomes questionnaires at their initial presentation to gain a better understanding of the spectrum and severity of pathology present among military patients with shoulder complaints. Ten classes of presenting diagnoses are represented in Fig. 7.2 [9]. The investigators found that military patients presenting

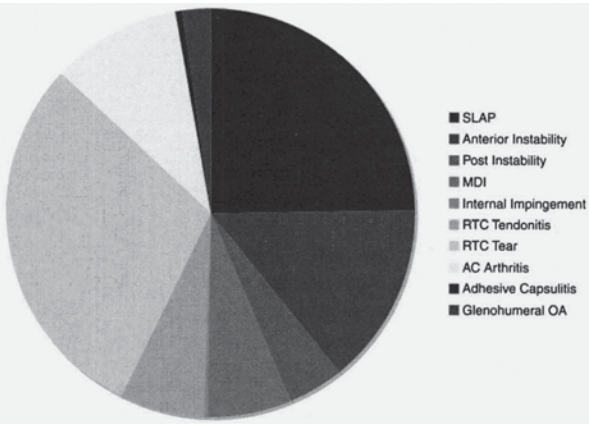

Fig. 7.2 Distribution of conditions in military patients presenting to orthopedic surgeons for shoulder pain [9]. *SLAP* superior labrum anterior posterior, *MDI* multidirectional instability, *RTC* rotator cuff, *AC* acromioclavicular, *OA* osteoarthritis

with shoulder complaints reported assessment scores approximately 50% of normal, across all conditions, representing fairly poor function overall [9]. Patients with superior labrum anterior posterior (SLAP) tears demonstrated the lowest overall scores, reflecting the highest degree of dysfunction, followed by instability and rotator cuff tears. Not surprisingly, those military members who required surgery had uniformly lower scores than those who were successfully treated nonoperatively.

Combat Shoulder Wounds

As discussed in Chap. 3, disease and non-battle injuries (DNBIs) continue to be a leading cause of morbidity and disability among troops deployed to Iraq and Afghanistan for Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF), respectively. Skeehan et al. conducted a recent epidemiological survey of deployed soldiers and found that 19.5% of all soldiers reported at least one DNBI and 85% sought care at least once during their deployment for symptoms [10]. The two most frequent causes of injury were sports/athletics and heavy gear lifting, with frequencies of 22.3 and 19.6%, respectively [10]. Belmont et al. reported on the DNBIs sustained by a US Army Brigade Combat Team during a counterinsurgency campaign in OIF. They found that musculoskeletal injuries were the most frequent body system casualties and accounted for 50.4% of all DNBIs [11]. Conditions related to the shoulder accounted for 11.8% of all DNBIs during the study period, the fifth most common body region behind the hand, knee, ankle, and lumbar spine. First-time shoulder dislocation was the fourth most common injury overall, behind ankle sprain, anterior cruciate ligament (ACL) rupture, and plantar fasciitis, with an incidence rate (IR) of 1.2 per 1000 soldier combat-years [11]. This compares similarly to previously reported IRs of 1.69 per 1000 person-years in the US Military as a whole and is approximately tenfold higher than the rates reported in civilian populations of between 0.11 and 0.24 per 1000 person-years [12, 13].

Roy recently examined another brigade combat team involved in operations in Afghanistan over a 15-month period in 2006–2007 to determine the prevalence of musculoskeletal diagnoses as well as mechanisms of injury in the deployed setting. This study better defined the at-risk nature of the military occupation in a deployed setting with regard to the shoulder. The shoulder was the fourth most frequently injured body region, affecting 164 of 1619 participants (10.1%) [14]. When broken down by Military Occupational Specialty (MOS), shoulder injuries were most prevalent in engineers, at 12% [14]. Engineers and maintenance personnel also had the highest percentage of shoulder impingement syndrome. This can be attributable to a number of factors, but likely represents the risk of overhead lifting combined with operating heavy equipment inherent within a military engineer's profession. Interestingly, this study confirmed that engineers sustain more upper extremity injuries in the deployed setting at a rate of 25% as compared to 15% in the non-deployed engineer unit [14].

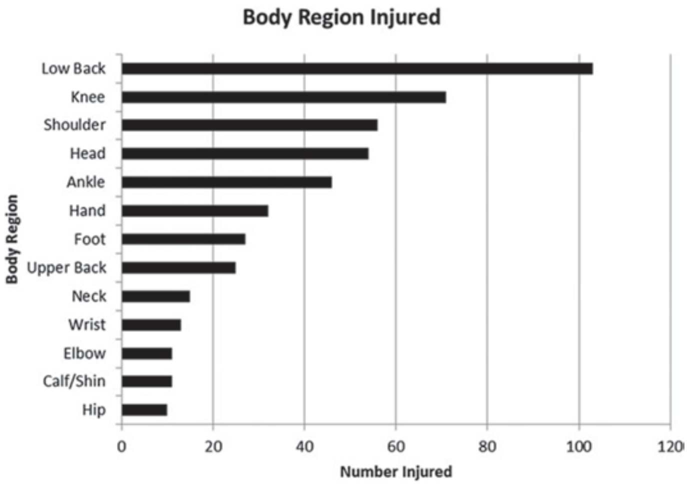

Fig. 7.3 Anatomical body regions injured most frequently during a 12-month deployment to Afghanistan [15]

Risk factors for injury in the deployed setting have been examined. In one cohort of troops in Afghanistan, the shoulder was the third most common body region injured with an incidence of 10 %, with an overall average of 8.5 days of limited duty per injury (Fig. 7.3, [15]). The most frequent activities leading to injury included lifting and carrying (9.8 %), dismounted patrolling (9.6 %), and physical training (8.0 %) [15]. Specific risk factors associated with higher incidence of injury included older age, higher enlisted rank, female gender, higher duration of deployment in months, longer strength training sessions, heaviest load worn, and heavier or more frequent lifting tasks [15].

Roy further examined the association between lifting tasks and injuries during the early portion (initial 3 months) of a Stryker Brigade Combat Team's deployment to Afghanistan between July 2009 and July 2010. Soldiers reported working on average 6 days per week and wearing their armored vest and carrying additional load (totaling a mean of 47.7 lbs) for > 8 h/day [16]. Over 23 % of soldiers sustained an injury in the third month of deployment, with the shoulder the second most common anatomical region affected at 14.5 %. Gender, more days per week of lifting objects, and higher height of objects lifted were all significantly associated with injury [16].

Of the top 15 most frequently treated diagnoses encountered in the deployed setting, three involved the shoulder with impingement accounting for 3 % of all diagnoses, acromioclavicular (AC) separation 1.6 %, and pectoralis strain 0.7 % [14]. Three of the top five most common mechanisms of injury were overuse (22 %), weight lifting in the gym (8 %), and sports (8 %), which differ from the most common mechanisms of injury in the non-deployed setting of falls, vehicle accidents, and sports [1, 14]. With regard to shoulder-specific injuries, the incidence of shoulder injuries seen in Afghanistan (10.1 %) is lower than that reported from Iraq (17.0 %) [14, 17]. One postulated explanation for this discrepancy is related to the wear of the Deltoid Axillary Protector (DAP) augmentation to the personal Interceptor Body Armor (IBA) while in Iraq, yet not in Afghanistan. The DAP consists of two separate ambidextrous components—the deltoid protector and the axillary protector, which are added to the protective vest system. Given the frequency of overuse injuries and shoulder impingement syndrome, the additional weight and possible altered shoulder biomechanics from the DAP may have contributed to a higher prevalence of shoulder injuries. This potential negative effect of the DAP in relation to overuse injuries must be weighed against the reported potential benefits in preventing direct shoulder injuries related to blast and penetrating trauma. Gondusky et al. reported on the injury rates in one Marine Light Armored Reconnaissance Battalion during OIF while the unit was field-testing the shoulder and axillary protector, and reported an overall shoulder injury rate from blast and penetrating trauma of 5 % [18].

Owens et al. reviewed the Joint Theater Trauma Registry (JTTR) for all traumatic wounds sustained by US service members in OIF and OEF from October 2001 through January 2005, excluding DNBIs [19]. They found a total of 1566 soldiers sustained 6609 combat wounds, and of these, 1281 soldiers had sustained 3575 extremity combat wounds, with 53 % penetrating soft-tissue wounds and 26 % fractures [19]. The 915 fractures were evenly distributed between the upper (461, 50 %) and lower extremities (454, 50 %), with 45 (9.8 %) of the upper extremity fractures occurring in the clavicle (13) and scapula (32) [19]. Fifty-three percent of the clavicle fractures and 87 % of the scapula fractures were open [19]. Overall, the shoulder accounted for 5 % of all open fractures in OIF and OEF, which compares similarly to the only other conflict for which we have reported open shoulder fracture data—Operation Just Cause—with a 7 % incidence [19, 20].

Mack et al. also reviewed open periarticular shoulder fractures, reviewing one tertiary care treatment facility's experience between March 2003 and January 2007 during OIF/OEF [21]. Reviewing 44 patients with open periarticular shoulder fractures, they found these to be extremely complicated injuries with high rates of associated neurologic (41 %), vascular (23 %), and other (86 %) injuries [21]. Forty-three percent of patients had a shoulder girdle injury with multiple fractures, with the top bones involved including the proximal humerus (66 %), acromion (36 %), glenoid (25 %), clavicle (23 %), and coracoid (18 %) [21]. Treatment challenges were highlighted by the high complication rates, with heterotopic ossification in 37 % of patients, postoperative deep infection/osteomyelitis in 14 %, nonfatal pulmonary embolus in 11 %, wound dehiscence in 6 %, and an overall amputation rate of 9 % [21].

Orthopedic injuries account for a significant proportion of long-term disability and subsequent discharge from military service in veterans injured during OIF and OEF. Army Physical Evaluation Board records of the 464 service members wounded between October 2001 and January 2005 reveal that 69 % of soldiers had unfitting orthopedic conditions [22]. Detailed descriptive analysis of combat-related orthopedic injuries by anatomic region in this population reveals that the shoulder alone accounts for 8 % of injuries, 10 % of disabling conditions, and an average percent disability for the service member of 23 %. [22].

Shoulder Girdle Injuries

Acromioclavicular Joint Sprains

Acromioclavicular (AC) joint injury is common among young athletes, and given the correlation in physical demands between competitive athletes and active-duty military personnel, it is also prevalent in the military population [23, 24]. AC joint injuries commonly occur in the third decade of life and have been reported to occur five times as often in males as compared to females in the civilian population [25]. However, data collected in a prospective, longitudinal cohort of US Military Academy cadets over a recent 4-year period show less of a discrepancy between the incidence in male and female cadets, with male patients only twice as likely to sustain an AC joint injury as females [24]. This is likely attributable to the younger mean age within this cohort, as well as the higher frequency of participation of females in higher risk intercollegiate athletic competition.

Pallis et al. reported an overall IR of 9.2 AC joint injuries per 1000 person-years in US Military Academy cadets [24]. The majority of these injuries (89 %) were classified as low-grade—type I or II according to the Rockwood classification system—with the vast majority of injuries (91 %) occurring as a result of participation in athletics [24, 25]. The distribution of injuries included AC sprains (87 %), fractures (7 %), sternoclavicular joint sprains (3 %), and inflammation/osteolysis (3 %). AC joint injuries resulted in an average of 18.4 days of duty lost per athlete, with low-grade injuries averaging 10.4 days versus high-grade injuries at 63.7 days per injury [24]. The IR of injury was significantly higher in intercollegiate athletes than intramural athletes, with an incidence rate ratio (IRR) of 2.11 [24]. The rate of surgical intervention was 19 times higher in high-grade injuries than low-grade injuries [24].

Clavicle Fractures

Clavicle fractures are one of the common injuries of the shoulder girdle both in the civilian and military populations, accounting for up to 5 % of all adult fractures and 35 % of shoulder girdle injuries in the general population [26, 27]. They hold a particular importance with respect to potential disability in military service members given their unique occupational demands. Military service members not only frequently perform high-risk overhead lifting and pulling activities but also participate in daily physical fitness training programs including push-ups and pull-ups, mandatory combatives training, obstacle courses, and frequently wear heavy shoulder-borne equipment such as rucksacks and individual body armor for extended periods of time [16, 24]. Injury to the shoulder girdle, including clavicle fractures, can render a soldier entirely incapable of performing these occupation-specific tasks for a period of time.

The trend in civilian trauma practice has moved toward operative management of displaced midshaft clavicle fractures to attempt to improve on the higher nonunion rates and poorer patient-centered outcomes scores associated with nonoperative management in these patients [26, 28, 29]. This trend is particularly applicable to the military population as well, given the specific occupational disability associated with painful midshaft clavicle fracture nonunions after nonoperative management in soldiers [30]. Huh et al. have challenged the notion that military patients cannot tolerate a plate on the clavicle due to the potential for symptomatic hardware, and shown promising early outcomes with plate fixation of midshaft clavicle fractures in a military cohort, with 93 % union rate at 3 months, 75 % patient satisfaction rate, and 79 % return of full shoulder motion [26]. They also reported on military -specific outcomes with 75 % able to do push-ups, 71 % able to wear body armor, 68 % able to wear a rucksack, and even in the short (6 month) study window, 21 % deployed after surgery [26].

Despite these promising results, others have challenged the notion of plate fixation in military patients. Wenninger et al. looked retrospectively at 62 patients undergoing surgical management of midshaft clavicle fractures and demonstrated a statistically higher complication rate in the plate fixation group (31 %) compared with the Hagie pin fixation group (9 %) [31]. The most common complication in both groups was symptomatic hardware and soft-tissue irritation, at an overall rate of 16 % [32].

Hsiao et al. queried the Defense Medical Epidemiology Database between 1999 and 2008 to determine the incidence of clavicle fractures in the US military and to identify any potential demographic risk factors for injury [33]. The authors reported a total of 12,514 clavicle fractures in an at-risk population with 13,770,767 person-years of follow-up, for an overall IR of 0.91 per 1000 person-years in the US Military [33]. Specific demographic variables that were significantly associated with increased incidence of clavicle fracture included sex, age, race, branch of service, and rank [33]. Men sustained clavicle fractures more than twice as often as females, with an IR of 0.67 per 1000 person-years in males compared to 0.29 for females. The adjusted IRR for men compared to women is 2.30 [33]. Clavicle fractures occurred significantly more often in white service members than both black service members and those listing "other" as their race. The adjusted IR for white service members is 0.66 per 1000 person-years, 0.49 for service members in the "other" category, and 0.27 for black service members. This leads to a greater than twofold increased risk for white service members as compared to black service members, with an adjusted IRR of 2.45 [33]. Rates of clavicle fractures generally decline with increasing age, with the peak incidence of injury occurring in the age groups of <20 years and 20–24 years. Service members in the age groups <20, 20–24, and 25–29 years had calculated IRs that were 38, 42, and 18 % higher, respectively, as compared to the >40-year-old group [33]. With respect to branch of service, the highest IR was found in those serving in the Marine Corps, followed by those in the Army, Air Force, and Navy. With respect to the Navy—the lowest risk category— the Marine Corps, Army, and Air Force had IRs that were 44, 16, and 6 % higher [33]. Military rank was also associated with the incidence of clavicle fracture, with the highest IR seen in the junior enlisted service members, followed in descending order by senior enlisted, junior officers, and senior officers. The IRs for junior enlisted, senior enlisted, and junior officers were 46, 35 and 12 % higher when compared to senior officers [33]. Overall, the IR of clavicle fractures is higher in the US military population (0.91 per 1000 person-years) than rates seen previously published for urban, civilian population which have ranged between 0.06 and 0.50 per 1000 person-years [27, 33, 34]. Demographic factors at highest risk in the military population are male gender, white race, and age less than 30 years [33].

Glenohumeral Joint Instability

Instability

Glenohumeral joint instability is a common orthopedic problem that can lead to pain and decreased ability to participate in physically demanding activities such as competitive athletics and military-specific occupational requirements [35]. Studies have evaluated a cohort of young, physically active military cadets at the US military Academy as well as the military population as a whole to determine the true incidence and characteristics of shoulder instability in the military population [13, 36]. Their findings highlight the importance of addressing this condition in the military, both from an initial management and treatment standpoint and a preventative standpoint by addressing modifiable and non-modifiable risk factors.

Several studies have reported on the incidence of shoulder dislocation in civilian populations. Simonet et al. estimated the incidence of primary, anterior shoulder dislocation to be 0.08 per 1000 person-years for the general population of Olmstead County, Minnesota [37]. European studies have estimated incidences of 0.17 per 1000 person-years in an urban population in Denmark, and 0.24 per 1000 person-years in a town in Sweden [21, 38].

In the largest US civilian population-based study of shoulder dislocations presenting to emergency departments, Zacchilli et al. reported an incidence of 0.24 per 1000 person-years [39]. In this study, utilizing the National Electronic Injury Surveillance System, the male IR was calculated as 0.35 per 1000 person-years, an IRR of 2.64 relative to females, with 71.8 % of all dislocations occurring in males [39]. When age was broken down by decade, the highest IR (0.48) occurred in those aged 20–29 years, with 46.8 % of all dislocations occurring in patients aged 15–29 years. There were no differences identified based on race in this cohort [39].

Owens et al. demonstrated in a closed population study among US military Academy cadets that the incidence of first-time traumatic shoulder dislocation is an order of magnitude greater in these military academy cadets than in previously reported studies [36]. The probability of a shoulder instability event (defined as a subluxation or dislocation) is 2.8 % per academic year, with an incidence proportion of 2.9 % for males and 2.5 % for females [36]. Overall, an IR of 4.35 per 1000 person-years was reported in this cohort [36]. The significantly higher IR in this study can be attributed both to the efficient methodology of data collection in a closed population as well as the younger age and higher activity level of these military cadets.

Of all instability events, 84.6 % were subluxations and 15.4 % were true glenohumeral dislocations, so when looking only at dislocation events, the incidence proportion is 0.43 % overall [36]. The majority of overall instability events were in the anterior direction (88 %), with 17 of 18 (94 %) of the dislocations occurring in the anterior direction [36]. This is consistent with previous reports of anterior dislocation rates of 97 % in the general population [38]. Mechanism of injury was recorded as well, showing that 43.6 % of instability events were a result of contact injuries and 41 % were from noncontact injuries [36]. High rates of intra-articular pathology were confirmed for both dislocations and subluxations. The high percentage of anterior dislocations with Bankart lesions (93 %) and Hill–Sachs lesions (86 %) in this military population is consistent with previous reports of Bankart tears and Hill–Sachs lesions in those who underwent surgery for instability, with rates of 97 and 90 %, respectively [36, 40]. Rates of pathologic lesions in the subluxation subset were reported for the first time, with incidences of Bankart lesions in 49 % and Hill–Sachs lesions in 48 % [36].

When evaluating the entire military population for shoulder dislocation, using the Defense Medical Epidemiology Database, the overall IR was calculated to be 1.69 dislocations per 1000 person-years [36]. Again, this is tenfold higher than rates of 0.08–0.24 per 1000 person-years previously reported in civilian population studies [12, 37, 38]. Significant independent risk factors for injury included male sex, white race, and age less than 30 years [13]. The calculated IR for males was 1.82 compared to 0.90 for females; and when controlling for race, age, branch of service, and rank, the adjusted IRR for males compared to females was reported as 1.95 [13]. Those service members with white race had an injury rate of 1.78 compared to 1.59 for "other" races and 1.41 for black race. The adjusted rate ratio for white race was 1.25 compared to black race [13]. Age also had a significant impact on injury rates, with increasing rates associated with the youngest age categories. The highest IR (2.35) occurred in the youngest age group (younger than 20 years old), yet all of the categories less than 30 years old had significantly greater risk than the older age groups [13]. With respect to branch of service, the highest IRs were seen in the Army (2.34) and marines (2.28) [13]. Finally, military rank played a significant role in risk for shoulder dislocation, with both junior and senior enlisted ranks having significantly higher rates than commissioned officers. Unadjusted IRs for junior enlisted, senior enlisted, and officers were 2.20, 1.32, and 1.12 per 1000 person-years, respectively [13].

Superior Labrum Anterior Posterior Tears

Superior labrum anterior posterior (SLAP) tears are a source of shoulder pain and disability in young, active patients. Mechanisms of injury include direct trauma, overhead traction to an outstretched arm, and repetitive overhead throwing motions especially in athletes. Military patients are at particular risk for injury given the physical nature of their profession, the risk of trauma, and demands of routine physical training. The incidence of SLAP lesions in military patients undergoing shoulder arthroscopy for pain, instability, or other reasons is significantly higher (38.6 %) than in the civilian population (11.1 %) [41]. Patients with a history of trauma (85.2 %) or symptoms of instability were more likely to have a SLAP lesion [41]. Of the SLAP lesions identified in this cohort, 20.5 % were type I, 69.3 % were type II, 5.1 % were type III, and 5.15 % were type IV according to the Snyder classification [41, 42].

Waterman et al. recently conducted the first population-based study to evaluate the trends in the incidence of SLAP lesions in a young, physically active military population at risk for shoulder pathology between 2002 and 2009 [32]. The authors report that the most important finding of their research is that within the military population, male gender, increasing age, white race, enlisted rank, and service in the Marine Corps are associated with the highest incidence of SLAP lesions [32]. Overall, approximately two incident cases of SLAP tears were found for every 1000 person-years at risk during the study period [32].

There is a high incidence (90 %) of associated shoulder pathology among patients who have arthroscopically diagnosed SLAP lesions [41]. Concomitant pathology was most frequently found in patients with type II SLAP lesions. In decreasing order of frequency, these findings included rotator cuff pathology (83 %), Hill–Sachs lesions (69 %), Bankart tears (63 %), and anterior instability on examination under anesthesia (67 %) [41].

Surgical management of SLAP tears in military patients, both in isolation and with associated pathology, has been shown to be successful [43, 44]. Arthroscopic repair of type II SLAP tears has been shown to have 94–97 % good to excellent results at 1–3-year follow-up in civilian populations including overhead athletes, with 91 % of patients regaining their pre-injury level of function [45–47]. Military service members have physical demands that have been shown to be unique from civilian occupations, and thus place significant demands on their shoulders—a particular challenge for surgeons caring for this demographic. Enad et al. have shown that arthroscopic treatment of SLAP lesions in military patients can yield results similar to previously published data on civilian populations despite these challenges [44]. In a cohort of 27 patients who underwent suture anchor repair of type II SLAP tears, at a mean follow-up of 30.5 months, 96 % had returned to full duty at a mean of 4.4 months postoperative, and 97 % eventually regained at least 80 % of their previous level of function based on University of California, Los Angeles (UCLA) and American Shoulder and Elbow Surgeons (ASES) scores, with 76 % returning to their previous level of recreational athletics outside of their military occupational specialty [44]. In a separate cohort of 36 age-matched active-duty males with isolated versus combined type II SLAP tears treated arthroscopically, Enad et al. demonstrated an identical return to duty rate of 94 % in each group [43]. This study also highlighted the importance of treating concomitant pathology at the same time, with significantly better improvements in postoperative ASES scores and Visual Analog

Scale (VAS) pain scores in those who had surgical correction of concomitant extra-articular shoulder pathology at the same time as SLAP repair [43].

Pectoralis Major Tears

Rupture of the pectoralis major muscle or tendon is a rare injury, with an observed increase in frequency in recent decades likely attributable in part to the increased rates of recreational athletic participation in society [48]. Pectoralis tendon ruptures typically occur in activities requiring forcible shoulder flexion, such as weight training—specifically bench press—or activities with potential for forced, traumatic shoulder extension such as football, wrestling, or rugby [49, 50]. Military-specific unique mechanisms of injury have also been described, including a soldier rupturing the pectoralis major tendon in his "brake hand" while rappelling in an air-assault descent and another occurring to a paratrooper whose arm was caught in the risers of his parachute during a static-line deployment [51, 52]. White et al. demonstrated that 92 % of all major tendon ruptures in an active-duty military population, including pectoralis tendon injuries, occurred during participation in sports or similar physical activity requiring plyometric movements [48]. Peak incidence for pectoralis major tendon injury occurs in active males, aged 20–40 years old, which corresponds to a large proportion of the active-duty military population [53].

White et al. showed that pectoralis major tendon ruptures account for 14 % of all major tendon ruptures in an active-duty military population, and most commonly occur secondary to bench pressing (71 %) [48]. Descriptive statistics show that, by race, pectoralis major tendon injuries occur 71 % in blacks and 14 % each in whites and other races. When evaluating all major tendon ruptures, including pectoralis major, Achilles, patellar, and quadriceps, the rate ratio, when adjusted for age and gender, was 13.3 between blacks and whites, and 2.9 between Latinos and whites [48]. Age also played a significant role in risk for tendon injury, with only 8 % of injuries in subjects younger than 24 years, 55 % in those aged 25–34 years, and 37 % in those 35 years or older [48].

Both acute and chronic pectoralis major tendon ruptures have been treated successfully with surgical repair. In a retrospective review of 14 active-duty military patients over an 8-year period, Antosh et al. showed acceptable overall results with operative repair, and a statistically significant difference in better outcomes for the immediate repair group compared to the delayed group [53]. The mean age of the patients was 31.4 years (range 21–48) which is consistent with previous reports, and for 11 of 14 patients (79 %) the mechanism of injury was bench-pressing weights [53]. Unfortunately, some residual disability was common in this cohort, with a mean postoperative Disabilities of the Arm, Shoulder and Hand (DASH) score of 12.74, a mean 39 % reduction in maximal bench-press weight, and a mean 34 % reduction in 2-min push-up maximum reps based on patient-reported data [53].

Degenerative Conditions

Impingement and Rotator Cuff Disease

Subacromial impingement syndrome (SIS) is one of the most common causes for shoulder pain in the general population. This syndrome spans a range of pathology from subacromial bursitis to rotator cuff tendinopathy and both partial- and full-thickness rotator cuff tears [54]. The etiology of rotator cuff disease remains a subject of ongoing debate, yet is likely multifactorial with contributions from external impingement (from the acromion, coracoacromial ligament, and AC joint), intrinsic age-related tendon degeneration, repetitive trauma, and vascular compromise [54]. Nonsurgical management is the mainstay of initial treatment for patients with SIS, and surgical intervention has been shown to be successful for a majority of patients in whom this initial treatment fails. Options for surgical intervention include open or arthroscopic acromioplasty, debridement, bursectomy, and rotator cuff repair.

The incidence of rotator cuff disease in the general population has been reported, and it increases with age. Full-thickness rotator cuff tears are present in approximately 25 % of people in their 60s and approximately 50 % of people in their 80s [55]. Asymptomatic full-thickness rotator cuff tears are common, increasing in frequency with age, and are present approximately 50 % of the time in patients over age 65 who have a contralateral symptomatic full-thickness rotator cuff tear [55].

Several studies have estimated the prevalence of both partial- and full-thickness rotator cuff tears in both cadaver specimens and using various imaging techniques in both asymptomatic and symptomatic patients. Cadaver and autopsy dissection studies estimate a prevalence of rotator cuff defects ranging from 5 to 40 % in the general population [56, 57]. Lehman et al. found a relationship between full-thickness tears and age in a cadaver study with a prevalence of 6 % in specimens less than 60 years old and 30 % in those older than 60 years [58]. The location of partial-thickness tears has also been investigated, with reported incidences for bursal-sided (2.4 %), intratendinous (7.2 %), and articular-sided (3.6 %) tears [59].

Imaging modalities such as ultrasound and magnetic resonance imaging (MRI) have been utilized to evaluate both asymptomatic and symptomatic patients for partial and complete rotator cuff tears. Rotator cuff tears have been shown to be present in asymptomatic individuals at an overall prevalence of between 17 and 34 % and in symptomatic patients 36 % of the time [60, 61].

In all studies, a higher prevalence of rotator cuff tears correlated to increased age. In asymptomatic subjects, Sher et al. demonstrated that MRI confirmed partial- and full-thickness tears in patients less than 40 years of age in 4 and 0 %, respectively, in patients between 40 and 60 years of age in 24 and 4 %, and in those older than 60 years in 26 and 28 %, respectively [60]. Yamamoto et al. reported that overall 25.6 % of individuals in their 60s have a rotator cuff tear and up to 50 % of subjects in their 80s have a tear [61].

A recent systematic review revealed that traumatic rotator cuff tears are more likely to occur in a younger age bracket (mean age 54.7 years) than attritional, chronic, atraumatic rotator cuff tears [62, 63]. This review examined specific tendon involvement with supraspinatus in 84 %, subscapularis in 78 %, and infraspinatus in 39 % [62]. Tear size was reported as < 3 cm in 22 % of tears, 3–5 cm in 36 %, and > 5 cm in 42 % [62]. Thus, when compared to atraumatic, attritional tears, the cohort of patients with traumatic tears were younger and had larger tears with significantly more subscapularis involvement [62].

Rotator cuff disease including impingement and partial- and full-thickness tears are among the most common of shoulder problems that affect US military service members. Walsworth et al. conducted a prospective descriptive analysis of patients presenting to a tertiary military medical treatment facility to characterize the diagnoses of those who presented with a chief complaint of shoulder pain. Of the 55 subjects, mean age of 40.6 years, who eventually underwent surgery, 84 % had more than one pathologic condition identified and impingement with rotator cuff disease (49 %) was the second most common pathologic condition encountered [7]. Seventy-six percent of patients were able to recall a specific mechanism of injury (top 3 including overuse related to physical training/sports, trauma related to physical training/sports, and fall), which further supports the higher incidence of traumatic rotator cuff tears in younger patient populations [7]. The most frequent concomitant injuries associated with impingement and rotator cuff tears in this military cohort included labral tears, instability, and AC joint arthritis [7].

Provencher et al. examined a cohort of 275 young, active military patients with a mean age of 36.5 years who presented to orthopedic surgeons with a complaint of shoulder dysfunction. Of the 10 categories of pathologic conditions, rotator cuff tear (both partial- and full-thickness) represented 29 % of all cases, and rotator cuff tendinopathy accounted for another 7 % (Fig. 7.2, [9]). This study also reported the considerable level of disability associated with these conditions and found that patients with partial- or full-thickness rotator cuff tears presented with mean Western Ontario Rotator Cuff Index (WORC) scores that were considerably worse than those with impingement alone [9].

Glenohumeral Joint Osteoarthritis

Osteoarthritis is the most common cause of disability in adults in the USA, affecting almost 27 million people in the general population [64]. Osteoarthritis is also the most common cause of disability in US military service members who are medically separated from active service [22].

Cross et al. reviewed the records of 464 military service members wounded in combat between October 2001 and January 2005 who underwent Army Physical Evaluation Board hearings to determine fitness for continued military service. Orthopedic conditions made up 69 % of all unfitting conditions, and degenerative arthritis was the top-ranking condition overall for which military service members were found unfit for duty [22]. Degenerative arthritis secondary to combat injury accounted for 29 % of all unfitting conditions, with an average percent disability rating of 15 % [22].

Of those military service members with osteoarthritis as their primary unfitting condition, injuries to the shoulder were second only to spine in prevalence, occurring in 32 % of patients in one cohort [65]. Combat injuries to the shoulder were determined to result in arthritis in 60 % of cases, highlighting the severity of these downrange shoulder injuries and their lasting impact on the injured soldier via long -term disability [65]. Traumatic injury causes 94.4 % of all cases of joint osteoarthritis in active-duty service members, with 75 % of these conditions resulting from fractures or arthrotomies caused by explosive devices [65].

Treatment for end-stage posttraumatic osteoarthritis (PTOA) involves total joint arthroplasty, most commonly in the hip, knee, and shoulder. The challenge in caring for these wounded warriors is that the average age of veterans with PTOA who undergo joint arthroplasty is much lower than that in the general population [66]. Fehringer et al. examined data from the Veterans Administration (VA) National Surgical Quality Improvement Program (NSQIP) between the fiscal years 1999 and 2006 to review total joint arthroplasties in US military veterans [67]. They found that total shoulder arthroplasties (TSA) accounted for 2.3 % of all joint arthroplasties in military veterans [67]. Interestingly, despite the longer mean operative time for TSA (3.0 h) as compared to total knee arthroplasty (TKA) (2.2 h) or total hip arthroplasty (THA) (2.4 h), both the 30-day mortality rates and postoperative complication rates for TSA were significantly lower. The 30-day mortality rates for THA, TKA, and TSA were 1.2, 1.1, and 0.4 %, respectively. The overall postoperative complication rates for THA, TKA, and TSA were 7.6, 6.8, and 2.8 %, respectively [67]. Controlling for multiple risk factors, it was determined that TSA resulted in shorter inpatient hospital stays, fewer postoperative complications, and fewer readmissions than both TKA and THA in the Veterans Health Administration (VA) population [67].

Conclusions

Shoulder injuries are common in US military service members. Occupational demands including mandatory physical training requirements and varied risks associated with combat training and deployment present a unique challenge to health-care providers caring for these individuals. Shoulder injuries contribute to significant lost-duty days in active-duty soldiers as well as long-term disability in those who retire or otherwise leave military service. Military service members experience a range of acute and chronic overuse injuries in the shoulder girdle region and these injuries have been associated with high rates of degenerative disease and osteoarthritis. The incidence of many shoulder injuries is significantly higher in the military population compared to civilians, which emphasizes the continuing need for effective delivery of orthopedic care to active-duty soldiers and veterans. Understanding the modifiable and non-modifiable risk factors for these shoulder injuries is also critical in developing and implementing primary prevention strategies to reduce the burden of shoulder injuries in military populations.

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