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Shoulder impingement in the United States military

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Background: Little is known about the incidence and characteristics of primary, or external, shoulder impingement in an occupationally and physically active population. A longitudinal, prospective epidemiologic database was used to determine the incidence and risk factors for shoulder subacromial impingement in the United States (U.S.) military. Our hypothesis was that shoulder impingement is influenced by age, sex, race, military rank, and branch of service.
Methods: The Defense Medical Epidemiology Database was queried for all shoulder impingement injuries using International Classification of Disease, Ninth Addition, Clinical Modification code 726.10 within a 10-year period from 1999 through 2008. An overall injury incidence was calculated, and a multivariate analysis performed among demographic groups.
Results: In an at-risk population of 13,768,534 person-years, we identified 106,940 cases of shoulder impingement resulting in an incidence of 7.77/1000 person-years in the U.S. military. The incidence of shoulder impingement increased with age and was highest in the group aged ≥40 years (incidence rate ratio [IRR], 4.90; 95% confidence interval [CI], 4.61-5.21), was 9.5% higher among men (IRR, 1.10, 95% CI, 1.06-1.13), and compared with service members in the Navy, those in the Air Force, Army, and Marine Corps were associated with higher rates of shoulder impingement (IRR, 1.46 [95% CI, 1.42-1.50], 1.42 [95% CI, 1.39-1.46], and 1.31 [95% CI, 1.26-1.36], respectively).
Conclusions: The incidence of shoulder impingement among U.S. military personnel is 7.77/1000 person-years. An age of ≥40 years was a significant independent risk factor for injury.
Level of evidence: Level III, Cross Sectional Design, Epidemiology Study.

Keywords: Shoulder; impingement; incidence; epidemiology; U.S. military; DMED

The Institutional Review Board at William Beaumont Army Medical Center (WBAMC Protocol #08/05; Keller Army Hospital, West Point Protocol #07/009) approved this study.

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Shoulder pain is a common condition associated with high societal cost and occupational burden for workers. In 2000, the direct costs for the treatment of shoulder dysfunction in the United States (U.S.) totaled $7 billion.[14] These shoulder disorders have multifactorial causes and can result from conditions such as bursitis, tendonitis, rotator cuff tear, adhesive capsulitis, avascular necrosis, glenohumeral osteoarthritis, or impingement sydrome.[14] Of these conditions, shoulder impingement can be particularly debilitating, affecting occupational function and health-related quality of life. In this study, we investigated the incidence of shoulder subacromial impingement in a physically active population.

Impingement syndromes in the shoulder are common in individuals with repetitive or prolonged overhead activities.[13] One proposed mechanical mechanism of shoulder impingement involves the narrowing of the subacromial space by subacromial spur formation or coracoacromial ligament hypertrophy, which reduces the space available for the rotator cuff.[16] The repetitive overhead motions of the arm in many sports and occupations can also lead to impingement in the vulnerable avascular region of the supraspinatus tendon.[6,8,15,20] One other proposed mechanism involves subacromial inflammation of the adjacent subacromial bursa in response to rotator cuff injury.

Despite the public health and occupational burden of shoulder impingement, little is known about the incidence of shoulder subacromial impingement in the general population. Although a limited number of reports have focused on shoulder impingement in tennis players[4,29] and different athletic groups,[13] as well as one report in an at-risk overhead occupational cohort of laborers,[7] the epidemiology of shoulder subacromial impingement in the general population, let alone in high-risk occupational and physically active populations, remains poorly studied.

The purpose of this study was to examine the incidence rate (IR) of primary, external shoulder impingement in a physically active population with particular occupational upper extremity demands. A secondary objective was to examine the relationship between demographic or occupational factors and the IR of shoulder impingement to identify specific groups that are susceptible to shoulder impingement. We hypothesized that a higher rate of shoulder impingement would be observed in certain populations and that the IR would be dependent on sex, race, age, military rank, or branch of U.S. military service. In this study, we queried a large administrative epidemiologic database to determine the incidence and the demographic risk factors for shoulder impingement across the 4 branches of U.S. military service.[1,21] Our study focused on primary or external shoulder subacromial impingement and its incidence in the active-duty military population of at-risk personnel.

Materials and methods

This study was conducted in accordance with good clinical practices. This retrospective cohort study used data collected between 1999 and 2008 to examine the IR for primary, external shoulder subacromial impingement in an active-duty U.S. military population. We used injury data from the Defense Medical Epidemiological Database (DMED). The DMED compiles International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) coding information for every patient encounter occurring in a U.S. military treatment facility or under civilian-contracted care. This database also contains patient demographics and military-specific data, which can be used to study epidemiology. In addition, the DMED maintains data on the total number of U.S. military personnel on active duty each year, which is obtained from the Defense Manpower Data Center. The structure, capabilities, and utility of this military database for public health surveillance and epidemiologic research have been previously described,[1,21] and injury data from the DMED have been used to study the epidemiology of a number of musculoskeletal injuries and conditions[2,9,17-19,23,30,32] as well as injuries to the shoulder specifically.[17] A secondary objective was to examine the association between demographic (eg, sex, age, race) and occupational (eg, branch of military service, rank) risk factors associated with the incidence of shoulder impingement during the study period.

To determine the number of incident cases of shoulder impingement, we queried the DMED by sex, age, race, branch of military service, and military rank for the years 1999 through 2008 using ICD-9-CM code 726.10 (unspecified disorders of shoulder tendons and bursae). The age categories were younger than 20, 20 to 24, 25 to 29, 30 to 34, 35 to 39, and 40 years and older. The race categories were white, black, and other. The service categories were U.S. Army, U.S. Marine Corps, U.S. Navy, and U.S. Air Force. The rank categories included junior enlisted (E1-E4), senior enlisted (E5-E9), junior officer (O1-O4), and senior officer (O5-O9). In-patient data were excluded to capture only ambulatory encounters with a primary diagnosis of shoulder impingement. Only the first occurrences for each patient were counted to exclude repeat coding of the same initial injury for all service members during the study period.[1]

The primary outcome of interest was the IR of shoulder impingement per 1000 person-years at risk of injury during the study period. The IR for an injury is defined as the number of new cases in a period of time in a population at risk for the injury. Incidence rates are calculated by dividing the total number of injuries observed in a population by a measure of exposure (person-time).[24] Accurate exposure data for IR calculations are available through DMED and are validated against Department of Defense personnel data obtained from the Defense Manpower Data Center.[1] The person-time at risk for injury during the current study period was calculated from the day each individual entered military service until he or she sustained an incident shoulder impingement injury, left military service, or reached the administrative end of the study on December 31, 2008. All IRs in this study are reported per 1000 person-years at-risk.

The overall incidence and 95% confidence interval (CI) of shoulder impingements in the study population was calculated by dividing the total number of injuries by the total person-years at risk, expressed as cases per 1000 person-years. We used a multivariable Poisson regression model on DMED injury and personnel data to estimate the IR of shoulder impingements by strata (eg, sex), while controlling for the influence of the other variables in the model (age, race, service, and rank). We calculated unadjusted and adjusted IRs, IR ratios (IRR), and 95% CIs for each demographic category. Linear regression was used to estimate the trend in IR across age categories in the present study.

Results

Between 1999 and 2008, 106,940 incident cases of shoulder impingement were documented in the DMED database among a population exposure of 13,768,534 person-years. An average of 10,694 incident cases of shoulder impingement were diagnosed annually during the study period, and the overall IR for shoulder impingement during the study period was 7.77 (95% CI, 7.77-7.77) cases/1000 person-years. The IR for injury varied significantly by sex, age, race, military service, and rank. All 5 demographic variables were independently associated with the incidence of shoulder impingement, indicating that sex, age, race, service, and rank are important factors associated with shoulder impingement.

Age

The IR for shoulder impingement was the highest in the group aged ≥40 years, and rates generally increased with increasing age (Table I). The IR for shoulder impingement among service members in the group aged ≥40 years was about 5 times higher (IRR], 4.90; 95% CI, 4.61-5.21) than those in the group aged <20 years. Service members in the groups aged 20 to 24, 25 to 29, 30 to 34, 35 to 39, and ≥40 years experienced IRs for shoulder impingements that were 0.18, 0.82, 1.32, 2.31, and 3.90 times higher, respectively, than those in the youngest age group. Every 5-year increase in the study population's age corresponded to an average increase of 2.31 (95% CI, 1.34-3.28; $P = .003$) cases/1000 person-year in the IR of shoulder impingement (Fig. 1). The IRs, IRRs, and 95% CIs by age group are presented in Table I.

Sex

For sex-classified shoulder impingement results, male service members accounted for 93,372 cases (87.31%), and female service members accounted for 13,568 cases (12.69%) among an at-risk population of 11,758,249 male and 2,010,285 female person-years. The IR of shoulder impingement was slightly higher for men than for women when controlling for the influence of the other risk factors in the model. Among all service members, men were slightly more likely (IRR, 1.10; 95% CI, 1.06-1.13) to be diagnosed with shoulder impingement than women. The adjusted IR for men was 6.67/1000 person-years at risk to injury compared with 6.09 for women. The IRs, IRRs, and 95% CIs by sex are presented in Table II.

Race

The IR of shoulder impingement was similar among those in the white, black, and "other" categories for race. The adjusted IR per 1000 person-years at risk for injury was 6.79 for white service members, 6.02 (IRR, 0.89; 95% CI, 0.86-0.91) for black service members, and 6.33 (IRR, 0.93; 95% CI, 0.91-0.96) for service members in the "other" category for race. When white service members were used as the reference category, black service members and those in the "other" racial category were slightly less likely to experience shoulder impingement injuries. The IR, IRRs, and 95% CIs for each racial group are presented in Table III.

Military rank and branch of military service

Branch of military service was an occupational risk factor associated with the IR for shoulder impingement. The highest IR of injury was experienced by those serving in the Air Force, followed by those in the Army, Marines, and Navy. Examining the IRs by service suggests that those serving in the Air Force, Army, and Marines experienced IRs for shoulder impingements that were 46%, 42%, and 31% higher, respectively, when those serving in the Navy were the reference category (Table IV). A complete listing of the IRs, IRRs, and 95% CIs by branch of military service is presented in Table IV.

Military rank was associated with the incidence of shoulder impingement after controlling for the influence of age and the other variables in the statistical model. The highest adjusted IR for shoulder impingement was observed in junior enlisted service members, followed by senior enlisted service members, senior officers, and junior officers. All groups experienced significantly lower IRs of shoulder impingement injury when junior enlisted service members were the reference category. IRs, IRRs, and 95% CIs by military rank are presented in Table V.

Discussion

In this study, we examined the IR of primary, external shoulder subacromial impingement in an active-duty military population during a 10-year period between 1999 and 2008. To our knowledge, no previous studies have investigated the IR and risk factors associated with shoulder impingement in a physically active population with upper extremity occupational demands. In a 1-year Dutch study, Van Der Windt et al[27] reported the cumulative incidence of shoulder complaints in general practice was 11.2 cases/1000 patient-years, whereas other Dutch studies estimated

Table I Incidence rate per 1000 person-years for shoulder impingement based on age*

Age (y)	Injuries	Person-years	Unadjusted		Adjusted	
			Rate	RR (95% CI)	Rate	RR (95% CI)
<20	4,499	1,106,294	4.07	1.00 (0.96-1.04)	3.07	
20-24	21,492	4,561,625	4.71	1.156 (1.12- 1.20)	3.62	1.18 (1.12-1.24)
25-29	19,419	2,870,268	6.77	1.66 (1.61-1.72)	5.57	1.82 (1.72-1.92)
30-34	16,700	2,010,821	8.31	2.04 (1.98-2.11)	7.10	2.32 (2.18-2.46)
35-39	21,333	1,809,088	11.79	2.90 (2.81-3.00)	10.14	3.31 (3.12-3.52)
>40	23,497	1,410,438	16.66	4.10 (3.97-4.23)	15.01	4.90 (4.61-5.21)

CI, confidence interval; *RR*, rate ratio.
* Male reference category; adjusted for sex, race, branch of service, and rank.

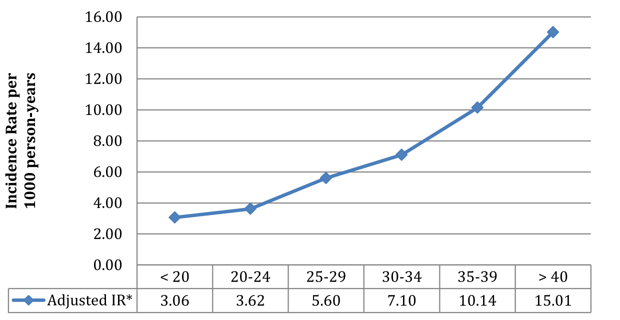

Figure 1 Incidence rates (*IR*) per 1000 person-years for shoulder impingement by age category for all active-duty United States military service personnel between 1999 and 2008.

the IR at 12 to 25 cases/1000 patient-years. Another study from England and Wales reported a lower IR of 6.6 cases/1000 patient-years.[5]

The IR rate for shoulder impingement observed within the active duty U.S. military population in the current study was 7.77/1000 person-years. The cohort studied represents a relatively young and active group with particular upper extremity demands that were required by the nature of their jobs. Although some of these demands are specialized training exercises and deployments for the military, some demands are also similar to those of individuals performing manual labor or participating in athletics.[17]

When age was evaluated as an independent risk factor for impingement syndrome in the current study, we found that those in the group aged ≥40 years experienced significantly higher IRs of injury than those in the <20, 20 to 24, 25 to 29, 30 to 34, and 35 to 39 age groups, and IRs were higher with increasing age (Fig. 1). Service members in the ≥40-year age group were 5 times as likely to sustain a shoulder impingement than those in the <20-year age group, consistent with other reports suggesting increased symptomatic shoulder disorders and rotator cuff pathology with increasing age.[3,5,12,24,25,28] Our data support the hypothesis that the development of external shoulder impingement is related to the accumulation of chronic, repetitive trauma or subclinical overuse injuries.

When sex was evaluated as an independent risk factor for shoulder impingement, we found that men have slightly higher incidence of shoulder subacromial impingement than women. When controlling for the influence of other risk factors in the model, the adjusted IR per 1000 person-years at risk to injury was 6.67 for men compared with 6.09 for women. Thus, men are more likely than women service members to be diagnosed with shoulder impingement.

The association between race and the incidence of shoulder impingements has not been evaluated previously. We found a significantly increased IR among white service members compared with black service members, indicating race is a factor for shoulder impingement.

Service in the Army and Air Force, as well as being in the enlisted ranks, were significant risk factors in our cohort. The higher injury rates in those 2 branches of the military might reflect differences in physical activity requirements (e.g., more strenuous training exercises), because shoulder-intensive activities have been shown to be a risk factor for impingement syndrome[7]; they could also arise from variability in injury surveillance methods between branches.[7] The observed difference between reported incidences in the enlisted ranks compared with the officer ranks is interesting and yet not easily explained. We hypothesize that potential sources of this discrepancy could possibly be attributed to differences between the enlisted and officer ranks in occupational demands, emphasis on physical fitness programs, or recreational activities such as weight lifting or recreational sports. Thus, further studies controlling for the differences in physical activity and injury documentation may be warranted.

Compared with other orthopedic conditions in the active-duty military population, shoulder impingements are relatively common, with 7.7 cases/1000 patient-years. Comparatively, other epidemiologic studies have reported cases per 1000 patient-years of 1.21 for scaphoid fractures,[30] 1.69 for shoulder dislocations,[17] 2.98 for lateral epicondylitis,[31] 3 for anterior cruciate ligament injuries,[18] 3.98 for carpal tunnel syndromes,[32] 10.5 for plantar fasciitis,[22] 34.95 for ankle sprains,[2] and 40.5 for low back pain.[10] For overall orthopedic and nonorthopedic

Table II Incidence rate per 1000 person-years for shoulder impingement based on sex*

Sex	Injuries	Person-years	Unadjusted		Adjusted	
			Rate	RR (95% CI)	Rate	RR (95% CI)
Male	93,372	1,1758,249	7.94	1.18 (1.16-1.20)	6.67	1.10 (1.06-1.13)
Female	13,568	2,010,285	6.75	N/A	6.09	

CI, confidence interval; *RR*, rate ratio.
* Male reference category; adjusted for race, age, branch of service, and rank.

Table III Incidence rate per 1000 person-years for shoulder impingement based on race*

Race	Injuries	Person-years	Unadjusted		Adjusted	
			Rate	RR (95% CI)	Rate	RR (95% CI)
White	74,786	9,444,404	7.92	1 (0.99-1.01)	6.79	
Black	19,708	2,604,922	7.57	0.96 (0.94-0.97)	6.02	0.89 (0.86-0.91)
Other	12,446	1,719,208	7.24	0.91 (0.90-0.93)	6.33	0.93 (0.91-0.96)

CI, confidence interval; *RR*, rate ratio.
* Male reference category; adjusted for sex, age, branch of service, and rank.

Table IV Incidence rate per 1000 person-years for shoulder impingement based on branch of service*

Service	Injuries	Person-years	Unadjusted		Adjusted	
			Rate	RR (95% CI)	Rate	RR (95% CI)
Army	40,827	4,897,019	8.34	1.37 (1.35-1.40)	7.05	1.42 (1.39-1.46)
Navy	21,800	3,587,430	6.08	1 (0.98-1.02)	4.96	
Air Force	32,903	3,513,408	9.37	1.54 (1.52-1.57)	7.25	1.46 (1.42-1.50)
Marines	11,410	1,770,677	6.44	1.06 (1.04-1.09)	6.50	1.31 (1.26-1.36)

CI, confidence interval; *RR*, rate ratio.
* Male reference category; adjusted for sex, race, age, and rank.

Table V Incidence rate per 1000 person-years for shoulder impingement based on rank*

Rank	Injuries	Person-years	Unadjusted		Adjusted	
			Rate	RR (95% CI)	Rate	RR (95% CI)
Junior Enlisted (E1-E4)	32,389	6,068,283	5.34	1 (0.99-1.02)	7.82	
Senior Enlisted (E5-E9)	55,262	5,480,090	10.08	1.89 (1.86-1.92)	7.26	0.93 (0.90-0.96)
Junior Officer (01-03)	8,676	1,348,611	6.43	1.21 (1.18-1.23)	5.35	0.68 (0.66-0.71)
Senior Officer (04-09)	10,613	871,550	12.18	2.28 (2.23-2.33)	5.42	0.69 (0.66-0.73)

CI, confidence interval; *RR*, rate ratio.
* Ranks E1-E4 and E5-E9 refer to Enlisted grades 1 through 4 and grades 5 through 9, respectively. Ranks 01-03 and 04-09 refer to Officer grades 1 through 3 and grades 4 through 9, respectively. Names of specific ranks can vary by branch of service. Male reference category; adjusted for sex, race, age, and branch of service.

conditions, the top 10 ambulatory diagnoses in the U.S. military from 2000 to 2009 were ICD-9-CM codes 719 (unspecified disorders of joints) with 313.3, code 724 (unspecified disorders of back) with 251.7, 367 (disorders of refraction and accommodations) with 215, code 465 (acute upper respiratory infections) with 170, code 309 (adjustment reaction) with 143.7, code 726 (peripheral enthesopathies and allied syndromes) with 104.72, code 780 (general symptoms) with 97.33, code 303 (alcohol dependence) with 94.16, code 729 (other disorders of soft tissues) with 93.66, and code 786 (symptoms involving respiratory and chest) with 93.47 cases/1000 patient-years.

Some limitations previously described in other studies should also be noted in the present study.[2,9,17-19,23,30,32] The overall quality of medical surveillance data depends on the completeness, validity, consistency, timeliness, and accuracy of the data.[1] The data collected and stored in this military database were comprehensive, but data quality issues are often found in large administrative health care databases. Errors, such as miscoding of cases by health care providers, or incomplete records could affect the overall data quality. In addition, this study only considered the first injury occurrence for each individual. This screen ensured only incident cases contributed to the study but limited our ability to analyze reinjury or contralateral injuries sustained by an individual.

Another limitation is that ICD-9-CM code 726.10 is a broad diagnosis code that could encompass impingement and other shoulder conditions. To report a true incidence of shoulder impingement, a review of individual patient medical record could be performed. However, reviewing each patient's medical record would not be feasible because of the large number of person-years and patients enrolled. Another limitation of our data is the lack of detailed information about levels of shoulder-intensive athletic activity or occupational exposure. We used branch of service and military rank in our study as representatives for level of activity, but these categoric representations provide limited insight into actual exposure. Although data on branch- and rank-specific athletic and occupational requirements were not available to us, future studies may incorporate them to help overcome some of the limitations in the present study.

Despite these limitations, the ambulatory care data contained within the DMED have many advantages over similar civilian systems. Data are collected for all visits for the population of interest (active-duty U.S. service members) using standardized inpatient and ambulatory care data records, and the Armed Forces Health Surveillance strives for a standardized and consistent approach to data processing and validation.[1] Furthermore, accurate demographic and exposure data are included in this database through the Defense Manpower Data Center. The exposure information detailing person-time at risk allows for IR calculations for the entire active-duty military population.[11,26]

Another strength of this investigation is the size of the physically active cohort studied. To our knowledge, this is the largest epidemiologic study examining the incidence and risk factors associated with shoulder impingement, with more than 100,000 incident cases documented during the study period. Although the study population may not be directly comparable to the general U.S. population, it may be representative of the population that regularly engages in athletic or occupational activities with upper extremity demands. By studying the epidemiology of shoulder impingement in a population with high IRs, we were able to identify demographic and occupational risk factors that may not have been apparent in a study of the general population. Also, a study of the military population would have the advantages of a closed health care system, closer patient observance, and more comprehensive records, leading to more accurate results.

Conclusions

The incidence of shoulder impingement in the U.S. military population is 7.77 cases/1000 person-years. An age of ≥40 years and male sex were associated with the highest rates of shoulder impingements in the study population. Demographic (sex, age) and occupational (service branch, rank) factors studied were associated with the incidence of shoulder impingement. Race was associated with the incidence of shoulder impingement. Future studies should focus on the effects of controllable risk factors associated with the incidence of shoulder impingement as well as potentially reducing any controllable and modifiable risk factors for shoulder impingement.

Disclaimer

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