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SHOULDER

Trends in the diagnosis of SLAP lesions in the US military

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Abstract
Purpose Shoulder pathology, particularly SLAP (superior labrum anterior-posterior) lesions, is prevalent in overhead athletes and physically active individuals. The aim of this study is to quantify the burden of SLAP lesions in the military and establish risk factors for diagnosis.
Methods A retrospective analysis of all service members diagnosed with a SLAP lesion (International Classification of Disease, Ninth Revision code 840.70) in the Defense Medical Epidemiological Database between 2002 and 2009 was performed. Available epidemiological risk factors including age, sex, race, military rank, and branch of service were evaluated using multivariate Poisson regression analysis, and cumulative and subgroup incidence rates were calculated.
Results During the study period, approximately 23,632 SLAP lesions were diagnosed among a population at risk of 11,082,738, resulting in an adjusted incidence rate of 2.13 per 1,000 person-years. The adjusted annual incidence rate for SLAP lesions increased from 0.31 cases per 1,000 person-years in 2002 to 1.88 cases per 1,000 person-years in 2009, with an average annual increase of 21.2 % (95 % CI 20.7 %, 22.0 %, $p < 0.0001$) during the study period. Age, sex, race, branch of military service, and military rank were independent risk factors associated with the incidence rate of SLAP lesion ($p < 0.01$). Male service members were over twofold more likely (IRR, 2.12; 95 % CI 2.01, 2.23) to sustain a SLAP lesion when compared with females. Increasing age category was associated with a statistically significant increase in the incidence rate for SLAP lesions in the present study ($p < 0.001$). After controlling for the other variables, those individuals of white race, enlisted ranks, or Marine Corps service experienced the highest incidence rates for SLAP.
Conclusion This is the first study to establish the epidemiology of SLAP lesions within an active military cohort in the American population. Sex, age, race, military rank, and branch of military service were all independently associated with the incidence rate of SLAP lesions in this physically active population at high risk for shoulder injury.
Level of evidence II.

Keywords SLAP · Superior labrum · Epidemiology · Military

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Introduction

First described by Snyder in 1990 [25], superior labrum anterior–posterior (SLAP) lesions represent a significant source of shoulder disability in active populations,

accounting for approximately 1.1–3 % of patients presenting to sports medicine referral centres [27]. Furthermore, SLAP lesions may be present in up to 26 % of patients proceeding to arthroscopic surgery [8, 12, 13, 24].

Superior labral pathology may arise from acute injury or repetitive microtrauma and contribute to mechanical symptoms during overhead activity, particularly combined abduction and external rotation. Considerable debate exists on the optimal algorithm for the diagnosis and management of SLAP lesions, even most surgeons rely on characteristic findings on advanced imaging study and concordant special examination testing. With 12 distinct subtypes of SLAP lesions, treatment has varied widely and has continued to evolve. Introduced as a formal diagnosis in 2001, SLAP repair was formally established as a Current Procedural Terminology (CPT) code 29807 in 2003. However, other surgical options including benign neglect, debridement, extended labral repair, and/or primary biceps tenodesis have been described with mixed clinical outcomes reported in the literature [18].

Concordantly, the prevalence of this condition and its subsequent surgical treatment has also increased substantially over the past two decades [27]. Unfortunately, little is known about the epidemiology of SLAP lesions, particularly in a young and physically active population at high risk to shoulder injury. To our knowledge, no prior population-based studies have rigorously investigated the epidemiology of SLAP lesions in a high-risk population with significant upper extremity occupational demands. The primary objective of this study is to examine trends in the incidence rate of SLAP lesions among active duty US military personnel between 2002 and 2009. A secondary objective was to assess the association between demographic and occupational factors associated with the incidence rate for SLAP lesions within this physically active population.

Materials and methods

A retrospective cohort study was performed to systematically examine the incidence rates and epidemiology of SLAP lesions within United States (U.S.) active duty military personnel between 2002 and 2009 using the Defense Medical Epidemiological Database (DMED) [1]. The DMED is an established tool for epidemiological research and public health surveillance for various musculoskeletal injuries, and its methodology is well described previously [3, 14–16]. A query was performed in the DMED for all encounters at military treatment facilities or contracted civilian centres with an International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) code 840.7, the billable code for superior glenoid labrum lesion introduced in 2001. From this dataset, all patients with symptomatic SLAP lesions were extracted and isolated for analysis. Using active duty military personnel information available through the Defense Manpower Data Center to calculate person-time at risk for injury, overall incidence rates were calculated.

Further subanalyses were performed according to various demographic (e.g. sex, age, race) and occupational (e.g. branch of military service, military rank) factors to determine incidence rates of SLAP by individual patient-specific factors. Age in years was organized according to the following categories: under 20, 20–24, 25–29, 30–34, 35–39, and greater than or equal to 40. Identified racial categories were white, black, or other. Service categories included US Army, Marine Corps, Navy, and Air Force, while rank was arranged by junior enlisted (E1–E4), senior enlisted (E5–E9), junior officer (O1–O4), and senior officer (O5–O9). Inpatient data were excluded to capture only ambulatory encounters with the primary diagnosis of SLAP lesion. As previously described, incident events were limited to a "first occurrence" to exclude repeat coding of the same initial injury for all service members during the study period.

This study received approval from the Keller Army Hospital Institutional Review Board (Protocol 07/009).

Statistical analysis

The primary outcome of interest was the incidence rate of SLAP lesions during the study period and expressed as the rate per 1,000 person-years at risk. The overall incidence rate of SLAP lesions in the study population, along with the 95 % confidence interval (95 % CI), was calculated by dividing the total number of injuries by the total person-years at risk and multiplying by 1,000. Using the injury and personnel data extracted from DMED, we used a multivariable Poisson regression model to estimate the incidence rate of SLAP lesions per 1,000 person-years by strata (e.g. sex), while controlling for the influence of the other variables in the model (e.g. age, race, service, and rank). We calculated unadjusted and adjusted incidence rates, incidence rate ratios (IRR), and 95 % confidence intervals for each demographic and occupational category using the subset with the lowest incidence rate as the referent category. To evaluate trends in the incidence rate of SLAP lesions, we modelled the average annual percentage increase during the study period along with 95 % confidence intervals. In a similar fashion, we also evaluated trends in the incidence rate of SLAP lesions with increasing age category. All statistical analyses were performed with SAS statistical software (SAS Inc, Cary, NC, USA).

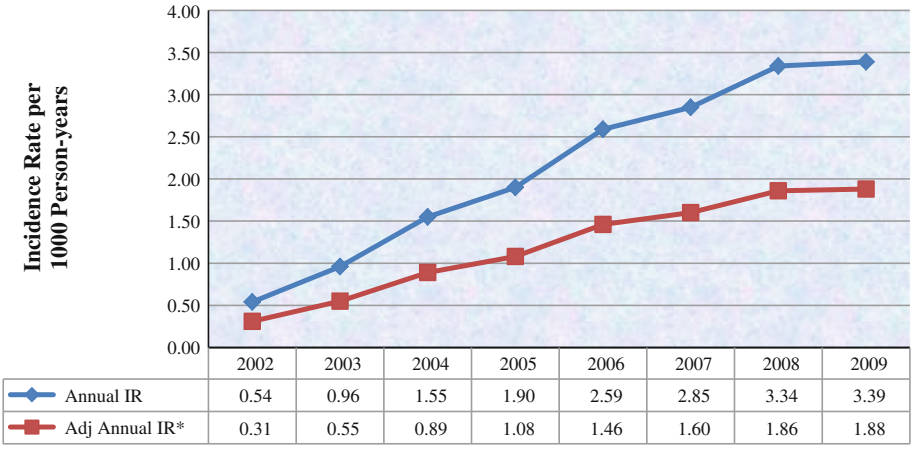

Fig. 1 Unadjusted and adjusted annual incidence rates for SLAP lesions among active duty US military service members between 2002 and 2009. *Incident rate (IR) adjusted for sex, age, race, branch of military service, and rank

Table 1 Unadjusted and adjusted incidence rates of SLAP lesions in active duty military personnel by calendar year, 2002–2009

Year	No. cases	Person-years	Unadjusted		Adjusted	
			Rate	% Increase from previous year (95 % CI)	Rate[a]	% Increase from previous year (95 % CI)
2002	750	1,389,984	0.54	–	0.31	–
2003	1,353	1,411,380	0.96	78 % (63 %, 94 %)	0.55	78 % (62 %, 94 %)
2004	2,184	1,411,280	1.55	61 % (51 %, 73 %)	0.89	61 % (51 %, 73 %)
2005	2,616	1,376,747	1.90	23 % (17 %, 30 %)	1.08	21 % (15 %, 28 %)
2006	3,528	1,362,012	2.59	36 % (30 %, 43 %)	1.46	35 % (29 %, 42 %)
2007	3,883	1,360,847	2.85	10 % (5 %, 15 %)	1.60	9 % (5 %, 15 %)
2008	4,592	1,375,282	3.34	17 (12 %, 22 %)	1.86	16 % (12 %, 21 %)
2009	4,726	1,395,206	3.39	1 % (−3 %, 6 %)	1.88	1 % (−3 %, 05 %)

[a] Incident rate (IR) adjusted for sex, age, race, branch of military service, and rank

Results

Between 2002 and 2009, a total of 23,632 incident SLAP lesions were identified from 11,082,738 person-years at risk. The overall unadjusted incidence rate during the study period was 2.13 (95 % CI 2.11–2.16) cases per 1,000 person-years, with an average of 2,954 incident SLAP lesions diagnosed per year. There was a significant increase in the adjusted annual incidence rate of SLAP lesions during the study period (Fig. 1), and the average annual increase in the incidence rate was 21.2 % (95 %CI 20.7 %, 22.0 %, $p < 0.001$; Table 1).

All examined demographic and occupational variables were independently associated with the incidence of SLAP lesions ($p < 0.001$). The incidence rate for injury varied significantly by sex, age, race, military rank, and branch of military service during the study period (Table 2). Increasing age category was associated with a statistically significant increase in the incidence rate for SLAP lesions after controlling for the other variables in the statistical model ($p < 0.001$), and on average, there was an 24.5 % (95 % CI 23.7 %, 25.3 %) increase in the adjusted incidence rate of SLAP lesions with increasing age category (Fig. 2). The adjusted incidence rate for SLAP lesions among male service members was over twice as high when compared to females (Table 2). Furthermore, the incidence rate for white service members was significantly higher than those of black and other race ($p < 0.001$), and individuals in the other category had higher incidence rates than those of black race ($p < 0.001$) (Table 2).

Military rank and branch of military service were occupational factors associated with the incidence rate of SLAP lesions in the current study. The highest incidence rate of SLAP lesions was observed among service members in the Marine Corps, followed by those serving in the Army, Navy, and Air Force, respectively (Table 2). When evaluating the influence of rank, adjusted incidence rates for SLAP lesions were highest among senior enlisted service members, followed by junior enlisted service members, junior officers, and senior officers, respectively. All groups experienced significantly higher incidence rates of injury when compared with senior officers (Table 2).

Table 2 Unadjusted and adjusted incidence rates and rate ratios for SLAP lesions in active duty military personnel by demographic and occupational factors

	No. cases	Percentage of cases (%)	Person-years	Unadjusted rate	Unadjusted rate ratio	95 % CI	Adjusted[a] rate	Adjusted rate ratio	95 % CI
Age (years)									
<20	571	2.4	833,016	0.69	1.00	–	0.37	1.00	–
20–24	5,560	23.5	3,744,404	1.48	2.17	1.99, 2.36	0.84	2.25	2.06,2.45
25–29	5,176	21.9	2,385,313	2.17	3.17	2.90, 3.45	1.30	3.48	3.18,3.81
30–34	3,773	16.0	1,587,773	2.37	3.47	3.17, 3.79	1.45	3.90	3.55,4.29
35–39	4,236	17.9	1,380,860	3.07	4.48	4.10, 4.88	1.91	5.13	4.66,5.64
>40	4,316	18.3	1,151,372	3.75	5.47	5.01, 5.97	2.44	6.54	5.93,7.20
Gender									
Male	22,151	93.7	9,463,035	2.34	2.56	2.43, 2.70	1.72	2.12	2.01,2.23
Female	1,481	6.3	1,619,685	0.91	1.00	–	0.81	1.00	–
Race									
White	18,064	76.4	7,639,256	2.36	1.67	1.60,1.74	1.53	1.74	1.67,1.81
Other	2,713	11.5	1,425,971	1.90	1.34	1.27,1.41	1.22	1.38	1.31,1.46
Black	2,855	12.1	2,013,911	1.42	1.00	–	0.88	1.00	–
Rank									
Jr. Enlisted	7,367	31.2	4,850,808	1.52	0.48	0.46,0.51	1.28	1.20	1.12,1.28
Sr. Enlisted	11,845	50.1	4,443,797	2.67	0.85	0.81,0.89	1.34	1.26	1.20,1.33
Jr. Officer	2,236	9.5	1,093,669	2.04	0.65	0.62,0.69	1.07	1.01	0.95,1.08
Sr. Officer	2,184	9.2	694,464	3.14	1.00	–	1.07	1.00	–
Service									
Army	9,760	41.3	4,029,704	2.42	1.39	1.3,1.45	1.35	1.52	1.47,1.57
Navy	5,123	21.7	2,807,400	1.82	1.05	1.01,1.10	0.98	1.10	1.06,1.15
Marines	3,927	16.6	1,460,723	2.68	1.55	1.48,1.62	1.68	1.89	1.80,1.97
Air Force	4,822	20.4	2,784,911	1.73	1.00	–	0.88	1.00	–

[a] Incidence rate is expressed per 1,000 person-years

Adjusted incidence rate is adjusted for all other variables in the table

RR denotes rate ratios compared with the referent category

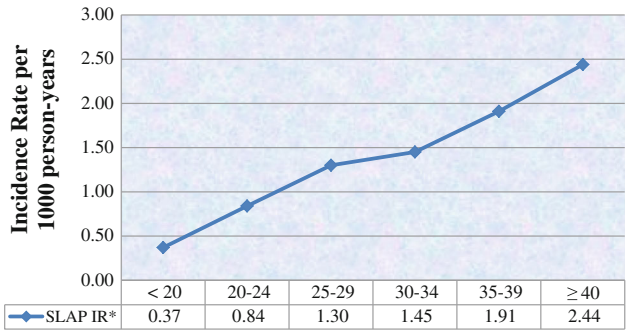

Fig. 2 Adjusted annual incidence rates for SLAP lesions by age group among active duty US military service members between 2002 and 2009. *Incident rate (IR) adjusted for sex, race, branch of military service, and rank

Discussion

The most important finding in this study is that male gender, increasing age, white race, enlisted rank, and service in the Marine Corps are associated with the highest incidence rates of SLAP lesion. In this young and physically active population at high risk for shoulder pathology [14], two incident cases of SLAP were identified for every 1,000 person-years at risk during the study period. Furthermore, there was a significant increase in the incidence rate of new SLAP cases, with a 25 % average annual increase over the eight-year time period. To our knowledge, this represents the first population-based study to evaluate trends in the incidence rate of SLAP lesions in a high-risk cohort.

Some authors have expressed concern about the disproportionate increase in the diagnosis and surgical treatment of these lesions. In one recent study [27], approximately 9.4 % of shoulder surgeries presented by Part II candidates to the American Board of Orthopaedic Surgery involved SLAP repair, nearly threefold greater than that expected from the existing literature. Similarly, Zhang et al. [28] have documented a 105 % increase the

rate of SLAP repair between 2004 and 2009 in a national database from the United States. Furthermore, studies [12, 24] have also described surgical treatment of SLAP lesions in 6–26 % of patients undergoing shoulder arthroscopy. This may correspond with a concordant increase in the diagnosis of SLAP lesions, either due to improved diagnostic sensitivity or increasing error in diagnosis. While the current investigation does not address the ultimate course of treatment for SLAP lesions in this cohort, we recognize that further clarification of the spectrum and prevalence of superior labral pathology is of paramount importance.

Likewise, judicious clinical judgment should be exercised when considering surgical intervention for superior labral pathology, especially in the absence of antecedent trauma or with patients of advancing age. As patients approach 40 years of age, cumulative degenerative changes occur that may resemble a pathologic SLAP lesion [21]. Similar to that of the meniscus, age-related labral degeneration occurs as a result of histological changes in the fibrocartilaginous soft tissues [9]. Ultimately, this fundamentally diminishes the labral thickness and modulus of elasticity, which may predispose patients to subsequent labral pathology in an acute on chronic injury pattern [5, 11] given the progressive, underlying patterns of age-related change identified between 30 and 50 years of age [17, 23].

Military service incurs significant physical demands, and cumulative exposure to overhead or other at-risk activity may also increase the rate of degenerative labral changes, particularly among senior enlisted and older soldiers with longer periods of service. The current study reveals a linear relationship between the incidence rate of SLAP lesion and increasing age category, although traumatic and degenerative aetiologies of other shoulder conditions may demonstrate disparate trends with regard to age [20]. Interestingly, Provencher et al. [19] have demonstrated worse clinical outcomes with superior labral repair in military service members of increased age. Of their series of 179 patients with surgical repair, 66 individuals (36.8 %) were classified as failures, with 50 requiring further revision procedures including biceps tenodesis, tenotomy, or arthroscopic debridement. Age was the most notable risk factor for post-operative failure, with an average age of 39.2 versus 29.7 years old in patients with successful primary arthroscopic treatment. In the light of this, further studies are required to better ascertain the optimal method for treating ageing, active cohorts with biceps–labral pathology, as well as to ascertain the utility of primary bicipital tenodesis in this population.

Gender has been evaluated as a contributory risk factor for multiple musculoskeletal conditions, particularly those involving the shoulder [2, 26]. The current study reveals that the male service members have over a twofold higher adjusted incidence rate of SLAP tears than females when controlling for other variables. Despite a disproportionately higher rate of shoulder hypermobility or patholaxity [22], female service members demonstrated a significantly lower incidence of SLAP lesions, which is consistent with reports from the civilian literature [28]. Other prior characterizations of SLAP lesions have largely focused on the epidemiology in overhead athletes, which may over-represent male baseball athletes more so than those involved in other coed sports (tennis, volleyball, and weightlifting). Similar studies in the military population have failed to include female patients in their outcome-based studies on operatively treated SLAP lesions [6, 7]. However, one study demonstrated a greater prevalence of traumatic SLAP lesions among men than women [10], although it is difficult to compare estimates of prevalence and incidence. The disparity by gender in the current study could potentially be explained by underlying differences in at-risk exposure. Particularly in the Army and Marine Corps, certain occupational hazards inherent to the military setting and service in the combat arms are currently restricted for female personnel.

The findings presented in this investigation implicate a higher incidence of SLAP lesions with Caucasian race. To our knowledge, no prior investigations have sought to address the role of race in the epidemiology of biceps–labral pathology, although notable differences have been discovered in other shoulder and musculoskeletal conditions [14, 16, 22]. Owens et al. [14] revealed an increased incidence of shoulder dislocation in white military service members when compared with other racial categories. In a similar cohort of military personnel, Scher et al. [22] described an increased incidence rate of joint hypermobility syndrome. Furthermore, subtle differences in glenohumeral anatomy have been documented by race [4]. In an evaluation of 172 young, pair-matched cadaveric scapulae, glenoid retroversion was significantly increased in white specimens when compared with sex-matched specimens of black race, while no differences were noted in glenoid size or inclination. Even though racial category was a significant risk factor in the current study, its influence on the incidence of SLAP lesions is complex and may not be as important as other environmental or demographic variables.

Service in the Marine Corps and enlisted ranks were identified as significant risk factors relevant to military service members. These findings mirror the epidemiological trends of other musculoskeletal injuries by military service branch and rank, and it may reflect relative differences in activity level, physical demands, and/or cumulative exposure to at-risk activity evident across these

categories. For example, the Marine Corps mandate the performance of pull-ups as a part of its physical fitness requirements, which may impose greater stress upon the biceps–labrum complex. Additionally, Marines adhere to more stringent criteria for temporary activity restrictions, and this may limit adequate rehabilitation and further exacerbate overuse shoulder injuries. Further specific occupational hazards associated with military rank and service branch should be articulated so that directed screening and risk-mitigating measures may be developed.

As with any large database study, certain limitations must be acknowledged. Symptomatic SLAP lesion had no preset diagnostic criteria and could not be independently verified with advanced imaging. In addition to provider miscoding, the accuracy of this diagnosis must also be considered amid the spectrum of anatomic variants of the superior labrum, which may comprise up to 25 % of certain populations [27] and complicate radiographic evaluation. While considered the gold standard, arthroscopic diagnosis of a SLAP lesion is also subject to significant interobserver reliability and it can be difficult to distinguish between a type II SLAP lesion and normal anatomy, even among experienced arthroscopic surgeons. Additionally, the presence of concomitant pathology frequently associated with SLAP lesions was not documented, and the progression to surgical management is unknown [7]. Despite these limitations, the strengths of this study include its large patient cohort, high degree of physical fitness, and relatively closed health care network.

With the elucidation of these non-modifiable risk factors in a physically active population, we can better identify patients at risk for the development of SLAP lesions and guide early conservative treatment. Furthermore, greater attention can be devoted to establishing the natural history and optimal treatment of SLAP lesions within this unique military cohort.

Conclusion

Sex, age, race, military rank, and branch of military service were all independently associated with the incidence rate of SLAP lesions in this physically active population at high risk for shoulder injury. Notably, male service members were twice as likely to sustain a SLAP lesion than female, while increasing age was associated with incrementally higher incidence rates. Those in the Army, Marine Corps, Navy, and more senior enlisted service members were more likely to have a SLAP lesion. Further study could focus on further identifying modifiable and non-modifiable risk factors for SLAP lesions in high-risk population.

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