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Burden and Risk Factors for Achilles Tendinopathy in the Military Population, 2006–2015: A Retrospective Cohort Study

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Context: Ankle-foot injuries are ubiquitous in the US military, with Achilles tendinopathy a common condition that affects function and health-related quality of life.

Objective: To evaluate the burden and associated factors of Achilles tendinopathy.

Design: Descriptive epidemiology study.

Setting: The Defense Medical Epidemiological Database was used to identify relevant health care encounters.

Patients or Other Participants: All active duty and reserve military members who served between 2006 and 2015 (officers = 2 149 887; enlisted = 9 503 995).

Main Outcome Measure(s): Multiyear prevalence of Achilles tendinopathy care episodes was calculated and compared by military rank, service branch, and year. Unadjusted and adjusted assessments of injury burden were calculated.

Results: Officers incurred 37 939 episodes at a prevalence of 17.65 per 1000 servicemembers (male officers = 18.20 per 1000 servicemembers, female officers = 14.80 per 1000 servicemembers). Among enlisted personnel, 116 122 episodes of Achilles tendinopathy occurred in 12.22 per 1000 servicemembers (male enlisted = 12.07 per 1000 servicemembers, female enlisted = 13.22 per 1000 servicemembers). All officer specialties had a higher burden of Achilles tendinopathy episodes than the ground and naval gunfire officers (prevalence ratio [PR] = 1.04–1.43) except for aviation, which demonstrated a lower burden (PR = 0.65). Among enlisted occupations, maritime or naval specialties had a lower burden of Achilles tendinopathy than infantry (PR = 0.82) and all other specialties except for aviation, which had a higher burden (PR = 1.07–1.71). Multiple associated factors were identified: sex, age, rank, military occupation, and service branch.

Conclusions: Achilles tendinopathy was ubiquitous in the US military, with a progressive increase in prevalence during the study epoch. Sex, age, rank, military occupation, and service branch were identified as associated factors. These findings highlight the need for both prophylactic interventions and identification of the populations with the greatest need.

Key Words: lower leg, epidemiology, injury burden

Key Points

- Achilles tendinopathy was ubiquitous in the US military, with sex, age, rank, military occupation, and service branch identified as salient factors.
- In the assessment of outcomes over time, the number of care episodes was incrementally higher in the latter years of the study, indicating a growing burden of Achilles tendinopathy in the military.
- These findings highlight the need for both prophylactic interventions and identification of the populations that can most greatly benefit from such interventions.

Achilles tendinopathy is a common ankle-foot condition that affects function and health-related quality of life in both military and civilian populations. Characterized by persistent tendon pain and loss of function related to mechanical loading,[1] Achilles tendinopathy is classified as insertional or noninsertional (midportion).[2] The incidence of Achilles tendinopathy has been estimated to be 2.16 per 100 000 person-years in the general population, although the actual burden is likely much higher, as many people do not seek medical treatment for this condition.[3] This repetitive microtraumatic injury contributes to impairments in the ability to generate force and power during propulsion, jumping, and landing, which precludes activities such as walking, marching or hiking, running, and obstacle negotiation during recreation and when performing occupational duties.[4]

The burden of Achilles tendinopathy affects not only the individual with the condition but also the organization and society to which the individual belongs. The combined indirect and direct costs of the condition are estimated to be $991 per patient due to the resources required for providing care, lost work productivity, and absenteeism.[5] Because Achilles tendinopathy in military members can result in limited duty, protracted and costly medical management, lost working time, and decreased military readiness, identification of the associated factors that may contribute to this injury may help us to prioritize targeted prophylactic interventions.

The authors of a systematic review of risk factors associated with Achilles tendinopathy in the general population identified alcohol use, training during cold weather, prior lower limb tendinopathy or fracture, use of fluoroquinolone antibiotics, decreased plantar-flexor strength, decreased forward progression of propulsion, and a more lateral plantar pressure progression during the stance phase of gait as important.[6] In the military population, the number of deployments, moderate alcohol use, body mass, and increased age were cited as salient factors for Achilles tendinopathy.[7] As the composition of the military changes and women are increasingly integrated into all military occupations,[8] assessing the influence of sex in various military occupations (each having different physical demands and environmental hazards) on the burden of Achilles tendinopathy is warranted. Although conflicting evidence exists pertaining to the role of sex in the development of Achilles tendinopathy,[6] evaluation of these factors would permit better planning of the medical capabilities needed to prevent and manage this condition as the force composition evolves. Furthermore, the US military experienced a substantial drawdown in conflict starting in 2011.[9] The reduced operational demand and training requirements during the subsequent years likely affected musculoskeletal injuries,[10] which warrants an updated assessment. Therefore, the purpose of our study was to determine the burden of Achilles tendinopathy in the military population with consideration of military occupation and the salient risk factors that may contribute to this condition. We hypothesized that male sex, occupations that were more administrative in nature, older age, senior enlisted and officer ranks, and service in the Army and Marine Corps would be risk factors for the diagnosis of Achilles tendinopathy. Furthermore, we anticipated a decrease in the Achilles tendinopathy burden in the latter half of the study as the US shifted from a wartime to a peacetime mission.

METHODS

A population-based epidemiologic retrospective cohort study of all servicemembers in the US Armed Forces was performed assessing sex, rank, military occupation, branch, and year on Achilles tendinopathy prevalence from 2006 to 2015. The Defense Medical Epidemiological Database (DMED; Defense Health Agency, https://bit.ly/DMED030724) was used to identify relevant health care encounters. This database provides aggregated data for the *International Classification of Diseases, Ninth Revision-Clinical Modification* (*ICD-9-CM*), codes and deidentified patient characteristics, including sex, categories of military occupations, and branch of service for all active duty and reserve military servicemembers who served between 2006 and 2015 (officers = 2 149 887; enlisted = 9 503 995). The database is Health Insurance Portability and Accountability Act compliant, does not include any personal identifiable or personal health information, and has been used for the epidemiologic study of ankle-foot injury in the military.[10,11] This study was approved as non–human-subjects research by the Institutional Review Board at the Naval Health Research Center (NHRC.2020.0207-NHSR). The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines[12] were used to guide reporting.

The database was queried for the number of distinct medical encounters with a primary diagnosis of Achilles tendinopathy (*ICD-9-CM* code 726.71) from 2006 to 2015. Prevalence calculations of patients diagnosed with Achilles tendinopathy were conducted for male and female military members, enlisted and officers, in each service branch (Air Force, Army, Marine Corps, and Navy) and occupational category.[10,11] We calculated prevalence ratio (PR) point estimates and 95% CIs, risk difference point estimates, attributable risk, and χ^2 statistics in the assessment of sex and occupation category using Excel for Mac (version 2016; Microsoft Corp) and a custom epidemiologic spreadsheet.[13] In the unadjusted evaluation of sex and occupation on the Achilles tendinopathy burden, male servicemembers, enlisted infantry, and ground or naval gunfire officer groups served as the reference categories.

Due to data overdispersion, we selected a negative binomial model over a Poisson model for the adjusted assessment of female sex (male reference), branch (US Army reference), officer rank (enlisted reference), and year (2006 reference) on the burden of Achilles tendinopathy.[14] Because excess zeros were present in the data, with many demographic categories not having any reported outcomes of interest (especially among the smaller subpopulations), we assessed convergence between the unadjusted and adjusted (hurdle) negative binomial regression models. In the hurdle negative binomial regression model, a logistic link was used to remove demographic categories that contributed no Achilles tendinopathy episodes from the final count model. By doing so, excess zeros that contributed to skewed point estimates, standard errors, and overdispersion were parsed in the truncated regression model.[14] Results of the hurdle negative binomial are reported using calculations of the predictors regressed on count data (count model assessing the prevalence of the outcome) as well as a linked logistic regression (zero model that assessed the probability within demographic categories of not having the outcome). Both the unadjusted and adjusted models are provided in the Supplemental Material (available online at https://dx.doi.org/10.4085/1062-6050-0182.23.S1). The regression analyses were performed using the PSCL (version 1.5) and MASS (version 7.3-58.1) packages in R (version 3.5.1; The R Foundation for Statistical Computing). The level of significance was $P < .05$ for all analyses. Prevalence ratio point estimates were interpreted as statistically significant if the CIs did not cross the 1.00 threshold. Convergence of *P* values, effect sizes, and 95% CIs were considered when evaluating significant findings.

RESULTS

Supplemental Tables 1 and 2 detail the counts and prevalences of Achilles tendinopathy in officer and enlisted personnel. During the study epoch, officers incurred 37 939 episodes at a prevalence of 17.65 per 1000 servicemembers (male officers = 18.20 per 1000 servicemembers, female officers = 14.80 per 1000 servicemembers). Among enlisted personnel, 116 122 episodes of Achilles tendinopathy occurred at a prevalence of 12.22 per 1000 servicemembers (male enlisted = 12.07 per 1000 servicemembers, female enlisted = 13.22 per 1000 servicemembers). The univariate factor of sex in occupational specialty on Achilles tendinopathy episodes is detailed in Table 1. In the officer community, female officers had a lower burden of Achilles tendinopathy than their male counterparts in all occupations (PR = 0.52–0.81). Female enlisted had a higher burden of Achilles tendinopathy than their male counterparts in the maintenance and maritime or

Table 1. Assessment of Achilles Tendinopathy Burden by Sex Within Occupation in Members of the US Armed Forces, 2006–2015[a]

Occupational Specialty	Prevalence Ratio (95% CI)[b]	Risk Difference (per 1000 Servicemembers)	Attributable Risk, %	*P* Value
Enlisted specialty				
Administration, intelligence, and communication	**0.94 (0.91, 0.96)**	**−1.0**	**−6.9**	**<.001**
Artillery or gunnery	1.04 (0.89, 1.22)	0.5	3.7	.64
Aviation	0.93 (0.72, 1.21)	−0.6	−7.1	.61
Combat engineer	0.96 (0.66, 1.39)	−0.4	−4.6	.81
Enlisted total	**1.04 (1.02, 1.06)**	**1.2**	**8.7**	**<.001**
Logistics	**0.95 (0.91, 0.99)**	**−0.6**	**−4.9**	**.02**
Maintenance	**1.08 (1.04, 1.11)**	**0.8**	**7.0**	**<.001**
Maritime or naval specialties	**1.33 (1.15, 1.55)**	**2.3**	**25.0**	**<.001**
Officer specialty				
Administration	**0.76 (0.70, 0.82)**	**−6.0**	**−31.4**	**<.001**
Aviation	**0.63 (0.53, 0.74)**	**−4.1**	**−58.9**	**<.001**
Engineering and maintenance	**0.84 (0.77, 0.91)**	**−3.1**	**−18.9**	**<.001**
Ground or naval gunfire	**0.52 (0.43, 0.63)**	**−8.1**	**−91.9**	**<.001**
Logistics	**0.78 (0.72, 0.84)**	**−5.6**	**−28.7**	**<.001**
Officer total	**0.81 (0.79, 0.84)**	**−3.4**	**−22.9**	**<.001**
Operations and intelligence	**0.78 (0.71, 0.85)**	**−4.6**	**−29.0**	**<.001**
Services	**0.70 (0.67, 0.74)**	**−5.7**	**−42.2**	**<.001**

[a] Female servicemembers referenced to male members.
[b] Bolded values indicate statistical significance.

naval specialties and in the aggregate of all occupations (PR = 1.04–1.33). Female sex was a protective factor in the administrative and logistic enlisted specialties (PR = 0.94–0.95).

In the evaluation of occupational exposure, all but 1 officer specialty had a higher burden of Achilles tendinopathy episodes than the ground and naval gunfire officers (PR = 1.04–1.43; Table 2). Aviation was the only officer community that demonstrated a significant protective effect (PR = 0.65). Among enlisted specialties, maritime or naval specialties had a lower burden of Achilles tendinopathy than infantry (PR = 0.82), and all other specialties except for aviation had a significantly higher burden (PR = 1.07–1.71). No difference was found between aviation specialties and infantry.

The results of the hurdle (adjusting for zero inflation) and standard multivariable negative binomial regression models are shown in Table 3. In both assessments, female sex and age greater than 30 years were salient factors once rank, branch, and year were controlled. Junior officers had a lower burden than junior enlisted, and service in the Army carried the greatest risk for Achilles tendinopathy episodes. The frequency of Achilles tendinopathy episodes was higher from 2010 to 2016 than in 2006.

DISCUSSION

Our primary findings were that Achilles tendinopathy was ubiquitous in the US military, with sex, age, rank, military

Table 2. Assessment of Achilles Tendinopathy Burden by Occupation in the US Armed Forces, 2006–2015

Occupational Specialty	Prevalence Ratio (95% CI)[a]	Risk Difference (per 1000 Servicemembers)	Attributable Risk, %	*P* Value
Enlisted specialties[b]				
Administration, intelligence, and communication	**1.71 (1.67, 1.75)**	**6.3**	**41.5**	**<.001**
Artillery or gunnery	**1.41 (1.36, 1.47)**	**3.7**	**29.2**	**<.001**
Aviation	0.94 (0.88, 1.01)	−0.5	−6.2	.08
Combat engineer	**1.10 (1.04, 1.16)**	**0.9**	**9.0**	**<.001**
Logistics	**1.42 (1.38, 1.46)**	**3.7**	**29.5**	**<.001**
Maintenance	**1.25 (1.22, 1.28)**	**2.2**	**20.0**	**<.001**
Maritime or naval specialties	**0.82 (0.77, 0.88)**	**−1.6**	**−22.1**	**<.001**
Mechanized or armor	**1.07 (1.01, 1.15)**	**0.7**	**6.9**	**.03**
Special operation forces	**1.17 (1.08, 1.25)**	**1.5**	**14.2**	**<.001**
Officer specialties[c]				
Administration	**1.40 (1.35, 1.46)**	**6.7**	**28.7**	**<.001**
Aviation	**0.65 (0.63, 0.68)**	**−5.8**	**−53.1**	**<.001**
Engineering and maintenance	**1.17 (1.13, 1.21)**	**2.8**	**14.3**	**<.001**
Logistics	**1.43 (1.38, 1.49)**	**7.2**	**30.1**	**<.001**
Operations and intelligence	**1.18 (1.13, 1.23)**	**3.0**	**15.2**	**<.001**
Services	**1.04 (1.00, 1.07)**	**0.6**	**3.6**	**.03**

[a] Bolded values depict statistical significance.
[b] Contrasted with enlisted infantry.
[c] Referenced to ground and naval gunfire officers.

Table 3. Results of the Adjusted and Unadjusted Negative Binomial Regressions Assessing Sex, Age, Rank, Service Branch, and Year on Prevalence of Achilles Tendinopathy in the US Armed Forces, 2006–2015[a]

	Hurdle Negative Binomial Model (Adjusted for Zero Inflation)		Unadjusted Negative Binomial Model	
	Prevalence Ratio	95% CI	Prevalence Ratio	95% CI
Sex: female	**1.21**	**1.13, 1.29**	**1.16**	**1.06, 1.26**
Age range, y				
20–29	**0.80**	**0.69, 0.93**	**0.73**	**0.60, 0.88**
30–39	**1.54**	**1.34, 1.78**	**1.29**	**1.08, 1.55**
40+	**3.06**	**2.64, 3.54**	**2.34**	**1.93, 2.82**
Rank				
Senior enlisted	**0.78**	**0.71, 0.87**	0.93	0.82, 1.05
Junior officers	**0.68**	**0.61, 0.75**	**0.74**	**0.65, 0.83**
Senior officers	**0.80**	**0.72, 0.90**	0.94	0.82, 1.09
US Branch				
Air Force	**0.91**	**0.83, 1.00**	**0.87**	**0.77, 0.98**
Marine Corps	**0.89**	**0.81, 0.97**	**0.74**	**0.65, 0.83**
Navy	**0.55**	**0.50, 0.60**	**0.51**	**0.45, 0.58**
Year				
2007	1.03	0.88, 1.20	1.07	0.88, 1.30
2008	0.97	0.83, 1.14	0.95	0.78, 1.15
2009	1.04	0.89, 1.22	1.06	0.87, 1.29
2010	**1.28**	**1.10, 1.49**	**1.36**	**1.12, 1.65**
2011	**1.31**	**1.12, 1.52**	**1.37**	**1.13, 1.67**
2012	**1.43**	**1.23, 1.67**	**1.49**	**1.23, 1.81**
2013	**1.58**	**1.36, 1.84**	**1.67**	**1.37, 2.02**
2014	**1.56**	**1.34, 1.81**	**1.60**	**1.32, 1.94**
2015	**1.63**	**1.40, 1.90**	**1.69**	**1.40, 2.05**
	Log-likelihood ratio: −3025 on 41 *Df*		Log-likelihood ratio: −6583 on 41 *Df*	

[a] The zero model used a binomial regression with logit link. In the second step, the count model used a truncated negative binomial regression (omitting zero counts) with log link. Contrasts: sex [male]; age [18–19]; rank [junior enlisted]; branch [US Army]; year [2006].
[b] Bolded values indicate statistical significance [$P < .05$].

occupation, and service branch identified as salient factors. In considering outcomes over time, the number of care episodes was incrementally higher in the latter years of the research. Based on the growing burden of Achilles tendinopathy in the US military we observed, these findings highlight the need for both prophylactic interventions and identification of the populations that can most greatly benefit from such interventions. Interventions may include administrative controls that ameliorate modifiable intrinsic risk factors and overexposure, such as adjusting training schedules, as well as engineering control, such as shock-absorbing insoles.[4] When used in the context of operational risk management, deliberate risk assessment, risk decision-making, and implementation or supervision of controls may help to prevent musculoskeletal injuries such as Achilles tendinopathy.[15]

Few plausible reasons exist for why Achilles tendinopathy was more common in the latter half of this study. The operational tempo of military operations earlier in the epoch likely influenced the degree of exposure to potentially injurious loads that may contribute to Achilles tendinopathy. The US military was involved in contingency operations in both Iraq and Afghanistan, with drawdowns occurring in both theaters beginning in 2011. Cumulative exposure to increased load carriage (due to body armor, equipment, etc) earlier in the time frame may have resulted in the manifestation of repetitive microtrauma in the later years. It is also conceivable that higher operational tempo earlier in the study epoch precluded the ability to seek care, with military drawdown providing an opportunity to seek care for more chronic conditions that were put off due to prioritization of the mission.[16] Another possible explanation of increased prevalence later in the study epoch may be associated with force-shaping requirements, with the need to expand the recruitment aperture to meet mission requirements.[16] Body mass among recruits[17] and active military members[18] has progressively increased over time, a factor that was associated with increased Achilles tendinopathy risk.[6,7]

Occupation was a salient factor for Achilles tendinopathy, a finding that has been reported in military populations.[7] Disparities in burden among occupations may be a function of the types of exposures and hazards unique to that vocation encountered during operations. In addition, social factors likely either foster or preclude the ability to seek care, especially when absence from the unit would affect the ability to meet mission requirements.[16] Social factors, such as occupational culture, may also influence care seeking and the degree to which a supervisor is willing to support and encourage workplace absence for medical care. This supposition may also explain why the greatest burden was observed in office-based occupations compared with combat arms. Military members in office-based occupations are frequently in greater proximity to medical services, which provides improved access and reduces the time absent from work when care is needed. Lastly, perceptual differences regarding injury and the value of medical care among occupations may also drive care-seeking behaviors.[16] Specifically, viewing injury as self-limiting or a sign of weakness may preclude care seeking.[16] Furthermore, fear of being pulled from the mission or distrust in the medical capability to adequately manage injury may also be barriers to care.[16]

Perceptual differences shaped by service culture may explain the significant differences among the military branches.

Older age was an especially salient factor for Achilles tendinopathy, demonstrating the strongest and largest magnitude effects observed. Although evidence for age as a factor is mixed across studies,[6] younger age appears to be a protective factor in military populations.[7] From a physiological perspective, elasticity and vascularity tend to decrease with age, with a curtailed ability to heal after repetitive microtrauma.[19] In addition, musculotendinous stiffness may play a role, with women generally displaying higher tendon compliance.[20,21] This may also explain why women tend to have a lower prevalence of rupture.[20] It is also plausible that age-related findings may be tied to the military retirement benefit.[22] Military members in their 40s and 50s are retirement eligible, which would foster increased care seeking to manage chronic Achilles tendinopathy symptoms that was postponed earlier in their career. Age-related increases in body mass in older military members could have contributed to the increased Achilles tendinopathy burden, as this group was shown to have the greatest rates of obsesity.[18] This supposition would require substantiation in future research.

In this study, we demonstrated that Achilles tendinopathy is an increasing threat to the medical readiness of the armed forces and a substantial burden to the military health system. In a resource-constrained environment, these results can be used to provide targeted prevention programs to the communities with the greatest risk. Furthermore, our findings can assist military leaders and medical logisticians by providing greater precision when planning the types of clinicians and supplies needed to address Achilles tendinopathy throughout the military.

A substantial strength of our investigation was that the DMED allowed for the assessment of population-level differences in Achilles tendinopathy by sex, occupation, military rank, branch of service, and year. However, limitations of this study also existed. Using diagnostic codes has inherent weaknesses, especially among military populations in whom many determinants can influence care seeking.[16] The data we used represented only individuals who sought treatment for their injuries and omitted those who self-managed their conditions. Considering that many military members do not seek care for their injuries due to psychosocial influences,[16] the burden of Achilles tendinopathy is likely much higher. Lastly, although personnel were categorized by their military occupation, a detailed task analysis to determine the specific duties and exposures that may be associated with these injuries was not possible.

CONCLUSIONS

Achilles tendinopathy was ubiquitous in the US military, with a progressive increase in prevalence during the study epoch. Multiple factors associated with Achilles tendinopathy were identified: sex, age, rank, military occupation, and service branch. Based on the growing burden of Achilles tendinopathy in the US military observed, these findings highlight the need for both prophylactic interventions and identification of the populations that can most greatly benefit from such interventions.

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SUPPLEMENTAL MATERIAL

Supplemental Table 1. Count and Prevalence of Achilles Tendinopathy Care Episodes Among Officers in the US Armed Forces, 2006–2015.

Supplemental Table 2. Count and Prevalence of Achilles Tendinopathy Care Episodes Among Enlisted Members in the US Armed Forces, 2006–2015.

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