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Anterior Knee Pain Risk in Male and Female Military Tactical Athletes

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Context: Anterior knee pain (AKP) is ubiquitous in early career military members and exacerbated during functional tasks required during military duties. Therefore, it is important to understand the risk of this condition among male and female tactical athletes in diverse military occupations.

Objective: To assess sex and occupation with respect to the AKP risk in military members.

Design: Descriptive epidemiology study.

Setting: United States Armed Forces.

Patients or Other Participants: All military members diagnosed with anteropatellar or retropatellar pain, patellar instability, or knee tendinopathy on their initial encounter from 2006 to 2015.

Main Outcome Measure(s): The Defense Medical Epidemiology Database was queried for the number of individuals with AKP. Relative risk (RR) and χ^2 statistics were calculated in the assessment of sex and occupational category. Regressions were calculated to determine associations between service branch, sex, and AKP across time.

Results: From 2006 to 2015, a total of 151 263 enlisted and 14 335 officer service members were diagnosed with AKP. Enlisted females had an incidence rate of 16.7 per 1000 person-years compared with enlisted males' incidence rate of 12.7 per 1000 person-years (RR = 1.32; 95% CI = 1.30, 1.34; $P < .001$) across all AKP diagnoses. Female officers had an incidence rate of 10.7 per 1000 person-years; male officers had an incidence rate of 5.3 per 1000 person-years (RR = 2.01; 95% CI = 1.94, 2.09). Differences in risk were also noted across military occupations for both enlisted and officer service members (P values $< .05$).

Conclusions: Sex and military occupation were salient factors for the AKP risk. Evaluating training requirements and developing intervention programs across military occupations could serve as a focus for future research aiming to decrease the incidence of chronic knee pain.

Key Words: knee injuries, military personnel, occupational injuries, sports medicine, public health

Key Points

- Enlisted females were at a 1.32-fold increased risk of anterior knee pain (AKP) compared with enlisted males, while female officers were at a 2.01-fold increased risk of AKP compared with male officers.
- Logistics, administration, intelligence and communication, engineering, maintenance, and artillery occupations had the highest risk, with enlisted special operators, maritime/naval occupations, and the aviation community at the lowest risk.
- Sex, rank, and military occupation were salient factors in the risk of AKP. These findings provide direction for the development of training programs to reduce attrition and improve military readiness.

Anterior knee pain (AKP) is a common lower extremity injury reported in various populations: adolescents,[1] physically active individuals,[2] the general population,[3] and the military.[4] *Anterior knee pain* is often used as a catch-all term for various types of injuries that relate to the patella and anterior aspect of the knee. These conditions often include patellofemoral pain, patellar tendinopathy, and patellar instability. Although diagnostic criteria vary among the subgroups of AKP, commonalities exist in patient presentations. Patients with AKP often report long-term recurrent symptoms,[5] decreased subjective function,[6] and limitations related to strenuous activity and sport.[2,7] More than 91% of patients with AKP will describe pain for up to 16 years after initial diagnosis,[8] demonstrating a significant burden on their health-related quality of life.

In a recent systematic review,[3] the incidence of AKP among military recruits ranged from 9.7 to 571.4 per 1000 person-years,[4,9–14] with higher rates in females (33 per 1000 person-years) than in their male counterparts (15 per 1000 person-years).[1,4] Additionally, the prevalence of AKP has been reported to be as high as 13.5% among naval midshipmen; 25% of females enrolling at the United States Naval Academy cited a previous diagnosis of AKP.[4] When clinical presentation and chronic symptoms are considered, the ubiquitous nature of AKP among military recruits is concerning. Symptoms of AKP are frequently exacerbated during weight-bearing tasks, such as walking, running, jumping, squatting, lunging, and stair negotiation.[15] Individuals experiencing pain during these tasks are limited in their ability to perform activities of daily living, recreational exercise, and occupational duties,[16] which could be very detrimental to those serving in the military. Activity

limitation resulting from AKP accounts for a larger proportion of medical discharge from the military than other lower extremity injuries.[9,13]

Because AKP is ubiquitous in early-career military members and exacerbated during the functional tasks required during military duties, it is important to understand if the incidence of this condition differs across diverse military occupations. Furthermore, if disparities in physical exposure to varying load carriage requirements, physical training, kneeling, and jumping exist between military occupations and sex-related factors of AKP in military occupations (with the assumption of similar occupational exposure) is currently unknown. Identification of the AKP risk across sex and military occupations would allow for greater precision in resource allocation and the development of more ecologically valid treatment approaches and targeted interventions for groups with the greatest need and improve military readiness. Therefore, the purpose of our study was to assess the risk of AKP in military service men and women across multiple military occupations.

METHODS

A population-based epidemiologic retrospective cohort study of all service members in the US Armed Forces was performed to assess the risk of sex and military occupation on the outcome of AKP incidence from 2006 to 2015. The Defense Medical Epidemiological Database (Defense Health Agency, https://bit.ly/DHADMED) was used to identify relevant health care encounters. This database provides aggregated data for International Classification of Diseases, Ninth Revision codes (ICD-9; https://www.cdc.gov/nchs/icd/icd9.htm) and deidentified patient characteristics, including sex, categories of military occupations, and branch of service for all active duty and reserve military service members. The database is Health Insurance Portability and Accountability Act (HIPAA) compliant, does not include any personal identifiable or personal health information, and has been used previously for an epidemiologic study of lower extremity injury in the military.[17] This study was approved as non–human-subjects research by the Institutional Review Board at the Naval Health Research Center (NHRC.2020.0203-NHSR).

Because AKP is characterized by a diverse set of potential diagnoses, the database was queried for the number of distinct patients with a primary diagnosis of anteropatellar and retropatellar pain (ICD-9 code 717.7, chondromalacia patella; code 726.65, prepatellar bursitis), patellar instability (code 718.36, patellar subluxation; code 836.3, patellar dislocation), and knee tendinopathy (code 726.60, quadriceps tendinopathy [enthesopathy of knee, unspecified]; code 726.64, patellar tendinopathy) for the initial medical encounter from 2006 to 2015. Patients with repeat visits for the same diagnosis were counted only once in all analyses.

The cumulative incidence of patients diagnosed with AKP was calculated for male and female military members, enlisted and officers, in each service branch (Army, Navy, Marine Corps, and Air Force) and occupational category. Relative risk (RR) point estimates and 95% CIs, risk difference point estimates, attributable risk (AR), number needed to harm (NNH), and χ^2 statistics were conducted to assess sex and occupation category. Male service members were the reference group in the assessment of sex. Enlisted infantry and ground/naval gunfire officer groups were the reference groups in the assessment of occupational risk. Linear regression was performed to evaluate the relationship of branch, sex, rank, and year with the incidence of AKP using R (version 3.5.1; The R Foundation for Statistical Computing). The level of significance was $P \leq .05$ for all analyses. An RR point estimate was considered statistically significant if the CI did not cross the 1.00 threshold. All calculations were performed using Excel for Mac (version 2016; Microsoft Corp) and a custom epidemiologic calculator spreadsheet.[18]

RESULTS

From 2006 to 2015, 151 263 enlisted service members were diagnosed with AKP: 60 670 with anteropatellar or retropatellar pain, 11 956 with patellar instability, and 78 637 with knee tendinopathy. A total of 14 335 military officers were diagnosed with AKP: 10 105 with anteropatellar or retropatellar pain, 1014 with patellar instability, and 3216 with knee tendinopathy. The total incidence rate of AKP in enlisted service members was 13.2 per 1000 person-years, while the rate for military officers was 6.2 per 1000 person-years. The AKP risk displayed no change between 2006 and 2015 ($t = 0.650$, $P = .517$).

Sex

The number of AKP cases and the incidence by sex is reported for enlisted service members in Table 1 and officers in Table 2. Incidence rates were 16.7 per 1000 person-years for enlisted females and 12.7 per 1000 person-years for enlisted males (RR = 1.32; 95% CI = 1.30, 1.34; $P < .001$) across all AKP diagnoses. Females enlisted in the Army had the greatest risk of AKP at 20.9 per 1000 person-years. Female enlisted service members also had a greater incidence risk for anteropatellar and retropatellar pain (RR = 1.32; 95% CI = 1.30, 1.35; $P < .001$), instability (RR = 1.56; 95% CI = 1.49, 1.63; $P < .001$), and tendinopathy (RR = 1.28; 95% CI = 1.26, 1.31; $P < .001$; Table 3). Female officers had an incidence rate of 10.7 per 1000 person-years and male officers had an incidence rate of 5.3 per 1000 person-years (RR = 2.01; 95% CI = 1.94, 2.09). Female officers had a greater relative risk of experiencing tendinopathy (RR = 4.75; 95% CI = 4.43, 5.09) than male officers.

Branch and Rank

The AKP incidences across the individual military services between 2006 and 2015 are reported in the Figure. Service members in the Army were at a greater risk of AKP: enlisted service members had a rate of 16.1 per 1000 person-years and officers had a rate of 7.7 per 1000 person-years ($t = 5.272$, $P < .001$). Those in the Navy were at less risk of AKP, with the rate for enlisted service members at 8.6 per 1000 person-years and the rate for officers at 4.4 per 1000 person-years ($t = -7.893$, $P < .001$). Military officers were at a lower risk of AKP compared with their enlisted counterparts ($t = -20.12$, $P < .001$).

Occupation

The risk of AKP by military occupation is reported in Table 4. Enlisted infantry and naval gunfire officers were

Table 1. Case Counts and Incidence Rates of Anterior Knee Pain Among Enlisted Members of the US Armed Forces

Condition / Military Service	No.			Incidence Rate (per 1000 Person-Years)		
	Males	Females	Total	Males	Females	Total
Anteropatellar and retropatellar pain (n = 60 670)						
Army	23 052	4986	28 038	6.1	8.7	6.4
Navy	6958	1814	8772	3.0	4.1	3.2
Air Force	11 165	3571	14 736	5.3	7.0	5.6
Marines	8480	644	9124	5.3	5.5	5.3
Total	49 655	11 015	60 670	5.1	6.7	5.3
Patellar instability (n = 11 956)						
Army	3515	812	4327	0.9	1.4	1.0
Navy	1881	567	2448	0.8	1.3	0.9
Air Force	2293	899	3192	1.1	1.8	1.2
Marines	1791	198	1989	1.1	1.7	1.2
Total	9480	2476	11 956	1.0	1.5	1.0
Knee tendinopathy (n = 78 637)						
Army	31 413	6206	37 619	8.3	10.8	8.6
Navy	9457	2690	12 147	4.1	6.1	4.5
Air Force	14 608	3902	18 510	6.9	7.7	7.1
Marines	9251	1110	10 361	5.8	9.4	6.0
Total	64 729	13 908	78 637	6.6	8.5	6.9
Total anterior knee pain (n = 151 263)						
Army	57 980	12 004	69 984	15.3	20.9	16.1
Navy	18 296	5071	23 367	8.0	11.5	8.6
Air Force	28 066	8372	36 438	13.3	16.5	13.9
Marines	19 522	1952	21 474	12.2	16.6	12.5
Total	123 864	27 399	151 263	12.7	16.7	13.2

the reference group for comparisons. Differences were identified in 6 enlisted specialties: mechanized/armor, artillery/gunnery, engineering, maintenance, administration/intelligence/communication, and logistics. The greatest risks of enlisted service members were in logistics (RR = 1.38; 95% CI = 1.35, 1.42) and administrative/intelligence/communication (RR = 1.33; 95% CI = 1.30, 1.46) occupations versus enlisted infantry service members. When comparing occupations of officers, administration, engineering/maintenance, operations/intelligence, and logistics were statistically significant. The occupations with the greatest risk in officers were logistics (RR = 1.42; 95% CI = 1.34, 1.50) and administration (RR = 1.35; 95% CI = 1.28, 1.43) versus naval gunfire officers.

Table 2. Case Counts and Incidence Rates of Anterior Knee Pain Among Officers of the US Armed Forces

Condition / Military Service	No.			Incidence Rate (per 1000 Person-Years)		
	Males	Females	Total	Males	Females	Total
Anteropatellar and retropatellar pain (n = 10 105)						
Army	4023	1052	5075	5.2	7.1	5.5
Navy	1300	312	1612	2.9	3.7	3.1
Air Force	2010	709	2719	3.8	5.8	4.2
Marines	626	73	699	3.2	5.7	3.3
Total	7959	2146	10 105	4.1	5.9	4.4
Patellar instability (n = 1014)						
Army	293	102	395	0.4	0.7	0.4
Navy	141	50	191	0.3	0.6	0.4
Air Force	237	114	351	0.4	0.9	0.5
Marines	70	7	77	0.4	0.5	0.4
Total	741	273	1014	0.4	0.7	0.4
Knee tendinopathy (n = 3216)						
Army	848	703	1551	1.1	4.8	1.7
Navy	272	259	531	0.6	3.1	1.0
Air Force	420	498	918	0.8	4.1	1.4
Marines	158	58	216	0.8	4.5	1.0
Total	1698	1518	3216	0.9	4.1	1.4
Total anterior knee pain (n = 14 335)						
Army	5164	1857	7021	6.6	12.6	7.6
Navy	1713	621	2334	3.9	7.4	4.4
Air Force	2667	1321	3988	5.0	10.8	6.1
Marines	854	138	992	4.4	10.8	4.8
Total	10 398	3937	14 335	5.3	10.7	6.2

Table 3. Assessment of Risk of Anterior Knee Pain by Sex in Female Members of the US Armed Forces, 2006–2015[a]

Personnel Occupation	Relative Risk (95% CI)	Risk Difference (per 1000 Person-Years)	Attributable Risk, %	*P* Value[b]	No. Needed to Harm
Enlisted specialty					
Artillery/gunnery	1.33 (1.16, 1.52)	4.5	24.8	**<.001**	224
Aviation	1.61 (1.33, 1.95)	5.7	37.9	**<.001**	175
Engineering	0.42 (0.32, 0.56)	−21.9	−136.4	**<.001**	−46
Maintenance	1.27 (1.23, 1.31)	3.1	21.2	**<.001**	323
Administration, intelligence, and communication	1.25 (1.23, 1.28)	3.3	20.2	**<.001**	299
Logistics	1.24 (1.20, 1.29)	3.4	19.5	**<.001**	295
Maritime/naval specialties	1.45 (1.27, 1.66)	3.8	31.2	**<.001**	264
Enlisted total					
Tendinopathy	1.28 (1.26, 1.31)	1.9	22	**<.001**	536
Instability	1.56 (1.49, 1.63)	0.5	35.8	**<.001**	1849
Anteropatellar and retropatellar pain	1.32 (1.30, 1.35)	1.6	24.4	**<.001**	609
All AKP diagnoses	1.32 (1.30, 1.34)	4.0	24.2	**<.001**	247
Officer specialty					
Ground/naval gunfire	0.96 (0.79, 1.17)	−0.3	−3.8	.71	−3322
Aviation	1.31 (1.11, 1.55)	1.7	23.6	**.001**	581
Engineering and maintenance	1.28 (1.16, 1.41)	2.8	21.8	**<.001**	364
Administration	1.23 (1.10, 1.36)	2.1	18.4	**<.001**	475
Operations and intelligence	1.01 (0.85, 1.19)	0.0	0.9	.91	24 867
Logistics	1.31 (1.19, 1.45)	3.5	23.9	**<.001**	287
Services	1.24 (1.16, 1.32)	1.8	19.1	**<.001**	548
Officer total					
Tendinopathy	4.75 (4.43, 5.09)	3.3	78.9	**<.001**	306
Instability	1.96 (1.70, 2.25)	0.4	48.9	**<.001**	2746
Anteropatellar and retropatellar pain	1.43 (1.37, 1.50)	1.8	30.2	**<.001**	566
All AKP diagnoses	2.01 (1.94, 2.09)	5.4	50.3	**<.001**	185

Abbreviation: AKP, anterior knee pain.
[a] Female service members referenced to male members.
[b] Bolded *P* values indicate statistical significance.

DISCUSSION

Our primary findings indicated that sex, rank, and military occupation were salient factors in the risk of AKP. Enlisted females were at a 1.32-fold increased risk of AKP compared with enlisted males, while female officers were at a 2.01-fold increase for risk of AKP compared with male officers. Additionally, females were at greater risk of anteropatellar or retropatellar pain, instability, and tendinopathy, with female officers having the greatest RR for patellar tendinopathy at 4.75 (95% CI = 4.43, 5.09). Finally, military service members who worked in logistics had an increased risk of AKP, as shown in both the enlisted (RR = 1.38; 95% CI = 1.35, 1.42) and officer (RR = 1.42; 95% CI = 1.34, 1.50) ranks.

Total incidences for AKP in the active-duty military were 13.2 and 6.2 per 1000 person-years in the enlisted and officer ranks, respectively. The incidence of chondromalacia patella in the current study was greater than previously reported (4.32 cases per 1000 person-years).[19] These findings are consistent with previous incidence data on patellofemoral pain in the military setting, which ranges between 9.7 and 571.4 cases per 1000 person-years.[10–14] Patellofemoral pain and chondromalacia patella are 2 specific conditions that can fall under the umbrella term of *AKP*, which does warrant some caution when comparing incidence rates across studies.

The 3 subgroups of AKP reviewed in this investigation (anteropatellar or retropatellar pain, patellar instability, and tendinopathy) provide an inclusive overview of the common forms of knee pain. Knee tendinopathy was the most common subgroup among enlisted service members, accounting for 6.9 cases per 1000 person-years. Owens et al[20] identified 584 cases of patellar tendinopathy among 80 106 active duty service members in 3 separate single-year time periods (2001, 2004, and 2007) but did not report incidence rate in person-years. When compared with the general population (1.6 cases per 1000 person-years),[21] the incidence of AKP in the military is much greater.[20] Prevention programs need to be prioritized to optimize military readiness, as recurrence rates range between 21% and 27%.[22,23]

Sex

Females had a higher incidence (10.7 to 16.7 per 1000 person-years) and RR (1.32–2.01) of AKP compared with their male counterparts. This result is consistent with previous research[4] that demonstrated females were 2.23 times more likely to experience patellofemoral pain. The rates of anteropatellar and retropatellar pain, including the chondromalacia patella diagnosis, in this study (5.3 and 4.4 per 1000 person-years in the enlisted and officer ranks, respectively) are also consistent with those reported earlier (4.32 per 1000 person-years).[19] Although our data indicated similar incidence rates, it should be noted that the conditions included in our definition of AKP were broader than the specific diagnosis of patellofemoral pain[4,10–12,14] or chondromalacia patella.[19]

Female enlisted members and officers presented with a higher incidence of knee tendinopathy than their male counterparts. Limited evidence has addressed sex factors in the incidence of knee tendinopathy, yet males have displayed a higher prevalence.[24] Our findings diverge from

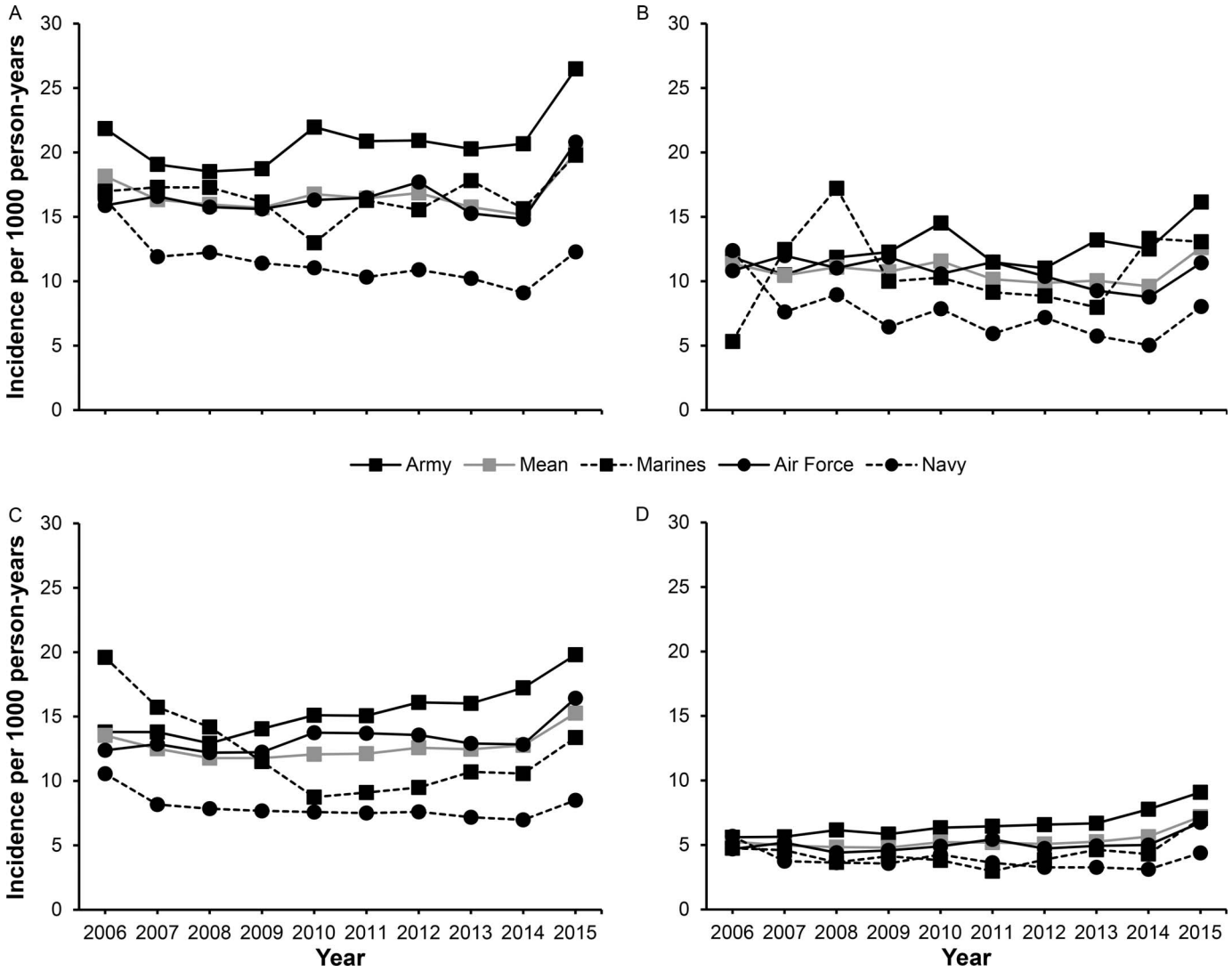

Figure. Risk of anterior knee pain in military service members. A, Female enlisted service members. B, Female officers. C, Male enlisted service members. D, Male officers.

Table 4. Assessment of Risk of Anterior Knee Pain by Occupation of US Armed Forces, 2006–2015

Personnel Occupation	Relative Risk (95% CI)	Risk Difference (per 1000 Person-Years)	Attributable Risk, %	*P* Value[c]	No. Needed to Harm
Enlisted specialty[a]					
Special operation forces	0.69 (0.64, 0.76)	−3.2	−43.9	**<.001**	−312
Mechanized/armor	1.08 (1.02, 1.15)	0.8	7.5	**.01**	1180
Artillery/gunnery	1.31 (1.26, 1.36)	3.2	23.6	**<.001**	308
Aviation	0.93 (0.87, 0.99)	−0.8	−7.9	**.02**	−1308
Engineering	1.21 (1.15, 1.27)	2.2	17.5	**<.001**	450
Maintenance	1.12 (1.10, 1.15)	1.3	11.0	**<.001**	768
Administration, intelligence, and communication	1.33 (1.30, 1.36)	3.5	25.0	**<.001**	286
Logistics	1.38 (1.35, 1.42)	4.0	27.8	**<.001**	248
Maritime/naval specialties	0.86 (0.81, 0.92)	−1.4	−15.8	**<.001**	−698
Officer specialty[b]					
Aviation	0.68 (0.65, 0.72)	−2.6	−46.5	**<.001**	−381
Engineering and maintenance	1.23 (1.17, 1.30)	1.9	18.8	**<.001**	520
Administration	1.35 (1.28, 1.43)	2.9	26.1	**<.001**	343
Operations and intelligence	1.17 (1.11, 1.23)	1.4	14.4	**<.001**	718
Logistics	1.42 (1.34, 1.50)	3.5	29.6	**<.001**	287
Services	1.00 (0.96, 1.05)	0.0	0.2	.95	72 979

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

those previously reported,[25,26] in which the authors speculated that males were at higher risk of developing knee tendinopathy due to greater athletic demands and cumulative exposure during sport. It is plausible that the incidence of knee tendinopathy may be affected by other factors, such as occupational exposure, strength, or lower extremity function. Increased demands in the military may explain why females had a greater incidence in our study, as knee tendinopathy and training volume have been found to be related.[27] Future research to assess the mechanical tendon load during military training may help to elucidate this and provide direction for appropriate interventions.

Rank and Branch

Enlisted service members had a greater risk for AKP than did officers, groups that included both junior and senior members. Earlier investigators[19] identified junior and senior enlisted personnel as having the highest incidence rate of chondromalacia patella (junior = 3.75, 95% CI = 3.57, 3.93; senior = 2.29, 95% CI = 2.20, 2.39) compared with military officers. Additionally, our findings of a greater risk for knee injuries in land-based service branches (Army and Marines) versus non–land-based service branches (Air Force and Navy) are consistent with those in the literature.[19,20,28] The requirements of both the enlisted and land-based service branches suggest a relationship between activity and training demands and risk of AKP. Although modification of military requirements is not plausible for all branches, the implementation of intervention programs that target those high-risk groups is warranted.

Occupation

Both enlisted and officer service members had the greatest risk of AKP when employed in logistics, administration, intelligence and communication, engineering, maintenance, and artillery occupations. The lowest risk was in enlisted special operators, maritime/naval occupations, and the aviation community. Our data agree with previous evidence evaluating chondromalacia patella,[19] patellar tendinopathy,[20] and other forms of knee injuries among various occupations.[28] These findings are interesting, as overuse and increased demands are suggested to be the cause of AKP, and yet, those occupations with higher demands had lower incidence rates. We could theorize that those in positions with more physical requirements, such as infantry, are accustomed to the occupational demands. However, it is also plausible that those in more demanding occupations might not have the same access to medical care or are less likely to actively seek care due to psychosocial determinants unique to the military.[29] Objective assessment of the required training load across military occupations is needed for us to better understand its role in the incidence rate of AKP.

Clinical and Research Implications

We are among the first to evaluate AKP in the active military across branches and occupations. Most of the established incidence rates have been reported in military recruits and cadets enrolling in a 6-week to 25-week training program, which may explain the wide range of incidence rates in the earlier studies.[10–14] Increased physical demands and overuse likely contribute to the development of AKP,[30] as the incidence rate of AKP is greatest in the early phases of training and decreases after the first month of training.[13] Although AKP is the most frequent cause of medical discharge of military recruits,[9] limited evaluation of AKP in service members beyond their initial training is available. Almost 3% of all military service members seek rehabilitative care for knee pain,[13] supporting our findings that AKP still presents a large concern in the military. Identifying those at greater risk across branches and occupations provides future direction for developing training programs to reduce occupational attrition and improve military readiness. Co-location of uniformed and civilian rehabilitation specialists, which includes both physical therapists and athletic trainers in proximity to the operational forces, is warranted in garrison and while deployed.[29] When complemented with sports medicine physicians, the diverse skills of the cohesive interdisciplinary musculoskeletal team allow preventive screening and the implementation of interventions to address identified risk factors, as well as provide timely comprehensive treatment after AKP symptom onset.

Anterior knee pain is characterized by heterogeneity of symptoms and impairments that stem from cumulative loads across the patellofemoral joint. Army personnel have the greatest risk of experiencing AKP, which can be troublesome with the recent advancements in the Army's physical fitness test. The new Army Combat Fitness Test requires a minimum deadlift of 140 lb (64 kg), a sprint/drag/carry task, and a 2-mi (3-km) run. These tasks replicate combat requirements and are sex neutral; the tasks also happen to be provocative for AKP symptoms. It is plausible that training for the new requirements will influence the risk for AKP conditions such as patellofemoral pain or patellar tendinopathy disproportionately in female personnel,[19,20] likely affecting physical readiness in this population. Future injury-surveillance efforts and epidemiologic studies evaluating the AKP risk after implementation of this requirement are warranted.

Among athletes, patellar tendinopathy has been suggested as related to decreased knee and hip range of motion during functional tasks.[30] Although physical requirements across military occupations are unknown and likely variable, ergonomic evaluations might provide further insight regarding exposure. Furthermore, load-management mitigation and strength training may be appropriate as both prophylactic and therapeutic interventions for the management of tendinopathies.[31] Additionally, quadriceps-focused strengthening programs should be considered to minimize the risk of patellofemoral pain.[32] Future study of interventions targeting the AKP risk in the military is warranted, because these have been shown to be beneficial in both clinical and research settings.[31,33]

Strengths and Limitations

Using the Defense Medical Epidemiological Database allowed for a large, population-based analysis of all service members diagnosed with AKP in each branch of military service. The ability to exclude repeat encounters resulted in an estimate of incidence and a criterion standard for epidemiologic measures of risk. Further, the stratification by sex addressed a timely military concern of public health

importance given that the full integration of women is currently underway. This is the first study to evaluate the AKP risk among military occupations across all branches of service.

This study had limitations. A wide range of ICD-9 codes were used for AKP diagnosis to account for the heterogeneity of diagnostic coding by health care professionals. The use of multiple ICD-9 codes for the 3 subdivisions of AKP minimized potential bias by providing a range of common codes used in the diagnosis. However, other codes may have been used by health care providers. Diagnostic variability could have plausibly overestimated or underestimated AKP. Recent clinical practice guidelines for patellofemoral pain[34] have provided clinician recommendations for both ICD-10 codes and International Classification of Functioning, Disability, and Health guidelines outlined by the World Health Organization, which will likely streamline the study of challenging injuries that encompass a wide range of conditions. Also, the data we presented only reflected active military service members who sought care. Disparity in care-seeking behaviors may have introduced a utilization bias in this analysis. Future assessment within occupational groups using direct survey is warranted. Military service members have demonstrated decreased care-seeking behaviors in other healthy conditions, related to self-reliance, emotional control, the stigma of weakness, or negative beliefs of coworkers.[35] Decreased care-seeking behaviors also exist in community populations experiencing chronic knee pain.[36] These barriers should be considered because these data were from a military population experiencing a chronic knee pain condition.

CONCLUSIONS

The average incidence of AKP among active-duty service members was 13.2 per 1000 person-years in enlisted personnel and 6.2 per 1000 person-years in officers from 2006 to 2015. Sex and occupation were salient risk factors for AKP, with females and occupations in logistics, administration, intelligence, and engineering being at greater risk. Further research is warranted to identify modifiable risk factors and effective treatment plans for these groups at greater risk for AKP.

DISCLAIMER

N.R.G. and J.J.F. are military service members or employees of the US Government. This work was prepared as part of their official duties. Title 17, U.S.C. §105 provides that copyright protection under this title is not available for any work of the US Government. Title 17, U.S.C. §101 defines a US Government work as work prepared by a military service member or employee of the US Government as part of that person's official duties. The views expressed in this article are those of the authors and do not necessarily reflect the official policy or position of the Department of the Navy, Department of Defense, nor the US Government. The study protocol was approved by the Naval Health Research Center Institutional Review Board in compliance with all applicable Federal regulations governing the protection of human subjects. Research data were derived from an approved Naval Health Research Center Institutional Review Board protocol, number NHRC.2020.0203-NHSR.

REFERENCES

1. Rathleff MS. Patellofemoral pain during adolescence: much more prevalent than appreciated. *Br J Sports Med*. 2016;50(14):831–832. doi:10.1136/bjsports-2016-096328
2. Glaviano NR, Baellow A, Saliba S. Physical activity levels in individuals with and without patellofemoral pain. *Phys Ther Sport*. 2017;27:12–16. doi:10.1016/j.ptsp.2017.07.002
3. Smith BE, Selfe J, Thacker D, et al. Incidence and prevalence of patellofemoral pain: a systematic review and meta-analysis. *PLoS One*. 2018;13(1):e0190892. doi:10.1371/journal.pone.0190892
4. Boling M, Padua D, Marshall S, Guskiewicz K, Pyne S, Beutler A. Gender differences in the incidence and prevalence of patellofemoral pain syndrome. *Scand J Med Sci Sports*. 2010;20(5):725–730. doi:10.1111/j.1600-0838.2009.00996.x
5. Lankhorst NE, Bierma-Zeinstra SM, van Middelkoop M. Factors associated with patellofemoral pain syndrome: a systematic review. *Br J Sports Med*. 2013;47(4):193–206. doi:10.1136/bjsports-2011-090369
6. Lankhorst NE, van Middelkoop M, Crossley KM, et al. Factors that predict a poor outcome 5–8 years after the diagnosis of patellofemoral pain: a multicentre observational analysis. *Br J Sports Med*. 2015;50(14):881–886. doi:10.1136/bjsports-2015-094664
7. Cook JL, Khan KM, Kiss ZS, Coleman BD, Griffiths L. Asymptomatic hypoechoic regions on patellar tendon ultrasound: a 4-year clinical and ultrasound followup of 46 tendons. *Scand J Med Sci Sports*. 2001;11(6):321–327. doi:10.1034/j.1600-0838.2001.110602.x
8. Stathopulu E, Baildam E. Anterior knee pain: a long-term follow-up. *Rheumatology*. 2003;42(2):380–382. doi:10.1093/rheumatology/keg093
9. Gemmell IM. Injuries among female army recruits: a conflict of legislation. *J R Soc Med*. 2002;95(1):23–27. doi:10.1258/jrsm.95.1.23
10. Kaufman KR, Brodine SK, Shaffer RA, Johnson CW, Cullison TR. The effect of foot structure and range of motion on musculoskeletal overuse injuries. *Am J Sports Med*. 1999;27(5):585–593. doi:10.1177/03635465990270050701
11. Milgrom C, Finestone A, Eldad A, Shlamkovitch N. Patellofemoral pain caused by overactivity. A prospective study of risk factors in infantry recruits. *J Bone Joint Surg Am*. 1991;73(7):1041–1043.
12. Thijs Y, Van Tiggelen D, Roosen P, De Clercq D, Witvrouw E. A prospective study on gait-related intrinsic risk factors for patellofemoral pain. *Clin J Sport Med*. 2007;17(6):437–445. doi:10.1097/JSM.0b013e31815ac44f
13. Wills AK, Ramasamy A, Ewins DJ, Etherington J. The incidence and occupational outcome of overuse anterior knee pain during army recruit training. *J R Army Med Corps*. 2004;150(4):264–269. doi:10.1136/jramc-150-04-07
14. Coppack RJ, Etherington J, Wills AK. The effects of exercise for the prevention of overuse anterior knee pain: a randomized controlled trial. *Am J Sports Med*. 2011;39(5):940–948. doi:10.1177/0363546510393269
15. Rothermich MA, Glaviano NR, Li J, Hart JM. Patellofemoral pain: epidemiology, pathophysiology, and treatment options. *Clin Sports Med*. 2015;34(2):313–327. doi:10.1016/j.csm.2014.12.011
16. Smith BE, Moffatt F, Hendrick P, et al. The experience of living with patellofemoral pain—loss, confusion and fear-avoidance: a UK qualitative study. *BMJ Open*. 2018;8(1):e018624. doi:10.1136/bmjopen-2017-018624
17. Cameron KL, Owens BD, DeBerardino TM. Incidence of ankle sprains among active-duty members of the United States Armed

Services from 1998 through 2006. *J Athl Train*. 2010;45(1):29–38. doi:10.4085/1062-6050-45.1.29
18. LaMorte WW. Epidemiology/biostatistics tools [Excel workbook]. 2006. Accessed August 3, 2019. http://bit.ly/Lamort3
19. Kusnezov N, Watts N, Belmont PJ II, Orr JD, Waterman B. Incidence and risk factors for chronic anterior knee pain. *J Knee Surg*. 2016;29(3):248–253. doi:10.1055/s-0035-1554921
20. Owens BD, Wolf JM, Seelig AD, et al; Millennium Cohort Study Team. Risk factors for lower extremity tendinopathies in military personnel. *Orthop J Sports Med*. 2013;1(1):2325967113492707. doi:10.1177/2325967113492707
21. Albers IS, Zwerver J, Diercks RL, Dekker JH, Van den Akker-Scheek I. Incidence and prevalence of lower extremity tendinopathy in a Dutch general practice population: a cross sectional study. *BMC Musculoskelet Disord*. 2016;17:16. doi:10.1186/s12891-016-0885-2
22. Fredberg U, Bolvig L, Andersen NT. Prophylactic training in asymptomatic soccer players with ultrasonographic abnormalities in Achilles and patellar tendons: the Danish Super League Study. *Am J Sports Med*. 2008;36(3):451–460. doi:10.1177/0363546507310073
23. Hagglund M, Zwerver J, Ekstrand J. Epidemiology of patellar tendinopathy in elite male soccer players. *Am J Sports Med*. 2011;39(9):1906–1911. doi:10.1177/0363546511408877
24. Zwerver J, Bredeweg SW, van den Akker-Scheek I. Prevalence of jumper's knee among nonelite athletes from different sports: a cross-sectional survey. *Am J Sports Med*. 2011;39(9):1984–1988. doi:10.1177/0363546511413370
25. Gaida JE, Cook JL, Bass SL, Austen S, Kiss ZS. Are unilateral and bilateral patellar tendinopathy distinguished by differences in anthropometry, body composition, or muscle strength in elite female basketball players? *Br J Sports Med*. 2004;38(5):581–585. doi:10.1136/bjsm.2003.006015
26. Lian OB, Engebretsen L, Bahr R. Prevalence of jumper's knee among elite athletes from different sports: a cross-sectional study. *Am J Sports Med*. 2005;33(4):561–567. doi:10.1177/0363546504270454
27. Ferretti A. Epidemiology of jumper's knee. *Sports Med*. 1986;3(4):289–295. doi:10.2165/00007256-198603040-00005
28. Jones JC, Burks R, Owens BD, Sturdivant RX, Svoboda SJ, Cameron KL. Incidence and risk factors associated with meniscal injuries among active-duty US military service members. *J Athl Train*. 2012;47(1):67–73. doi:10.4085/1062-6050-47.1.67
29. Fraser JJ, Schmied E, Rosenthal MD, Davenport TE. Physical therapy as a force multiplier: population health perspectives to address short-term readiness and long-term health of military service members. *Cardiopulm Phys Ther J*. 2020;31(1):22–28. doi:10.1097/CPT.0000000000000129
30. Trojan JD, Treloar JA, Smith CM, Kraeutler MJ, Mulcahey MK. Epidemiological patterns of patellofemoral injuries in collegiate athletes in the United States from 2009 to 2014. *Orthop J Sports Med*. 2019;7(4):2325967119840712. doi:10.1177/2325967119840712
31. Malliaras P, Cook J, Purdam C, Rio E. Patellar tendinopathy: clinical diagnosis, load management, and advice for challenging case presentations. *J Orthop Sports Phys Ther*. 2015;45(11):887–898. doi:10.2519/jospt.2015.5987
32. Neal BS, Lack SD, Lankhorst NE, Raye A, Morrissey D, van Middelkoop M. Risk factors for patellofemoral pain: a systematic review and meta-analysis. *Br J Sports Med*. 2019;53(5):270–281. doi:10.1136/bjsports-2017-098890
33. Ferber R, Bolgla L, Earl-Boehm JE, Emery C, Hamstra-Wright K. Strengthening of the hip and core versus knee muscles for the treatment of patellofemoral pain: a multicenter randomized controlled trial. *J Athl Train*. 2015;50(4):366–377. doi:10.4085/1062-6050-49.3.70
34. Willy RW, Hoglund LT, Barton CJ, et al. Patellofemoral pain. *J Orthop Sports Phys Ther*. 2019;49(9):CPG1–CPG95. doi:10.2519/jospt.2019.0302
35. Bass SB, Muniz J, Gordon TF, Maurer L, Patterson F. Understanding help-seeking intentions in male military cadets: an application of perceptual mapping. *BMC Public Health*. 2016;16:413. doi:10.1186/s12889-016-3092-z
36. Thorstensson CA, Gooberman-Hill R, Adamson J, Williams S, Dieppe P. Help-seeking behaviour among people living with chronic hip or knee pain in the community. *BMC Musculoskelet Disord*. 2009;10:153. doi 10.1186/1471-2474-10-153

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