CLINICAL RESEARCH STUDY

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No One Left Behind: Incidence of Sudden Cardiac Arrest and 30-Day Survival in Military Members

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ABSTRACT

OBJECTIVES: Military service requires intense exercise, increasing the risk of sudden cardiac arrest, which is typically fatal without bystander cardiopulmonary resuscitation (CPR) combined with immediate defibrillation. Out-of-hospital cardiac arrest survival rates average 10%. The US military emphasizes team responsibility for providing immediate rescue to individual members. Data suggest that CPR and bystander defibrillation rates are higher on military bases than off bases. We hypothesized that sudden cardiac arrest rates would be greater in the military, but survival posthospitalization would be better than in civilian cohorts.

METHODS: The Military Health System Data Repository was queried from fiscal years 2016-2019 for the diagnoses of cardiac arrest, torsades de pointes, ventricular fibrillation, and ventricular flutter in a cross-sectional study of actively serving U.S. military members ages 17-64 years.

RESULTS: A total of 958 military personnel were identified with sudden cardiac arrest/ventricular arrhythmia from fiscal years 2016 to 2019 with a sudden cardiac arrest rate of 10.8 per 100,000 person-years. Thirty-day survival rates were high at 73% for subjects aged <35 and 76% for those aged 35-64 years.

CONCLUSIONS: Despite a high incidence of sudden cardiac arrest in the military, survival beyond 30 days for those transported to the hospital was excellent. While greater efforts toward preventing sudden cardiac arrest in the military are indicated, these data suggest that increased rates of bystander CPR and defibrillation result in meaningful gains in survival.

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INTRODUCTION

Sudden cardiac arrest is a life-threatening condition marked by a disruption of heart function resulting in a lack of blood flow and abrupt unconsciousness. Without intervention, sudden cardiac arrest leads to sudden cardiac death. In the United States, sudden cardiac arrest is a leading cause of death in exercising athletes, with an incidence that ranges from 1.7 to 32 per 100,000 athlete years, higher in more demanding sports, and highest among black male athletes.[1-4] Data collected before 2011 found that military sudden cardiac death rates were 1-3 per 100,000 person-years,[5] higher in recruits at 13 per 100,000.[6] Sudden cardiac death is the most common nontraumatic cause of death in military recruits, with 86% occurring with exercise.[6] Historical military rates of sudden cardiac death are consistent with civilian studies showing that 85% of cardiac-related deaths in young athletes occur during exercise.[7,8] Although exercise is health-promoting and an occupational requirement for the military profession, vigorous exercise, particularly when timed or scored, increases the risk of sudden cardiac arrest for individuals who may be at higher risk due to unrecognized cardiac conditions.[9] Exercise increases the relative risk of sudden cardiac death by 7.6-16.9 times the rate of less strenuous activities.[10,11]

CLINICAL SIGNIFICANCE

- Sudden cardiac arrest (SCA) rates are higher than expected in the military.
- 30-day survival from SCA is also higher in the military population.
- Improved survival on military bases may be from higher bystander intervention.

Survival rates for out-of-hospital cardiac arrest averaged 10% in two large meta-analyses[12,13] Bystander cardiopulmonary resuscitation (CPR) and early defibrillation substantially improve the chances of survival. Survival from sudden cardiac arrest is high (89%) when an Automated External Defibrillator (AED) is used in the resuscitation of young athletes and the survival rate is associated with the proximity of AEDs.[14-18] If an AED is not on-site, the North American mean emergency medical services (EMS) response time is 9 minutes,[19] and the time to first defibrillation typically exceeds 11 minutes.[20] While EMS arrival can be further delayed on military posts due to the distance to field sites of high-risk training, all Soldiers and Airmen must undergo basic life-support training. This level of preparation should increase the probability of bystander CPR and AED use.

Currently, there is no official registry tracking sudden deaths in the US military. Cardiac screening of recruits and cardiac arrest preparedness depends on such data. A surrogate is the military medical data repository for insurance claims. The Military Health System (MHS) serves over 9 million beneficiaries. All actively serving warfighters receive their health care through the MHS, either through direct care in Military Treatment Facilities or indirect care billed to the MHS. The objective of this study was to leverage claims made on behalf of sudden cardiac arrest victims transported to the hospital or receiving medical treatment, estimating the rates of sudden cardiac arrest and postarrest survival in the military.

METHODS

Information was gathered through a cross-sectional study of all sudden cardiac arrests among actively serving personnel (U.S. Army, Air Force, Space Force, Navy, and Marine Corps active-duty personnel and National Guard and Reserve personnel on active-duty status), ages 17-64 years, during fiscal years (FYs) 2016-2019. Personnel 65 years and older were excluded because Medicare is the primary insurance payer. The study utilized health-care claims data from the MHS Data Repository to identify sudden cardiac arrest in the study population, defined through the use of the following International Classification of Diseases, 10th revision (ICD-10), and Common Procedure Terminology (CPT) code: cardiac arrest (I46, Z86.74), torsades de pointes (I47.21), ventricular fibrillation (I49.01), or ventricular flutter (I49.02). Because it may not be life-threatening, data for ventricular tachycardia (I47.2) were intentionally excluded. Individuals with narcotic overdose were also excluded to focus on sudden cardiac arrest due to cardiac causes, not secondary to respiratory arrest from opioid overdose.

Analyses included descriptive statistics on patient demographics (age, sex, race, beneficiary type, rank, branch of service), incidence, and unadjusted odds ratios for the risk of a sudden cardiac arrest event. Analysis involved four age groups (Table 1), with additional analysis using a cut point of incidence of sudden cardiac arrest was defined as a study subject with a sudden cardiac arrest event during the study period and expressed as per 100,000 person-years. Odds ratios were used rather than hazard ratios because person-time data for each individual SCA case was not available.

Subset analysis of 30-day survival rates was estimated among those with a sudden cardiac arrest event and expressed as per 100,000 person-years. The date of ICD-10 or CPT coding was defined as Day 1. Thirty-day survival was determined using two methods: 1) date of death >30-day after the initial sudden cardiac arrest event, or 2) if no date of death was found, then identifying all those who received health care in the MHS at least 31 days after initial sudden cardiac arrest event. Unadjusted risk ratios were calculated to compare risk of 30-day survival between groups. Unadjusted odds ratios and risk ratios were calculated using OpenEpi, version 3. This study was reviewed and found exempted by the Institutional Review Board of the Uniformed Services University (IRB Protocol number PMB-87-10022).

Table 1 Demographics, Incidence, and Risk of Sudden Cardiac Arrest among Active Duty and National Guard/Reserve Members* on Active Duty, FY 2016-2019

Variables	Active Duty/Nat'l Guard/Reserve with Sudden Cardiac Arrest	Total Active Duty/Nat'l Guard/Reserve	Prevalence per 100,000 Person Years (4 Y)	
Total	958	2220,701	10.8	
Age group				
17-24	268	1138,085	5.9	7.6 (<35)
25-34	286	673,866	10.6	
35-49	329	371,233	22.2	24.7 (≥35)
50-64	75	37,517	50.0	
Race				
White	658	1587,947	10.4	
Black	186	382,245	12.2	
Asian/Pacific Islander and American Indian/Alaska Native	52	148,131	8.8	
Other/missing	62	102,378	15.1	
Beneficiary status				
Active duty	836	1728,122	12.1	
National guard/reserve on active duty	122	492,579	6.2	
Rank				
Junior enlisted	324	1259,908	6.4	
Senior enlisted	445	620,803	17.9	
Junior officer	101	236,706	10.7	
Senior officer	56	52,280	26.8	
Warrant officer	26	26,366	24.7	
Unknown	<11	24,638	N/A	
Branch of service				
Army	463	1023,249	11.3	
Air force	200	536,476	9.3	
Navy	198	342,726	14.4	
Marine corps	97	318,250	7.6	
Location of initial treatment				
Private-sector facility	79%			
Military treatment facility	21%			

*The study population was identified using the ICD-10 diagnostic and CPT codes from the Appendix List. An individual event per patient was defined and counted as having the presence of any ICD-10 or CPT code with a unique encounter date.

RESULTS

We identified 2220,701 active duty, National Guard, and Reserve personnel on active status during FY 2016-2019. Table 1 shows 958 experienced a sudden cardiac arrest/Ventricular Arrhythmia event, most of whom were aged 35-49 years (34%), White (69%), male (89%), active duty (87%), senior enlisted rank (46%), and in the Army (48%). Most individuals received initial care at a private-sector facility (79%).

Incidence of Sudden Cardiac Arrest

The incidence of sudden cardiac arrest was 10.8 per 100,000 person-years (Table 1). That incidence increased with age: 5.9 per 100,000 person-years in those 17-24 years; 10.6 in 25-34 years; 22.2 in 35-49 years; and 50.0 in 50-64 years. These groupings match enlistment periods and other military studies. Also, an age cut point at 35 years facilitated comparison to studies of young cardiac arrest.

Table 2 details unadjusted odds ratio results for the odds of a sudden cardiac arrest among the study population. The lowest odds were seen in females and those under 35 years. Compared to their respective reference groups, lower odds were also observed activated National Guard and Reserve personnel, junior enlisted and officer ranks, and those in the Air Force. No significant difference was seen with race except an increased risk among those categorized as "other" or missing race. "Other" race could consist of those who identify as Hispanic or of multiple races and ethnic backgrounds, but missing data may impact the validity of this result.

Thirty-Day Survival

The subset analysis of 30-day survival is in Table 3. Of those with sudden cardiac arrest (N=958), we observed 709 (74%) with 30-day survival. For those with health care follow-up in the MHS, 30-day survival was 73% in those

Table 2 Unadjusted Odds of Sudden Cardiac Arrest among Active Duty and National Guard/Reserve on Active Duty, FY 2016-2019

	Unadjusted Odds Ratio (95% CI)	
Sex		
Male	Ref	
Female	0.02 (0.02-0.03)*	
Age group (y)		
17-24	0.27 (0.23-0.31)*	0.31 (0.27-0.35)*
25-34	0.48 (0.41-0.56)*	
35-49	Ref	Ref
50-64	2.26 (1.76-2.90)*	
Race		
White	Ref	
Black	1.17 (0.99-1.38)	
Asian/Pacific Islander and American Indian/ Alaska Native	0.85 (0.63-1.11)	
Other/missing	1.46 (1.12-1.88)*	
Beneficiary status		
Active duty	Ref	
National guard/ reserve on active duty	0.04 (0.03-0.05)*	
Rank		
Junior enlisted	0.36 (0.31-0.41)*	
Senior enlisted	Ref	
Junior officer	0.59 (0.48-0.74)*	
Senior officer	1.49 (1.12-1.96)*	
Warrant officer	1.38 (0.91-2.01)	
Unknown	-	
Branch of service		
Army	Ref	
Air force	0.82 (0.69-0.97)*	
Navy	1.28 (1.08-1.51)*	
Marine corps	0.67 (0.54-0.83)*	

*Statistically significant, 95% confidence interval does not include 1.

younger than 35 years and 76% in those 35 years and older. The unadjusted risk ratio analysis indicates no significant difference in risk among those under 35 years (0.93 RR, 0.86-1.00 95% CI). Compared to White personnel, Black personnel had lower 30-day survival (0.86 RR, 0.77-0.97 95% CI). Those of "other" or missing race had higher 30-day survival (1.17 RR, 1.05-1.30 95% CI). Compared to the most predominant rank of senior enlisted personnel, senior officers had higher 30-day survival (1.15 RR, 1.01-1.30 95% CI). The Marine Corps had the lowest 30-day survival (0.83 RR, 0.71-0.97 95% CI) of all Services.

DISCUSSION

In this study, we describe two main findings. First, the sudden cardiac arrest rate in the military is 10.8 per 100,000 person-years among all age groups and 5.9 in the young (17-24 years). Second, the 30-day survival rate for those reaching the Emergency Department is high, with rates of 73% for those under 35 years of age and 76% for those 35 and older. Consistent with other studies, sudden cardiac arrest rates in male service members were higher than among females. There were also statistically significant differences in the odds of sudden cardiac arrest by age, beneficiary status, rank, and branch of service. Previous studies have indicated that exertion requirements may differ by some of these variables.[21] Thirty-day survival was also lower for Black personnel with sudden cardiac arrest compared to White, while 30-day survival was higher for those of Other/Missing Race. These may represent important differences and/or health disparities that should be explored further in additional studies regarding sudden cardiac arrest in the MHS population.

As noted, our data includes only those who survived long enough to incur an insurance claim (eg, to the Emergency Department). Some assumptions are required to estimate the event incidence that includes those not transported. A survival rate of 75% implies fatal sudden cardiac death rate of approximately 25%. Successful on-site resuscitation ranges from 33% in European data[22] to 89% at young athlete sporting events,[14] resulting in an on-scene sudden cardiac death rate of 67% to 11%. Using an average from these studies, if one assumes that 39% of military sudden cardiac arrest victims are declared dead on the scene, our data may be missing cases. Applying that assumption would raise the sudden cardiac arrest rate and lower our estimate of sudden cardiac arrest survival. If 39% of military sudden cardiac arrest victims are declared dead on the scene, then the true sudden cardiac arrest rate is 8.0 sudden cardiac arrest per 100,000 person-years in those 17-24 years; 14.3 in 25-34 years; 30 in 35-49 years; and 67.5 in 50-64 years. These rates of sudden cardiac arrest are several-fold higher than reported in civilian cohorts such as King County, Washington. Meyer and colleagues reported the sudden cardiac arrest rate per 100,000 person-years as 1.44 in those 14-24 years of age, and 4.40 in those 25-35 years of age.[23]

Similarly, applying the assumption that 39% of sudden cardiac arrest victims are not transported reduces the estimated military survival rate to approximately 48% for those aged <35 years and 49% for 35-64 years. Comparing this survival rate to existing data is sobering. Survival to hospital discharge in European data was 8% overall.[24] Danish registry data representing 21,480 events occurring between 2001 and 2011 showed a significant improvement in 30-day survival for out-of-hospital cardiac arrest, yet among patients aged 18-65 years, OHCA 30-day survival rose from 6% to only 22%,[25] well below our adjusted rate of 48%. It is important to note, however, that these two survival rates were achieved by different methods, so caution should be used for direct comparisons.

CLINICAL IMPLICATIONS

The present study was unable to determine the reasons for a higher survival rate in the military population. However, a

Table 3 Demographics of Active Duty and National Guard/Reserve Members on Active Duty with Sudden Cardiac Arrest and 30-Day Survival from FY 2016 to 2019

	Active Duty/Nat'l Guard/Reserve with Sudden Cardiac Arrest and 30-d Survival	30-d Survival Rate (30-d Survival Patients/Patients with Sudden Cardiac Arrest in Table 1, %)	Unadjusted Risk Ratio (95% CI)
	N (% of total)		
Total	709		
Gender			
Male	624 (88.0)	73.2	Ref
Female	85 (12.0)	81.0	1.11 (1.00-1.22)
Age group (y)			
<35	403 (56.8)	72.7	0.93 (0.86-1.00)
≥35	306 (43.2)	75.7	Ref
Race			
White	491 (69.3)	74.6	Ref
Black	120 (16.9)	64.5	0.86 (0.77-0.97)*
Asian/Pacific Islander and American Indian/Alaska Native	44 (7.6)	84.6	1.13 (1.00-1.28)
Other/missing	54 (6.2)	87.1	1.17 (1.05-1.30)*
Beneficiary status			
Active duty	615 (86.7)	73.6	Ref
National guard/reserve on active duty	94 (13.3)	77.0	1.05 (0.94-1.16)
Rank			
Junior enlisted	237 (33.4)	73.1	1.00 (0.91-1.09)
Senior enlisted	326 (46.0)	73.3	Ref
Junior officer	76 (10.7)	75.2	1.03 (0.91-1.16)
Senior officer	47 (6.6)	83.9	1.15 (1.01-1.30)*
Warrant officer	18 (2.5)	69.2	0.94 (0.73-1.23)
Unknown	<11 (NA)	NA	-
Branch of service			
Army	334 (47.1)	72.1	Ref
Air force	154 (21.7)	77.0	1.07 (0.97-1.17)
Navy	150 (21.2)	75.8	1.05 (0.95-1.16)
Marine corps	71 (10.0)	73.2	0.83 (0.71-0.97)*

*Statistically significant, 95% confidence interval does not include 1.

2023 review of the EMS national registry in the United States showed that intervention is more likely on a military base compared to a civilian setting for bystander CPR (85% vs. 63%) and AED use before EMS arrival (55% vs. 28%).[26] Rapid utilization of an AED is associated with increased survival,[14-17] and military bases have strategically placed AEDs in fixed structures (eg, barracks, fitness centers, restaurants, schools, and larger buildings) and on emergency vehicles (police, fire, and EMS). In addition, CPR training is required in recruit training ("boot camp") for the Air Force[27] and Army.[28] Although not required for the Navy and Marine Corps, many Sailors and Marines get CPR training as part of collateral duties.[29]

In addition to training and a distributed network of AEDs, military culture may contribute to increased intervention and survival. The Soldier's Creed is: "I will never leave a fallen comrade." This "leave no one behind" imperative captures the philosophy of a first responder and may contribute to the previously reported intervention rate. Our results do not include measures of bystander intervention nor culture and further work is needed to understand these fully.

Nevertheless, these data highlight areas in military medicine that require improvement. The high rates of sudden cardiac arrest observed in servicemembers compared to civilian cohorts indicate that the current cardiovascular screening of recruits is inadequate. In 2022, Congress mandated the institution of electrocardiographic screening of all recruits to the military academies, and based on this experience, it recently required the extension of this program to all incoming recruits.[30] Data from these pilot programs may have implications for the preparticipation screening of civilian athletes. The screening of NCAA athletes has expanded over the past few years, and emergency action plans have been implemented emphasizing bystander CPR and early AED use. These actions may have contributed to a drop in the sudden cardiac arrest incidence among NCAA athletes (5-year incidence ratio 0.71 [95% CI 0.61-0.82]) while noncardiovascular death rates were unchanged.[4]

It seems likely that the intensity of military training is responsible for the high sudden cardiac arrest rates. All services require periodic timed and graded fitness testing to determine whether a servicemember can be promoted or retained. In addition to periodic physical fitness testing ("PFT"), servicemembers must meet height and weight standards. The stress of "making weight" in an officer cadet program led to an overall eating disorder risk of 32% with adverse behaviors including binge eating (12%), laxative use (9%), and diuretics or diet pills (9%).[31] These events represent a predictable trigger for sudden cardiac arrest, yet there are significant differences in how the Services perform their PFT in relation to access to AEDs. The Navy and Air Force typically complete their PFT in, or immediately adjacent to, fixed structures. In addition, the Navy and Air Force instructions require AEDs to be available, as well as CPR training for those administering the PFT.[32,33] The Army and Marine Corps instructions do not mandate CPR training nor an AED on site, but do require those supervising the testing to make a risk assessment regarding safety concerns and medical support.[34,35] This discrepancy likely places Soldiers and Marines at an increased risk, and addressing this gap should further improve sudden cardiac arrest survival in the military. Public access defibrillation, which places AEDs in the hands of trained laypersons, is the single most significant advancement in the treatment of cardiac arrest since the development of CPR.[36]Our data supports the contention that increased rates of bystander CPR and defibrillation result in meaningful gains in survival.

STRENGTHS AND LIMITATIONS

This cross-sectional study filled a critical gap in currently available knowledge regarding the incidence of sudden cardiac arrest and showed that the risk of sudden cardiac arrest is present even among the youngest tactical athletes. Additionally, this study utilized data from the MHS, which is a unique environment without barriers to access to care, which is a challenge when examining data in the broader United States Health System. Furthermore, the large sample size allows for robust inferences from the analyses.

There are limitations to consider when interpreting this data. Because activity at the time of the event is not available, we cannot test the association between sudden cardiac arrest and exercise. There are limitations inherent to claims data, including the inability to assess the clinical presentation, incomplete or missing data, and inaccurate or nonspecific billing codes. Narrow ICD-10 codes were used to overcome the limitations of claims data, but this may have underestimated the true incidence of sudden cardiac arrest because many sudden cardiac arrest victims may not survive to the hospital setting where these diagnostic and billing codes are used. Importantly, the total incidence of sudden cardiac arrest cannot be accurately calculated because the available data only captures those who survive cardiac arrest long enough to receive insurance-reimbursed care. Consequently, 30-day survival is only reported for a minority of the total sudden cardiac arrest population, which may overestimate overall survival. The impact may be overestimated by including those who had iatrogenic events coded as cardiac arrest during a medical procedure. Furthermore, this study did not include data on prehospital care, including bystander/first responder/EMS and in-hospital interventions. Additional work is also needed to clarify the relationship among demographic variables, the risk of sudden cardiac arrest, and the odds of 30-day survival.

CONCLUSIONS

Sudden cardiac arrest is more common in the military than in the civilian population, but 30-day survival in the Military appears relatively good. Military and civilian policymakers could incorporate these data in determining optimal sudden cardiac arrest screening and response strategies, including improving access to AEDs. Additional work is needed to better understand the rates of sudden cardiac death in the Military population and to implement better prevention and response approaches.

AVAILABILITY OF THE DATA

The data supporting this study's findings are available from the United States Defense Health Agency. Restrictions apply to the availability of these data, which were used under federal Data User Agreements for the current study and are not publicly available.

DISCLAIMER

The contents of this publication are the sole responsibility of the authors and do not necessarily reflect the views, assertions, opinions or policies of the Uniformed Services University of the Health Sciences (USUHS), the Henry M. Jackson Foundation for the Advancement of Military Medicine, Inc. (HJF), the Department of Defense (DoD), the Veterans Health Administration (VHA), or the Departments of the Army, Navy, or Air Force. Mention of trade names, commercial products, or organizations does not imply endorsement by the U.S. Government.

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