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ORIGINAL ARTICLE

Longitudinal associations of military-related factors on self-reported sleep among U.S. service members

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Abstract

Study Objectives: Sleep loss is common in the military, which can negatively affect health and readiness; however, it is largely unknown how sleep varies over a military career. This study sought to examine the relationships between military-related factors and the new onset and reoccurrence of short sleep duration and insomnia symptoms.

Methods: Millennium Cohort Study data were used to track U.S. military service members over time to examine longitudinal changes in sleep. Outcomes were self-reported average sleep duration (categorized as ≤5 h, 6 h, or 7–9 h [recommended]) and/or insomnia symptoms (having trouble falling or staying asleep). Associations between military-related factors and the new onset and reoccurrence of these sleep characteristics were determined, after controlling for multiple health and behavioral factors.

Results: Military-related factors consistently associated with an increased risk for new onset and/or reoccurrence of short sleep duration and insomnia symptoms included active duty component, Army or Marine Corps service, combat deployment, and longer than average deployment lengths. Military officers and noncombat deployers had decreased risk for either sleep characteristic. Time-in-service and separation from the military were complex factors; they lowered risk for ≤5 h sleep but increased risk for insomnia symptoms.

Conclusions: Various military-related factors contribute to risk of short sleep duration and/or insomnia symptoms over time, although some factors affect these sleep characteristics differently. Also, even when these sleep characteristics remit, some military personnel have an increased risk of reoccurrence. Efforts to improve sleep prioritization and implement interventions targeting at-risk military populations, behaviors, and other significant factors are warranted.

Statement of Significance

Sleep loss is a pervasive and long-standing issue within the military. This study tracked a large, representative U.S. military cohort throughout their career and found that certain military-related factors (e.g. active component, ground-based troops, and combat deployment) were associated with the new onset and reoccurrence of short sleep duration and/or insomnia symptoms. These findings highlight the persistent nature of high-risk sleep characteristics within the military and underscore the importance of greater oversight such as panels to evaluate, address, and promote healthy sleep for service members. Given the complexity of the findings related to time-in-service and separation from service, future work should examine long-term health outcomes related to sleep among veterans and active duty service members.

Key words: self-reported sleep; sleep initiation and maintenance disorders; military personnel; veterans; prospective studies.

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Introduction

Awareness of the importance of sleep health has increased sharply over the last two decades as the widespread impacts of sleep loss and other sleep disturbances on health and performance have become known [1–5]. Military personnel are presented with unique operational challenges and may be more susceptible to sleep disturbances than the general population due to a variety of occupational, environmental, and behavioral factors [6, 7]. Determining the extent to which these unique challenges impact sleep health in military populations requires special attention. Much research has found that a high proportion of military personnel self-report short average daily sleep duration—often 6 or fewer hours per day [8], which is lower than the 7–9 h of sleep recommended for adults to achieve optimal health and functioning [9]. Further, many military members endorse poor sleep quality and/or insomnia symptoms that may be related to several underlying factors inherent to military life (e.g. round-the-clock operations, early morning physical training, deployment experiences), cultural beliefs that tend to undervalue sleep, and less-than-ideal sleeping conditions (e.g. uncontrolled noise and light, extreme temperatures, crowded spaces) [6, 10, 11]. Sleep loss and other sleep challenges in military operational environments have been shown to elevate the risks of illnesses, missed workdays, errors, injuries, and mishaps, all of which can negatively impact mission success [12–14]. Unfortunately, these potential problems related to short sleep and fatigue (and the risks they pose to the military) have been known for several decades [15]. Thus, there is a continued need to emphasize the importance of sleep health to the U.S. Department of Defense (DoD), Defense Health Agency, Congress, and other governmental organizations to advocate for improving operational sleep when possible.

Previous studies have found associations between sleep and military deployment-related factors, such as combat experiences (e.g. blast exposures and witnessing psychologically disturbing events) and the number and length of deployments and mission characteristics [8, 12, 16–24]. While it is evident that such military-related factors do impact sleep health, it remains unclear if the effects are brief or long-lasting, remit and reoccur, and whether the severity of effects on sleep are dependent upon the number and duration of these military experiences.

While it is encouraging that there are some military educational initiatives in place, such as the Army Office of the Surgeon General's Performance Triad (P3) which launched in 2013 [5] and included a broad sleep educational campaign, there is a need to better understand which military personnel are at risk of short sleep duration and/or insomnia, as this may help focus further educational and interventional efforts on those that most need them. Specifically, identifying which military-related factors are associated with sleep across a military career may lead to more tailored and more effective implementation of sleep health interventions, and it can be viewed as a necessary step toward understanding how best to improve the sleep health of military members.

In the present study, we aimed to determine the factors associated with the new onset and reoccurrence of short sleep duration and insomnia symptoms across a military member's career (including separation from the military). To accomplish this, we leveraged data from the Millennium Cohort Study, the largest longitudinal cohort of military members and veterans representing all U.S. service branches.

Methods

Study population

The study population was drawn from the Millennium Cohort Study, the largest and longest-running longitudinal survey study of U.S. military service members. This study was designed to prospectively evaluate the effects of military service on the health of its members both during and after leaving the military. Study participants were enrolled from active duty, Reserve Guard and National Guard rosters. Active duty personnel work full time for the military while Reserve and National Guard personnel have part time military obligations. Enrollment of the first panel began in mid-2001, with panels 2, 3, and 4 enrolled in 2004, 2007, and 2011, respectively, resulting in 201,619 total enrolled participants. Once enrolled, participants are asked to complete follow-up surveys every 3–5 years, even after separation from military service. Follow-up surveys are currently planned through 2068 to capture health throughout the life span of the service members. Survey items include mental, physical, and social factors, health behaviors, and combat and environmental exposures. Additional information about the methods and scope of the Millennium Cohort Study has been published previously [25, 26]. Analysis of the Millennium Cohort Study data was approved by the Institutional Review Board at the Naval Health Research Center, and all surveyed participants voluntarily provided informed consent. Participants from all four panels were included in the present analyses, with their enrollment survey indicated as Time 1, and each subsequent follow-up as Time 2, Time 3, etc. The maximum number of time points observed in this study was 5 (Time 5) for Panel 1 participants who enrolled in 2001 (see Figures 1 and 2).

Inclusion criteria

New onset of short sleep duration and/or insomnia symptoms. Eligible participants for the analyses of new-onset short sleep duration and/or insomnia symptoms met the following criteria: joined the military within 4 years of their Time 1 survey, completed a Time 2 survey, had not yet deployed before Time 1, and were actively serving at the time of their Time 1 and Time 2 surveys. Further, participants had to meet criteria for healthy sleep at Time 1 by reporting recommended sleep duration (7–9 h on average per day), no insomnia symptoms, no history of obstructive sleep apnea (OSA), and no mental health conditions. Of the 8,951 eligible participants, those with complete covariate information on the Time 1 survey, primary predictors (e.g. combat exposure), and sleep outcomes on at least one follow-up survey were retained for new-onset insomnia symptoms analyses (n = 7,719). Participants who reported 10 or more hours of sleep were examined separately (n = 239; see Supplementary Material Tables S1 and S2), leaving 7,480 for the new-onset short sleep duration analyses.

Reoccurrence of short sleep duration and/or insomnia symptoms. Eligible participants for the analyses of reoccurrence of short sleep duration and/or insomnia symptoms met the following criteria: completed Time 1, 2, and 3 surveys; were on continuous active service between Time 1 and Time 2 survey; reported short (<7 h per day) or long (≥10 h per day) sleep duration and at least one insomnia symptom at Time 1; and subsequently

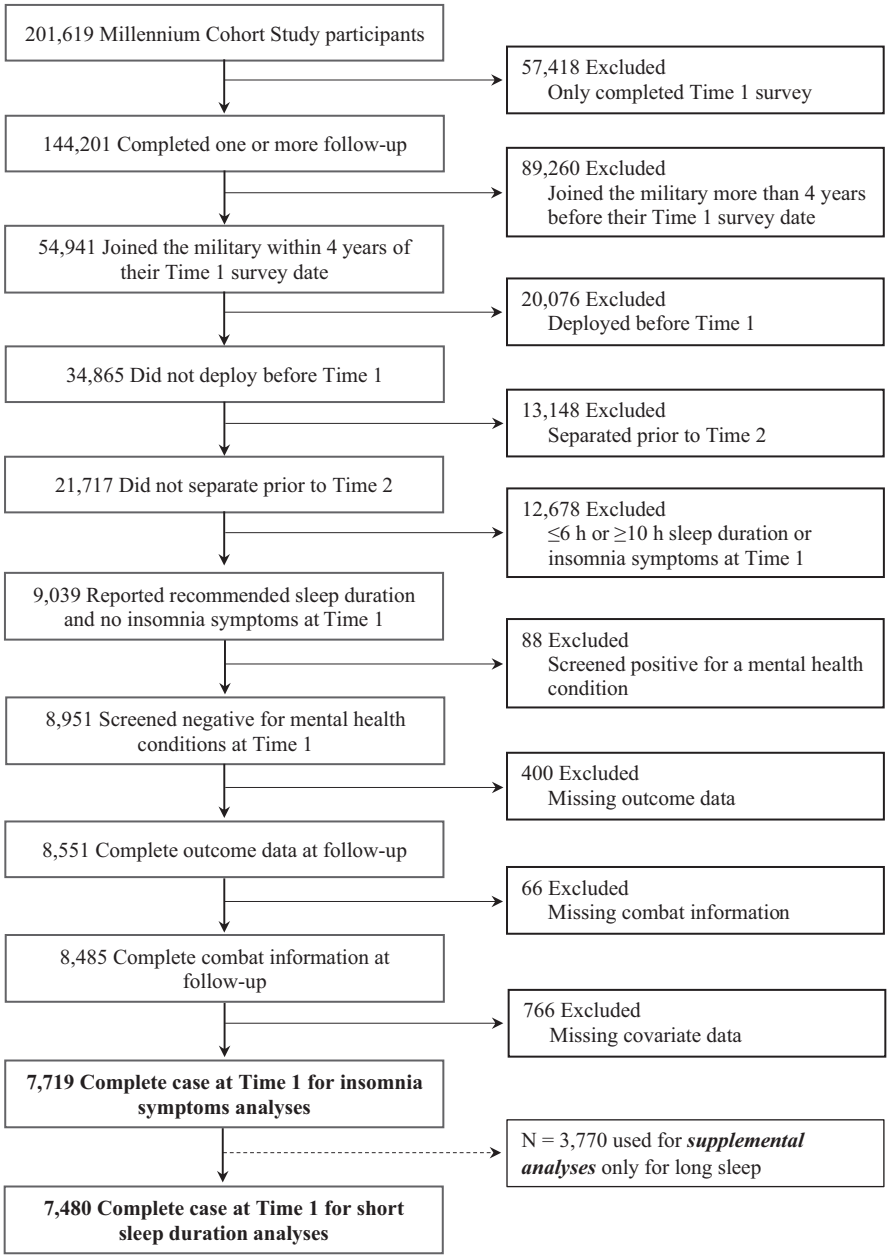

Figure 1. Study observation period for new-onset short sleep duration and insomnia symptoms. Analyses were run separately for each outcome.

reported recommended sleep duration (7–9 h) and endorsed no insomnia symptoms at their Time 2 survey (n = 2,268). Among these eligible participants, those with complete outcome and covariate information were retained for the reoccurrence of insomnia symptom analyses (n = 2,153). Participants who reported 10 or more hours of sleep were examined separately (n = 58; see Supplementary Material Tables S1 and S2), leaving 2,095 for the reoccurrence of short sleep duration analyses.

Self-reported sleep characteristics

Sleep duration. Sleep duration was determined using the survey item that asks, "Over the past month, how many hours of sleep did you get in an average 24-hour period?," with responses collected as a whole number. In order to provide evidence-based recommendations that would more easily translate to potential policy, the study team decided a priori to categorize sleep duration as ≤5, 6, and 7–9 h ("recommended"). Throughout the paper, where relevant for brevity, the ≤5 and 6 h sleep duration categories are collectively referred to as "short sleep." Due to the relatively small number (n = 239 in new-onset and 58 in reoccurrence analyses) of participants reporting a sleep duration longer (≥10 h) than the recommended sleep duration and the much more pervasive problem of short sleep duration in the military, we examined long sleepers separately (see Supplemental Material Tables S1 and S2).

Insomnia symptoms. Insomnia symptoms were assessed using two questions from standardized instruments. The first question was from the Patient Health Questionnaire (PHQ), which asks, "Over the last 4 weeks, how often have you experienced trouble falling asleep or staying asleep?," with the response options "not at all," "several days," or "more than half the days." The second question was from the PTSD Checklist – Civilian Version (PCL-C), which asks "In the past month, have you had trouble falling asleep or staying asleep?," with the response options "not

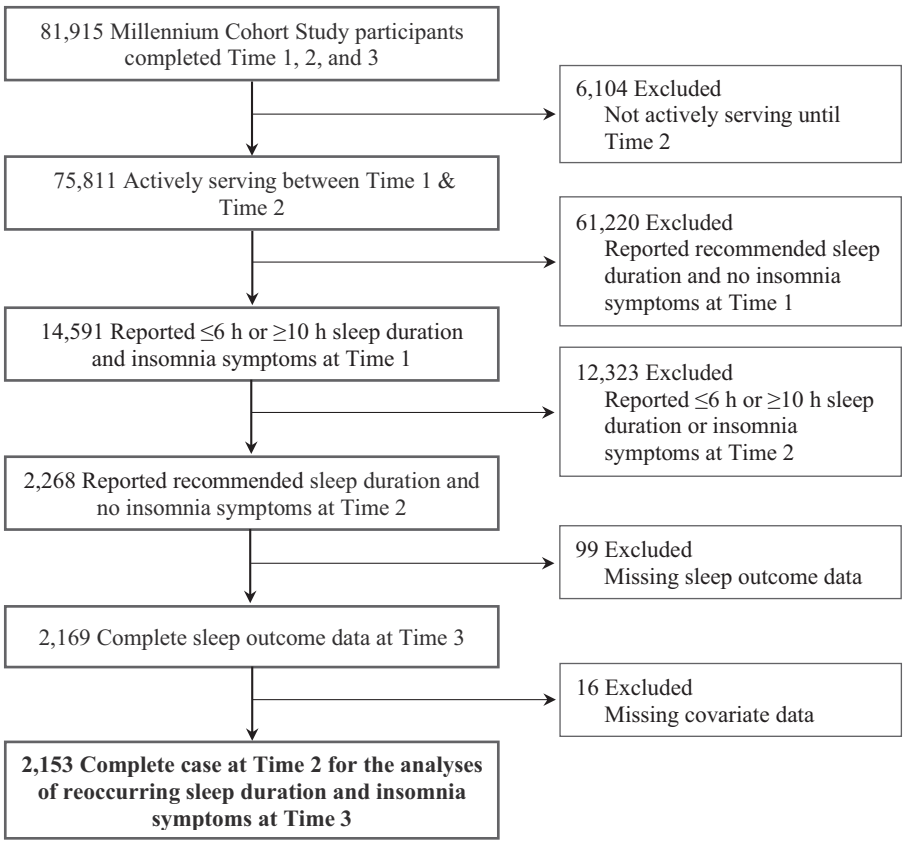

Figure 2. Study observation period for reoccurrence of short sleep duration and insomnia symptoms. Analyses were run separately for each outcome.

at all," "a little bit," "moderately," "quite a bit," or "extremely." Endorsing response options of "several days" or more to the PHQ question *or* endorsing response options of "moderately" or greater on the PCL-C question indicated presence of insomnia symptoms [21, 27].

Primary exposures of interest

Military-related factors were obtained from the Defense Manpower Data Center (DMDC) and included component status (active duty, National/Reserve Guard), service branch (Army, Navy/Coast Guard, Air Force, Marine Corps), basic rank classification (enlisted, officer), occupation (administration/supply, health care specialist, combat specialist, other), time in service (continuous number of years), and military separation status (yes/no). Coast Guard was combined with Navy in these analyses given the very small number of Coast Guard participants (3.3% at Time 1), which prohibited adjusted analyses of these participants if analyzed separately.

Deployment dates were obtained from DMDC records, and self-report of combat experience was assessed at each follow-up survey based on at least one affirmative response to witnessing any one of five combat-like exposures (e.g. witnessing dead or decomposing bodies or maimed soldiers or civilians) [28]. Participants were asked at each follow-up whether these experiences had occurred in "the last 3 years" so that reports of combat experiences could be linked with deployments occurring during the same 3-year period. Additionally, average length of deployments was determined using DMDC data, and a flag was created for deployments that were equal to or longer than service branch average (yes vs. no). Branch average deployment lengths (months) by service branch were 8.9 for Army, 5.0 for Navy/Coast Guard, 5.1 for Air Force, and 6.4 for Marine Corps personnel based on DMDC records for deployments to Operation Enduring Freedom, Operation Iraqi Freedom, and Operation New Dawn from 2001 to the end of 2015 [29].

Demographic factors

Demographics including birth year (pre-1960, 1960–1969, 1970–1979, 1980 or after), sex, and race/ethnicity (White non-Hispanic, Black non-Hispanic, other) were obtained for all participants from DMDC monthly personnel files. Marital status (single, married, no longer married), and highest educational level attained (associate's degree or less, bachelor's or higher) were self-reported on the survey and backfilled using DMDC data if survey data were missing.

Behavioral, physical, and mental well-being

Body mass index (BMI) was calculated from self-reported height and weight (kg/m^2) and categorized as normal/underweight (<25.0 kg/m^2), overweight (25.0–29.9 kg/m^2), or obese (≥30.0 kg/m^2). Underweight individuals (<18.5 kg/m^2) were included with normal weight (18.5–24.9 kg/m^2) because only a small percentage (1.2%) of all surveys reported underweight status. Heavy weekly drinking was indicated for men reporting more than 14 drinks per week and women reporting more than seven drinks per

week.[30, 31] Smoking status was categorized as never, former, or current smoker. Five life stressors (i.e. divorce/separation, major financial problems, sexual assault, sexual harassment, and violent assault) from the modified Holmes and Rahe Social Readjustment Rating Scale [32] were summed at each follow-up and categorized as none, one, or two or more.

PTSD was assessed with the PCL-C [33] using *Diagnostic and Statistical Manual of Mental Disorders*, 4th Edition (DSM-IV) sensitive criteria [34]. Panic and other anxiety were assessed using the corresponding PHQ subscales (panic disorder and other anxiety, respectively) and PHQ criteria (endorsement of all four panic attack items and endorsement of any four of 11 panic attack symptoms for panic disorder; endorsement of nervous/anxious feelings and three anxiety symptoms for more than half the days in 4 weeks for anxiety disorder) [35]. Screening positive for PTSD, other anxiety, or panic disorder constituted a "yes" for any anxiety-related disorders, while screening negative for all three constituted a "no." Major depression was assessed using the PHQ 8-item depression module [36] and categorized as a positive or negative screen using the DSM-IV criteria [34]. Disabling injury was assessed at each follow-up with a single yes/no question from the modified version of the Holmes and Rahe Stress Scale [32], which asks "Have you suffered a disabling illness or injury" over the past 3 years. General health ("poor," "fair," "good," "very good," or "excellent") was assessed using the standardized item from the Medical Outcomes Study SF-36 Health Survey for Veterans (SF-36V) [37]. Bodily pain was assessed using the bodily pain scale from the SF-36V and categorized into tertiles, with the lowest tertile representing those with the least amount of bodily pain.

Statistical analyses

Descriptive frequencies of military, demographic, and physical and mental well-being were reported separately by new onset and reoccurrence of short sleep duration and insomnia symptoms. Variables statistically significant at the bivariate level ($p < 0.05$) were included in stepwise model building. Covariates that maintained significance at $p < 0.05$ in multivariable modeling were retained in the adjusted model. Stepwise model building was conducted for the new onset and reoccurrence of both of the sleep outcomes separately. Because the goal of this study was to examine the association of military factors with sleep outcomes, military factors were kept in the models regardless of statistical significance but all other factors (demographic, behavioral, physical, and mental factors) were removed from the model if they were not significant. Collinearity among the independent variables was assessed using variance inflation factors; factors of 4 or greater indicated the presence of collinearity [38]. Adjusted risk ratios were estimated for the associations between military factors and new-onset short sleep duration and insomnia symptoms using multivariable complementary log–log models. This model's framework allows participants to have multiple rows of data representing each follow-up point for the estimation of dichotomous outcomes. Because complementary log-log option requires a dichotomous outcome in SAS version 9.4, separate models were run for each category of sleep duration versus the reference to utilize the complementary log-log framework. Models were adjusted for the approximate 3-year period between each follow-up, as well as for the total follow-up time for each participant. For new-onset analyses, covariates were time varying and participants were censored once they reported either sleep characteristic (short sleep duration and/or insomnia symptoms), or their follow-up time ended, whichever came first. Analyses examining the reoccurrence of these sleep characteristics were conducted using logistic regression models to estimate adjusted odds ratios, since the outcome determination was made at Time 3 among a group of participants who met criteria for either sleep characteristic at Time 1 and then remitted at Time 2. All analyses were conducted using SAS/STAT software, version 9.4 (SAS Institute, Inc., Cary, NC, USA).

Results

Sleep duration

Descriptive characteristics. Among participants at risk for new onset of short sleep duration (i.e. those with recommended sleep duration and no insomnia symptoms at Time 1), slightly less than half (47%) maintained a recommended sleep duration throughout the follow-up period. During the follow-up period, 40% reported 6 h and 13% reported ≤5 h sleep duration (Table 1). Most participants were on active duty status, enlisted, and in occupations other than administration, health care, or combat arms; had not separated from the military during the follow-up period; had not deployed by the first follow-up; and had either shorter than average deployment lengths or no deployments. Demographically, the sample was predominantly born after 1980, male, White non-Hispanic, and had attained less than a bachelor's degree. The majority of the sample also had a normal BMI, were not heavy weekly drinkers, were nonsmokers, did not report significant life stressors or disabling injuries, reported very good or excellent general health, and had low or middle levels of self-reported bodily pain (Table 1).

Among participants at risk for the reoccurrence of short sleep (i.e. those who initially reported both a short sleep duration and insomnia symptoms on their Time 1 survey and then neither sleep characteristic on their Time 2 survey), 51% maintained a recommended sleep duration, 34% reported 6 h, and 15% reported ≤5 h sleep duration (Table 1). Many military and demographic characteristics of the overall reoccurrence sample were similar to those of the overall new onset of short sleep duration sample, except that the reoccurrence sample included participants who had served for relatively longer periods of time and who were older, and it included higher proportions of participants who had separated from the military during follow-up, and those with obesity. These differences are likely due to the fact the reoccurrence sample was *not* restricted to newer accessions with less than 4 years of service (Table 1).

Adjusted models. The adjusted models for new-onset short sleep duration (Table 2), controlled for all military factors, birth year, race/ethnicity, sex, marital status, level of educational attainment, BMI, smoking status, life stressors, bodily pain, any anxiety-related disorders, and general health at the time point prior to the outcome assessment. Active duty service members were at significantly higher risk than Reserve/Guard members for newly reporting ≤5 h sleep, while there was no increased risk of active duty members newly reporting 6 h sleep. Additional factors associated with increased risk of newly reporting ≤5 h

Table 1. Frequencies and proportions of participant characteristics by self-reported sleep duration

	New onset of short sleep duration population N = 7,480				Reoccurrence of short sleep duration population N = 2,095			
	Frequencies	≤5 h n = 994 (13.3%)	6 h n = 2,955 (39.5%)	Recommended (7–9 h) n = 3,531 (47.2%)	Frequencies	≤5 h n = 312 (14.9%)	6 h n = 721 (34.4%)	Recommended (7–9 h) n = 1,062 (50.7%)
Military factors								
Active duty status*								
Reserve/Guard	3,322	12.6	40.6	46.8	1,052	13.2	34.3	52.5
Active duty	4,158	13.8	38.6	47.6	1,043	16.6	34.5	48.9
Service branch*								
Army	2,742	16.9	40.6	42.5	928	18.4	35.3	46.2
Navy/Coast Guard	1,320	12.7	37.9	49.5	409	12.7	35.2	52.1
Marine Corps	393	15.5	40.7	43.8	139	15.8	33.1	51.1
Air Force	3,025	10.0	39.0	50.9	619	10.8	32.8	56.4
Pay grade*								
Enlisted	5,584	15.8	40.4	43.8	1,688	16.3	34.7	49.0
Officer	1,896	5.9	37.0	57.1	407	9.1	33.2	57.7
Occupation*			9					
Admin/supply	1,863	15.4	38.1	46.6	660	14.6	34.2	51.2
Health care specialist	1,052	14.0	37.2	48.9	237	13.9	34.2	51.9
Combat	802	10.9	42.5	46.6	325	17.9	35.7	46.5
Other	3,763	12.6	40.2	47.2	873	14.3	34.1	51.6
Time in service (mean, *SD*)	1.7 (0.8)	1.6 (0.8)	1.6 (0.8)	1.7 (0.8)	7.7 (7.7)	6.5 (6.5)	7.5 (7.4)	8.3 (8.2)
Separated during follow-up period†								
No	6,750	13.7	40.3	45.9	1,080	15.8	36.7	47.5
Yes	730	9.3	31.8	58.9	1,015	13.9	32.0	54.1
Deployed/combat†,‡								
Not deployed	4,180	12.7	39.2	48.2	1,692	14.7	33.5	51.8
Deployed, no combat	1,213	11.8	38.4	49.8	107	6.5	39.3	54.2
Deployed, combat	2,087	15.4	40.8	43.8	296	18.9	38.2	42.9
Deployed equal to or longer than branch average†								
No	6,534	13.2	41.2	45.6	1,933	14.5	33.5	52.0
Yes	946	13.7	27.7	58.6	162	19.8	45.1	35.2
Demographic factors								
Birth year*								
Pre-1960	99	5.1	32.3	62.6	252	9.1	29.0	61.9
1960–1969	586	12.3	42.5	45.2	513	13.5	34.1	52.4
1970–1979	2,356	12.4	42.9	44.7	623	15.9	36.8	47.4
1980+	4,439	14.1	37.5	48.5	707	17.1	34.5	48.4
Sex*								
Male	4,559	12.3	40.0	47.7	1,328	15.4	34.9	49.8
Female	2,921	14.8	38.8	46.5	767	14.1	33.6	52.3
Race/ethnicity*								
White	5,676	12.0	39.0	49.0	1,668	13.3	34.2	52.5
Black	654	19.7	39.3	41.0	176	24.4	38.6	36.9
Other	1,150	16.0	42.2	41.8	251	18.7	32.7	48.6
Marital status*								
Single	3,653	13.5	39.2	47.3	468	15.6	30.3	54.1
Married	3,413	12.8	39.8	47.5	1,302	14.3	36.2	49.5
No longer married	414	15.7	40.3	44.0	325	16.3	33.2	50.5
Education*								
Associate's degree or less	4,825	16.4	40.7	42.9	1,382	17.3	35.6	47.1
Bachelor's degree or higher	2,655	7.7	37.4	55.0	713	10.2	32.2	57.6
Behavioral, physical, and mental factors								
Body mass index*								
Normal/underweight	4,155	13.3	38.1	48.6	754	13.0	30.6	56.4
Overweight	3,014	12.9	40.7	46.4	997	16.4	37.6	46.0
Obese	311	16.7	47.0	36.3	344	14.8	33.4	51.7
Heavy weekly drinking*,§								
No	6,938	13.2	39.5	47.4	1,888	14.9	34.2	50.9
Yes	542	14.9	40.2	44.8	207	15.0	36.2	48.8

Table 1. Continued

	New onset of short sleep duration population N = 7,480				Reoccurrence of short sleep duration population N = 2,095			
	Frequencies	≤5 h n = 994 (13.3%)	6 h n = 2,955 (39.5%)	Recommended (7–9 h) n = 3,531 (47.2%)	Frequencies	≤5 h n = 312 (14.9%)	6 h n = 721 (34.4%)	Recommended (7–9 h) n = 1,062 (50.7%)
Smoking status*								
Never	5,344	11.7	38.8	49.5	1,108	14.0	33.3	52.7
Former	1,242	15.8	40.4	43.8	669	14.7	36.9	48.4
Current	894	19.5	42.5	38.0	318	19.0	33.0	48.4
Life stressors*								
None	5,751	11.8	39.2	49.0	1,666	14.3	34.3	51.4
1	1,239	17.6	40.4	42.1	339	16.2	36.3	47.5
2 or more	490	20.0	40.8	39.2	90	21.1	28.9	50.0
Any anxiety-related disorders†,‖								
No	7,436	13.3	39.5	47.3	2,035	14.9	34.2	51.0
Yes	44	18.2	47.7	34.1	60	15.0	43.3	41.7
Depression†,¶								
No	7,455	13.3	39.5	47.2	2,079	15.0	34.4	50.6
Yes	25	8.0	28.0	64.0	16	0.0	37.5	62.2
Disabling injury*								
No	7,233	13.2	39.3	47.5	1,988	14.3	34.3	51.4
Yes	247	15.0	45.8	39.3	107	25.2	37.4	37.4
General health*								
Fair/poor	155	20.7	41.3	38.1	136	22.8	33.8	43.4
Good	1,654	16.1	39.8	44.0	776	15.7	37.8	46.5
Very good	3,532	13.3	40.4	46.3	887	13.8	34.4	51.9
Excellent	2,139	10.6	37.6	51.8	296	12.5	26.0	61.5
Bodily pain*								
Lowest tertile (less pain)	3,086	12.4	37.1	50.5	526	10.7	37.3	52.1
Middle tertile	2,464	11.7	40.9	47.4	920	15.3	32.8	51.9
Highest tertile (more pain)	1,930	16.8	41.6	41.7	649	17.7	34.4	47.9
Time between surveys (mean, SD)	3.6 (1.4)	3.7 (1.6)	3.5 (1.4)	3.7 (1.4)	3.3	3.3 (0.6)	3.3 (0.7)	3.3 (0.7)

*Assessed at Time 1.

†Measured over the full follow-up period for each participant and assessed at the final time point prior to outcome assessment.

‡Combat experience assessed by exposure to the following while deployed: feeling that you were in danger of being killed, being attacked or ambushed, receiving small arms fire, clearing/searching homes or buildings, having an improvised explosive device (IED) or booby trap explode near you, being wounded or injured, seeing dead bodies or human remains, handling or uncovering human remains, knowing someone seriously injured or killed, seeing Americans who were seriously injured or killed, having a member of your unit be seriously injured or killed, being directly responsible for the death of an enemy combatant, and/or being directly responsible for the death of a non-combatant.

§Heavy weekly drinking was determined based on the number of alcoholic beverages in the previous week. Women were defined as heavy weekly drinkers if they consumed more than seven alcoholic beverages. Men were defined as heavy weekly drinkers if they consumed more than 14 alcoholic beverages.

‖Screened positive for either panic (measure: Patient Health Questionnaire [PHQ]), anxiety (measure: PHQ), or posttraumatic stress disorder (measure: PTSD Checklist – Civilian Version).

¶Major depression (measure: PHQ-8).

sleep included being members of the Army, Navy/Coast Guard, or Marine Corps (vs. Air Force), having a combat deployment (vs. nondeployment), and longer than service branch average deployments. Army and Marine Corps service members had significantly higher risk of newly reporting 6 h sleep, although the magnitudes of the associations were weaker for new reports of 6 h sleep than the associations of new reports of ≤5 h sleep (vs. recommended sleep). Officers (vs. enlisted personnel) and participants with more time in service were at lower risk of newly reporting ≤5 h sleep, and participants who separated from the military during follow-up were at significantly lower risk of newly reporting both short sleep duration categories. Among the demographic factors, those born before 1960 (vs. those born after 1980) were at lower risk of newly reporting both short sleep durations. Additionally, black and other ethnicities (vs. white) were at a higher risk of newly reporting both short sleep durations and those currently married (vs. single) were at a higher risk of newly reporting 6 h sleep.

The adjusted model examining reoccurrence of short sleep duration controlled for all military factors, sex, race/ethnicity, level of educational attainment, BMI, smoking status, disabling injury, bodily pain, and general health at Time 2. For the reoccurrence of short sleep duration (Table 2), Army personnel (vs. Air Force personnel) had significantly increased odds of ≤5 h sleep duration and those deployed longer than their branch average had significantly increased odds of 6 h sleep duration. Those with more time in service and noncombat deployers (vs. nondeployers) were significantly less likely to report reoccurrence of ≤5 h sleep, and those who separated from the military were significantly less likely to report reoccurrence of 6 h sleep.

Table 2. Adjusted associations between military factors and new onset and reoccurrence of short sleep duration among Millennium Cohort Study participants

	New onset of short sleep duration, N = 7,480				Reoccurrence of shortsleep duration, N = 2,095			
	≤5 h		6 h		≤5 h		6 h	
	RR	95% CI	RR	95% CI	OR	95% CI	OR	95% CI
Military factors								
Active duty status (ref: Reserve/Guard)								
Active duty	**1.40**	**1.20–1.62**	1.09	1.00–1.18	1.21	0.92–1.59	1.00	0.81–1.22
Service branch (ref: Air Force)								
Army	**1.78**	**1.51–2.10**	**1.15**	**1.05–1.26**	**1.76**	**1.25–2.47**	1.25	0.98–1.59
Navy/Coast Guard	**1.30**	**1.07–1.58**	0.98	0.88–1.10	1.22	0.81–1.86	1.17	0.88–1.55
Marine Corps	**1.84**	**1.39–2.45**	**1.25**	**1.05–1.48**	1.25	0.69–2.26	1.08	0.70–1.68
Pay grade (ref: enlisted)								
Officer	**0.55**	**0.43–0.72**	0.89	0.78–1.01	0.73	0.44–1.22	1.08	0.77–1.50
Occupation (ref: admin/supply)								
Health care specialist	1.06	0.86–1.30	1.00	0.88–1.14	1.03	0.64–1.65	1.04	0.74–1.47
Combat	0.84	0.66–1.08	1.10	0.97–1.26	1.37	0.90–2.09	1.15	0.84–1.58
Other	0.95	0.82–1.11	1.06	0.96–1.16	0.93	0.67–1.30	0.97	0.77–1.23
Time in service (5-year increases)	**0.81**	**0.70–0.93**	0.96	0.89–1.04	**0.84**	**0.76–0.93**	0.94	0.87–1.01
Separated (ref: no)								
Yes	**0.72**	**0.55–0.93**	**0.82**	**0.71–0.94**	**0.74**	**0.54–1.00**	**0.78**	**0.63–0.98**
Deployed/combat (ref: not deployed)								
Deployed, no combat	1.00	0.83–1.21	0.97	0.87–1.08	**0.38**	**0.16–0.88**	0.88	0.56–1.40
Deployed, combat	**1.33**	**1.13–1.55**	**1.10**	**1.00–1.20**	1.05	0.67–1.63	0.97	0.69–1.37
Deployed equal to or longer than branch average (ref: no)								
Yes	**1.35**	**1.14–1.61**	1.10	0.98–1.23	1.57	0.90–2.76	**1.72**	**1.12–2.63**
Demographic factors								
Birth year (ref: 1980+)								
Pre-1960	**0.35**	**0.14–0.86**	**0.56**	**0.39–0.82**				
1960–1969	0.87	0.66–1.15	0.88	0.75–1.02				
1970–1979	0.94	0.81–1.09	0.97	0.89–1.05				
Sex* (ref: male)								
Female	1.03	0.89–1.19	0.99	0.90–1.07	0.93	0.68–1.27	0.99	0.79–1.25
Race/ethnicity* (ref: white)								
Black	**1.74**	**1.42–2.13**	**1.30**	**1.13–1.49**	**2.61**	**1.67–4.08**	**1.62**	**1.12–2.36**
Other	**1.42**	**1.20–1.68**	**1.25**	**1.13–1.38**	**1.50**	**1.02–2.21**	0.99	0.73–1.34
Marital status* (ref: single)								
Married	1.05	0.91–1.21	**1.10**	**1.01–1.20**				
No longer married	0.80	0.61–1.06	0.97	0.82–1.14				
Education* (ref: associate's degree or less)								
Bachelor's degree or associate's degree	**0.62**	**0.50–0.77**	**0.79**	**0.70–0.89**	**0.59**	**0.40–0.87**	**0.74**	**0.57–0.98**

BMI, body mass index; CI, confidence interval; OR, odds ratio; RR, risk ratio.
Bolding indicates statistically significant associations.
*New-onset model adjusted for BMI, smoking status, life stressors, bodily pain, any anxiety-related disorders, and general health, along with all other variables shown in the table.
Reoccurrence model adjusted for BMI, smoking status, disabling injury, bodily pain, and general health, along with all other variables shown in the table.

Among the demographic factors, black and other ethnicities (vs. white) were at a higher risk of reporting reoccurrence of ≤5 h sleep and black (vs. white) were also at a higher risk of reporting reoccurrence of 6 h sleep. Additionally, those with a bachelor's degree or higher were at lower risk of reporting reoccurrence of either short sleep duration category.

Insomnia symptoms

Descriptive characteristics. The sample characteristics for the new onset of insomnia symptoms participants were nearly identical to the new-onset short sleep duration sample (see descriptive characteristics in the Sleep Duration section in the Results and in Table 1). During the follow-up period, 36% of participants reported new onset of insomnia symptoms (Table 3).

Descriptive characteristics of the reoccurrence of insomnia symptoms sample are also presented in Table 3. Of those eligible, 41% reported reoccurrence of insomnia symptoms during follow-up. Many characteristics of the reoccurrence sample were similar to those of the new-onset insomnia symptoms sample (see previous text and Table 3), but notable differences, including more time in service and older age, could also be attributable to the reoccurrence sample *not* being restricted to newer accessions (Table 3).

Adjusted models. The adjusted model examining new-onset insomnia symptoms controlled for all military factors, birth year, sex, heavy weekly drinking, smoking status, life stressors, bodily pain, any anxiety-related disorders, and general health at the time point prior to the outcome assessment. In the adjusted model, several military factors were associated with

Table 3. Frequencies and proportions of participant characteristics by self-reported insomnia symptoms

	New-onset insomnia symptoms population N = 7,719			Reoccurrence of insomnia symptoms population N = 2,153		
	Frequencies	No insomnia symptoms *n* = 4,951 (64%)	Insomnia symptoms *n* = 2,768 (36%)	Frequencies	No reoccurrence *n* = 1,261 (58.6%)	Reoccurrence *n* = 892 (41.4%)
Military factors						
Active duty status*						
Reserve/Guard	3,452	63.3	36.7	1,088	60.2	39.8
Active duty	4,267	64.8	35.2	1,065	56.9	43.1
Service branch*						
Army	2,854	58.9	41.1	960	55.9	44.1
Navy/Coast Guard	1,354	65.7	34.3	423	59.8	40.2
Marine Corps	403	62.3	37.7	140	47.9	52.1
Air Force	3,108	68.5	31.5	630	64.1	35.9
Pay grade*						
Enlisted	5,794	63.0	37.0	1,739	57.2	42.8
Officer	1,925	67.7	32.3	414	64.3	35.7
Occupation*						
Admin/supply	1,927	64.5	35.5	687	57.1	42.9
Health care specialist	1,091	60.0	40.0	242	56.6	43.4
Combat	828	65.6	34.4	335	57.3	42.7
Other	3,873	64.8	35.2	889	60.7	39.3
Time in service	1.7 (0.8)	1.7 (0.8)	1.6 (0.8)	7.8 (7.8)	8.3 (8.0)	7.0 (7.3)
Separated during follow-up period†						
No	6,722	64.9	35.1	1,097	61.2	38.8
Yes	997	59.3	40.7	1,056	55.9	44.1
Deployed/combat†,‡						
Not deployed	4,133	66.1	33.9	1,744	58.5	41.5
Deployed, no combat	1,260	69.9	30.1	110	76.4	23.6
Deployed, combat	2,326	57.6	42.4	299	52.5	47.5
Deployed equal to or longer than branch average†						
No	6,623	62.1	37.9	1,989	58.6	41.4
Yes	1,096	76.6	23.4	164	57.9	42.1
Demographic factors						
Birth year						
Pre-1960	103	61.2	38.8	259	66.4	33.6
1960–1969	600	61.2	38.8	525	62.5	37.5
1970–1979	2,440	62.4	37.6	637	60.6	39.4
1980+	4,576	65.5	34.5	732	51.2	48.8
Sex*						
Male	4,653	67.7	32.3	1,355	61.1	38.9
Female	3,066	58.7	41.3	798	54.3	45.7
Race/ethnicity*						
White	5,832	64.1	35.9	1,706	59.1	40.9
Black	699	66.2	33.8	181	55.3	44.7
Other	1,188	63.3	36.7	266	57.5	42.5
Marital status*						
Single	3,808	63.2	36.8	485	58.1	41.9
Married	3,482	65.8	34.2	1,330	59.9	40.1
No longer married	429	59.4	40.6	338	54.1	45.9
Education*						
Associate's degree or less	5,019	62.8	37.2	1,429	57.7	42.3
Bachelor's degree or higher	2,700	66.6	33.4	724	60.2	39.8
Behavioral, physical, and mental factors						
Body mass index*						
Normal/underweight	4,305	64.1	35.9	770	59.1	40.9
Overweight	3,092	64.9	35.1	1,026	57.8	42.2
Obese	322	58.1	41.9	357	59.7	40.3
Heavy weekly drinking*,§						
No	7,158	64.6	35.4	1,940	59.4	40.6
Yes	561	58.8	41.2	213	51.2	48.8
Smoking status*						
Never	5,509	65.3	34.7	1,139	60.7	39.3
Former	1,288	61.0	39.0	679	56.1	43.9
Current	922	61.7	38.3	335	56.4	43.6
Life stressors*						
None	5,917	67.0	33.0	1,707	61.5	38.5
1	1,291	56.0	44.0	349	47.0	53.0
2 or more	511	51.5	48.5	97	49.5	50.5

Table 3. Continued

	New-onset insomnia symptoms population N = 7,719			Reoccurrence of insomnia symptoms population N = 2,153		
	Frequencies	No insomnia symptoms *n* = 4,951 (64%)	Insomnia symptoms *n* = 2,768 (36%)	Frequencies	No reoccurrence *n* = 1,261 (58.6%)	Reoccurrence *n* = 892 (41.4%)
Any anxiety-related disorders†,‖						
No	7,694	64.2	35.8	2,090	59.0	41.0
Yes	25	32.0	68.0	63	42.9	57.1
Depression†,¶						
No	7,700	64.1	35.9	2,135	58.8	41.2
Yes	19	63.2	36.8	18	33.3	66.7
Disabling injury						
No	7,464	64.5	35.5	2,045	59.5	40.5
Yes	255	54.5	45.5	108	41.7	58.3
General health*						
Fair/poor	166	51.8	48.2	148	46.0	54.0
Good	1,723	58.2	41.8	802	53.7	46.3
Very good	3,640	64.3	35.7	902	61.8	38.2
Excellent	2,190	69.5	30.5	301	68.1	31.9
Bodily pain*						
Lowest tertile(less pain)	3,188	70.6	29.4	535	67.1	32.9
Middle tertile	2,531	63.4	36.6	943	59.8	40.2
Highest tertile(more pain)	2,000	54.8	45.2	675	50.1	49.9
Time between surveys (mean, SD)	3.6 (1.4)	3.6 (1.4)	3.5 (1.4)	3.3 (0.7)	3.3 (0.7)	3.3 (0.6)

*Assessed at Time 1.

†Measured over the full follow-up period for each participant and assessed at the final time point prior to outcome assessment.

‡Combat experience assessed by exposure to the following while deployed: feeling that you were in danger of being killed, being attacked or ambushed, receiving small arms fire, clearing/searching homes or buildings, having an improvised explosive device (IED) or booby trap explode near you, being wounded or injured, seeing dead bodies or human remains, handling or uncovering human remains, knowing someone seriously injured or killed, seeing Americans who were seriously injured or killed, having a member of your unit be seriously injured or killed, being directly responsible for the death of an enemy combatant, and/or being directly responsible for the death of a non-combatant.

§Heavy weekly drinking was determined based on the number of alcoholic beverages in the previous week. Women were defined as heavy weekly drinkers if they consumed more than 7 alcoholic beverages. Men were defined as heavy weekly drinkers if they consumed more than 14 alcoholic beverages.

‖Screened positive for either panic (measure: Patient Health Questionnaire [PHQ]), anxiety (measure: PHQ), or posttraumatic stress disorder (measure: PTSD Checklist – Civilian Version).

significantly higher risk for new-onset insomnia symptoms, including being on active duty (vs. Reserve/Guard), being in the Army or Marines (vs. Air Force), having a health care occupation (vs. administration/supply), having more time in service, separating from the military during follow-up, experiencing combat deployment (vs. nondeployment), and having a longer deployment than the service branch average. Officers (vs. enlisted personnel) and noncombat deployers (vs. nondeployers) were at a significantly lower risk of new-onset insomnia symptoms (see Table 4). Among the demographic factors, those born between 1960–1969 or 1970–1979 (vs. after 1980) were less likely to report new-onset insomnia symptoms and females were more likely to report new-onset insomnia symptoms.

The adjusted model examining reoccurrence of insomnia symptoms controlled for all military factors, birth year, sex, life stressors, disabling injury, bodily pain, and general health at Time 2. Like the new-onset models, Army and Marine Corps personnel were significantly more likely than Air Force members to report reoccurrence of insomnia symptoms. Also, combat deployment was associated with significantly increased odds of reoccurrence of insomnia symptoms, while noncombat deployment was associated with significantly decreased odds of reoccurrence of insomnia symptoms (vs. nondeployment). No other military factors were significantly associated with the reoccurrence of insomnia symptoms (Table 4). Among the demographic factors, those born between 1960–1969 or 1970–1979 (vs. after 1980) were less likely to report reoccurrence of insomnia symptoms and females were more likely to report reoccurrence of insomnia symptoms.

Discussion

In this longitudinal study, we examined the temporal relationships between military-related factors and the new onset and reoccurrence of short sleep duration and insomnia symptoms. In addition to factors like longer deployment lengths, combat experience, and serving in the Army or Marine Corps, which consistently predicted one or both sleep characteristics, some of the more novel findings indicated that increased time in service and separation from the military were protective for short sleep duration, while also being risk factors for insomnia symptoms. This is one of the first studies to our knowledge to follow relatively newly-accessed service members throughout their career and during their transition to civilian life for those who separated.

We found that the new onset and reoccurrence of short sleep duration (52.8% and 49.3%, respectively) was slightly more common in our sample than the new onset and/or reoccurrence of insomnia symptoms (36.0% and 41.4% respectively), and also that active duty service (versus Reserve/Guard) was a risk factor for all outcomes except the reoccurrence of short sleep duration. These findings indicate that short sleep and insomnia symptoms are pervasive across the military. This is not surprising given the demanding schedules that active duty members must adhere to, including early morning physical training sessions. Such early morning trainings may not only minimize the amount of hours slept, but may impact sleep quality due to anticipated early wake times coupled with the stress of mandated punctuality [39, 40]. These findings also suggest that certain military service members who report and then later remit to short sleep duration and/or insomnia symptoms are at a

Table 4. Adjusted associations between military factors and new onset and reoccurrence of insomnia symptoms among Millennium Cohort Study participants

	New onset ofinsomnia symptomsN = 7,719		Reoccurrence ofinsomnia symptomsN = 2,153	
Military factors	RR	95% CI	OR	95% CI
Military factors				
Active duty status (ref: Reserve/Guard)				
Active duty	**1.18**	**1.08–1.28**	**1.21**	**1.00–1.45**
Service branch (ref: Air Force)				
Army	**1.24**	**1.13–1.37**	**1.27**	**1.01–1.58**
Navy/Coast Guard	1.09	0.98–1.22	1.19	0.91–1.55
Marine Corps	**1.41**	**1.18–1.68**	**1.67**	**1.11–2.49**
Pay grade (ref: enlisted)				
Officer	**0.88**	**0.80–0.97**	0.92	0.71–1.18
Occupation (ref: admin/supply)				
Health care	**1.19**	**1.05–1.34**	1.02	0.75–1.41
Combat	0.98	0.86–1.13	0.99	0.74–1.32
Other	1.07	0.98–1.18	0.82	0.65–1.02
Time in service (5-year increases)	**1.24**	**1.15–1.33**	0.98	0.88–1.11
Separated (ref: no)				
Yes	**1.43**	**1.28–1.60**	1.15	0.94–1.42
Deployed/combat (ref: not deployed)				
Deployed, no combat	**0.86**	**0.77–0.97**	**0.61**	**0.37–0.99**
Deployed, combat	**1.27**	**1.16–1.38**	**1.67**	**1.22–2.28**
Deployed equal to or longer than branch average (ref: no)				
Yes	**1.29**	**1.15–1.44**	0.84	0.56–1.25
Demographic factors				
Birth year (ref: 1980+)				
Pre-1960	0.79	0.57–1.09	0.59	0.34–1.03
1960–1969	**0.81**	**0.70–0.94**	**0.67**	**0.47–0.97**
1970–1979	**0.84**	**0.77–0.91**	**0.70**	**0.55–0.89**
Sex* (ref: male)				
Female	**1.26**	**1.16–1.37**	**1.29**	**1.05–1.58**

CI, confidence interval; OR, odds ratio; RR, risk ratio.
Bolding indicates statistically significant associations.
New onset model adjusted for heavy weekly drinking, smoking status, life stressors, bodily pain, any anxiety-related disorders, and general health, along with all other variables shown in the table.
*Reoccurrence model adjusted for life stressors, disabling injury, bodily pain, and general health, along with all other variables shown in the table.

higher risk of reoccurrence during their lifetime, even after military service.

Some of the more novel aspects of this study include the examination of time in service and separation from service in relation to sleep characteristics. Few studies are able to track service members throughout their military career and even following separation, as many prior studies have used cross-sectional research designs and lack longer follow-up times. Greater time in and separation from service were protective factors for the new onset and reoccurrence of short sleep duration, while also being risk factors for the new onset of insomnia symptoms. These findings may appear to be incongruous but may demonstrate the possibility of sleeping for a recommended duration but still suffering from insomnia symptoms, even among those with the ability to control their sleep schedules [41, 42]. For example, those with longer time in service may have shifted away from front-line duties, and those recently separating from service no longer have strict scheduling demands for getting out of bed, resulting in increased opportunity to obtain sleep. However, past experiences in the military may still be a negative influence on the quality of that extra sleep time [43, 44]. These findings may also indicate that the time period around the transition out of service may be an important point for interventions promoting healthy sleep.

Deployment-related factors such as longer than branch-average lengths and combat experience were also consistently associated with short sleep duration and insomnia symptoms. These findings corroborate previous reports that combat deployment conferred a significant negative influence on these sleep characteristics [8, 21]. Further, these findings suggest that the stress related to combat experience while deployed is an important driver of developing shorter sleep durations and/or insomnia symptoms, but also an important driver of the reoccurrence of insomnia symptoms among those whose symptoms previously remitted. Deployment without combat, interestingly, was protective against the development and reoccurrence of insomnia symptoms as well as protective against the reoccurrence of ≤5 h sleep duration. Those who deploy, on average, are typically healthier than those who do not deploy [45]; so if these service members do not experience combat during deployment, they may have less chronic stress and therefore a lower risk of sleep disturbances and a greater sleep opportunity. Findings demonstrating that longer than branch-average deployments are associated with the new onset and reoccurrence of short sleep duration and new onset of insomnia symptoms may be of interest to military leaders who monitor the effects of the deployment environment on health. Taken together, these findings related to deployment are supported by a

recent study evaluating the Military Service Sleep Assessment which demonstrated that deployments were the second most commonly-reported reason for sleep challenges in military personnel [46].

Organizational factors such as service branch, pay grade, and military occupation were associated with sleep in this study. Although these are not readily modifiable factors, elucidating these differences is important in order to encourage leadership to implement cultural shifts towards the promotion of healthy sleep. Specifically, serving in the Army, Marines, or Navy/Coast Guard (versus serving in the Air Force) was consistently associated with risk for new onset and reoccurrence of short sleep duration and insomnia symptoms. Some possible reasons for differences in these sleep characteristics among service branches may be related to variations in the physical sleep environment, sleeping conditions, and emphasis placed on the importance of sleep. For instance, in a study conducted on board deployed U.S. Naval ships, Sailors frequently reported ambient temperature, poor bedding conditions, noise, and ambient light as disrupting sleep while underway [47]. Similarly, in the operational theatre environment, Army and Marine Corps personnel listed a poor sleep environment as one of the factors that interfered with getting sleep [48, 49]. Finally, inconsistencies between the service branches, while apparent, are not surprising given the differences in mission specifics and the respective promotion of policies in place to protect sleep [6, 50]. The findings from these studies indicate that the sleep environment (to some extent) and as well as other factors such as operational schedules may be useful interventional targets for improving sleep in the military.

The finding that serving as an officer is protective against the development of short sleep duration and/or insomnia symptoms may reflect an increased opportunity to obtain sleep over the course of a military career as front-line duties diminish. This finding is also in line with previous research studies such as those conducted by the Naval Postgraduate School within a naval surface warfare ship environment [22], and Navy officers in the present study reported the recommended sleep duration more often than enlisted sailors (63.0% vs. 44.2%, respectively). Also, a cross-sectional study of a large Army cohort found that officers had much lower rates of insomnia than enlisted personnel prior to deployment [51].

The finding that health care occupation (and not combat arms occupation) was associated with insomnia symptoms may reflect the irregular work hours and high stress that is required for staffing around-the-clock medical operations [6, 10, 11]. As mentioned, combat deployment *was* associated with insomnia symptoms, which may indicate that having a combat military occupational specialty by itself does not necessarily result in insomnia symptoms, but instead it is a combination of factors, such as stress related to a combat deployment, that place an individual at greater risk.

This study identified some high-risk military factors that should be considered when interventional efforts are designed with the aim of addressing and mitigating sleep challenges. Nonpharmacological approaches to improve sleep in military personnel are preferred based on the known safety risks associated with prescription medications (e.g. long-acting sedation, dependency, side effects). For instance, cognitive-behavioral therapy for insomnia (CBT-I), which is considered the gold standard for treating insomnia [52], has been shown to improve insomnia symptoms and related sleep disturbances in active duty military [53, 54] and veterans [55]. Although we could not ascertain diagnosed cases of insomnia in this study, it is plausible that individuals reporting insomnia symptoms and/or short sleep over time may be actual insomnia cases. CBT-I has performed in the short term as effectively as pharmacological insomnia treatments but with even better long-term efficacy in civilian patients [56]. While CBT-I is not an appropriate treatment strategy within a combat environment due to practical and logistical limitations, behavioral sleep interventions (such as CBT-I) may prove useful during periods when military personnel are provided more liberty with their sleep and daily activities such as when stationed within the United States or deployed to non-combat zones. Additionally, educational interventions on best sleep practices could be implemented working together with military leadership to identify opportunities to connect sleep to operational outcomes to help increase the importance of sleep prioritization among the military.

The Army's P3 is an example of an initiative that is intended to increase general understanding of sleep and the impacts of sleep disturbances by linking poor sleep, activity, and nutrition to physical health and operational performance outcomes and fatigue levels [5]. The U.S. Army Field Manual 6–22.5 further reinforces the importance of sleep and details how to reduce sleep disturbances as well as how to educate leadership on mitigation strategies [57]. The Navy has also recently made policy changes regarding the scheduling of watch bills at sea to align with circadian rhythms, which should have positive effects on sleep [58]. Combined with an expansive DoD report on the effects of sleep deprivation in the military, commissioned by the U.S. Congressional Armed Services Committees [59], these are positive steps that reflect an increased awareness of the importance of sleep to military health and readiness. Still, until there is greater oversight of policies that serve to protect sleep in the operational environment, sleep challenges will likely continue to persist.

Furthermore, incorporating valid sleep monitoring devices into military training and within health promotion efforts, such as the Army's P3, could help improve compliance with sleep recommendations and treatments, allowing military leaders to provide targeted sleep education and ensure that recommendations are followed. Given the operational risk of sleep loss and ensuing fatigue, enhanced monitoring capabilities are needed to provide military personnel and leadership direct feedback on sleep and provide the opportunity to employ sleep health education quickly when needed. Additionally, focus should be placed on the costs/benefits associated with current practices, including early morning physical training sessions, which likely do not align well with the "evening" chronotypes of most young adults [40, 60]. Perhaps implementing alternate or flexible training schedules, to the afternoon or evening, may allow "non-morning chronotype" military members to gain extra sleep and optimize their performance by better aligning their training with individual differences in circadian rhythms.

There was a relatively low sample size that reported an average long sleep duration of ≥10 h per day (n = 239). For purposes of simplicity and clarity, we did not include this subset of participants into the general analyses and instead performed a post hoc analysis (presented in the Supplemental Material Tables S1 and S2). In general, we found similar trends as those for short duration sleepers, which may not be surprising given that long sleep duration is also not typically considered a healthy sleep

pattern in adults; it has often been found to be associated with comorbidities and poor health and behavioral outcomes [61].

This study has strengths, such as the large sample size that included all branches of the military, breadth of military-related factors analyzed, longitudinal design allowing for the examination of both the new onset and the reoccurrence of sleep characteristics, and availability of behavioral and life experience covariates. For example, we controlled for multiple life stressors in the present study (e.g. death of a loved one, financial problems, divorce), and "stressful life events" were reported as having the greatest adverse impact on service members' sleep in a recent study [46]. However, there are some notable limitations. It is possible that our sample may not be representative of all military personnel. However, the Millennium Cohort Study is based on a random sampling of all U.S. military members, and investigation of potential sources of selection bias revealed a well-representative military population [62–65]. In addition, loss to follow-up inherent in prospective cohort studies may have potentially biased the results, although analyses on weighting for nonresponses have not identified changes in metrics for health outcomes [66]. Additionally, certain life stressors, such as pregnancy or child rearing, which may be more impactful on a service woman's sleep could not be fully assessed on the available longitudinal survey data. Further, a validated measure for insomnia symptoms was not available on all survey instruments included in these analyses. The Insomnia Severity Index [67] has been added to Millennium Cohort survey instruments starting in 2011, and future studies utilizing this validated tool are currently underway. Lastly, the self-report measures of sleep may have been affected by varying levels of accuracy in recall, although these have been used in prior epidemiological research studies.

In summary, the findings from this study demonstrate that military-related factors play a significant role in the new onset and reoccurrence of short sleep duration and insomnia symptoms in military members. These results identify specific at-risk groups and factors within the military that should be targeted for the development and/or implementation of strategies to improve specific issues related to sleep duration and insomnia symptoms. Further research using a longitudinal research design should examine these military-related factors in the context of sleep disorders common within military populations, such as OSA and insomnia.

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Data Availability Statement

The data underlying this article are not currently publicly available due to institutional regulations protecting service member survey responses, but may be available from the corresponding author on reasonable request, pending the development of required data use agreements.

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I am a military service member or employee of the U.S. Government. This work was prepared as part of my official duties. Title 17, U.S.C. §105 provides that copyright protection under this title is not available for any work of the U.S. Government. Title 17, U.S.C. §101 defines a U.S. Government work as work prepared by a military service member or employee of the U.S. Government as part of that person's official duties. Report No. 20-93 was supported by the Military Operational Medicine Research Program, Defense Health Program, and Veterans Affairs under work unit no. 60002. 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 U.S. 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.2000.0007.

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