UCLA

UCLA Previously Published Works

Title

Sex differences in US military personnel with insomnia, obstructive sleep apnea, or comorbid insomnia and obstructive sleep apnea.

Permalink

https://escholarship.org/uc/item/747575kk

Journal

Journal of Clinical Sleep Medicine, 20(1)

Authors

Mysliwiec, Vincent

Pruiksma, Kristi

Matsangas, Panagiotis

et al.

Publication Date

2024

DOI

10.5664/jcsm.10774

Peer reviewed

SCIENTIFIC INVESTIGATIONS

Sex differences in US military personnel with insomnia, obstructive sleep apnea, or comorbid insomnia and obstructive sleep apnea

Vincent Mysliwiec, MD[1]; Kristi E. Pruiksma, PhD[1,2]; Panagiotis Matsangas, PhD[3]; Tyler Powell, MD[4]; Casey L. Straud, PsyD[1,2,5]; Daniel J. Taylor, PhD[6]; Shana Hansen, MD[4]; Shannon N. Foster, DO[4]; Sara Mithani, PhD[7]; Sarah Zwetzig, PhD[1]; Jennifer Martin, PhD[8,9]; Kelsi Gerwell, PhD[1]; Stacey Young-McCaughan, RN, PhD[1,2]; John A. Blue Star, PhD[4]; Daniel G. Cassidy, PhD[4]; Kimberly D. Gomes[10]; Brian A. Moore, PhD[10]; Alan L. Peterson, PhD[1,2,5]; Matthew S. Brock, MD[4]; on behalf of STRONG STAR Consortium

[1]Department of Psychiatry and Behavioral Sciences, The University of Texas Health Science Center at San Antonio, San Antonio, Texas; [2]Research and Development Service, South Texas Veterans Health Care System, San Antonio, Texas; [3]Crew Endurance Team, Naval Postgraduate School, Monterey, California; [4]Wilford Hall Ambulatory Surgical Center, Joint Base San Antonio-Lackland, Texas; [5]Department of Psychology, The University of Texas at San Antonio, San Antonio, Texas; [6]Department of Psychology, University of Arizona, Tucson, Arizona; [7]School of Nursing, The University of Texas Health Science Center at San Antonio, San Antonio, Texas; [8]David Geffen School of Medicine at the University of California, Los Angeles, Los Angeles, California; [9]Geriatric Research, Education and Clinical Center, VA Greater Los Angeles Healthcare System, Los Angeles, California; [10]Department of Psychological Science, Kennesaw State University, Kennesaw, Georgia

Study Objectives: The aim of this study was to evaluate sex-related differences in symptoms of sleep disorders, sleep-related impairment, psychiatric symptoms, traumatic brain injury, and polysomnographic variables in treatment-seeking military personnel diagnosed with insomnia, obstructive sleep apnea (OSA), or comorbid insomnia and OSA (COMISA).

Methods: Participants were 372 military personnel (46.2% women, 53.8% men) with an average age of 37.7 (standard deviation = 7.46) years and median body mass index of 28.4 (5.50) kg/m^2. Based on clinical evaluation and video-polysomnography, participants were diagnosed with insomnia (n = 118), OSA (n = 118), or COMISA (n = 136). Insomnia severity, excessive daytime sleepiness, sleep quality, nightmare disorder, sleep impairment, fatigue, posttraumatic stress disorder, anxiety, depression symptoms, and traumatic brain injury were evaluated with validated self-report questionnaires. Descriptive statistics, parametric and nonparametric *t*-tests, and effect sizes were used to assess sex differences between men and women.

Results: There were no significant differences between women and men with insomnia or OSA in sleep-related symptoms, impairment, or polysomnography-based apnea-hypopnea index. Military men with COMISA had a significantly greater apnea-hypopnea index as compared to military women with COMISA, but women had greater symptoms of nightmare disorder, posttraumatic stress disorder, and anxiety.

Conclusions: In contrast to civilian studies, minimal differences were observed in self-reported sleep symptoms, impairment, and polysomnography metrics between men and women diagnosed with the most frequent sleep disorders in military personnel (ie, insomnia, OSA, or COMISA) except in those with COMISA. Military service may result in distinct sleep disorder phenotypes that differ negligibly by sex.

Keywords: military, service member, sex, sleep, insomnia, obstructive sleep apnea, comorbid insomnia and obstructive sleep apnea, COMISA, nightmares, posttraumatic stress disorder, traumatic brain injury, anxiety, veteran

Citation: Mysliwiec V, Pruiksma KE, Matsangas P, et al. Sex differences in US military personnel with insomnia, obstructive sleep apnea, or comorbid insomnia and obstructive sleep apnea. *J Clin Sleep Med*. 2024;20(1):17–30.

BRIEF SUMMARY

Current Knowledge/Study Rationale: There are recognized differences in the sleep-related symptoms and objective polysomnographic variables in civilian men and women with insomnia and obstructive sleep apnea; however, there is a substantial lack of understanding regarding differences or similarities in military men and women with these sleep disorders. In order to develop a better understanding of sex-related characteristics of sleep disorders in military personnel, this study evaluated treatment-seeking service members, both men and women, who were diagnosed with insomnia, OSA, or COMISA.

Study Impact: In contrast to most civilian studies, there were no significant differences between military women and men with insomnia or OSA in sleep-related symptoms, impairment, or PSG-based apnea-hypopnea index (AHI). The referral patterns for clinical sleep evaluations and polysomnography of military women should be evaluated as military service potentially results in distinct sleep disorder phenotypes that differ negligibly by sex.

INTRODUCTION

Although women constitute approximately 17% of the active duty US military,[1] relatively little is known regarding sleep disorders and associated comorbid diagnoses affecting women serving in the military.[2] Previous studies evaluating clinical sleep disorders in military personnel have included predominantly military men and focused on insomnia and obstructive sleep apnea (OSA).[3] In addition to the fact that military populations are primarily men, this focus on sleep disorders in military men was potentially driven by two biases: (1) the presumption that women in the military do not have OSA, as many are

premenopausal and thus do not have typical risk factors for this sleep disorder and (2) the presumption that women do not have the same combat experiences as men and thus are not at as high risk for sleep disorders and associated comorbid diagnoses.[4] Both of these presumptions are problematic. First, the majority of clinical cohorts were those who had undergone polysomnography (PSG) for suspected OSA, which requires a referral from a primary care provider who is less familiar with the nuances of sleep medicine. Second, in 2015, women in the US military were authorized to serve in the same combat jobs as men.[5] Since that time, diagnoses of insomnia and OSA have steadily increased throughout all branches of the US military, but military women remain underdiagnosed,[2,6] possibly because they are underassessed.

In the civilian population, sex differences in OSA have long been recognized.[7] Snoring, witnessed apneas, and excessive daytime sleepiness are considered hallmark symptoms of OSA, though women with OSA often do not present with these symptoms. Instead, women are more likely than men to present with symptoms of insomnia and fatigue. The lack of recognition of these differences has led to the underdiagnosis and delayed diagnosis of OSA in women.[8–10] For instance, in a retrospective cohort of 130 men and women with similar degrees of OSA severity, Shepertycky et al reported that women were significantly more likely than men to have insomnia symptoms, depression, and hypothyroidism.[11] In a larger study of 2,827 men and women, Basoglu et al reported that women diagnosed with OSA were older, had higher body mass indexes and more comorbid medical disorders, and more frequently reported insomnia and nonrestorative sleep than their male counterparts.[12] Women in the study had a significantly lower apnea-hypopnea index (AHI) but greater rapid eye movement (REM) AHI than the men. Regarding REM-related OSA, this finding is aligned with previous studies whereby women have a higher prevalence of REM-related OSA compared to men.[13] In the military, men and women are of similar ages, with comparable physical fitness requirements and experiences inherent to military service, including high levels of trauma exposure. Considering this, it is currently unknown if the sex-related differences in the characteristics of OSA reported in civilian populations also exist in military men and women.

In research among civilian populations, there is substantial evidence that insomnia is more prevalent in women compared to men.[14] In large part this finding is ascribed to psychosocial factors such as women often being primary caregivers for children and family members and experiencing higher rates of anxiety and depression. However, military research of the prevalence of insomnia has found different patterns. Specifically, in a study of soldiers in the US Army prior to deployment, the overall prevalence of insomnia was 19.9% with no difference between men and women.[15] In a study that evaluated sleep disorders in all branches of the US military, women were found to have a *lower* rate of insomnia than men.[6] Potential reasons for these findings may be that military men and women have similar military occupational requirements or that the rates of comorbid disorders to include anxiety, depression, posttraumatic stress disorder (PTSD), and mild traumatic brain injury (TBI) are similarly high in men and women. Another potential

reason is that the underlying neurobiological mechanisms of insomnia, including hyperarousal and homeostatic and circadian dysregulation, are similarly present in military men and women.[16] Currently, there is a limited understanding regarding the differences in the clinical presentation of insomnia in military men and women, which likely has diagnostic and treatment implications.

The combination of insomnia and OSA, also known as comorbid insomnia and OSA (COMISA), was first reported in the military population in 2013.[17] COMISA as a distinct clinical condition is increasingly recognized and noted to be associated with higher rates of medical and psychiatric disorders than either insomnia or OSA alone in the civilian population[17–20] and in miliary populations.[21] Differences between men and women with COMISA are less well established than differences found with OSA and insomnia, but women appear to present with greater insomnia and sleep disturbance symptoms than men whereas men have more witnessed apneas than women.[22] This is similar to their overall presentations of OSA. One study performed PSG to evaluate differences in OSA in men and women with chronic insomnia. Men had a higher overall prevalence of COMISA that peaked between 45 and 55 years of age while the peak in women was ≥ 55 years of age.[23] We have recently found that COMISA is the most frequent sleep disorder diagnosed in service members seen in a sleep disorders clinic and is associated with greater overall morbidity than OSA alone, to include significantly higher rates of PTSD.[18] However, given the younger age of this population and relatively few studies evaluating COMISA in military populations, it is currently unknown if there are sex differences in this sleep condition or associated diagnoses.

To develop a better understanding of sex-related differences in the most frequent sleep disorders in military personnel (ie, insomnia, OSA, and COMISA), we examined baseline data collected as part of a larger prospective observational study of active duty military men and women seeking treatment for sleep disturbance. The primary objective of the current study was to determine if there are overall differences in self-reported symptoms of sleep disorders, sleep-related impairment, comorbid psychiatric symptoms, and history of mild TBI between military women and men. The secondary objective was to determine if there are differences in objective PSG variables between military men and women diagnosed with insomnia only, OSA only, or COMISA.

METHODS

Participants

This parent study recruited men and women seeking treatment for sleep disturbance and subsequently diagnosed with the three different sleep disorders (**Figure 1** and **Figure 2**). A total of 372 active duty US military personnel were enrolled, including 200 men (54%) and 172 women (46%). Recruitment was from June 2019 to May 2022 at the Wilford Hall Ambulatory Surgical Center Sleep Disorders Center located at Joint Base San Antonio-Lackland in San Antonio, Texas. The current paper focused on data collected at baseline. All participants were

Figure 1—Study flow chart.
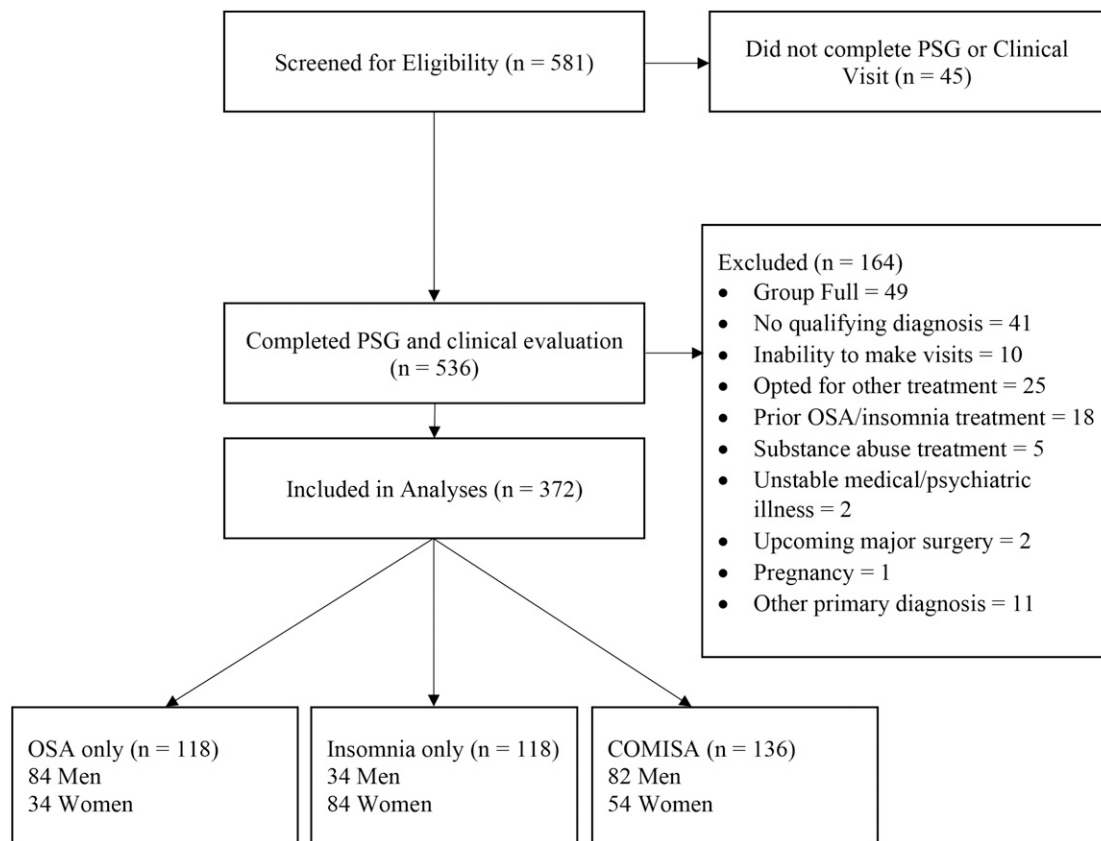
COMISA = comorbid obstructive sleep apnea and insomnia, OSA = obstructive sleep apnea.

(1) active duty military personnel; (2) ≥ 18 years of age; and (3) diagnosed with insomnia only, OSA only, or COMISA following an overnight attended in-lab video-PSG (vPSG) and clinical evaluation to determine their sleep diagnosis. Exclusion criteria were (1) primary sleep diagnosis other than insomnia, OSA, or

COMISA (noting co-occurrence of another sleep disorder was not exclusionary); (2) previous positive airway pressure treatment for OSA or cognitive behavioral therapy for insomnia; (3) opted for a treatment other than cognitive behavioral therapy for insomnia, Brief Behavioral Treatment for Insomnia, or

Figure 2—Number of women and men in each sleep disorder group.
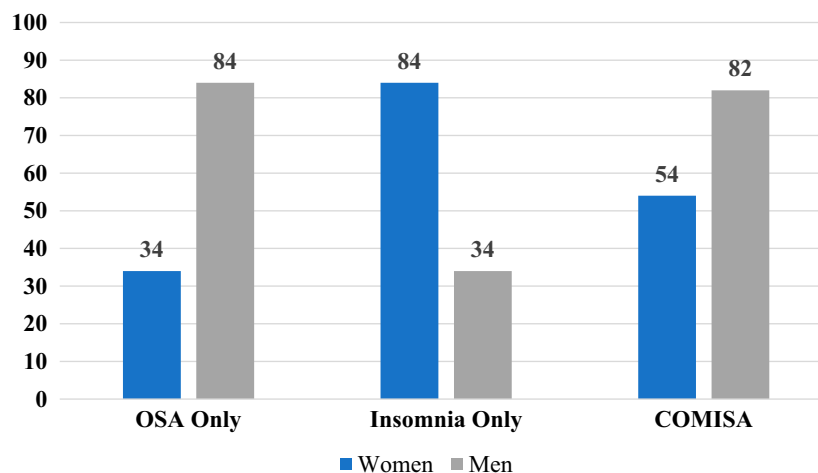
positive airway pressure; (4) unstable medical or psychiatric illness; (5) receiving treatment for alcohol or substance abuse; (6) pregnant; (7) experiencing suicidality warranting immediate care; (8) planned major surgery; or (9) inability to make follow-up visits.

Procedures

Following informed consent, participants completed the clinical assessments of sleep and associated comorbid disorders, an overnight-attended in-lab vPSG, and clinical evaluation to determine their sleep diagnosis. Participants with other sleep disorders such as insufficient sleep syndrome or nightmare disorder in addition to OSA, insomnia, or COMISA were not necessarily excluded unless the other sleep disorder was determined to be the primary reason for the patient's sleep-related symptoms. For cases in which two or more sleep disorders were present, the study team consisting of at least two board-certified sleep medicine physicians (M.B., S.F., S.H., V.M., T.P.) determined if a potential participant was included or excluded.

The 59th Medical Wing Institutional Review Board served as the institutional review board of record for this study. The University of Texas Health Science Center at San Antonio deferred their institutional review board review to the 59th Medical Wing. The regulatory approvals were monitored by the US Army Medical Research and Development Command Human Research Protection Office.

Sleep medicine evaluation

Video-polysomnography

All service members underwent an in-lab attended diagnostic, level 1 vPSG performed in accordance with American Academy of Sleep Medicine standards in an American Academy of Sleep Medicine-accredited lab. The system used was Sleepware G3 version 3.9.0 (Philips Respironics, Murrysville, PA). Studies were scored utilizing the American Academy of Sleep Medicine Scoring Manual Version 2.5 from June 2019 until March 2020 and 2.6 from March 2020 until study completion.[24] Hypopneas were scored according to the recommended criteria with either an arousal and/or ≥ 3% desaturation.

Sleep medication usage

Sleep medication usage was assessed for each participant with a standardized list including the following medications: zolpidem, diphenhydramine, eszopiclone, prazosin, trazodone, melatonin, Nyquil, valerian root, or other.

Sleep disorder diagnosis

Participants were diagnosed in accordance with the *International Classification of Sleep Disorders*, third edition[25] by a physician board-certified in sleep medicine. All diagnoses were adjudicated by the study team. Note that participants were *not* excluded for other co-occurring sleep disorders (eg, nightmare disorder, shift work disorder, restless legs syndrome, etc.).

Chronic insomnia disorder: Participants in the "insomnia group" were diagnosed with chronic insomnia disorder by a clinical interview. This diagnosis was rendered when participants reported symptoms of difficulty initiating or maintaining sleep and/or awakening earlier than desired ≥ 3 times per week for at least 3 months and reported associated daytime impairments (ie, daytime sleepiness, irritability, risk of accidents/errors).[25] For a diagnosis of chronic insomnia disorder, participants were required to have an AHI < 5 events/h.

Obstructive sleep apnea: OSA was diagnosed if participants had an AHI ≥ 5 events/h on vPSG with symptoms of sleepiness, fatigue, and/or problems with nocturnal breathing (ie, snoring, gasping, choking) or an associated illness (eg, hypertension, mood disorder, etc.).[25]

COMISA: For the diagnosis of COMISA participants were required to meet the *International Classification of Sleep Disorders,* third edition diagnostic criteria for both chronic insomnia disorder and OSA as described earlier. Further, on clinical interview, insomnia symptoms (eg, nocturnal or early morning awakenings) could not be solely attributed to the symptoms of sleep-disordered breathing, as the symptoms of insomnia and OSA can overlap.[20] Specifically, a service member could not describe their nocturnal awakenings were exclusively due to the symptoms of gasping, choking, snoring, and so on.

Measures

The measures to evaluate sleep-related symptoms and impairment as well as psychiatric symptoms and TBI were administered in a supervised setting by a research assistant or a postdoctoral fellow and included the following.

Demographics

Demographic questionnaire: The self-reported demographic information collected included sex, race, ethnicity, height, weight, marital status, and highest level of education. Military service information included branch of service, current rank, number of deployments, duties during deployment, and the military operations in which they served.

Sleep characteristics

Insomnia Severity Index: The seven-item Insomnia Severity Index[26] evaluates self-reported insomnia symptoms over the preceding month. Items measure the severity of falling asleep, staying asleep, waking up too early as well as sleep satisfaction, functional impact, how noticeable their impairment is, and an individual's degree of concern about their sleep. Responses are summed to produce a score ranging from 0 to 28. A score of ≥ 15 is consistent with clinically significant insomnia. The Insomnia Severity Index has adequate internal consistency (Cronbach's α = 0.74) in civilian populations and high internal consistency in military populations (Cronbach's α = 0.92).[15]

Epworth Sleepiness Scale: The eight-item Epworth Sleepiness Scale[27] is a measure of self-reported daytime sleepiness. Individuals rate the likelihood of dozing or falling asleep on a 4-point Likert scale ranging from 0 ("would never doze") to 3 ("high chance of dozing") across eight situations. Responses are summed for a total score ranging from 0 to 24, with higher scores indicating greater levels of daytime sleepiness. Internal

consistencies range from 0.73 to 0.88. Test–retest reliability is reported at 0.82.[28]

The Pittsburgh Sleep Quality Index: The Pittsburgh Sleep Quality Index (PSQI)[29] evaluates sleep quality in the preceding month. The PSQI global score is derived from seven components: self-reported sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction. A threshold score of ≥ 5 differentiates "good" vs "poor" sleepers. The PSQI has good internal homogeneity (Cronbach's α = 0.83) and test–retest reliability (r = .85).[29]

Patient Reported Outcomes Measurement Information System Sleep-Related Impairment Short Form: The eight-item Patient Reported Outcomes Measurement Information System (PROMIS) Sleep-Related Impairment short form is a self-report measure of sleep-related impairments in the past week to include alertness, sleepiness, tiredness, and functional impairments. The PROMIS items use a 5-point Likert scale from 1 ("not at all") to 5 ("very much"). The overall raw score is converted to a standardized *t* score using conversion tables available on the PROMIS website.[30] The PROMIS has shown strong reliability and construct validity.[31]

Nightmare Disorder Index: The five-item Nightmare Disorder Index[32] was used to evaluate for nightmare disorder in accordance with the *Diagnostic and Statistical Manual of Mental Disorders*, fifth edition[33] criteria. Higher scores on the Nightmare Disorder Inventory indicate greater nightmare severity. The Nightmare Disorder Inventory has adequate psychometric characteristics, with a good internal consistency (α = 0.80) and interitem correlations (r = .50).[32] For this study, participants were determined to have nightmare disorder if their score on all Nightmare Disorder Inventory items was ≥ 2. This is indicative of experiencing nightmares one to three nights per week, awakening and becoming alert at least "sometimes," and experiencing distress and impairment at least "somewhat" for ≥ 1 month.

Fatigue

Multidimensional Fatigue Inventory: The Multidimensional Fatigue Inventory[34] is a 20-item self-report measure of fatigue symptoms, designed to index five dimensions of fatigue: general fatigue, physical fatigue, mental fatigue, reduced motivation, and reduced activity. Each fatigue dimension includes four questions that are scored on a 5-point Likert scale ranging from 1 ("Yes, that is true") to 5 ("No, that is not true"). For this study, the overall fatigue measures were summed for a total score, with higher scores indicating greater fatigue. Clinically significant fatigue is considered present if the summed score for all five dimensions is greater than 60. The Multidimensional Fatigue Inventory has been shown to have good internal consistency (α = 0.84).[34]

Psychiatric disorders

Generalized Anxiety Disorder Screener: The Generalized Anxiety Disorder screener [35] is a validated instrument for measuring anxiety symptoms. It consists of seven items that ask participants to rate the frequency with which they have been bothered by anxiety symptoms within the past 2 weeks on a scale ranging from 0 ("not at all") to 3 ("nearly every day"). Scores for all questions are summed with a higher score corresponding to greater anxiety symptoms. The Generalized Anxiety Disorder screener has been shown to have high internal consistency (Cronbach's α = 0.92).[35] A Generalized Anxiety Disorder screener score ≥ 10 was considered diagnostic of anxiety.

Patient Health Questionnaire-9: The Patient Health Questionnaire-9[36] is a validated instrument for measuring the severity of depressive symptoms. It consists of nine items that assess affective and somatic symptoms related to depression. Individuals rate the frequency with which they have been bothered by depressive symptoms within the past 2 weeks on a scale ranging from 0 ("not at all") to 3 ("nearly every day"). Scores for all questions are summed with a higher score corresponding to greater depressive symptomatology. The Patient Health Questionnaire-9 has high internal consistency (eg, α ranging from 0.83 to 0.92) and correlates strongly with other measures of depression.[36] For this study, a Patient Health Questionnaire-9 score of ≥ 10 was considered diagnostic of depression.

The PTSD Checklist for DSM-5: The PTSD Checklist for DSM-5[37] consists of 20 self-report items that assess the severity of PTSD symptoms based on *Diagnostic and Statistical Manual of Mental Disorders*, fifth edition[33] criteria. Participants rate how bothersome a symptom has been in the past month, from 0 ("not at all") to 4 ("extremely"). Higher scores reflect greater perceived PTSD symptom severity. The PTSD Checklist for DSM-5 has demonstrated good internal consistency (α = 0.96), test–retest reliability (r = .84), and convergent and discriminant validity.[37] To meet the diagnostic criteria for PTSD, individuals must report a Criterion A traumatic event (ie, that the person was exposed to death, threatened death, actual or threatened serious injury, or actual or threatened sexual violence) and at least one B item (intrusion or re-experiencing symptoms), one C item (avoidance), two D items (negative alterations in cognitions and mood), and two E items (alterations in arousal and reactivity or hyperarousal), each at a severity rating of "moderately" or higher.[37]

Traumatic brain injury

History of head injuries: The modified Defense and Veterans Brain Injury Center three-item screening tool[38] asks about causes of head injuries, altered consciousness following the injury, and postconcussive symptoms following the head injury. This tool was modified to capture the number of TBIs that occurred in both deployed and nondeployed settings.

Statistical analysis

Descriptive statistics were used to examine the demographic and military service characteristics of the total sample, and we assessed sex differences in demographic and military service variables. Next, participants were classified in three groups: OSA only, insomnia only, or COMISA. Within each of these groups, we assessed sex differences in terms of demographic characteristics,

sleep medication usage, self-reported measures of interest (ie, insomnia severity, daytime sleepiness, sleep quality, sleep duration, nightmares, sleep-related impairment, fatigue, PTSD symptoms, anxiety, depression, and TBI), and PSG variables.

Statistical analyses were conducted with a statistical software package (JMP Pro 16; SAS Institute; Cary, NC). Data normality was assessed with the Shapiro-Wilk test. Given that some of variables violated the assumption of normality, statistical analysis was based on parametric (*t*-test assuming unequal variances) and nonparametric (Wilcoxon's rank sum test) methods as appropriately needed. Fisher's exact test was used for pairwise comparisons between proportions.

An α level of 0.05 was used to determine statistical significance. Accounting for family-wise error, post hoc statistical significance was assessed by the Benjamini–Hochberg false discovery rate-controlling procedure with $q = 0.20$.[39] To assess the strength of the observed differences we used relative risk with 95% confidence interval, Hedge's *g*, and the nonparametric effect size *r*. Data is presented as mean ± standard deviation, median (interquartile range), or number of occurrences (percentage).

The data from this study are maintained at The University of Texas Health Science Center at San Antonio in the South Texas Research Organizational Network Guiding Studies on Trauma and Resilience Repository.

RESULTS

Detailed demographic and military service characteristics are shown in **Table 1**. Participants were 21 to 57 years old (37.7 ± 7.46) with 200 (53.8%) men and 172 women (46.2%). Participants were predominantly non-Hispanic (76.3%), White (67.5%), and married or living with a partner (76.9%). Participants were from all branches of the military but primarily served in the Air Force (50.0%) and Army (36.6%). Approximately, 73.0% of the military personnel evaluated had deployed. The study flow chart is depicted in **Figure 1**.

Comparisons within each of the three sleep disorder groups (OSA only, insomnia only, or COMISA) are presented in **Table 2**, **Table 3**, and **Table 4**. In the OSA only group (118 patients in total, 34 women), there were no statistically significant differences between men and women on self-report or objective PSG variables. Of note, women diagnosed with OSA only tended to be older than men (∼3.4 years on average), but this difference was not statistically significant in post hoc analysis. In the insomnia only group (118 patients in total, 84 women), there were no statistically significant differences between men and women on self-report or objective PSG variables. In the COMISA group (136 patients in total, 54 women), analyses of the self-report measures indicated that women were at significantly higher risk than men to have symptoms denoting probable nightmare disorder ($P = .009$) and probable PTSD ($P = .033$). Women also reported significantly worse symptoms of anxiety ($P = .013$) compared to men. On objective PSG variables, women spent significantly less time of their sleep in N1 ($P = .009$), had lower wake after sleep onset ($P = .022$), non-REM AHI ($P < .001$), and overall AHI ($P < .001$) as compared to men.

DISCUSSION

This prospective study compared active duty military men and women seeking treatment for sleep disturbance who were subsequently diagnosed with insomnia only, OSA only, or COMISA. Although sex differences in patients diagnosed with insomnia only and OSA only are well studied among civilians, relatively less is known regarding the sex differences in civilians diagnosed with COMISA. The overall similarity in PSG variables and symptoms of sleep disorders between men and women in our sample was unexpected. Specifically, in those with insomnia and OSA alone, there were no significant sex differences in any self-reported symptoms or PSG variables. To our knowledge, this has not otherwise been reported in any other patient population with sleep disturbances. In civilian studies, women with OSA[40] and insomnia[41] report higher rates of nightmares and psychiatric symptoms and are diagnosed with anxiety and depression more often than men.[7,42] Our findings may be a result of similarities in age, health status, and other factors among active duty service members. However, it is still common to find differences between men and women in objective sleep metrics in the general population, and we found the absence of significant differences somewhat surprising.

Across the three sleep disorder groups, there were no differences between men and women on measures of sleepiness (Epworth Sleepiness Scale), sleep impairment (PROMIS), and fatigue (Multidimensional Fatigue Inventory). Minor statistical differences in insomnia symptoms (Insomnia Severity Index) and sleep quality (PSQI) were observed but are likely not clinically meaningful.[43,44] This degree of similarity in symptomatology is distinctly different than what is reported in civilians with sleep disorders in which men generally have greater sleepiness and women more fatigue and insomnia.[8,42] Research specifically focusing on sex differences in OSA symptomatology has generally shown men to endorse typical symptoms such as loud snoring, witnessed apneas, and daytime sleepiness while women more often endorse atypical symptoms like insomnia, fatigue, and depression.[45,46] Military men and women with OSA only in our cohort demonstrated similar degrees of sleepiness and insomnia symptoms. Previous studies that evaluated the Epworth Sleepiness Scale[21] and Insomnia Severity Index[15] in service members have found no significant differences between men and women.

In all three sleep disorder groups, one potential reason for the similarities in self-reported symptoms between sexes in our military sample may be the rigorous military lifestyle for both men and women, which includes deployments and military duties, both of which are associated with insufficient sleep.[3] Of note, the average sleep duration in both men and women in our cohort was only 6 hours. Another potential reason for the similarities in self-reported symptoms may be cultural, whereby both military men and women have learned throughout their military careers to acknowledge sleepiness and associated impairment in similar ways.

The lack of significant differences in any of the PSG variables between men and women with OSA only in our cohort was substantially different from the corresponding civilian

Table 1—Demographic and military service characteristics: women compared to men.

Variables	Entire Sample	Women	Men	
	(n = 372)	(n = 172)	(n = 200)	Unadjusted P
Age (years), M ± SD	37.7 ± 7.46	37.7 ± 7.72	37.6 ± 7.28	.845[a]
Ethnicity, total # (%)				.328[c]
Non-Hispanic	284 (76.3)	127 (73.8)	157 (78.5)	
Hispanic	88 (23.7)	45 (26.1)	43 (21.5)	
Race, total # (%)				.047[c,d]
African American	74 (19.9)	40 (23.3)	34 (17.0)	
Caucasian	251 (67.5)	105 (61.1)	146 (73.0)	
Other[e]	47 (12.6)	27 (15.6)	20 (10.0)	
Marital status, total # (%)				<.001[c,d]
Divorced/separated	36 (9.68)	28 (16.3)	8 (4.0)	
Married/living with partner	286 (76.9)	114 (66.3)	172 (86.0)	
Single/not living with partner	50 (13.4)	30 (17.4)	20 (10.0)	
Education, total # (%)				.498[c]
High school diploma to associate degree	168 (45.2)	72 (41.9)	96 (48.0)	
Four-year college degree	97 (26.1)	48 (27.9)	49 (24.5)	
Graduate degree	107 (28.8)	52 (30.2)	55 (27.5)	
Branch, total # (%)				.187[c]
Air Force	186 (50.0)	94 (54.7)	92 (46.0)	
Army	136 (36.6)	56 (32.6)	80 (40.0)	
Marines	6 (1.61)	1 (0.58)	5 (2.5)	
Navy	44 (11.8)	21 (12.2)	23 (11.5)	
Rank group, total # (%)				.061[c,d]
E1–E3	5 (1.3)	0 (0.0)	5 (2.5)	
E4–E6	135 (36.3)	56 (32.6)	79 (39.5)	
E7–E9	127 (34.1)	66 (38.4)	61 (30.5)	
W01-O6	105 (28.2)	50 (29.1)	55 (27.5)	
Years in the military, MD (IQR)	17.4 (10.7)	17.7 (11.6)	17.0 (9.5)	.902[b]
Number of deployments, total # (%)				<.001[c,d]
0	101 (27.2)	66 (38.4)	35 (17.5)	
1	91 (24.5)	45 (26.2)	46 (23.0)	
2	67 (18.0)	27 (15.7)	40 (20.0)	
3+	113 (30.4)	34 (19.7)	79 (39.5)	

[a]Statistical comparisons between women and men with *t*-test assuming unequal variances. [b]Statistical comparisons between women and men with Wilcoxon's rank sum test. [c]Statistical comparisons between women and men with Fisher's exact test. [d]Statistically significant according to posthoc analysis with the Benjamini–Hochberg false discovery rate controlling procedure. [e]Other race category was comprised of Asian, Native American, Pacific Islander, and multiracial individuals. IQR = interquartile range, M = mean, MD = median, SD = standard deviation.

literature. While both men and women with OSA have higher body mass indexes, most research has found that women present with less severe OSA as represented by AHI and SpO2 nadir, likely related to sex-related differences in susceptibility to sleep-disordered breathing.[12] This was especially surprising considering the relatively young age of women in our study (38.6 years, standard deviation = 7.63). Other differences noted in prior research of patients presenting with OSA include less impact of sleep position on respiratory events (less positional OSA) and greater frequency of events during REM sleep in women.[13,47,48] These trends were not found in the women in our OSA-only group. Women displayed a similarly mild severity of sleep-disordered breathing to men with a comparable degree of REM-related events, a phenotype that has been found in studies of primarily military men.[49] This pattern has been theorized to represent a "low-arousal threshold" in which sleep-disordered breathing is characterized by a propensity to arouse from sleep during less pronounced upper airway obstruction.[50] A validated explanation for this phenotypic association in military personnel remains unclear but may be related to a state of

Table 2—Comparisons between female and male service members with OSA only.

Variables	Women (n = 34)	Men (n = 84)	Unadjusted P
Age (years), M± SD	39.9 ± 8.55	36.5 ± 6.91	.043[a]
BMI (lb./in^2), MD (IQR)	29.3 (9.01)	30.0 (5.28)	.617[b]
Sleep medication use, # (%)	6 (17.7)	4 (4.76)	.033[c]
PSG variables			
SOL (minutes), MD (IQR)	9.25 (13.4)	6.9 (11.4)	.128[b]
REM latency (minutes), MD (IQR)	111 (104)	99 (75.5)	.209[b]
TST (hours), MD (IQR)	6.1 (1.03)	6.2 (1.18)	.671[b]
SE (%), MD (IQR)	87 (12.6)	89 (11.2)	.577[b]
N1 (%), MD (IQR)	6 (4.23)	8 (8.7)	.126[b]
N2 (%), M ± SD	56.7 ± 8.95	56.2 ± 11.8	.814[a]
N3 (%), M ± SD	17.6 ± 6.83	15.5 ± 9.34	.201[a]
REM (%), M ± SD	18.6 ± 7.56	18.7 ± 6.04	.939[a]
WASO (minutes), MD (IQR)	44 (40.9)	37.1 (46.0)	.713[b]
AHI (events/h), MD (IQR)	15.1 (22.2)	15.9 (12.8)	.854[b]
ARI (events/h), MD (IQR)	22 (17.6)	21.6 (14.2)	.854[b]
REM index (A+H), MD (IQR)	28.4 (28.7)	24 (29.9)	.536[b]
Non-REM index (A+H), MD (IQR)	11.6 (18.0)	13.1 (16.8)	.607[b]
Desaturation (%), MD (IQR)	86.5 (7.75)	88 (4)	.610[b]
SpO2 < 89 (minutes), MD (IQR)	0.15 (1.05)	0 (0.68)	.387[b]
ARI (PLM), MD (IQR) (only 18 data points)	1.3 (2.6)	0.8 (1.0)	.632[b]
Index (PLM), MD (IQR)	0 (3.1)	0 (1.5)	.305[b]
Time in bed (hours), M ± SD	7.03 ± 0.41	7.08 ± 0.51	.622[a]
Self-report measures			
Insomnia severity score (ISI), M ± SD	13.9 ± 5.07	13.9 ± 4.58	.990[a]
Daytime sleepiness score (ESS), M ± SD	11.5 ± 4.30	12.4 ± 4.16	.297[a]
Excessive daytime sleepiness (ESS > 10), # (%)	22 (64.7)	60 (71.4)	.512[c]
Sleep quality score (PSQI), M ± SD	9.94 ± 3.80	9.54 ± 3.13	.584[a]
Sleep duration in hours (PSQI Item 4), M ± SD	6.12 ± 1.19	5.94 ± 1.24	.465[a]
Nightmare disorder score (NDI), MD (IQR)	1.5 (9.25)	0.5 (8.75)	.866[b]
Probable nightmare disorder diagnoses (NDI), # (%)	2 (5.88)	2 (2.38)	.578[c]
Sleep impairment (PROMIS), MD (IQR) (only 45 points)	53.8 (14.8)	56.3 (9.2)	.525[b]
Multidimensional fatigue score (MFI), M± SD	61.9 ± 4.81	60.0 ± 5.15	.062[a]
Clinically significant fatigue (MFI > 60), # (%)	21 (61.8)	36 (42.9)	.071[c]
PTSD severity score (PCL-5), MD (IQR)	8.5 (23.8)	11 (15.8)	.879[b]
PTSD diagnosis (PCL-5), # (%)	6 (17.7)	10 (11.9)	.392[c]
Generalized anxiety score (GAD-7), MD (IQR)	6.5 (7.5)	4.5 (7)	.239[b]
Anxiety diagnosis (GAD-7), # (%)	11 (32.4)	17 (20.2)	.231[c]
Depression score (PHQ-9), M ± SD	9.32 ± 4.79	7.66 ± 4.09	.080[a]
Depression diagnoses (PHQ-9 ≥ 10), # (%)	14 (41.2)	25 (29.8)	.281[c]
TBI diagnosis (HHI), # (%)	10 (29.4)	33 (39.3)	.399[c]

[a]Statistical comparisons between women and men with *t*-test assuming unequal variances. [b]Statistical comparisons between women and men with Wilcoxon's rank sum test. [c]Statistical comparisons between women and men with Fisher's exact test. [d]Statistically significant according to post hoc analysis with the Benjamini–Hochberg false discovery rate controlling procedure. A+H = apnea + hypopnea, AHI = apnea-hypopnea index, ARI = arousal index, BMI = body mass index, COMISA = comorbid obstructive sleep apnea and insomnia, ESS = Epworth Sleepiness Scale, GAD-7 = Generalized Anxiety Disorder screener, HHI = history of head injury, IQR = interquartile range, ISI = Insomnia Severity Index, MFI = Multidimensional Fatigue Inventory, M = mean, MD = median, NDI = Nightmare Disorder Inventory, OSA = obstructive sleep apnea, PCL-5 = PTSD Checklist for DSM-5, PHQ-9 = Patient Health Questionnaire-9, PLM = periodic limb movement, PROMIS = PROMIS Sleep Disturbance subscale, PSG, polysomnography, PSQI = Pittsburgh Sleep Quality Index, PTSD = posttraumatic stress disorder, REM = rapid eye movement, RDI = respiratory disturbance index, REM = rapid eye movement, SE = sleep efficiency, SD = standard deviation, SOL = sleep onset latency, TBI = traumatic brain injury, TST = total sleep time, WASO = wake after sleep onset.

Table 3—Comparisons between female and male service members with insomnia only.

Variables	Women (n = 84)	Men (n = 34)	Unadjusted *P*
Age (years), M ± SD	36.3 ± 7.22	36.8 ± 7.71	.775[a]
BMI (lb/in²), MD (IQR)	27.2 (4.19)	28.0 (3.76)	.318[b]
Sleep medication use, # (%)	27 (32.1)	7 (20.6)	.265[c]
PSG variables			
SOL (minutes), MD (IQR)	15.7 (19.9)	11.1 (14.9)	.074[b]
REM latency (minutes), MD (IQR)	106.5 (73.5)	103 (92.4)	.313[b]
TST (hours), MD (IQR)	6 (0.98)	6.05 (0.8)	.558[b]
SE (%), MD (IQR)	85 (13)	88 (12.3)	.574[b]
N1 (%), MD (IQR)	6 (5.4)	5 (7.6)	.794[b]
N2 (%), M ± SD	55.8 ± 8.68	55.0 ± 9.06	.652[a]
N3 (%), M ± SD	18.6 ± 9.72	19.0 ± 9.81	.834[a]
REM (%), M ± SD	18.7 ± 7.0	17.9 ± 6.70	.532[a]
WASO (minutes), MD (IQR)	40.5 (45.9)	41.5 (38.4)	.456[b]
AHI (events/h), MD (IQR)	2.4 (2.3)	2.8 (2.4)	.152[b]
ARI (events/h), MD (IQR)	13.4 (8.8)	13.8 (8.25)	.724[b]
REM index (A+H), MD (IQR)	3.95 (5.9)	4.65 (7.5)	.662[b]
Desaturation (%), MD (IQR)	93 (3)	91 (3.3)	.087[b]
Non-REM index (A+H), MD (IQR)	1.5 (1.8)	1.7 (1.7)	.119[b]
SpO2 < 89 (minutes), MD (IQR)	0 (0)	0 (0)	.732[b]
ARI (PLM), MD (IQR) (only 29 data points)	1.9 (3.1)	1.1 (1.1)	.370[b]
Index (PLM), MD (IQR)	0 (1.8)	0 (2.0)	.910[b]
Time in bed (hours), M ± SD	7.08 ± 0.47	6.92 ± 0.38	.064[a]
Self-report measures			
Insomnia severity score (ISI), M ± SD	18.9 ± 4.09	18.5 ± 5.41	.658[a]
Daytime sleepiness score (ESS), MD (IQR)	12 (7)	14 (7.3)	.176[b]
Excessive daytime sleepiness (ESS > 10), # (%)	54 (64.3)	22 (64.7)	.990[c]
Sleep quality score (PSQI), M ± SD	13.7 ± 3.06	13.5 ± 3.28	.779[a]
Sleep duration in hours (PSQI Item 4), MD (IQR)	5 (1.5)	5 (1.5)	.052[b]
Nightmare disorder score (NDI), MD (IQR)	8.5 (9.75)	7.5 (11.3)	.513[b]
Probable nightmare disorder diagnoses (NDI), # (%)	13 (15.5)	8 (23.5)	.301[c]
Sleep impairment (PROMIS), M ± SD	59.0 ± 6.78	59.0 ± 4.43	.980[a]
Multidimensional fatigue score (MFI), MD (IQR)	61 (6)	60 (9.3)	.870[b]
Clinically significant fatigue (MFI > 60), # (%)	45 (53.6)	16 (47.1)	.548[c]
PTSD severity score (PCL-5), MD (IQR)	22 (30.8)	34 (34.3)	.091[b]
PTSD diagnosis (PCL-5), # (%)	28 (33.3)	18 (52.9)	.061[c]
Generalized anxiety score (GAD-7), M ± SD	10.1 ± 5.03	11.3 ± 6.28	.324[a]
Anxiety diagnosis (GAD-7), # (%)	44 (52.4)	20 (58.8)	.548[c]
Depression score (PHQ-9), M ± SD	11.2 ± 4.50	12.1 ± 4.90	.345[a]
Depression diagnoses (PHQ-9 ≥ 10), # (%)	48 (57.1)	23 (67.7)	.309[c]
TBI diagnosis (HHI), # (%)	35 (41.7)	9 (26.5)	.145[c]

[a]Statistical comparisons between females and males with *t*-test assuming unequal variances. [b]Statistical comparisons between females and males with Wilcoxon's rank sum test. [c]Statistical comparisons between females and males with Fisher's exact test. [d]Statistically significant according to post hoc analysis with the Benjamini–Hochberg false discovery rate controlling procedure. A+H = apnea + hypopnea, AHI = apnea-hypopnea index, ARI = arousal index, BMI = body mass index, COMISA = comorbid obstructive sleep apnea and insomnia, ESS = Epworth Sleepiness Scale, GAD-7 = Generalized Anxiety Disorder screener, HHI = history of head injury, ISI = Insomnia Severity Index, M = mean, MFI = Multidimensional Fatigue Inventory, NDI = Nightmare Disorder Inventory, OSA = obstructive sleep apnea, PCL-5 = PTSD Checklist for DSM-5, PHQ-9 = Patient Health Questionnaire-9, PLM = periodic limb movement, PROMIS = PROMIS Sleep Disturbance subscale, PSG, polysomnography, PSQI = Pittsburgh Sleep Quality Index, PTSD = posttraumatic stress disorder, RDI = respiratory disturbance index, REM = rapid eye movement, SD, standard deviation, SE = sleep efficiency, SOL = sleep onset latency, TBI = traumatic brain injury, TST = total sleep time, WASO = wake after sleep onset.

Table 4—Comparisons between female and male service members with COMISA.

Variables	Women (n = 54)	Men (n = 82)	Unadjusted *P*	Effect Size
Age (years), M ± SD	38.6 ± 7.63	39.0 ± 7.32	.729[a]	–
BMI (lb/in^2), MD (IQR)	29.6 (6.7)	28.7 (4.42)	.312[b]	–
Sleep medication use, # (%)	16 (29.6)	23 (28.1)	.495[c]	–
PSG variables				
SOL (minutes), MD (IQR)	16.7 (18.1)	14 (22.6)	.448[b]	–
REM latency (minutes), MD (IQR)	113 (92.5)	99.5 (85.5)	.458[b]	–
TST (hours), MD (IQR)	6 (0.5)	5.95 (0.83)	.596[b]	–
SE (%), MD (IQR)	86 (10.6)	85 (12.6)	.132[b]	–
N1 (%), MD (IQR)	5 (5.3)	9 (10.7)	.009[b,d]	0.225[e]
N2 (%), M ± SD	54.8 ± 10.5	55.9 ± 11.2	.570[a]	–
N3 (%), M ± SD	18.7 ± 7.95	16.0 ± 8.84	.065[a,d]	0.319[g]
REM (%), M ± SD	19.3 ± 6.98	17.5 ± 6.17	.144[a]	–
WASO (minutes), MD (IQR)	41.2 (42.9)	46.4 (48.6)	.022[b,d]	0.197[e]
AHI (events/h), MD (IQR)	8.8 (7.1)	15.8 (15.9)	<.001[b,d]	0.394[e]
ARI (events/h), MD (IQR)	20.2 (9.4)	22.4 (13.4)	.062[b,d]	0.160[e]
REM index (A+H), MD (IQR)	17.1 (14.7)	23.7 (26.7)	.079[b]	–
Non-REM index (A+H), MD (IQR)	6.8 (6.4)	13.1 (16.5)	<.001[b,d]	0.393[e]
Desaturation (%), MD (IQR)	90 (5.5)	88 (5.25)	.156[b]	–
SpO2 < 89 (minutes), MD (IQR)	0 (0.3)	0 (0.8)	.035[b,d]	0.181[e]
ARI (PLM), MD (IQR) (only 32 data points)	1.45 (2.4)	0.85 (0.98)	.379[b]	–
Index (PLM), MD (IQR)	0 (3.3)	0 (3.78)	.868[b]	–
Time in bed (hours), M ± SD	6.96 ± 0.57	7.08 ± 0.40	.178[a]	–
Self-report measures				
Insomnia severity score (ISI), M ± SD	18.9 ± 5.15	18.6 ± 4.66	.681[a]	–
Daytime sleepiness score (ESS), MD (IQR)	13.5 (6.3)	14 (7)	.943[b]	–
Excessive daytime sleepiness (ESS > 10), # (%)	41 (75.9)	60 (73.2)	.842[c]	–
Sleep quality score (PSQI), M ± SD	14.5 ± 3.26	13.8 ± 3.70	.220[a]	–
Sleep duration in hours (PSQI Item 4), M ± SD\	5.04 ± 0.98	4.97 ± 1.13	.692[a]	–
Nightmare disorder score (NDI), MD (IQR)	10 (9)	7 (11)	.022[b]	0.197[e]
Probable nightmare disorder diagnoses (NDI), # (%)	18 (33.3)	11 (13.4)	.009[c,d]	2.49 (1.28 – 4.84)[f]
Sleep impairment (PROMIS), MD (IQR) (only 56 points)	59 (16.4)	58.3 (8.3)	.832[b]	–
Multidimensional fatigue score (MFI), MD (IQR)	60 (5.25)	60 (7)	.544[b]	–
Clinically significant fatigue (MFI > 60), # (%)	25 (46.3)	40 (48.8)	.861[c]	–
PTSD severity score (PCL-5), MD (IQR)	30.5 (33)	22.5 (27)	.054[b,d]	0.165[e]
PTSD diagnosis (PCL-5), # (%)	29 (53.7)	28 (34.2)	.033[c,d]	1.57 (1.07 – 2.33)[f]
Generalized anxiety score (GAD-7), MD (IQR)	14 (11)	10 (9)	.013[b,d]	0.213[e]
Anxiety diagnosis (GAD-7), # (%)	36 (66.7)	45 (54.9)	.212[c]	–
Depression score (PHQ-9), MD (IQR)	12 (10.5)	11 (7.3)	.054[b,d]	0.165[e]

Table 4 (*continued*)—Comparisons between female and male service members with COMISA.

	Women	Men		
Variables	**(n = 54)**	**(n = 82)**	**Unadjusted P**	**Effect Size**
Depression diagnoses (PHQ-9 ≥ 10), # (%)	37 (68.5)	48 (58.5)	.280[c]	–
TBI diagnosis (HHI), # (%)	15 (27.8)	31 (37.8)	.269[c]	–

[a]Statistical comparisons between females and males with *t*-test assuming unequal variances. [b]Statistical comparisons between females and males with Wilcoxon's rank sum test. [c]Statistical comparisons between females and males with Fisher's exact test. [d]Statistically significant according to post hoc analysis with the Benjamini–Hochberg false discovery rate controlling procedure. [e]Effect size *r*. [f]Relative risk (95% confidence interval). [g]Hedge's *g*. A+H = apnea + hypopnea. AHI = apnea-hypopnea index, ARI = arousal index, BMI = body mass index, COMISA = comorbid obstructive sleep apnea and insomnia, ESS = Epworth Sleepiness Scale, GAD-7 = Generalized Anxiety Disorder screener, HHI = history of head injury, ISI = Insomnia Severity Index, M = mean, MFI = Multidimensional Fatigue Inventory, NDI = Nightmare Disorder Inventory, OSA = obstructive sleep apnea, PCL-5 = PTSD Checklist for DSM-5, PHQ-9 = Patient Health Questionnaire-9, PLM = periodic limb movement, PROMIS = PROMIS Sleep Disturbance subscale, PSG = polysomnography, PSQI = Pittsburgh Sleep Quality Index, PTSD = posttraumatic stress disorder, RDI = respiratory disturbance index, REM = rapid eye movement, SD = standard deviation, SE = sleep efficiency, SOL = sleep onset latency, TBI = traumatic brain injury, TST = total sleep time, WASO = wake after sleep onset.

hyperarousal related to military service, exposure to traumatic events, and the presence of psychiatric comorbidities including anxiety and PTSD.[21,51,52] Recognition of this phenotype in both military men and women has important implications as OSA in this population may be less responsive to traditional treatment options, such as positive airway pressure therapy, and patients may benefit from treatments addressing maintenance of sleep continuity, such as sedative hypnotics.[53]

The similar rate of sleep medication use in women and men in our study is consistent with a Department of Defense-wide study in which military men and women received sedative hypnotics in similar proportions.[54] Women in the general population report a higher rate of sedative hypnotic use. In military women, a referral from primary care to a specialty sleep center may be delayed or foregone in favor of prescribing hypnotics as women tend to lack the usual clinical presentation of OSA. Given that we did not find differences in AHI among military men and women with OSA only, it may be important to increase diagnostic testing for OSA in military women.

Interestingly, most of the sex-related difference in psychiatric morbidity appeared to be in those with COMISA. COMISA as a distinct sleep condition with unique clinical characteristics is increasingly recognized in military, veteran, and civilian populations.[17,18,55,56] Relatively little is known regarding the sex-related differences in COMISA, with one study finding that men with COMISA were younger than women with this disorder.[23] The finding that military women with COMISA had more psychiatric symptoms was unexpected. Military men in our cohort had a higher rate of deployment, which has been linked to overall risk for psychiatric symptoms in prior research.[57] However, in a prior retrospective study of sex differences in sleep disorders in the US military, military women had significantly higher rates of anxiety and depression but not of PTSD.[21] A large study of active duty soldiers studied upon return from deployment reported women to have slightly greater depressive symptoms compared to the men, but PTSD symptoms did not differ between the sexes.[58]

The reason for the increased psychiatric symptoms in women with COMISA is not readily apparent. It may be that the presence of both insomnia and psychiatric comorbidities, like anxiety or PTSD, predispose women to the development of OSA, especially of a low-arousal threshold phenotype.[20,59] Conversely, it may be that the concomitant diagnoses of insomnia and OSA exacerbate underlying psychiatric vulnerabilities, specifically to anxiety and PTSD, a theory that is supported by prior research showing greater incidence of mood disorders and PTSD in patients with COMISA.[21,55] Further, it may be due to a sex bias in referring military women to sleep disorders centers as has been reported in civilian settings.[60]

In our sample of military women and men with insomnia only, there were no significant differences in any of their polysomnographic variables. This is consistent with the findings from a meta-analysis of polysomnographic studies of civilians with insomnia that reported no differences in PSG variables between men and women.[61] There were also no sex-related differences in sleep medication usage or self-reported measures of interest (ie, sleep, fatigue, psychiatric, and TBI variables) in patients with insomnia only. This represents a departure from civilian literature in which women with insomnia report higher levels of depression as compared to men[62] and further suggests military service may result in distinct sleep disorder phenotype(s) that differ minimally by sex.

Strengths and limitations

This was the largest study to comprehensively evaluate military men and women diagnosed with the three most common sleep disorders and represents a substantial advancement in our understanding of insomnia, OSA, and COMISA in those serving in the military. Furthermore, all participants underwent an attended in-lab PSG, which increases the precision of OSA severity assessment compared to home sleep apnea testing or symptom screening alone. This is relevant to military personnel who are in high-risk occupations for which precise determination of disease severity is critical. Despite its strengths, it is worth noting this study recruited only treatment-seeking active duty military personnel and focused on the three most prevalent sleep disorders in service members (insomnia only, OSA only, and COMISA) with less focus on other sleep disorders (eg, hypersomnias, restless legs syndrome, periodic limb movement disorder, circadian rhythm sleep-wake disorders), which may

play an important role in sex differences in military personnel overall; thus this study does not represent the overall prevalence of sleep disorders in the military. The assessment of sex was also a limitation of this study. Participants responded to a dichotomous variable (ie, What is your sex: [1] Male or [2] Female) and further assessment of gender identity (ie, whether participants were transgender, cisgender, or other gender identities) was not included. Also, the study was performed at one academic military sleep disorders center, and, although participants in our study represented all branches of the Department of Defense, the study included more individuals serving in the Air Force and Army than in the Marines or Navy. Lastly, there were multiple questionnaires performed as part of the study, and questionnaire-related fatigue may have resulted in spurious responses. Thus, these findings may not be generalizable to all military personnel, those with nonspecific sleep disturbances, or those with other sleep disorders. Nearly half of service members regardless of branch have sleep disturbances.[63] As standardized questionnaires such as the STOP-BANG, Epworth Sleepiness Scale, and PSQI are markedly less useful in assessing military populations compared to civilians, the results from this study represent a substantial advancement in the understanding of the similarities and differences in military men and women diagnosed with insomnia, OSA, and COMISA.[63–65]

CONCLUSIONS

The overarching finding of our study is that there are minimal differences in self-reported symptoms and PSG metrics between military men and women with insomnia, OSA, or COMISA. These findings indicate unique military phenotypes that do not substantially differ between the sexes in the same way these conditions differ in nonmilitary populations. However, the differences we found between military men and women with COMISA suggest sex-specific factors emerge when these two sleep disorders (ie, OSA and insomnia) co-occur. This may have implications for treatment as men with higher AHI may experience greater insomnia symptom reduction when OSA is treated concurrently with insomnia, while women with COMISA may require interventions to address comorbid psychiatric symptoms in addition to treatment of OSA and insomnia disorder. As this is the first study to comprehensively evaluate military men and women with these sleep disorders, confirmatory studies are required. Given the high rates of comorbid behavioral medicine disorders in military personnel and the absence of useful screening measures for sleep disorders, a clinical evaluation and objective testing to include vPSG are indicated for military men and women who report sleep disturbances.

ABBREVIATIONS

AHI, apnea-hypopnea index
COMISA, comorbid insomnia and obstructive sleep apnea
OSA, obstructive sleep apnea

PROMIS, Patient Reported Outcomes Measurement Information System
PSG, polysomnography
PSQI, Pittsburgh Sleep Quality Index
PTSD, posttraumatic stress disorder
REM, rapid eye movement
TBI, traumatic brain injury
vPSG, video-polysomnography

REFERENCES

1. US Government Accountability Office. *Female Active-Duty Personnel: Guidance and Plans Needed for Recruitment and Retention Efforts. GAO-20-61*. US Government Accountability Office; 2020. https://www.gao.gov/products/gao-20-61. Accessed on April 6, 2023.

2. Siaki L, Hasslen S, Hoffecker L, Trego LL. Sleep health in US military women: a scoping review of the literature, 2000–2019. *Womens Health Issues.* 2021;31 (Suppl 1):S22–S32.

3. Capaldi VF, Balkin TJ, Mysliwiec V. Optimizing sleep in the military: challenges and opportunities. *Chest.* 2019;155(1):215–226.

4. Sodhi A, Cox-Flaherty K, Greer MK, et al. Sex and gender in lung diseases and sleep disorders: a state-of-the-art review: part 2. *Chest.* 2023;163(2):366–382.

5. Kamarck KN. *Women in Combat: Issues for Congress*. Congressional Research Service; 2016. https://sgp.fas.org/crs/natsec/R42075.pdf. Accessed on April 6, 2023.

6. Moore BA, Tison LM, Palacios JG, Peterson AL, Mysliwiec V. Incidence of insomnia and obstructive sleep apnea in active duty United States military service members. *Sleep.* 2021;44(7):zsab024.

7. Lin CM, Davidson TM, Ancoli-Israel S. Gender differences in obstructive sleep apnea and treatment implications. *Sleep Med Rev.* 2008;12(6):481–496.

8. Eliasson AH, Kashani MD, Howard RS, Vernalis MN, Modlin RE; Integrative Cardiac Health Project Registry. Fatigued on Venus, sleepy on Mars—gender and racial differences in symptoms of sleep apnea. *Sleep Breath.* 2015;19(1):99–107.

9. Ye L, Pien GW, Weaver TE. Gender differences in the clinical manifestation of obstructive sleep apnea. *Sleep Med.* 2009;10(10):1075–1084.

10. Geer JH, Hilbert J. Focus: health equity: gender issues in obstructive sleep apnea. *Yale J Biol Med.* 2021;94(3):487–496.

11. Shepertycky MR, Banno K, Kryger MH. Differences between men and women in the clinical presentation of patients diagnosed with obstructive sleep apnea syndrome. *Sleep.* 2005;28(3):309–314.

12. Basoglu OK, Tasbakan MS. Gender differences in clinical and polysomnographic features of obstructive sleep apnea: a clinical study of 2827 patients. *Sleep Breath.* 2018;22(1):241–249.

13. Koo BB, Patel SR, Strohl K, Hoffstein V. Rapid eye movement-related sleep-disordered breathing: influence of age and gender. *Chest.* 2008;134(6):1156–1161.

14. Zhang B, Wing Y-K. Sex differences in insomnia: a meta-analysis. *Sleep.* 2006; 29(1):85–93.

15. Taylor DJ, Pruiksma KE, Hale WJ, et al; STRONG STAR Consortium. Prevalence, correlates, and predictors of insomnia in the US Army prior to deployment. *Sleep.* 2016;39(10):1795–1806.

16. Riemann D, Spiegelhalder K, Feige B, Voderholzer U, Berger M, Perlis M, Nissen C. The hyperarousal model of insomnia: a review of the concept and its evidence. *Sleep Med Rev.* 2010;14(1):19–31.

17. Mysliwiec V, Gill J, Lee H, et al. Sleep disorders in US military personnel: a high rate of comorbid insomnia and obstructive sleep apnea. *Chest.* 2013;144(2): 549–557.

18. Mysliwiec V, Brock MS, Pruiksma KE, et al; STRONG STAR Consortium. A comprehensive evaluation of insomnia, obstructive sleep apnea and comorbid insomnia and obstructive sleep apnea in US military personnel. *Sleep.* 2022;45 (12):zsac203.

19. Lechat B, Appleton S, Melaku YA, et al. Comorbid insomnia and sleep apnoea is associated with all-cause mortality. *Eur Respir J.* 2022;60(1):2101958.

20. Sweetman A, Lack L, McEvoy RD, et al. Bi-directional relationships between co-morbid insomnia and sleep apnea (COMISA). *Sleep Med Rev.* 2021;60:101519.

21. Foster SN, Hansen SL, Capener DC, Matsangas P, Mysliwiec V. Gender differences in sleep disorders in the US military. *Sleep Health.* 2017;3(5):336–341.

22. Ong JC, Crawford MR, Wallace DM. Sleep apnea and insomnia: emerging evidence for effective clinical management. *Chest.* 2021;159(5):2020–2028.

23. Li Z, Li Y, Yang L, Li T, Lei F, Vgontzas AN, Tang X. Characterization of obstructive sleep apnea in patients with insomnia across gender and age. *Sleep Breath.* 2015; 19(2):723–727.

24. Berry RB, Quan SF, Abreu AR, et al; for the American Academy of Sleep Medicine. *The AASM Manual for the Scoring of Sleep and Associated Events: Rules, Terminology and Technical Specifications.* Version 2.6. Darien, IL: American Academy of Sleep Medicine; 2020.

25. American Academy of Sleep Medicine. *International Classification of Sleep Disorders.* 3rd ed. Darien, IL: American Academy of Sleep Medicine; 2014.

26. Morin CM, Belleville G, Bélanger L, Ivers H. The Insomnia Severity Index: psychometric indicators to detect insomnia cases and evaluate treatment response. *Sleep.* 2011;34(5):601–608.

27. Johns MW. A new method for measuring daytime sleepiness: the Epworth Sleepiness Scale. *Sleep.* 1991;14(6):540–545.

28. Rosenberg R, Babson K, Menno D, Morris S, Baladi M, Hyman D, Black J. Test-retest reliability of the Epworth Sleepiness Scale in clinical trial settings. *J Sleep Res.* 2022;31(2):e13476.

29. Buysse DJ, Reynolds CF 3rd, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. *Psychiatry Res.* 1989;28(2):193–213.

30. PROMIS. HealthMeasures. https://www.healthmeasures.net/explore-measurement-systems/promis. Accessed on February 22, 2022.

31. Yu L, Buysse DJ, Germain A, et al. Development of short forms from the PROMIS™ sleep disturbance and Sleep-Related Impairment item banks. *Behav Sleep Med.* 2011;10(1):6–24.

32. Dietch JR, Taylor DJ, Pruiksma K, et al. The Nightmare Disorder Index: development and initial validation in a sample of nurses. *Sleep.* 2021;44(5): zsaa254.

33. American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders.* 5th ed. Washington, DC: American Psychiatric Association; 2013.

34. Smets EM, Garssen B, Bonke B, De Haes JC. The Multidimensional Fatigue Inventory (MFI) psychometric qualities of an instrument to assess fatigue. *J Psychosom Res.* 1995;39(3):315–325.

35. Spitzer RL, Kroenke K, Williams JB, Löwe B. A brief measure for assessing generalized anxiety disorder: the GAD-7. *Arch Intern Med.* 2006;166(10): 1092–1097.

36. Kroenke K, Spitzer RL, Williams JB. The PHQ-9: validity of a brief depression severity measure. *J Gen Intern Med.* 2001;16(9):606–613.

37. Bovin MJ, Marx BP, Weathers FW, Gallagher MW, Rodriguez P, Schnurr PP, Keane TM. Psychometric properties of the PTSD Checklist for Diagnostic and Statistical Manual of Mental Disorders-Fifth Edition (PCL-5) in veterans. *Psychol Assess.* 2016;28(11):1379–1391.

38. Schwab K, Baker G, Ivins B, Sluss-Tiller M, Lux W, Warden D. The Brief Traumatic Brain Injury Screen (BTBIS): investigating the validity of a self-report instrument for detecting traumatic brain injury (TBI) in troops returning from deployment in Afghanistan and Iraq. *Neurology.* 2006;66(5, Suppl 2):A235–A235.

39. Benjamini Y, Hochberg Y. Controlling the false discovery rate: a practical and powerful approach to multiple testing. *J R Stat Soc B.* 1995;57(1):289–300.

40. Asghari A, Mohammadi F, Kamrava SK, Tavakoli S, Farhadi M. Severity of depression and anxiety in obstructive sleep apnea syndrome. *Eur Arch Otorhinolaryngol.* 2012;269(12):2549–2553.

41. Taylor DJ, Lichstein KL, Durrence HH, Reidel BW, Bush AJ. Epidemiology of insomnia, depression, and anxiety. *Sleep.* 2005;28(11):1457–1464.

42. Valipour A, Lothaller H, Rauscher H, Zwick H, Burghuber OC, Lavie P. Gender-related differences in symptoms of patients with suspected breathing disorders in sleep: a clinical population study using the sleep disorders questionnaire. *Sleep.* 2007;30(3):312–319.

43. Yang M, Morin CM, Schaefer K, Wallenstein GV. Interpreting score differences in the Insomnia Severity Index: using health-related outcomes to define the minimally important difference. *Curr Med Res Opin.* 2009;25(10):2487–2494.

44. Mollayeva T, Thurairajah P, Burton K, Mollayeva S, Shapiro CM, Colantonio A. The Pittsburgh Sleep Quality Index as a screening tool for sleep dysfunction in clinical and non-clinical samples: a systematic review and meta-analysis. *Sleep Med Rev.* 2016;25:52–73.

45. Bonsignore MR, Saaresranta T, Riha RL. Sex differences in obstructive sleep apnoea. *Eur Respir Rev.* 2019;28(154):190030.

46. Nigro CA, Dibur E, Borsini E, et al. The influence of gender on symptoms associated with obstructive sleep apnea. *Sleep Breath.* 2018;22(3):683–693.

47. Koo BB, Dostal J, Ioachimescu O, Budur K. The effects of gender and age on REM-related sleep-disordered breathing. *Sleep Breath.* 2008;12(3):259–264.

48. Won CHJ, Reid M, Sofer T, et al. Sex differences in obstructive sleep apnea phenotypes, the multi-ethnic study of atherosclerosis. *Sleep.* 2020;43(5):zsz274.

49. Mysliwiec V, McGraw L, Pierce R, Smith P, Trapp B, Roth BJ. Sleep disorders and associated medical comorbidities in active duty military personnel. *Sleep.* 2013;36(2):167–174.

50. Smith PR, Sheikh KL, Costan-Toth C, Forsthoefel D, Bridges E, Andrada TF, Holley AB. Eszopiclone and zolpidem do not affect the prevalence of the low arousal threshold phenotype. *J Clin Sleep Med.* 2017;13(1):115–119.

51. Russell PD, Judkins JL, Blessing A, Moore B, Morissette SB. Incidences of anxiety disorders among active duty service members between 1999 and 2018. *J Anxiety Disord.* 2022;91:102608.

52. Judkins JL, Moore BA, Collette TL, Hale WJ, Peterson AL, Morissette SB. Incidence rates of posttraumatic stress disorder over a 17-year period in active duty military service members. *J Trauma Stress.* 2020;33(6):994–1006.

53. Eckert DJ, Owens RL, Kehlmann GB, et al. Eszopiclone increases the respiratory arousal threshold and lowers the apnoea/hypopnoea index in obstructive sleep apnoea patients with a low arousal threshold. *Clin Sci (Lond).* 2011;120(12): 505–514.

54. Thelus Jean R, Hou Y, Masterson J, Kress A, Mysliwiec V. Prescription patterns of sedative hypnotic medications in the military health system. *J Clin Sleep Med.* 2019;15(6):873–879.

55. Sweetman A, Lack L, Bastien C. Co-morbid insomnia and sleep apnea (COMISA): prevalence, consequences, methodological considerations, and recent randomized controlled trials. *Brain Sci.* 2019;9(12):371.

56. Brock MS, Foster SN, Motamedi V, Mysliwiec V. COMISA (comorbid insomnia and sleep apnea): a practical approach. *Curr Sleep Med Rep.* 2018;4(4): 255–267.

57. Bliese PD, Wright KM, Adler AB, Thomas JL, Hoge CW. Timing of postcombat mental health assessments. *Psychol Serv.* 2007;4(3):141–148.

58. Maguen S, Luxton DD, Skopp NA, Madden E. Gender differences in traumatic experiences and mental health in active duty soldiers redeployed from Iraq and Afghanistan. *J Psychiatr Res.* 2012;46(3):311–316.

59. Meira E Cruz M, Kryger MH, Morin CM, Palombini L, Salles C, Gozal D. Comorbid insomnia and sleep apnea: mechanisms and implications of an underrecognized and misinterpreted sleep disorder. *Sleep Med.* 2021;84:283–288.

60. Larsson L-G, Lindberg A, Franklin KA, Lundbäck B. Gender differences in symptoms related to sleep apnea in a general population and in relation to referral to sleep clinic. *Chest.* 2003;124(1):204–211.

61. Baglioni C, Regen W, Teghen A, et al. Sleep changes in the disorder of insomnia: a meta-analysis of polysomnographic studies. *Sleep Med Rev.* 2014:18(3):195–213.

62. Vargas I, Perlis ML. Insomnia and depression: clinical associations and possible mechanistic links. *Curr Opin Psychol.* 2020;34:95–99.

63. Troxel WM, Shih RA, Pedersen ER, et al. Sleep in the military: promoting healthy sleep among US servicemembers. *Rand Health Q.* 2015;5(2):19.

64. McMahon MJ, Sheikh KL, Andrada TF, Holley AB. Using the STOPBANG questionnaire and other pre-test probability tools to predict OSA in younger, thinner patients referred to a sleep medicine clinic. *Sleep Breath.* 2017;21(4): 869–876.

65. Matsangas P, Mysliwiec V. The utility of the Pittsburgh Sleep Quality Index in US military personnel. *Mil Psychol.* 2018;30(4):360–369.

ACKNOWLEDGMENTS

SUBMISSION & CORRESPONDENCE INFORMATION

DISCLOSURE STATEMENT