Obstructive Sleep Apnea Among Army Aircrew

Claire Goldie; Benjamin Stork; Kyle Bernhardt; Steven J. Gaydos; Amanda M. Kelley

INTRODUCTION: Obstructive sleep apnea (OSA) is a condition characterized by disrupted sleep and excessive daytime fatigue. Associated cognitive and psychomotor decrements pose a threat to aviators' performance and flight safety. Additionally, the longer term health effects associated with the disease can jeopardize an aviator's career and negatively impact operational outputs. This study reviews OSA prevalence, related comorbid conditions in Army aviators, and analyzes the aeromedical dispositions of affected individuals.

METHODS: The U.S. Army Aeromedical Electronic Resource Office (AERO) database was interrogated for all cases of OSA from June 2005 through June 2015 using ICD-9 code 327.23. Prevalence rates for OSA and other comorbid conditions were then calculated using the total number of aviators in the AERO database.

RESULTS: A total of 663 unique instances of OSA were found among the aviator population (N = 24,568), giving a point prevalence of 2.69%. Four cases affected women. Mean age of initial presentation was 42.62 yr and mean Body Mass Index was 28.69. The top five most prevalent comorbid conditions were hypertension, lumbago, degeneration of a lumbar or lumbosacral intervertebral disc, PTSD, and testicular hypofunction.

DISCUSSION: Prevalence of OSA among aviators is lower than the general population but is not uncommon. A positive diagnosis requires a waiver or can result in suspension if not managed effectively, potentially leading to a reduction in aviator numbers. Aggressive health promotion and robust medical surveillance and aeromedical disposition management by the aeromedical community is essential to reduce OSA numbers, maintain aviator health, and maximize flight safety.

KEYWORDS: OSA, aviator, obesity, epidemiological review.

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Obstructive sleep apnea (OSA) is a syndrome of disordered nighttime breathing which occurs when the muscles in the back of the throat, which support soft tissue structures around the upper airway (soft palate, uvula, tonsils, and tongue), relax during sleep, causing the upper airway to intermittently narrow or close. When the airway collapses, an affected individual cannot breathe in normally against the compromised airway, resulting in a temporary cessation of the normal respiratory pattern, also known as apnea. Episodes of apnea can last up to 10 s at a time and will usually occur repeatedly during the night, resulting in a drop in blood oxygenation levels (hypoxia). The brain senses this hypoxia and the individual will briefly awaken or move to a lighter stage of sleep to re-establish muscular tone around the airway. These repeated interruptions to sleep throughout the night disrupt normal sleep architecture and make restorative sleep impossible. This can result in excessive daytime drowsiness, fatigue, difficulty concentrating, and impairment of other executive functions. Those with OSA often complain of memory problems, morning headaches, mood swings or depression, and a need to urinate frequently at night (nocturia). Additionally, the repeated episodes of hypoxia associated with OSA significantly increase the risk of developing hypertension, coronary artery disease, heart attack, and stroke.[16] These cardiovascular risks and the effects of disturbed sleep have significant impacts on flight safety and make

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undiagnosed and untreated OSA in an aviation population an unacceptable situation.

OSA is a highly prevalent and growing disorder in the United States affecting 3–7% of the male population and 2–5% of the female population.[17] A transportation industry-specific study conservatively estimates the prevalence in commercial drivers at 21%.[2] Additionally, this study found that 30% of all drivers screened were determined to be “high risk” for OSA; of those, 68% tested positive for OSA with polysomnography (PSG). A 2017 meta-analysis of 24 major OSA prevalence studies found that when the criterion included mild sleep apnea, population prevalence ranged from 9 to 38% and was higher in men.[18] The same study found that when only moderate and severe sleep apnea were included the prevalence, it ranged from 6 to 17% in the general adult population. In both categories OSA increased with increasing age and Body Mass Index (BMI). BMI is a ratio of a patient’s height to their weight and is widely used to study the relationship between weight and various health conditions while controlling for height. A BMI > 30 is defined as obese and may cause excess buildup of fat tissue around the chest and neck, contributing to airway compromise. The CDC reports that 42.4% of American adults are obese and 1 in 10 are morbidly so.[3] As one of the primary drivers of OSA prevalence it is important to consider the prevalence and severity of obesity in the target population.

In aviation, fatigue, the primary symptom of OSA, is a significant flight safety issue and a commonly cited contributor to mishaps. According to the National Transportation Safety Board (NTSB), “Nearly 20 percent of the 182 major NTSB investigations completed between January 1, 2001, and December 31, 2012, identified fatigue as a probable cause, contributing factor, or a finding.”[15] These numbers align with a 2018 review of Class A and B U.S. Army aviation mishaps that estimated fatigue to be present in 28% of reviewed mishaps.[7]

In addition to fatigue and increased daytime sleepiness, those with OSA can experience cognitive deficits. These deficits can be categorized into four domains (attention, executive function, motor function, and episodic recall), all of which are pertinent to aviation and flight performance.[9] While some research suggests that continuous positive airway pressure (CPAP) treatment can lessen the severity of these deficits,[8,9] neuroimaging studies suggest that OSA, particularly if left undiagnosed and untreated, may result in permanent damage to the brain areas associated with cognitive function. Specifically, research demonstrated significant gray matter atrophy in the hippocampus and amygdala (areas associated with memory) as well as the frontal lobe (responsible for executive function and attention).[8] This finding was further supported by a study employing functional MRI, which measures the real-time activity of the brain by imaging the amount of blood flow to the different regions. Specifically, reduced blood flow and metabolic activity was observed in those same regions of the brain (hippocampus, amygdala, and frontal lobe) in individuals with chronic OSA.[19] Taken together, these findings suggest that OSA poses risks to aviator performance through increased fatigue, daytime sleepiness, and decreased cognitive function.

The U.S. Army Aeromedical Activity hosts a database that archives aeromedical records, physicals, waivers, and suspensions known as the Aeromedical Electronic Resource Office (AERO; also referred to as the Aeromedical Epidemiological Data Repository). This system presents opportunity for epidemiological review and study with respect to holistic or specific pathophysiological conditions or diagnoses. This current study is a descriptive epidemiological review of medical records of the U.S. Army AERO covering 10 years of OSA among Army rated aviators. The objectives of the present study were to: 1) demonstrate the prevalence of OSA in Army aviators; 2) describe the aeromedical dispositions associated with OSA; and 3) identify the conditions most prevalent as comorbid to OSA.

METHODS

Prior to analysis, the study was reviewed and approved according to the U.S. Army Aeromedical Research Laboratory’s Human Subjects Research Protection Plan by the U.S. Army Aeromedical Research Laboratory Regulatory Compliance Office.

Subjects

The archival dataset is composed of a total of 24,568 aviators, of which 5.2% (N = 1282) are women. This mirrors the overall percentage (5.2) of female aviators in the U.S. Army (Human Resources Command, 2016; personal communication). Between June 2005 and June 2015, a total of 181,471 cases were identified with ages ranging from 17 to 73 yr (M = 37.60, SD = 8.46, N = 146,156).

Materials

The dataset is de-identified such that the 19 protected health information data types listed in the Health Insurance Portability and Accountability Act have been removed. Patients are labeled by an arbitrary identification number in order to account for the longitudinal nature of the database, thus still enabling individual cases/observations/trends to be discerned. The dataset consists of 77 variables, a subset of which were isolated for the purposes of this study, including demographic information (e.g., age, rank), ICD diagnostic codes, and aeromedical disposition.

Procedure and Statistical Analysis

The dataset was interrogated for all cases of OSA diagnosed between June 2005 and June 2015 using the ICD-9 code 327.23. Frequencies of aeromedical disposition and primary diagnoses among the OSA cases were calculated. The following case inclusion/exclusion criteria were applied to the search:

- Only the aeromedical summaries were counted when paired with an associated flight physical.
- If an individual patient diagnosed with OSA received multiple waiver/suspension recommendations, only the first instance was counted.

- Age was defined as the age of the patient with OSA at the first reporting of a waiver recommendation, suspension recommendation, or waiver continuation.
- The total number of unique instances of OSA was limited to waiver recommendations, suspension recommendations, and waiver continuations.
- For calculations of suspensions and waiver recommendations, associated visits (i.e., physical attached to an aeromedical summary) and multiple instances were filtered out.

RESULTS

Overall, there were 663 individuals with OSA, representing 2.69% of the total number of aviators in the dataset ($N = 24{,}568$). The mean age of initial presentation of OSA was 42.62 yr. Only four of the cases were women. BMI was reported for 141 cases and ranged from 20 to 39 (M = 28.69, SD = 3.41).

The resulting distribution of waiver recommendations, suspension recommendations, and waiver continuations is displayed in **Fig. 1**. Overall, 459 waiver recommendations were made for OSA. Of these, 241 were made in conjunction with other ICD codes (comorbid conditions) and 218 were made with OSA as the only diagnosis. All waiver recommendations were granted, with the exception of one, which was missing a result. Additionally, 51 suspension recommendations were made for OSA. Two recommendations were made when OSA was the only diagnosis and 49 were made with other comorbid conditions present. All suspensions were granted, except for one which was missing a decision. Finally, there were 98 waiver continuations for OSA combined with other conditions and 55 continuations where OSA was the sole diagnosis.

For any case of OSA, the top five most common comorbid conditions are depicted in **Table I**. Overall, the ratio of waivers to suspensions granted in association with OSA was 9:1. With respect to the waivers, the split between those granted with OSA alone ($N = 218$) and those granted with OSA combined with another condition ($N = 241$) was roughly similar. In contrast, for the suspensions only 2 out of 51 were with OSA alone. The remaining 49 suspensions were associated with multiple other diagnoses. Notably, PTSD and depressive disorder occurred the most for suspensions when OSA was present.

Table I. Summary of Top Five Obstructive Sleep Apnea Comorbid Conditions.

COHORT	DIAGNOSIS (*N*)
All cases	Hypertension (81)
	Lumbago (53)
	Degeneration of lumbar or lumbosacral intervertebral disc (42)
	Posttraumatic stress disorder (42)
	Testicular hypofunction (32)
Suspension granted	Posttraumatic stress disorder (17)
	Depressive disorder (8)
	Insomnia (8)
	Lumbago (7)
	Cervicalgia (7)
Waiver granted	Hypertension (30)
	Degeneration of lumbar or lumbosacral intervertebral disc (19)
	Lumbago (17)
	Esophageal reflux (17)
	Testicular hypofunction (17)

DISCUSSION

OSA is an increasingly common condition in the U.S. general population and, due to its association with an elevated BMI, is often seen with, or is contributory to, other obesity-related health problems. One might expect that a military population, with its younger demographic overall and the requirement to maintain a minimum level of physical fitness, would not see the same (and increasing) prevalence of OSA as a civilian one. Furthermore, the military aviator population with its stringent medical fitness standards and robust health surveillance requirements might be expected to show a lower prevalence, as well.

However, the Army is not immune to this trend as the prevalence of obesity has increased from 25.8% in 1989 to 37.1% in 2012, the most recent year for which data are available.[11] Additionally, a study looking at longitudinal changes in BMI in British Army pilots found an average increase of 1.3 points over an individual's flying career.[1] Regression analysis also suggested that the change in BMI was equal to 1.62 times the number of years served as a pilot. With the increase in OSA in the general population and its known pathological correlates on the rise in the military population, it is important to understand the risks OSA poses to aviators' performance, safety, and career longevity. Our data (2.69% overall, 2.68% for men, and 0.02% for females) does indicate lower prevalence in this Army cohort, yet the figures on increasing levels of obesity in the military generally and the wide range, and somewhat elevated mean, of recorded BMI figures (20–39, $M = 28.69$) for aviators demonstrates little room for complacency when regarding the potential impact of OSA in this subpopulation.

The effects of OSA on aviator performance and flight safety are well known, with the disrupted sleep and excessive daytime sleepiness having demonstrable effects on cognitive and psychomotor performance. Additionally, the increased risk of hypertension, angina, myocardial infarction, dilated cardiomyopathy, and stroke can lead to sudden incapacitation and catastrophic loss of life and aircraft. Other health effects such as the development of pulmonary hypertension and cor pulmonale from repeated nocturnal desaturations could impact career longevity too. Hence, any aviator diagnosed with OSA is disqualified from flying duties. However, current U.S. Army aeromedical policy (Aeromedical Policy Letters and Aeromedical Technical Bulletins, dated June 2021) states that waivers may be granted for rated (pilots) and nonrated (crew chief) aviators on a case-by-case basis.

OSA is diagnosed using PSG, where breathing patterns, arm and leg movements, blood oxygen levels, and the number of

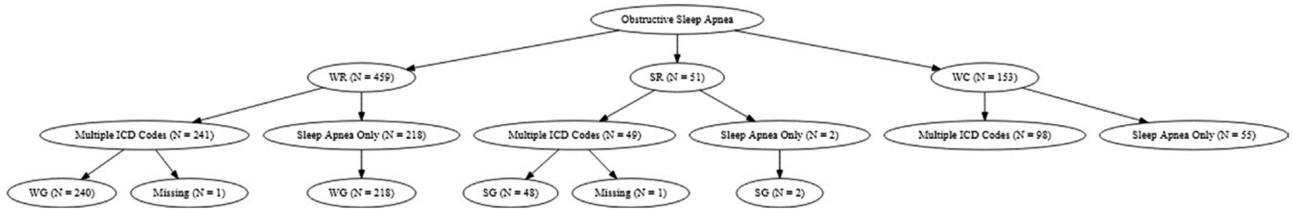

Fig. 1. Tree diagram of aeromedical dispositions associated with obstructive sleep apnea.

arousals during sleep are monitored. The most common treatment of OSA generally involves using CPAP, which acts as a pneumatic splint and prevents the upper airway from collapsing. In some milder cases a dental device which advances the jaw or holds the tongue in a different position during sleep may be used. Surgical intervention, where soft tissue from the back of the throat is removed (uvulopalatopharyngoplasty) can also alleviate symptoms for some individuals. Without treatment, the natural history of OSA will result in continued episodes of apnea and degraded sleep throughout the night, increasing daytime sleepiness, reduction in performance on skilled, multidimensional tasks (such as driving or flying), and increased risk of the associated longer term cardiovascular issues.[16] However, given that the condition is amenable to screening, diagnosis, and treatment, waivers may be granted provided adequate redress with weight loss, dental device, surgery, or CPAP use and documented resolution via PSG. There is also a requirement for continued compliance with therapy and stability of symptoms. If these requirements are not met then suspension from flying duties is the only likely outcome.

For this study, when calculating the point prevalence of OSA cases in Army aviators from the available AERO data, the count of Aeromedical Summaries (AMS) related to this diagnosis was used as the numerator. An AMS, which is collated by the attending flight surgeon or aviation medical examiner, summarizes the past medical history, the current principal complaint, and associated physical exam findings and is required for any medical condition that requires waiver or permanent medical suspension from flying duties, such as OSA. For this analysis only the first AMS related to a diagnosis of OSA (waiver recommendation, suspension, or waiver continuation) was counted for each affected individual so that the prevalence was not erroneously elevated. Other ICD-9 codes associated with the OSA cases were used to identify the five most prevalent comorbid conditions, overall and by waivered or suspended individuals.

When reviewing the waivered cases there was a roughly equitable split between those with OSA as a sole diagnosis (N = 218) and those with other conditions too (N = 241). Hypertension was a common cofinding, both in this group and overall. The link between OSA and hypertension is well established and so this observation comes as little surprise. The other prevalent conditions for this group, lumbago (N = 17) and intervertebral disc disease (N = 19), could be related to high background prevalence of back pain within the general adult population, contributions from comorbid conditions such as elevated BMI, or from factors specific to rotary-wing platforms (or a combination thereupon).[10] The main limitation with the AERO data available for this analysis is that, where comorbid conditions are present, it does not allow the primary reason(s) for the waiver to be elucidated, making it impossible to know what specifically initiated the generation of an AMS. However, we know that a confirmed diagnosis of OSA is always going to attract a waiver (at best), in line with aeromedical policy, but we cannot determine whether the comorbid condition was also a waiverable condition or simply a cofinding.

Two further common comorbid findings among the waivered OSA cases were testicular hypofunction (N = 17) and esophageal reflux (N = 17). Obesity is known to be strongly correlated with hypogonadism[14] and OSA in middle-aged men is also significantly associated with decreased testosterone secretion[13] and male infertility, particularly with greater OSA “exposure time” or when left untreated.[12] The prevalence of testicular hypofunction as a comorbid diagnosis in our data concurs with the wider evidence base. Similarly, truncal adiposity is known to lead to an increase in esophageal reflux symptoms. A commonly suggested patho-genetic pathway is the increased abdominal pressure relaxes the lower esophageal sphincter and increases the risk of hiatus hernia, thus exposing the esophageal mucosa to gastric content.[6] Additionally, there is evidence that visceral adipose tissue is metabolically active and secretes adipokines, along with inflammatory cytokines, that may predispose to complications of esophageal reflux such as Barrett esophagus and esophageal carcinoma.[4]

With respect to suspensions there were only two cases where OSA was the sole diagnosis and therefore, one assumes, the cause for the suspension. The remaining 49 suspension cases had other health conditions besides OSA, many of them being mental health issues (PTSD = 17 and depressive disorder = 8). For these cases it is conceivable that the poor sleep and daytime fatigue associated with OSA could have caused, contributed to, or exacerbated a mental health diagnosis, or be completely unrelated. Again, due to the data limitations described above, it is impossible to ascertain whether it was the OSA, the mental health diagnosis, or both that led to the suspensions. The authors consider that the most likely scenario is that the mental health diagnosis was the primary driver and OSA was a related or coincidental issue.

Despite this difficulty with the data set our analysis shows that OSA is common in the aviator population, albeit rates are lower than those cited in the wider civilian population, particularly females. Younger age and lower BMIs appear to be the main drivers for this difference. Whether comparative prevalence rates between aviators and civilian populations are actually similar and are not demonstrated by our data due to undiagnosed cases is doubtful, but open to conjecture. The stringent health surveillance applied to aviators renders missed diagnoses more unlikely, particularly for those who are evidently overweight. However, as OSA is usually identified via self-declared symptoms there is a possibility that some aviators could withhold such declarations due to concerns over the potential impact on their flying careers. Our data cannot delineate between these two hypotheses, but the age and BMI data suggest these are relevant factors in our different prevalence findings. What is clear from our data is that, when OSA is positively diagnosed, the appropriate aeromedical disposition actions are being applied. The fact that the majority of the cases are being waivered and there are very few cases of suspension that we know are specifically due to OSA also suggests that applied treatments appear to be effective. A few comments on prevention are warranted, as well. The concepts of comprehensive fitness and related effects upon health and readiness are not new to the military. And aircrew must all also undergo annual flight physicals, as well as periodic health assessments to address health, duty fitness, and wellness. However, a relatively novel initiative with far-reaching implications is that of the Army's Holistic Health and Fitness (H2F) System.[5] H2F brings a unified and multidomain approach down to the unit level with integrated resources. While certainly not assembled specifically for OSA or related conditions, it is projected to have far-reaching positive health-related outcomes. Notably, H2F will see cadres such as physical and occupational therapists, registered dietitians, athletic trainers, and strength and conditioning coaches imbedded within units across the service, within all components, and in all geographic locations. The impacts of such large-scale investment, resourcing, and cultural change, ultimately focused on military readiness, will include health promotion and disease prevention for a number of duty and occupationally limiting medical conditions, including those associated with OSA.

As OSA is often seen in conjunction with other health diagnoses which could affect career longevity it inevitably requires robust management in the short and long term to minimize losses to the operationally available aviator pool. Further longitudinal analysis of AERO data would be useful to assess whether the prevalence of this condition is changing over time, both as a marker of treatment compliance and effectiveness in currently diagnosed individuals and to assess whether more new OSA cases are being identified, mirroring the increasing trend seen in the wider civilian population.

The main limitation associated with this study is that it assumes that health data input into the AERO database is accurate and miscoding has not taken place. The inability to elucidate primary causes for waivers or suspensions in cases with multiple diagnoses is also a weakness associated with the data available to this study. The smaller number of female aviators in the AERO database also renders health conclusions about this subgroup less authoritative.

In conclusion, our data demonstrate that OSA has a lower prevalence among U.S. Army aviators (especially women) compared to the general population, as would be expected. However, the trend of rising obesity in the military generally, as well as the extant prevalence figures for OSA presented in this paper suggest that robust health promotion measures, detailed medical surveillance, and aggressive management of cases and associated comorbid conditions by the aeromedical community remains vital if we are to maintain individual health, preserve career longevity and operational output, and improve flight safety.

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