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SCIENTIFIC INVESTIGATIONS

STOP-BANG screener vs objective obstructive sleep apnea testing among younger veterans with PTSD and insomnia: STOP-BANG does not sufficiently detect risk

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Study Objectives: Posttraumatic stress disorder (PTSD) and obstructive sleep apnea (OSA) cooccur even in veterans who are younger with lower body mass index. The STOP-BANG screener for OSA relies heavily on high blood pressure, age, and body mass index and may not generalize to veterans with PTSD. The inability to effectively screen veterans for OSA is problematic given negative outcomes of untreated OSA.

Methods: Our study compared the STOP-BANG to objective OSA diagnostic testing in 48 younger veterans (mean age 43.7 years; 43.8% Caucasian; 20.8% female) seeking treatment for PTSD and insomnia. Apnea-hypopnea events per hour (apnea-hypopnea index), recorded by NOX T3 sleep monitors, were used to diagnose OSA (apnea-hypopnea index ≥ 5 events/h). Logistic regressions examined how STOP-BANG cut-off scores (≥ 3 and ≥ 5) classified OSA status (apnea-hypopnea index ≥ 5 events/h). Follow-up chi-square goodness-of-fit tests examined single-item STOP-BANG performance in the OSA-positive subsample (n = 28).

Results: The STOP-BANG (≥ 3) had good sensitivity (92.6%) but poor specificity (47.6%) and negative (0.16) and positive (1.77) likelihood ratios. The STOP-BANG (≥ 5) led to improved specificity (76.19%), but sensitivity (37.04%) and positive (1.56)/negative likelihood ratios (0.83) were poor. Single-item OSA subgroup analyses revealed that body mass index, age, and neck circumference performed poorly, while tiredness and sex performed well.

Conclusions: Findings suggest that the STOP-BANG correctly diagnosed OSA in some veterans but missed OSA in large number of younger veterans with PTSD. This suggests objective diagnostic OSA testing is needed in veterans with PTSD. Future research is needed to develop more accurate OSA screening measures in this population.

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Keywords: STOP-BANG, obstructive sleep apnea, posttraumatic stress disorder, PTSD, OSA

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BRIEF SUMMARY

Current Knowledge/Study Rationale: Self-report screening measures for obstructive sleep apnea (OSA) may overly rely upon age, blood pressure, and body mass index and not accurately classify OSA in veterans with posttraumatic stress disorder who often are younger with lower body mass index. This is problematic because untreated OSA may play an instrumental role in maintaining posttraumatic stress disorder and interfering with posttraumatic stress disorder treatment.

Study Impact: Our findings showed that the STOP-BANG classified some veterans with posttraumatic stress disorder correctly but had unacceptable levels of misclassification. Findings suggest that increasing use of objective measures of OSA should be used and a population-specific OSA screening tool should be developed and tested in veterans with posttraumatic stress disorder.

INTRODUCTION

Studies have increasingly implicated the role of disturbed sleep in both the development, severity, and treatment of posttraumatic stress disorder (PTSD), with sleep disorders including obstructive sleep apnea (OSA), insomnia, nightmares, and parasomnias correlating with worse outcomes.[1–5] Individuals with PTSD have significantly higher rates of sleep disturbances than the general population, with up to 87% of patients with PTSD reporting sleep disturbances.[6–10] Specifically, individuals with PTSD are at higher risk for sleep-disordered breathing (SDB) than individuals without PTSD, with studies reporting a substantially higher frequency (40%–83%) in PTSD vs non-PTSD samples (1.2%–3.6%).[6,11–14] There is evidence that the classic predictors of OSA, such as higher body mass index (BMI) and older age, may not apply to younger veterans with PTSD[15,16] and, as such, may be missed through screeners that rely on that information (eg, Berlin and STOP-BANG screening measures). This is concerning given that OSA directly interferes with evidence-based PTSD treatments and health outcomes, making screening and treating

OSA in veterans with PTSD critical.[10,17–19] Our study aimed to examine objective diagnostic testing compared to subjective screening for OSA in a sample of younger veterans with PTSD.

SDB is a spectrum[20] ranging from mild upper airway resistance (eg, snoring) to severe OSA. OSA is defined by repeated episodes of apneas (pauses in breathing) and hypopneas (reductions in airflow) that result in oxygenation desaturations and/or arousal during sleep. The apnea-hypopnea index (AHI) per hour is the most commonly used metric of OSA severity. OSA has been associated with multiple comorbidities among individuals such as hypertension (60.1%), obesity (30.5%), diabetes mellitus (32.9%), cardiovascular disease (27.6%), heart failure (13.5%), cerebrovascular disease (5.7%), cognitive impairment, and increased all-cause mortality.[21] OSA is the most common type of SDB, with a current prevalence rate of moderate to severe OSA (AHI ≥ 15 events/h) of about 10%–20% among the general population and 40%–83% among veterans with PTSD.[6,22,23] An analysis of 200 consecutive veterans with PTSD screened for OSA via polysomnography found that more than half (56.6%) met criteria for OSA at AHI ≥ 5 events/h and 43.6% when using AHI ≥ 10 events/h, rates that are significantly higher in individuals with PTSD than without.[22] A majority of studies are from sleep clinic referrals, and, as such, these rates may be higher than those seen in a PTSD clinic.

Established OSA risk factors include advanced age, male sex (3:1 ratio),[24] obesity, and high blood pressure, with prevalence rates increasingly progressing as BMI rises.[25] There is increasing evidence that the classic predictors of OSA, such as BMI and age, may not apply to younger veterans with PTSD. Two recent studies found 67.3%–69.2% were at high risk of OSA in younger veterans (mean age = 33.40–35.1 years) with lower BMI (BMI = 19.08–28.9).[15,16] Similarly, in a recent polysomnography study comparing Iranian veterans with and without PTSD, AHI was higher and BMI lower in the PTSD group compared to the non-PTSD group, and AHI was unrelated to BMI.[26]

It is not entirely clear why younger veterans with a lower BMI and PTSD have higher rates of PTSD. However, there is evidence that OSA is increasingly recognized to occur for both anatomical (classic OSA) and nonanatomical factors (atypical OSA) that vary between individuals.[27] It has been suggested that the chronic hyperarousal of PTSD may affect anatomical upper airway muscles or low arousal threshold, leading to waking up too easily, causing fragmentation.[28,29] Insomnia and PTSD in particular are disorders of heightened arousal, and it has been suggested that a low arousal threshold may predispose to OSA, which would suggest why OSA is found in those with PTSD who are generally younger and thinner than expected.

Undiagnosed and untreated OSA are major concerns in individuals with PTSD, with estimates of 80% of individuals with moderate to severe OSA remaining undiagnosed and therefore untreated.[30] This is concerning given there is evidence that untreated OSA interferes with efficacy of PTSD treatment. A retrospective study of veterans who had completed cognitive processing therapy at a Veterans Affairs (VA) facility found that those with OSA (n = 69) showed less symptom improvement than those without OSA (n = 276).[17] Reist et al[18] found similar results in a smaller sample (n = 18) undergoing prolonged exposure, where PCL scores were reduced by 28.25 points in those without SDB and only 7.17 points in the untreated SDB group. Reist et al[18] suggest that OSA and insomnia may have differential impacts on PTSD treatment effectiveness and should both be assessed for case conceptualization and treatment planning purposes. Treating OSA in PTSD patients has shown improvements in PTSD-related nightmares, sleep quality, daytime functioning, depression, quality of life, AHI, and overall PTSD symptom severity.[17,18,31–34]

Commonly used screening measures for OSA risk include the Epworth Sleepiness Scale,[35] the Berlin Questionnaire,[36] the STOP,[37] and the STOP-BANG.[39] A systematic review of these screening measures found that the STOP-BANG and the Berlin Questionnaire had the highest sensitivity and specificity, respectively, with regard to predicting moderate or severe OSA.[40] A systematic review and meta-analysis of the STOP-BANG questionnaire,[41] for instance, revealed its high screening performance in sleep clinic and surgical populations, with the probability of moderate and severe OSA increasing with higher STOP-BANG scores.[41] However, it is unclear how the STOP-BANG performs in younger veterans with PTSD.

A study evaluating STOP-BANG performance in veterans referred to a VA sleep clinic (n = 1,196) found that the STOP-BANG demonstrated excellent sensitivity but poor specificity.[37] The sample was limited to older, obese male veterans—a population already at moderate to high risk for OSA, so findings cannot be assumed to generalize to younger veterans. More recently, McMahon et al examined STOP-BANG performance in a younger active-duty sample (mean age = 40.3 years) with lower BMI (mean BMI = 28.7) referred for in-laboratory polysomnography at a sleep clinic.[39] Similar to previous research, the STOP-BANG demonstrated good sensitivity but poor specificity in this younger sample. Although extant literature suggests that the STOP-BANG underperforms in classifying OSA status in military and veteran samples, neither study examined the performance of the STOP-BANG in individuals with PTSD. Research examining STOP-BANG performance in younger veterans with PTSD is necessary, as this understudied population is at high risk for OSA, and OSA is commonly undiagnosed in PTSD.[26]

The aim of the present study was to determine sensitivity and specificity of the STOP-BANG in a sample of younger veterans with PTSD and insomnia by examining the relationships between STOP-BANG scores and objectively derived AHI scores. Based on recent research with this population, it was hypothesized that total STOP-BANG scores would not be able to sufficiently detect OSA risk or severity in veterans with PTSD. In exploratory analyses, we examined the item-by-item analyses where the STOP-BANG produced false negatives for OSA in veterans with PTSD.

METHODS

Participants

These data are a subset of a larger randomized controlled trial comparing integrated cognitive-behavioral therapy for insomnia and prolonged exposure to integrated nonactive sleep hygiene and prolonged exposure in the treatment of co-occurring PTSD

and insomnia. This study was approved by the local VA institutional review board. Participants were 48 adult treatment-seeking veterans from any service era (mean age = 43.7; standard deviation = 13.2; 79.2% male) with confirmed PTSD and insomnia presenting to a baseline assessment. Eligibility criteria included (1) over 19 years of age, (2) *Diagnostic and Statistical Manual of Mental Disorders*, fifth edition (DSM-5) PTSD and insomnia disorder diagnoses, and (3) English literacy. Exclusion criteria for the current study consisted of (1) unmanaged psychosis or mania, (2) substance use disorder in the past 6 months, and (3) OSA diagnosed and currently treated with a continuous positive air pressure machine. See **Table 1** for study participant demographic characteristics.

Procedures

Data from the current study were collected during the baseline visit of the aforementioned parent randomized controlled trial, which occurred in a metropolitan VA hospital between February 2017 and February 2020. Recruitment methods included referrals from VA primary care and PTSD clinics, flyers, and brochures. Participants provided written informed consent and completed a battery of traditional measured and structured interviews to determine randomized controlled trial eligibility. Participants completed the Clinician-Administered PTSD Scale for DSM-5 (CAPS-5), the Diagnostic Interview for Sleep Patterns and Disorders, the STOP-BANG, and NOX T3 type III portable monitoring testing using American Academy of Sleep Medicine scoring guidelines,[42] which were included in the current study's analyses. Assessments were conducted by trained postbaccalaureate assessors who participated in weekly individual supervision with a licensed clinical psychologist.

Measures

PTSD

The CAPS-5 was used to assess PTSD diagnosis. The CAPS-5 is a semistructured interview used to assess DSM-5 PTSD diagnostic status and severity. The 30-item CAPS-5 interview corresponds to the DSM-5 diagnosis of PTSD. CAPS-5 represents the gold standard in PTSD assessment, and CAPS-5 diagnostic and severity scores display excellent psychometric properties in military samples.[43] This study used the CAPS-5 to confirm current (past month) PTSD diagnostic status.

Insomnia

Sleep was assessed using the Diagnostic Interview for Sleep Patterns and Disorders, which is a clinician-administered assessment used for diagnosing sleep disorders. Based on the *International Classification of Sleep Disorders*, the Diagnostic Interview for Sleep Patterns and Disorders displays good concordance with sleep expert diagnosis using objective sleep assessment for OSA and insomnia.[44] The Diagnostic Interview for Sleep Patterns and Disorders was used to evaluate insomnia.

OSA screener

The STOP-BANG was used to screen for and assess OSA risk. The STOP-BANG is an 8-item binary-choice OSA risk-screening measure. The presence of established risk factors (eg, tired during the day), demographics (eg, male sex), and common comorbidities (eg, hypertension) are included. Positive responses are summed for a total possible score ranging from 0 to 8. A STOP-BANG score ≥ 3 is the recommended cut-off score in surgical and sleep clinic populations.[37,41] Scores of ≥ 5 on the STOP-BANG represent high probability of severe OSA in the

Table 1—Demographics and baseline characteristics.

	Full Sample (n = 48)	AHI ≤ 5 events/h (n = 21)	AHI ≥ 5 events/h (n = 27)
Age, mean (SD)	43.7 (13.2)	38.52 (11.60)	47.66 (13.17)
Female, n (%)	10 (20.8)	6 (15.0)	4 (14.8)
College graduate, n (%)	19 (39.6)	10 (47.6)	9 (33.3)
Hispanic, n (%)	7 (14.6)	2 (9.7)	5 (18.5)
Race, n (%)			
Caucasian	21 (43.8)	9 (42.9)	12 (44.4)
African American	13 (27.1)	7 (33.3)	6 (22.2)
Asian	5 (10.4)	3 (14.3)	2 (7.4)
Other/unknown	9 (18.8)	2 (9.5)	7 (25.9)
PTSD severity (CAPS-5), mean (SD)	34.8 (10.4)	33.58 (8.76)	36.77 (9.16)
AHI, events/h, mean (SD)	7.4 (7.1)	1.99 (1.23)	11.64 (6.86)
STOP-BANG, mean (SD)	3.7 (1.6)	3.05 (1.66)	4.22 (1.37)
BMI, kg/m^2, mean (SD)	28.8 (5.1)	28.34 (4.99)	29.24 (5.25)
Neck circumference, cm, mean (SD)	40.0 (5.3)	38.88 (6.67)	40.93 (3.95)
ISI total, mean (SD)[a]	19.72 (4.65)	19.95 (3.97)	19.54 (5.19)

[a]ISI data are missing for four cases. AHI = apnea-hypopnea index, BMI = body mass index, CAPS-5 = Clinician-Administered PTSD Scale for DSM-5, ISI = Insomnia Severity Index, PTSD = posttraumatic stress disorder, SD = standard deviation.

sleep clinic population.[41] STOP-BANG scores of ≥ 3 and ≥ 5 were used in the current study as intermediate and high risk for OSA status.

Objective OSA diagnostic testing

Objective measure of AHI was assessed using the NOX T3 recorders. The NOX T3 is a portable sleep monitoring system that can accurately diagnose OSA. Polysomnography- and NOX T3–derived AHI are strongly and positively correlated.[45] The NOX T3, and other similar type III devices, are standard of care for hospitals and research studies diagnosing OSA among PTSD samples.[5,19,46,47] The current study follows American Academy of Sleep Medicine 1B scoring guidelines in determining at least mild OSA using AHI ≥ 5 events/h.[42]

Analyses

All analyses were conducted using SPSS software version 27. Frequencies (proportions) and means (standard deviations) are used to describe categorical and continuous variables, respectively. We utilized binary logistic regressions to evaluate the association between screening assessment and objective measurement of OSA. Separate models evaluated the performance of STOP-BANG scores (independent variable) for intermediate (≥ 3) and high risk (≥ 5) for OSA on determining at least mild OSA as defined by AHI (≥ 5 events/h; dependent variable). STOP-BANG independent variables were coded as dichotomous (0 = not meeting risk threshold; 1 = risk present), and the objective OSA status-dependent variable was coded as dichotomous as well (0 = AHI < 5 events/h; 1 = AHI ≥ 5 events/h). Given that the current sample had co-occurring insomnia, we ran logistic regression models controlling for insomnia severity. Including insomnia severity as a covariate did not improve model fit, nor did it substantively change model results. As such, unadjusted model results are reported for parsimony. Sensitivity, specificity, and likelihood ratios (+/−) are provided for both models.

Exploratory analyses were conducted in the objective OSA diagnosis-positive group (n = 27) to see where individual STOP-BANG items were showing false negatives. Chi-square goodness-of-fit tests examined if there were group differences between endorsement of STOP-BANG items (positive or negative response) in the OSA subgroup. Significant group differences in the direction of negative responses suggest that individual STOP-BANG items were *underperforming* in the OSA subgroup, whereas significant differences in the direction of positive responses suggest good performance. For individual STOP-BANG items for which we also had continuous data (including BMI, age, neck circumference) we determined the magnitude of effect between negative and positive response groups using Cohen's *d*.

RESULTS

Participants were 48 younger veterans (mean age = 43.7 years; 43.8% Caucasian; 20.8% female). Demographic information for the full sample and OSA status subgroups are displayed in **Table 1**. STOP-BANG item endorsement descriptive statistics for the full sample are displayed in **Table 2**. Intermediate STOP-BANG risk (≥ 3) was significantly associated with at least mild OSA status ($OR = 11.36$, $P = .004$). Sensitivity and specificity for intermediate STOP-BANG risk were 92.6% and 47.6%, respectively. Positive and negative likelihood ratios were 1.77 and 0.16. High STOP-BANG risk (≥ 5) was not significantly associated with at least mild OSA status ($OR = 1.88$, $P = .30$). Sensitivity and specificity for high STOP-BANG risk were 37.04% and 76.19%, respectively. Positive and negative likelihood ratios were 1.56 and 0.83, respectively.

Table 2—STOP-BANG item endorsement for full sample (n = 48).

	Positive Response, n (%)
Snoring	18 (37.5)
Tired	44 (91.7)
Observed apneas	28 (58.3)
Pressure (hypertension)	11 (22.9)
BMI, kg/m^2 (>35 kg/m^2)	7 (14.6)
Age (>50 y)	15 (31.3)
Neck circumference (>43 cm for males, >41 cm for females)	17 (35.4)
Gender (male)	38 (79.2)

BMI = body mass index.

We wanted to examine differences between where the STOP-BANG was correct in predicting high-risk OSA and where it produced false negatives for veterans with PTSD who had OSA. Specifically, BMI ($\chi^2 = 24.08$, $P < .001$), age ($\chi^2 = 6.75$, $P = .009$), and neck circumference ($\chi^2 = 4.08$, $P = .04$) performed poorly while tiredness ($\chi^2 = 16.33$, $P > .001$) and sex ($\chi^2 = 13.37$, $P < .001$) performed well in the OSA subsample. Moreover, snoring ($\chi^2 = .037$, $P = .85$), observed apnea ($\chi^2 = 3.00$, $P = .08$), and hypertension ($\chi^2 = 3.00$, $P = .08$) were not statistically significant, suggesting that they did not provide adequate performance in classifying OSA status. See **Table 3** for individual STOP-BANG item descriptive details for the OSA sample.

DISCUSSION

We examined the STOP-BANG's performance in detecting at least mild OSA status in a younger veteran sample presenting for treatment of PTSD and insomnia. The STOP-BANG ≥ 3 displayed good sensitivity (92.6%) but poor specificity (47.6%) and positive (1.77) and negative likelihood ratios (0.16). With a STOP-BANG cut-off score of ≥5 we saw improved specificity (76.19%) but poor sensitivity (37.04%) and positive (1.56) and negative (0.82) likelihood ratios. This suggests the STOP-BANG ≥ 3 accurately captures some veterans with PTSD well but gives false positives on a large percentage of the group. Moreover, low STOP-BANG (≥3) likelihood ratios suggest that the STOP-BANG cut-off scores do not meaningfully change the probability of OSA status. Examining a stricter STOP-BANG cut-off score of ≥ 5 did not improve the classification of OSA, as we saw poor

Table 3—STOP-BANG item endorsement for veterans with AHI ≥ 5 events/h (n = 27).

	Positive Response, n (%)	Negative Response, n (%)	Cohen's *d*
Snoring	13 (48.1)	14 (51.9)	
Tired	24 (88.9)	3 (11.1)	
Observed apneas	18 (66.7)	9 (33.3)	
Pressure (hypertension)	9 (33.3)	18 (66.7)	
BMI, kg/m^2 (>35 kg/m^2)	4 (14.8)	23 (85.2)	4.04
Age (>50 y)	12 (44.4)	15 (55.6)	2.89
Neck circumference[a]	11 (40.7)	16 (59.3)	2.11
Gender (male)	23 (85.2)	4 (12.8)	

[a]Neck circumference was positive at > 43 cm for males or > 41 cm for females. AHI = apnea-hypopnea index, BMI = body mass index.

sensitivity, with resultant high false negatives. As such, the STOP-BANG is not sufficient in detecting high risk of OSA in veterans with PTSD.

When we compared veterans the STOP-BANG correctly identified to those with false negatives we found significant differences in 5 out of the 8 items. Specifically, BMI, age, and neck circumference performed poorly in the OSA subsample at large effect sizes (Cohen's $d = 2.11–4.04$). Tiredness and sex performed well in the OSA subsample. The three remaining items (snoring, observed apnea, and hypertension) did not demonstrate significant differences between positive or negative endorsement, suggesting that they underperformed in OSA classification as well. This suggests that classic risk factors of OSA associated with older and larger-sized adults may not perform well in younger and thinner veterans with PTSD, whereas tiredness and male sex may be considered as potential items in a PTSD-specific OSA screening tool.

Unfortunately, our study does not shed light on *why* we are seeing atypical OSA in veterans with PTSD. The current hypothesis is since insomnia and PTSD are disorders of heightened arousal it may lead to low arousal threshold.[28,29] Low arousal threshold would account for increased fragmentation throughout the night regardless of BMI, age, or blood pressure. Future studies should examine the specific endotype of OSA in veterans with PTSD.

Current results are in line with other studies finding good sensitivity but poor specificity in detecting OSA.[38,48] For instance, Kunisaki et al found that the ability of STOP-BANG to confirm the presence of OSA among an older veteran sleep clinic sample was only modest.[48] Moreover, in a younger active-duty sleep clinic sample (mean age = 40.3 years; standard deviation = 9.9) the STOP-BANG displayed good sensitivity (83.8%) but poor specificity (18.0%) in determining OSA status.[38] Taken together, findings suggest that the STOP-BANG is insufficient alone in determining OSA status, perhaps due to major demographic differences, particularly related to size and age, in younger adult and veteran samples.

Given the historical reliance on BMI and age for detecting OSA, it is possible that the screening questionnaires may miss high risk of OSA in younger and thinner veterans with PTSD. For example, only 14.8% of veterans in the current sample with AHI ≥ 5 events/h had a BMI of > 35 kg/m^2, 33.3% had hypertension, and 44.4% were over 50 years of age. It should be noted that not all STOP-BANG items performed poorly. Although strictly descriptive, of the subsample of veterans in the current study with AHI ≥ 5 events/h, 85.2% were male and 88.9% reported being tired throughout the day. While it is possible other screening measures of OSA will fare better, it is unlikely since they are also based on classic predictors of OSA (eg, Berlin). For example, Colvonen et al found that the Berlin Questionnaire has high sensitivity (79%) with its ability to accurately classify OSA status in younger veterans presenting to a VA PTSD clinic who completed polysomnography; however, they did not examine specificity, which likely leaves a large subset of veterans underdiagnosed.[15] Other nonspecific screeners, like the Epworth Sleepiness Scale, did not show ability to predict high risk of OSA.[49] Without updated and validated questionnaires in veterans with PTSD specifically we thus recommend all veterans with PTSD receive objective OSA diagnostic testing.

Current VA PTSD clinical practice guidelines[50] recommend an independent assessment of co-occurring sleep disorders in the presence of PTSD, but unfortunately regular screening for OSA is not commonly a part of clinical practice in VA mental health clinics.[19] Ambulatory type III devices (eg, Watchpat, Apnea Airlink, and NOX T3) may offer a better and more accessible option for veterans to assess sleep in their home environment. There is increasing use of validated portable devices for the detection of sleep apnea that are affordable and easy to use.[51] As such, some VA facilities use these portable or unattended devices to facilitate more timely and cost-effective diagnostic testing compared to traditional polysomnography. While these devices cannot report stages of sleep or sleep architecture they accurately track apneas/hypopneas for OSA diagnosis. Perhaps more widespread adoption of ambulatory type III devices is necessary to help better inform sleep disturbance and disorder assessment in veterans with PTSD; however, validation efforts are necessary.

Limitations

The current study is not without its limitations. For instance, STOP-BANG and other OSA screening measures have not been validated in a veteran PTSD/insomnia population. The current sample was small, resulting in few veterans meeting criteria for moderate or severe OSA (AHI ≥15 or 30 events/h). Consequently, it is unclear how the STOP-BANG would perform

in younger veterans with PTSD and insomnia who have more severe OSA. Findings related to single-item performance in the OSA-positive subgroup should be interpreted with caution due to the small sample size of this subgroup. Future studies should include larger samples to increase generalizability of findings and provide power to examine (1) the classification properties of other OSA screening tools (eg, Berlin and Epworth Sleepiness Scale) and (2) examine the performance of single items in larger samples to potentially inform development of a PTSD population-specific OSA screening tool for younger veterans.

CONCLUSIONS

Although the STOP-BANG is a previously well-established screening assessment, the present study suggests an unacceptable number of false negatives and does not provide support for its use to accurately classify OSA risk in younger veterans with PTSD and insomnia. Examination of additional existing OSA screening measures and objective testing, development of more sensitive population-specific screening measures, and the validation of ambulatory type III devices in younger veterans with PTSD are necessary to potentially improve OSA detection in this population.

There are currently no guidelines for screening for sleep disorders in PTSD, although VA clinical practice guidelines call for independent sleep assessment in the case of co-occurring PTSD and sleep disorders.[50] Many providers consider insomnia as a symptom or secondary condition rather than a comorbid diagnosis, reflecting an attitude that is inconsistent with current nosologies[52] and unsupported by scientific evidence.[53] Clinically, we recommend a comprehensive sleep assessment to include OSA and insomnia screening, with treatment planning to match. Due to the detrimental effect of OSA on PTSD treatments and health outcomes we strongly recommend objective OSA diagnostic testing and treatment of OSA, even in younger individuals with a lower BMI with PTSD, prior to the start of PTSD treatment. Because of the potentially serious adverse consequences and suboptimal clinical outcomes associated with untreated OSA, prompt diagnosis and treatment of unrecognized OSA are essential.

ABBREVIATIONS

AHI, apnea-hypopnea index
BMI, body mass index
CAPS-5, Clinician-Administered PTSD Scale for DSM-5
DSM, *Diagnostic and Statistical Manual of Mental Disorders*
OSA, obstructive sleep apnea
PTSD, posttraumatic stress disorder
SDB, sleep-disordered breathing
VA, Veterans Affairs

REFERENCES

1. van Liempt S, van Zuiden M, Westenberg H, Super A, Vermetten E. Impact of impaired sleep on the development of PTSD symptoms in combat veterans: a prospective longitudinal cohort study. *Depress Anxiety.* 2013;30(5):469–474.
2. van Liempt S. Sleep disturbances and PTSD: a perpetual circle? *Eur J Psychotraumatol.* 2012;3(1):19142.
3. Spoormaker VI, Montgomery P. Disturbed sleep in post-traumatic stress disorder: secondary symptom or core feature? *Sleep Med Rev.* 2008;12(3):169–184.
4. Lamarche LJ, De Koninck J. Sleep disturbance in adults with posttraumatic stress disorder: a review. *J Clin Psychiatry.* 2007;68(8):1257–1270.
5. Orr JE, Smales C, Alexander TH, et al. Treatment of OSA with CPAP is associated with improvement in PTSD symptoms among veterans. *J Clin Sleep Med.* 2017; 13(1):57–63.
6. Krakow B, Melendrez D, Warner TD, et al. Signs and symptoms of sleep-disordered breathing in trauma survivors: a matched comparison with classic sleep apnea patients. *J Nerv Ment Dis.* 2006;194(6):433–439.
7. Kinoshita LM, Yesavage JA, Noda A, et al. Modeling the effects of obstructive sleep apnea and hypertension in Vietnam veterans with PTSD. *Sleep Breath.* 2012;16(4): 1201–1209.
8. Maher MJ, Rego SA, Asnis GM. Sleep disturbances in patients with post-traumatic stress disorder: epidemiology, impact and approaches to management. *CNS Drugs.* 2006;20(7):567–590.
9. Colvonen PJ, Almklov E, Tripp JC, Ulmer CS, Pittman JOE, Afari N. Prevalence rates and correlates of insomnia disorder in post-9/11 veterans enrolling in VA healthcare. *Sleep.* 2020;43(12):zsaa119.
10. Colvonen PJ, Rivera GL, Park J. Sleep Disorders in Veterans: Prevalence, Consequences, and Treatment. In: Sedky K, Nazir R, Bennett D, eds. *Sleep Medicine and Mental Health: A Guide for Psychiatrists and Other Health Care Professionals.* Cham, Switzerland: Springer; 2020: 315–340.
11. Zhang Y, Weed JG, Ren R, Tang X, Zhang W. Prevalence of obstructive sleep apnea in patients with posttraumatic stress disorder and its impact on adherence to continuous positive airway pressure therapy: a meta-analysis. *Sleep Med.* 2017;36: 125–132.
12. Yesavage JA, Kinoshita LM, Kimball T, et al. Sleep-disordered breathing in Vietnam veterans with posttraumatic stress disorder. *Am J Geriatr Psychiatry.* 2012;20(3): 199–204.
13. Webber MP, Lee R, Soo J, et al. Prevalence and incidence of high risk for obstructive sleep apnea in World Trade Center-exposed rescue/recovery workers. *Sleep Breath.* 2011;15(3):283–294.
14. Calabrese JR, Prescott M, Tamburrino M, et al. PTSD comorbidity and suicidal ideation associated with PTSD within the Ohio Army National Guard. *J Clin Psychiatry.* 2011;72(8):1072–1078.
15. Colvonen PJ, Masino T, Drummond SP, Myers US, Angkaw AC, Norman SB. Obstructive sleep apnea and posttraumatic stress disorder among OEF/OIF/OND veterans. *J Clin Sleep Med.* 2015;11(5):513–518.
16. Williams SG, Collen J, Orr N, Holley AB, Lettieri CJ. Sleep disorders in combat-related PTSD. *Sleep Breath.* 2015;19(1):175–182.
17. Mesa F, Dickstein BD, Wooten VD, Chard KM. Response to cognitive processing therapy in veterans with and without obstructive sleep apnea. *J Trauma Stress.* 2017; 30(6):646–655.
18. Reist C, Gory A, Hollifield M. Sleep-disordered breathing impact on efficacy of prolonged exposure therapy for posttraumatic stress disorder. *J Trauma Stress.* 2017;30(2):186–189.
19. Colvonen PJ, Straus LD, Stepnowsky C, McCarthy MJ, Goldstein LA, Norman SB. Recent advancements in treating sleep disorders in co-occurring PTSD. *Curr Psychiatry Rep.* 2018;20(7):48.
20. Schwab R, Goldberg A, Pack A, Sleep Apnea Syndromes. In: Fishman AP, ed. Fishman's Pulmonary Diseases and Disorders. New York, NY: McGraw-Hill Book Company; 1998: 1617–1637.
21. Sharafkhaneh A, Giray N, Richardson P, Young T, Hirshkowitz M. Association of psychiatric disorders and sleep apnea in a large cohort. *Sleep.* 2005;28(11): 1405–1411.
22. Lettieri CJ, Williams SG, Collen JF. OSA syndrome and posttraumatic stress disorder: clinical outcomes and impact of positive airway pressure therapy. *Chest.* 2016; 149(2):483–490.
23. Peppard PE, Young T, Barnet JH, Palta M, Hagen EW, Hla KM. Increased prevalence of sleep-disordered breathing in adults. *Am J Epidemiol.* 2013;177(9):1006–1014.
24. Bixler EO, Vgontzas AN, Lin HM, et al. Prevalence of sleep-disordered breathing in women: effects of gender. *Am J Respir Crit Care Med.* 2001;163(3 Pt 1):608–613.

25. Peppard PE, Young T, Palta M, Dempsey J, Skatrud J. Longitudinal study of moderate weight change and sleep-disordered breathing. *JAMA.* 2000;284(23):3015–3021.
26. Rezaeitalab F, Mokhber N, Ravanshad Y, Saberi S, Rezaeetalab F. Different polysomnographic patterns in military veterans with obstructive sleep apnea in those with and without post-traumatic stress disorder. *Sleep Breath.* 2018;22(1):17–22.
27. Malhotra A, Mesarwi O, Pepin J-L, Owens RL. Endotypes and phenotypes in obstructive sleep apnea. *Curr Opin Pulm Med.* 2020;26(6):609–614.
28. Lettieri CJ, Collen JF, Williams SG. Challenges in the management of sleep apnea and PTSD: is the low arousal threshold an unrealized target? *J Clin Sleep Med.* 2017; 13(6):845–846.
29. El-Solh AA, Lawson Y, Wilding GE. Impact of low arousal threshold on treatment of obstructive sleep apnea in patients with post-traumatic stress disorder. *Sleep Breath.* 2020;25(2):1–8.
30. Young T, Evans L, Finn L, Palta M. Estimation of the clinically diagnosed proportion of sleep apnea syndrome in middle-aged men and women. *Sleep.* 1997;20(9):705–706.
31. Orr N, Carter K, Collen JF, Hoffman M, Holley AB, Lettieri CJ. Prevalence of sleep disorders among soldiers with combat-related posttraumatic stress disorder. *Chest.* 2010;138(4):704A.
32. Gupta MA, Simpson FC, Lyons DCA. The effect of treating obstructive sleep apnea with positive airway pressure on depression and other subjective symptoms: a systematic review and meta-analysis. *Sleep Med Rev.* 2016;28:55–68.
33. Tamanna S, Parker JD, Lyons J, Ullah MI. The effect of continuous positive air pressure (CPAP) on nightmares in patients with posttraumatic stress disorder (PTSD) and obstructive sleep apnea (OSA). *J Clin Sleep Med.* 2014;10(6):631–636.
34. Krakow BJ, McIver ND, Obando JJ, Ulibarri VA. Changes in insomnia severity with advanced PAP therapy in patients with posttraumatic stress symptoms and comorbid sleep apnea: a retrospective, nonrandomized controlled study. *Mil Med Res.* 2019; 6(1):15.
35. Johns MW. A new method for measuring daytime sleepiness: the Epworth Sleepiness Scale. *Sleep.* 1991;14(6):540–545.
36. Netzer NC, Stoohs RA, Netzer CM, Clark K, Strohl KP. Using the Berlin Questionnaire to identify patients at risk for the sleep apnea syndrome. *Ann Intern Med.* 1999;131 (7):485–491.
37. Chung F, Yegneswaran B, Liao P, et al. STOP questionnaire: a tool to screen patients for obstructive sleep apnea. *Anesthesiology.* 2008;108(5):812–821.
38. 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.
39. Chung F, Subramanyam R, Liao P, Sasaki E, Shapiro C, Sun Y. High STOP-Bang score indicates a high probability of obstructive sleep apnoea. *Br J Anaesth.* 2012; 108(5):768–775.
40. Abrishami A, Khajehdehi A, Chung F. A systematic review of screening questionnaires for obstructive sleep apnea. *Can J Anaesth.* 2010;57(5):423–438.
41. Nagappa M, Liao P, Wong J, et al. Validation of the STOP-Bang questionnaire as a screening tool for obstructive sleep apnea among different populations: a systematic review and meta-analysis. *PLoS One.* 2015;10(12):e0143697.
42. Kapur VK, Auckley DH, Chowdhuri S, et al. Clinical practice guideline for diagnostic testing for adult obstructive sleep apnea: an American Academy of Sleep Medicine clinical practice guideline. *J Clin Sleep Med.* 2017;13(3):479–504.
43. Weathers FW, Bovin MJ, Lee DJ et al. The Clinician-Administered PTSD Scale for DSM–5 (CAPS-5): development and initial psychometric evaluation in military veterans. *Psychol Assess.* 2018;30(3):383–395.
44. Merikangas KR, Zhang J, Emsellem H, et al. The structured diagnostic interview for sleep patterns and disorders: rationale and initial evaluation. *Sleep Med.* 2014;15(5): 530–535.
45. Cairns A, Wickwire E, Schaefer E, Nyanjom D. A pilot validation study for the NOX T3(TM) portable monitor for the detection of OSA. *Sleep Breath.* 2014;18(3): 609–614.
46. Colvonen PJ, Rivera G, Park J, Haller M, Ancoli-Israel S, Norman S. Screening and treating obstructive sleep apnea in a residential treatment program for veterans with substance use disorders and PTSD. *Psychol Trauma.* 2021.
47. Department of Veterans Affairs and Department of Defense. VA/DoD clinical practice guideline for the management of chronic obstructive pulmonary disease. https://www.healthquality.va.gov/guidelines/cd/copd/. Accessed August 1, 2020.
48. Kunisaki KM, Brown KE, Fabbrini AE, Wetherbee EE, Rector TS. STOP-BANG questionnaire performance in a Veterans Affairs unattended sleep study program. *Ann Am Thorac Soc.* 2014;11(2):192–197.
49. Soler X, Liao S-Y, Marin JM, et al. Age, gender, neck circumference, and Epworth Sleepiness Scale do not predict obstructive sleep apnea (OSA) in moderate to severe chronic obstructive pulmonary disease (COPD): the challenge to predict OSA in advanced COPD. *PLoS One.* 2017;12(5):e0177289.
50. Department of Veterans Affairs and Department of Defense. VA/DOD clinical practice guideline for management of post-traumatic stress. https://www.healthquality.va.gov/guidelines/MH/ptsd/. Accessed August 1, 2020.
51. Collop NA, Anderson WM, Boehlecke B, et al.; Portable Monitoring Task Force of the American Academy of Sleep Medicine. Clinical guidelines for the use of unattended portable monitors in the diagnosis of obstructive sleep apnea in adult patients. *J Clin Sleep Med.* 2007;3(7):737–747.
52. Iber C, Ancoli-Israel S, Chesson AL Jr, Quan SF; for the American Academy of Sleep Medicine. *The AASM Manual for the Scoring of Sleep and Associated Events: Rules, Terminology and Technical Specifications.* 1st ed. Westchester, IL: American Academy of Sleep Medicine; 2007.
53. Lichstein KL. Secondary insomnia: a myth dismissed. *Sleep Med Rev.* 2006; 10(1):3–5.

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