https://doi.org/10.5664/jcsm.8758

JCSM | Journal of Clinical Sleep Medicine

REVIEW ARTICLES

Dream enactment behavior—a real nightmare: a review of post-traumatic stress disorder, REM sleep behavior disorder, and trauma-associated sleep disorder

Daniel A. Barone, MD

Weill Cornell Medical College, New York, New York

Dream enactment behavior is a phenomenon demonstrated in patients with post-traumatic stress disorder, rapid eye movement sleep behavior disorder, as well as with a more recently described condition entitled trauma-associated sleep disorder, which shares diagnostic criteria for rapid eye movement sleep behavior disorder. While these conditions share some commonalities, namely dream enactment behavior, they are quite different in pathophysiology and underlying mechanisms. This review will focus on these 3 conditions, with the purpose of increasing awareness for trauma-associated sleep disorder in particular.

Keywords: REM sleep, dream enactment behavior, RBD, PTSD, trauma associated sleep disorder, parasomnia

Citation: Barone DA. Dream enactment behavior—a real nightmare: a review of post-traumatic stress disorder, REM sleep behavior disorder, and trauma-associated sleep disorder. *J Clin Sleep Med*. 2020;16(11):1943–1948.

INTRODUCTION

Patients with post-traumatic stress disorder (PTSD) experience significant sleep disturbances, notably within rapid eye movement (REM) sleep.[1] It is estimated that 70–91% of patients with PTSD experience poor sleep, both by self-report[2] and by objective assessments.[1,3] PTSD has been linked to REM sleep behavior disorder (RBD)[4,5] in the medical literature, currently with only theoretical support as to why. Additionally, PTSD can be associated with a more recently described condition known as trauma-associated sleep disorder (TASD),[6–8] which shares diagnostic criteria for RBD.[9] While these conditions share some commonalities, namely dream enactment behavior (DEB), they are quite different in pathophysiology and underlying mechanisms. This review will focus on these 3 conditions, with the purpose of increasing awareness for TASD in particular. A summary of the relevant studies that have been performed in this arena can be seen in **Table 1**.

POST-TRAUMATIC STRESS DISORDER

PTSD is a psychiatric condition resulting from experiencing, witnessing, or learning about an actual or threatened traumatic event.[13] To be diagnosed with PTSD, per the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5), a patient must have symptoms from each of the 5 criteria, along with the presence of symptoms lasting for more than 1 month, creating distress or functional impairment, and that are not due to medication, substance use, or other illness[14]: criterion A: stressor; criterion B: intrusion symptoms; criterion C: avoidance; criterion D: negative alterations in cognitions and mood; criterion E: alterations in arousal and reactivity.[14] Additionally, there are subtypes and variants of PTSD that may have effects on sleep health, namely the dissociative subtype of PTSD and complex PTSD.

The 11th revision to the World Health Organization's *International Classification of Diseases* proposed the PTSD variant condition known as complex PTSD,[15] which may be more common and more debilitating than PTSD.[16] Complex PTSD includes 3 additional clusters: affective dysregulation, negative self-concept, and disturbances in relationships.[17] These disturbances are proposed to be typically associated with sustained, repeated, or multiple forms of traumatic exposure (such as genocide campaigns, childhood sexual abuse, or child soldiering).[18] First-line treatment for PTSD includes trauma-focused psychotherapy that comprises such modalities as exposure therapy (such as prolonged exposure), trauma-focused cognitive-behavioral therapy (which is a combination of exposure and a cognitive therapy), or eye movement desensitization and reprocessing.[19]

The dissociative subtype of PTSD is known for increased severity of PTSD symptoms and comorbidity with other psychiatric disorders, a predominance of derealization and depersonalization symptoms, and a more significant history of early-life trauma.[20] Additionally, in response to traumatic reminders, those with "regular" PTSD exhibit an increased heart rate and other measures of sympathetic activation, whereas those with the dissociative subtype demonstrate an opposite pattern,[20] and may have increased depression, anxiety, hostility, and/or sleeping difficulties.[21]

Approximately 70% of patients with PTSD report sleep disturbance, 41% report difficulty initiating sleep, 47% report difficulty maintaining sleep,[22] and 50–70% report recurrent nightmares.[23] Some evidence suggests that sleep disturbance is a risk factor for the development of PTSD following a traumatic event[13,24,25]; and following treatment for PTSD, persistent sleep disturbances are a negative predictor for long-term outcome in various psychopathological and somatic domains.[13,26] However, patients with PTSD report a variety of sleep complaints beyond the core symptoms of insomnia and nightmares.[1] One such complaint

Table 1—A selection of relevant studies.

Ross RJ, et al. *Motor dysfunction during sleep in posttraumatic stress disorder.* Sleep, 1994. 17(8):723-32.	Muscle activity during sleep was studied in a group of Vietnam combat veterans with PTSD and in an age-matched normal control group. The PTSD participants had a higher percentage of REM sleep epochs with at least 1 prolonged twitch burst; they also were more likely to have PLMS. The identification of RBD-like signs in PTSD adds to the evidence for a fundamental disturbance of REM sleep phasic mechanisms in PTSD.[10]
Husain AM, Miller PP, Carwile ST. *REM sleep behavior disorder: potential relationship to posttraumatic stress disorder.* J Clin Neurophysiol, 2001. 18(2):148-157.	A study of 27 military veterans with RBD, 15 were diagnosed with PTSD; the authors suggest that it is possible that similar neuropathologic processes are responsible for both conditions, at times in the same patient.[4]
Kobayashi I, Boarts JM, Delahanty DL. *Polysomnographically measured sleep abnormalities in PTSD: a meta-analytic review.* Psychophysiology, 2007. 44(4):660-669.	A meta-analysis of PSG-monitored sleep in participants with PTSD demonstrated that there was less non-REM sleep, higher REM density, and lighter sleep as compared with controls.[11]
Feemster JC, et al. *Trauma-associated sleep disorder: a posttraumatic stress/rem sleep behavior disorder mash-up?* J Clin Sleep Med, 2019. 15(2):345-349.	The authors report RSWA and other neurological features in a patient with complex vocal and motor DEB following traumatic combat military exposure. The patient demonstrated overlapping clinical features of PTSD and RBD with PSG features of RSWA supportive of idiopathic RBD but not suggesting underlying synucleinopathy.[6]
Ney LJ, et al. *The effect of self-reported REM behavior disorder symptomology on intrusive memories in post-traumatic stress disorder.* Behav Sleep Med, 2020: 1-14.	Reporting on 34 PTSD, 52 trauma-exposed (TE) and 42 non–trauma-exposed (NTE) participants, the PTSD group reported poorer sleep quality and higher RBDSQ scores than both TE and NTE groups and significantly more negative intrusive memories than the NTE group. RBD symptomology is an indicator of consolidation of intrusive memories in PTSD but not TE or NTE participants.[12]
Elliott JE, et al, *Posttraumatic stress disorder increases the odds of REM sleep behavior disorder and other parasomnias in veterans with and without comorbid traumatic brain injury.* Sleep, 2020. 43(3).	These present data lend support that comorbid TBI and PTSD may similarly potentiate symptomology related to RBD; comorbid TBI and PTSD were associated with the highest crude prevalence rate for RBD (21%), prevalence odds ratios (4.59 to 3.43 pending age-adjustment), and prevalence ratios (295–190%).[9]

DEB = dream enactment behavior; PSG, polysomnography; PLMS = periodic limb movements of sleep; PTSD = post-traumatic stress disorder; RBD = rapid eye movement sleep behavior disorder; RBDSQ = RBD screening questionnaire; REM = rapid eye movement; RSWA = rapid eye movement sleep without atonia; TBI = traumatic brain injury.

is DEB, which includes movements or vocalizations, such as kicking, thrashing, or yelling, that are presumed to occur in response to dream content during sleep.[1,27] DEB was previously described as a manifestation of PTSD-related phenomena,[27–28] but the differential diagnosis of DEB is broader and includes other sleep-related conditions such as severe obstructive sleep apnea, periodic limb movement disorder, or RBD.[29]

DEB is considered to be a surrogate marker of altered REM architecture, namely the loss of REM atonia that accompanies RBD,[29] and PTSD can be associated with another DEB-based disorder, known as TASD[6–8] (see section entitled "Trauma-associated sleep disorder").[9] Those with PTSD have been demonstrated to have disturbances in REM sleep,[30] including motor dysfunction,[10] increased activity in the REM-on and wake-promoting regions of the amygdala and medial prefrontal cortex, and corresponding decreased activity in the REM-off and anterior hypothalamic sleep-facilitating regions.[31] The question, however, of whether DEB in a patient with PTSD represents "true" RBD remains open.

The importance of this question is underscored in studies concerning Operation Enduring Freedom/Operation Iraqi Freedom/Operation New Dawn veterans, given the relatively high rates of mild traumatic brain injury (TBI)[32,33] and PTSD[34] reported in these individuals, and the fact either condition may contribute to future neurodegeneration risk.[29] In addition, other factors that may present in these individuals may predispose to RBD, such as antidepressant use and alcohol withdrawal,[35] or are associated with future neurodegeneration—for example, depressive disorders.[36] As such, an exploratory analysis was published recently using data of post-9/11 veterans with high rates of TBI exposures, PTSD, and sleep disturbances.[37,38] In this paper, the authors found recurrent DEB to be most strongly associated with the number of mild TBIs, the severity of global sleep impairment, and increased PTSD symptom severity.[29] Following adjustment for sleep impairment, the association of recurrent DEB with PTSD severity became statistically non-significant, suggesting that the relationship between PTSD severity and recurrent DEB is mediated by the severity of global sleep impairment.[29] Further studies will be needed to determine this exact pathophysiological link between PTSD and DEB, and how that may relate to neurodegenerative risk.

REM SLEEP BEHAVIOR DISORDER

RBD is a parasomnia consisting of elevated muscle tone during REM sleep (REM sleep without atonia; RSWA) combined with a history of recurrent nocturnal DEB.[39] Per the *International Classification of Sleep Disorders*, 3rd edition (ICSD-3), the clinical diagnosis of RBD requires the presence of RSWA on overnight polysomnography (PSG) in conjunction with either sleep-related injurious, potentially injurious, or disruptive behaviors by history, and/or abnormal REM sleep behavior documented during PSG monitoring[40]; there must also be the absence of epileptiform activity, and the sleep disorder cannot be better explained by another sleep disorder, medical or

neurological disorder, mental disorder, medication use, or substance use disorder.[40] RBD is one of the most important diagnostic considerations in a patient with DEB,[29] mostly due to the fact that the presence of RBD can herald the onset of neurodegeneration, most commonly an alpha-synucleinopathy.[35]

Currently, the pathophysiology of RBD is not fully understood,[41] but it has been suggested that brainstem structures contributing to the central autonomic network are involved,[42] as well as other proposed regions, including the primary and premotor cortices, with input from the basal ganglia, or from brainstem or spinal cord motor generators.[43–45] REM sleep physiology[46,47] has been proposed to involve the laterodorsal tegmentum and the pedunculopontine tegmentum, which consist of populations of cholinergic neurons and reside in the pontomesencephalic junction of the brainstem.[48] Through nicotinic and muscarinic acetylcholine projections, the laterodorsal tegmentum and pedunculopontine tegmentum send excitatory signals to neurons in the pontine reticular formation and the mesencephalic reticular formation, which then result in producing the classic characteristics of REM sleep, including muscle atonia.[46]

It has been suggested through several human and animal studies[49–51] that altered noradrenergic functioning exists in the locus coeruleus (LC) and peri-LC nuclei in patients with RBD, which may be the same neuropathologic process demonstrated in patients with alpha-synucleinopathy.[52,53] The association between RBD and subsequent development of an alpha-synucleinopathy is well known,[5] as is the suggested association between neuropsychiatric trauma (ie TBI and/or PTSD) and alpha-synucleinopathy.[34,54–56] It is currently not possible to say whether repeated traumas represent a risk factor for idiopathic RBD or whether RBD associated with PTSD is actually a distinct entity.[57] One hypothesis for this association is that increased noradrenaline turnover can result from repeated traumas, which then may result in its depletion in the LC, which may, in turn, inhibit the cholinergic laterodorsal tegmentum nucleus; hence, LC dysfunction may play a role in both RBD and PTSD[4] as the LC and laterodorsal tegmentum nuclei are involved in REM sleep regulation.[57] This could ultimately result in decreased neuronal output to other REM sleep-modulating nuclei, such as the pedunculopontine and magnocellularis nuclei, thus altering the output of these structures,[58] which are associated with other neuronal groups involved in REM-onset, which also regulate REM sleep atonia.[58,59]

Selective serotonin reuptake inhibitors and selective norepinephrine reuptake inhibitors have well-known associations with RSWA and RBD, and 1 study demonstrated a nearly 10-fold increase in risk for RSWA while taking these medications.[60] It is estimated that the odds ratio of developing RBD is 1.9 with antidepressant use,[61] but the factors that predict the risk of developing RSWA while taking selective serotonin reuptake inhibitors or selective norepinephrine reuptake inhibitors and its prevalence remain unknown.[5] Other medications with known associations to RSWA and RBD include the tricyclic antidepressants[61,62] and case reports have demonstrated acute RBD with the use of monoamine oxidase inhibitors, a beta-adrenergic blocker, and a cholinesterase inhibitor.[63] Although improvement in RSWA and RBD has been noted upon discontinuation of fluoxetine,[64,65] there is a suggestion that antidepressants may "unmask" RBD rather than cause it[66]; moreover, RBD can persist for at least 19 months after discontinuation of selective serotonin reuptake inhibitors.[67] It is unclear whether antidepressant-associated RBD is a benign side effect of the medication or simply a marker of prodromal neurodegenerative disease.[68]

In veterans referred to a sleep center, an RBD prevalence rate of 9% has been reported, mostly commonly in those with comorbid TBI and PTSD.[9] However, the question of whether RBD in veterans with TBI and/or PTSD is in fact "true" RBD, and not TASD (see "Trauma-associated sleep disorder"), is still unclear despite the fact that diagnostic criteria separate TASD from RBD.[9] Of particular importance is that medications such as selective serotonin reuptake inhibitors, selective norepinephrine reuptake inhibitors, and tricyclic antidepressants are frequently used in patients with PTSD and TBI, and at this time it is not clear if the higher rate of RSWA and RBD in PTSD and TASD is independent of antidepressants or not. Expanded studies looking into the relationship between PTSD and RBD, and RBD in general,[69,70] will help answer this question.

TRAUMA-ASSOCIATED SLEEP DISORDER

PTSD can be associated with another distinct sleep disorder, known as TASD,[6–8] which shares the diagnostic criteria for RBD (ie, self or witnessed DEB, and PSG-confirmed evidence of RSWA); thus, only individuals meeting criteria for RBD are potentially eligible to be categorized as having TASD.[9]

The diagnostic criteria proposed for TASD are as follows[7,71]:

1. Inciting traumatic experience
2. A history of altered dream mentation that is related to prior traumatic experience
3. Self or witnessed reports of DEB, including abnormal vocalizations or abnormal motor behaviors in sleep.
4. Symptoms of autonomic hyperarousal or monitoring that demonstrate tachycardia, tachypnea, or diaphoresis not due to sleep-disordered breathing
5. A PSG demonstrating RSWA or DEB in REM sleep
6. Absence of electroencephalographic epileptiform activity on PSG

TASD is distinct from RBD in that individuals with TASD report having an inciting traumatic experience, as well as a history of dream mentation related to this prior traumatic experience, and evidence of autonomic hyperarousal not due to sleep-disordered breathing[7]; additionally, prior work has shown that, while capturing overt DEB in RBD is often very common,[72] it is somewhat uncommon in TASD.[73] However, the possibility remains that TASD and RBD are on the same pathological spectrum.[9] In 1 report,[6] a patient with PTSD demonstrated significantly greater complex DEB that is atypical for a PTSD diagnosis alone; the authors concluded that, due to the complexity of his DEB, the prominence of RSWA, and the absence of hypervigilance and re-experiencing of the event as factors indicating that this was more than PTSD (ie TASD).[6]

The underlying pathophysiology of TASD and how it relates to other parasomnias and PTSD are not well understood. However, it may be that in TASD there exists an overdrive phenomenon, which results in loss of both REM atonia and sympathetic suppression.[7] Hyperactivity in LC and peri-LC regions, due to a traumatic event, may result in RSWA and DEB, as suggested by Mysliwiec et al[7]; in addition, chronic stress, psychiatric and comorbid sleep disorders, and antidepressant use either independently or synergistically may further facilitate RSWA.

There is evidence that a patient's age at the time of trauma exposure may impact the development of TASD; for example, in 1 study, age at time of trauma exposure led to differences in nocturnal symptoms.[73] In this report, avalanche survivors who were children (ages 2–12) at the time of trauma exposure were more likely to endorse DEB 16 years later (relative risk: 3.54), but those who were adults at the time of the exposure reported increased trauma-associated nightmares (relative risk: 2.69) without an increase in DEB.[73] These findings seem to suggest that an immature brain may be particularly susceptible to the development of trauma-related motor pathologies.[74]

PTSD appears to be characterized by hyperadrenergic function of the LC,[4,25] and blockade of this hyperadrenergic function is thought to be the primary mechanism of action of prazosin,[75] also proposed as a potential treatment for TASD, which is the standard treatment for PTSD-associated nightmares.[76] The improvement in symptoms with prazosin could be useful in differentiating TASD from idiopathic RBD, as prazosin would not be expected to be effective in idiopathic RBD (which is typically treated with high-dose melatonin and/or low-dose clonazepam).[6] Furthermore, it suggests that TASD and RBD due to PTSD are probably distinct phenotypes of DEB, not entirely related to idiopathic RBD pathophysiology. As a final point, it should be noted that the criteria for TASD, in which there is a history of altered dream mentation related to a prior traumatic event, are somewhat relaxed in definition and thus open to discrepancies in interpretation. As such, nearly every patient with PTSD may meet these diagnostic criteria on some level, prompting the need for further clarification.

CONCLUSIONS

The symptom of DEB noted in PTSD, RBD, and TASD seems to share somewhat common semiology, despite differences in underlying pathology. While obtaining a better grasp of RBD is paramount given its relationship to the alpha-synucleinopathies, a further understanding of DEB in the context of these 3 conditions may provide clues to uncovering how/why neurodegeneration occurs in some individuals but not others. For example, longitudinal studies may be able to determine that patients with TASD fail to progress to "true" RBD, and thus are at minimal risk of pheno-conversion to alpha-synucleinopathy; a finding such as this would provide valuable clinical insight as well as potentially improved understanding of the mechanisms at play.[9] Regardless, it is clear that more work needs to be done in TASD, and while PTSD and RBD are somewhat well understood, further clarification is of imminent need.

ABBREVIATIONS

DEB, dream enactment behavior
LC, locus coeruleus
PSG, polysomnography
PTSD, post-traumatic stress disorder
RBD, rapid eye movement sleep behavior disorder
REM, rapid eye movement
RSWA, rapid eye movement sleep without atonia
TASD, trauma-associated sleep disorder
TBI, traumatic brain injury

REFERENCES

1. Germain A. Sleep disturbances as the hallmark of PTSD: where are we now? *Am J Psychiatry*. 2013;170(4):372–382.
2. 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.
3. Kobayashi I, Huntley E, Lavela J, Mellman TA. Subjectively and objectively measured sleep with and without posttraumatic stress disorder and trauma exposure. *Sleep*. 2012;35(7):957–965.
4. Husain AM, Miller PP, Carwile ST. Rem sleep behavior disorder: potential relationship to post-traumatic stress disorder. *J Clin Neurophysiol*. 2001;18(2): 148–157.
5. Barone DA, Henchcliffe C. Rapid eye movement sleep behavior disorder and the link to alpha-synucleinopathies. *Clin Neurophysiol*. 2018;129(8):1551–1564.
6. Feemster JC, Smith KL, McCarter SJ, St Louis EK. Trauma-associated sleep disorder: a posttraumatic stress/REM sleep behavior disorder mash-up? *J Clin Sleep Med*. 2019;15(2):345–349.
7. Mysliwiec V, O'Reilly B, Polchinski J, Kwon HP, Germain A, Roth BJ. Trauma associated sleep disorder: a proposed parasomnia encompassing disruptive nocturnal behaviors, nightmares, and REM without atonia in trauma survivors. *J Clin Sleep Med*. 2014;10(10):1143–1148.
8. Rachakonda TD, Balba NM, Lim MM. Trauma-associated sleep disturbances: a distinct sleep disorder? *Curr Sleep Med Rep*. 2018;4(2):143–148.
9. Elliott JE, Opel RA, Pleshakov D, et al. Posttraumatic stress disorder increases the odds of REM sleep behavior disorder and other parasomnias in veterans with and without comorbid traumatic brain injury. *Sleep*. 2020;43(3):zsz237.
10. Ross RJ, Ball WA, Dinges DF,et al. Motor dysfunction during sleep in posttraumatic stress disorder. *Sleep*. 1994;17(8):723–732.
11. Kobayashi I, Boarts JM, Delahanty DL. Polysomnographically measured sleep abnormalities in PTSD: a meta-analytic review. *Psychophysiology*. 2007;44(4): 660–669.
12. Ney LJ, Hsu CMK, Nicholson E, et al. The effect of self-reported rem behavior disorder symptomology on intrusive memories in post-traumatic stress disorder. [published online ahead of print, 2020 January 27]. *Behav Sleep Med*. doi: 10.1080/15402002.2020.1722127.
13. Roepke S, Hansen ML, Peter A, Merkl A, Palafox C, Danker-Hopfe H. Nightmares that mislead to diagnosis of reactivation of PTSD. *Eur J Psychotraumatol*. 2013;4(1):18714.
14. American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders*. 5th ed. American Psychiatric Publishing: Washington, DC; 2013.
15. World Health Organization. International statistical classification of diseases and related health problems. 11th ed. 2019. Available from: https://icd.who.int/. Accessed July 25, 2020.
16. Karatzias T, Cloitre M, Maercker A, et al. PTSD and complex PTSD: ICD-11 updates on concept and measurement in the UK, USA, Germany and Lithuania. *Eur J Psychotraumatol*. 2017;8(Suppl 7):1418103.
17. Maercker A, Brewin CR, Bryant RA, et al. Proposals for mental disorders specifically associated with stress in the International Classification of Diseases-11. *Lancet*. 2013;381(9878):1683–1685.

18. Cloitre M, Garvert DW, Brewin CR, Bryant RA, Maercker A. Evidence for proposed ICD-11 PTSD and complex PTSD: a latent profile analysis. *Eur J.Psychotraumatol.* 2013;4(1):20706.
19. Bisson J, Andrew M. Psychological treatment of post-traumatic stress disorder (PTSD). *Cochrane Database Syst Rev.* 2007;18(3):CD003388.
20. van Huijstee J, Vermetten E. The dissociative subtype of post-traumatic stress disorder: research update on clinical and neurobiological features. *Curr Topics Behav Neurosci.* 2018;38:229–248.
21. Armour C, Elklit A, Lauterbach D, Elhai JD. The DSM-5 dissociative-PTSD subtype: can levels of depression, anxiety, hostility, and sleeping difficulties differentiate between dissociative-PTSD and PTSD in rape and sexual assault victims? *J Anxiety Disord.* 2014;28(4):418–426.
22. Ohayon MM, Shapiro CM. Sleep disturbances and psychiatric disorders associated with posttraumatic stress disorder in the general population. *Compr Psychiatry.* 2000;41(6):469–478.
23. Lamarche LJ, De Koninck J. Sleep disturbance in adults with posttraumatic stress disorder: a review. *J Clin Psychiatry.* 2007;68(8):1257–1270.
24. Harvey AG, Bryant RA. The relationship between acute stress disorder and posttraumatic stress disorder: a prospective evaluation of motor vehicle accident survivors. *J Consult Clin Psychol.* 1998;66(3):507–512.
25. Mellman TA, Kulick-Bell R, Ashlock LE, Nolan B. Sleep events among veterans with combat-related posttraumatic stress disorder. *Am J Psychiatry.* 1995;152(1): 110–115.
26. Belleville G, Guay S, Marchand A. Persistence of sleep disturbances following cognitive-behavior therapy for posttraumatic stress disorder. *J Psychosom Res.* 2011;70(4):318–327.
27. Germain A, Hall M, Krakow B, Katherine Shear M, Buysse DJ. A brief sleep scale for posttraumatic stress disorder: Pittsburgh Sleep Quality Index Addendum for PTSD. *J Anxiety Disord.* 2005;19(2):233–244.
28. Insana SP, Hall M, Buysse DJ, Germain A. Validation of the Pittsburgh Sleep Quality Index Addendum for posttraumatic stress disorder (PSQI-A) in U.S. male military veterans. *J Trauma Stress.* 2013;26(2):192–200.
29. Jones MB, Jeevan S, Wang J, et al. Clinical correlates of dream enactment behaviors in previously deployed OEF/OIF/OND veterans: an exploratory analysis. *J Neuropsychiatry Clin Neurosci.* 2020;32(2):147–153.
30. Ross RJ, Ball WA, Dinges DF, et al. Rapid eye movement sleep disturbance in posttraumatic stress disorder. *Biol Psychiatry.* 1994;35(3):195–202.
31. Germain A, Buysse DJ, Nofzinger E. Sleep-specific mechanisms underlying posttraumatic stress disorder: integrative review and neurobiological hypotheses. *Sleep Med Rev.* 2008;12(3):185–195.
32. Gardner RC, Byers AL, Barnes DE, Li Y, Boscardin J, Yaffe K. Mild TBI and risk of Parkinson disease: a Chronic Effects of Neurotrauma Consortium study. *Neurology.* 2018;90(20):e1771–e1779.
33. Postuma RB, Montplaisir JY, Pelletier A, et al. Environmental risk factors for REM sleep behavior disorder: a multicenter case-control study. *Neurology.* 2012; 79(5):428–434.
34. Chan YE, Bai YM, Hsu JW, et al. Post-traumatic stress disorder and risk of Parkinson disease: a nationwide longitudinal study. *Am J Geriatr Psychiatry.* 2017; 25(8):917–923.
35. St Louis EK, Boeve BF. REM sleep behavior disorder: diagnosis, clinical implications, and future directions. *Mayo Clin Proc.* 2017;92(11):1723–1736.
36. Gustafsson H, Nordström A, Nordström P. Depression and subsequent risk of Parkinson disease: a nationwide cohort study. *Neurology.* 2015;84(24):2422–2429.
37. DeGutis J, Chiu C, Thai M, Esterman M, Milberg W, McGlinchey R. Trauma sequelae are uniquely associated with components of self-reported sleep dysfunction in OEF/OIF/OND veterans. *Behav Sleep Med.* 2018;16(1):38–63.
38. McGlinchey RE, Milberg WP, Fonda JR, Fortier CB. A methodology for assessing deployment trauma and its consequences in OEF/OIF/OND veterans: the TRACTS longitudinal prospective cohort study. *Int J Methods Psychiatr Res.* 2017;26(3);e1556.
39. Schenck CH, Bundlie SR, Ettinger MG, Mahowald MW. Chronic behavioral disorders of human REM sleep: a new category of parasomnia. *Sleep.* 1986;9(2): 293–308.
40. American Academy of Sleep Medicine. *International Classification of Sleep Disorders*. 3rd ed. Darien, IL: American Academy of Sleep Medicine; 2014.
41. Gagnon JF, Postuma RB, Mazza S, Doyon J, Montplaisir J. Rapid-eye-movement sleep behaviour disorder and neurodegenerative diseases. *Lancet Neurol.* 2006;5(5):424–432.
42. Lanfranchi PA, Fradette L, Gagnon JF, Colombo R, Montplaisir J. Cardiac autonomic regulation during sleep in idiopathic REM sleep behavior disorder. *Sleep.* 2007;30(8):1019–1025.
43. Grillner S, Zangger P. On the central generation of locomotion in the low spinal cat. *Exp Brain Res.* 1979;34(2):241–261.
44. Noga BR, Kettler J, Jordan LM. Locomotion produced in mesencephalic cats by injections of putative transmitter substances and antagonists into the medial reticular formation and the pontomedullary locomotor strip. *J Neurosci.* 1988;8(6): 2074–2086.
45. Blumberg MS, Lucas DE. Dual mechanisms of twitching during sleep in neonatal rats. *Behav Neurosci.* 1994;108(6):1196–1202.
46. Ng M, Pavlova M. Why are seizures rare in rapid eye movement sleep? Review of the frequency of seizures in different sleep stages. *Epilepsy Res Treat.* 2013; 2013:932790.
47. Barone DA, Krieger AC. Muscle Tone Control of REM Sleep. In: Chelsea L. Saylor, ed. *REM Sleep: Characteristics, Disorders, and Physiological Effects*. Hauppauge, NY: Nova Science Publishers; 2014.
48. Mitani A, Ito K, Hallanger AE, Wainer BH, Kataoka K, McCarley RW. Cholinergic projections from the laterodorsal and pedunculopontine tegmental nuclei to the pontine gigantocellular tegmental field in the cat. *Brain Res.* 1988;451(1-2): 397–402.
49. Naegeli C, Zeffiro T, Piccirelli M, et al. Locus coeruleus activity mediates hyperresponsiveness in posttraumatic stress disorder. *Biol. Psychiatry.* 2018; 83(3):254–262.
50. Vanderheyden WM, Poe GR, Liberzon I. Trauma exposure and sleep: using a rodent model to understand sleep function in PTSD. *Exp Brain Res.* 2014;232(5): 1575–1584.
51. Pietrzak RH, Gallezot JD, Ding YS, et al. Association of posttraumatic stress disorder with reduced in vivo norepinephrine transporter availability in the locus coeruleus. *JAMA Psychiatry.* 2013;70(11):1199–1205.
52. Boeve BF. REM sleep behavior disorder: updated review of the core features, the REM sleep behavior disorder-neurodegenerative disease association, evolving concepts, controversies, and future directions. *Ann N Y Acad Sci.* 2010; 1184(1):15–54.
53. Boeve BF, Silber MH, Ferman TJ, et al. REM sleep behavior disorder and degenerative dementia: an association likely reflecting Lewy body disease. *Neurology.* 1998;51(2):363–370.
54. Crane PK, Gibbons LE, Dams-O'Connor K, et al. Association of traumatic brain injury with late-life neurodegenerative conditions and neuropathologic findings. *JAMA Neurol.* 2016;73(9):1062–1069.
55. Camacho-Soto A, Warden MN, Searles Nielsen S, et al. Traumatic brain injury in the prodromal period of Parkinson's disease: a large epidemiological study using medicare data. *Ann Neurol.* 2017;82(5):744–754.
56. Collins JM, Woodhouse A, Bye N, Vickers JC, King AE, Ziebell JM. Pathological links between traumatic brain injury and dementia: australian pre-clinical research. *J Neurotrauma.* 2020;37(5):782–791.
57. Manni R, Ratti PL, Terzaghi M. Secondary "incidental" REM sleep behavior disorder: do we ever think of it? *Sleep Med.* 2011;12(Suppl 2):S50–S53.
58. Garcia-Rill E. Disorders of the reticular activating system. *Med Hypotheses.* 1997;49(5):379–387.
59. Bracha HS, Garcia-Rill E, Mrak RE, Skinner R. Postmortem locus coeruleus neuron count in three American veterans with probable or possible war-related PTSD. *J Neuropsychiatry Clin Neurosci.* 2005;17(4):503–509.
60. Lee K, Baron K, Soca R, Attarian H. The prevalence and characteristics of REM sleep without atonia (RSWA) in patients taking antidepressants. *J Clin Sleep Med.* 2016;12(3):351–355.
61. Hoque R, Chesson AL Jr. Pharmacologically induced/exacerbated restless legs syndrome, periodic limb movements of sleep, and REM behavior disorder/REM sleep without atonia: literature review, qualitative scoring, and comparative analysis. *J Clin Sleep Med.* 2010;6(1):79–83.

62. Manni R, Terzaghi M, Glorioso M. Motor-behavioral episodes in REM sleep behavior disorder and phasic events during REM sleep. *Sleep*. 2009;32(2): 241–245.
63. Yeh SB, Yeh PY, Schenck CH. Rivastigmine-induced REM sleep behavior disorder (RBD) in a 88-year-old man with Alzheimer's disease. *J Clin Sleep Med.* 2010;6(2):192–195.
64. Parish JM. Violent dreaming and antidepressant drugs: or how paroxetine made me dream that I was fighting Saddam Hussein. *J Clin Sleep Med.* 2007;3(5): 529–531.
65. Applebee GA, Attarian HP, Schenck CH. An angry bed partner. *J Clin Sleep Med.* 2009;5(5):477–479.
66. Postuma RB, Lanfranchi PA, Blais H, Gagnon JF, Montplaisir JY. Cardiac autonomic dysfunction in idiopathic REM sleep behavior disorder. *Mov Disord.* 2010;25(14):2304–2310.
67. Winkelman JW, James L. Serotonergic antidepressants are associated with REM sleep without atonia. *Sleep*. 2004;27(2):317–321.
68. Postuma RB, Gagnon JF, Montplaisir JY. REM sleep behavior disorder and prodromal neurodegeneration—where are we headed? [published online ahead of print, 2013 March 26] *Tremor Other Hyperkinet Mov (N Y)*. doi: 10.7916/D8N879HS.
69. Postuma RB, Iranzo A, Hu M, et al. Risk and predictors of dementia and parkinsonism in idiopathic REM sleep behaviour disorder: a multicentre study. *Brain*. 2019;142(3):744–759.
70. Barone DA, Wang F, Ravdin L, et al. Comorbid neuropsychiatric and autonomic features in REM sleep behavior disorder. *Clinical Parkinsonism & Related Disorders*. 2020;3
71. Mysliwiec V, Brock MS, Creamer JL, O'Reilly BM, Germain A, Roth BJ. Trauma associated sleep disorder: a parasomnia induced by trauma. *Sleep Med Rev.* 2018; 37:94–104.
72. Fernández-Arcos A, Iranzo A, Serradell M, Gaig C, Santamaria J. The clinical phenotype of idiopathic rapid eye movement sleep behavior disorder at presentation: a study in 203 consecutive patients. *Sleep*. 2016;39(1):121–132.
73. Thordardottir EB, Hansdottir I, Valdimarsdottir UA, Shipherd JC, Resnick H, Gudmundsdottir B. The manifestations of sleep disturbances 16 years post-trauma. *Sleep*. 2016;39(8):1551–1554.
74. Brock MS, Powell TA, Creamer JL, Moore BA, Mysliwiec V. Trauma associated sleep disorder: clinical developments 5 years after discovery. *Curr Psychiatry Rep.* 2019;21(9):80.
75. Raskind MA, Peskind ER, Hoff DJ, et al. A parallel group placebo controlled study of prazosin for trauma nightmares and sleep disturbance in combat veterans with post-traumatic stress disorder. *Biol Psychiatry*. 2007;61(8): 928–934.
76. Raskind MA, Dobie DJ, Kanter ED, Petrie EC, Thompson CE, Peskind ER. The alpha1-adrenergic antagonist prazosin ameliorates combat trauma nightmares in veterans with posttraumatic stress disorder: a report of 4 cases. *J Clin Psychiatry*. 2000;61(2):129–134.

SUBMISSION & CORRESPONDENCE INFORMATION

Submitted for publication May 1, 2020
Submitted in final revised form August 6, 2020
Accepted for publication August 6, 2020
Address correspondence to: Daniel A. Barone, MD, Associate Professor of Clinical Neurology, Weill Cornell Medical College, Center for Sleep Medicine, 425 East 61st 5th Floor, New York, NY, 10065; Tel: (646) 962-7378; Fax: (646) 962-0455; Email: dab9129@med.cornell.edu

DISCLOSURE STATEMENT

The author has seen and approved this manuscript. This work was performed at Weill Cornell Medical College, New York, New York. This study was funded by private grant support. The author reports no conflicts of interest.