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Sleep Disturbances Among Combat Military Veterans: A Comparative Study Using Subjective and Objective Sleep Assessments

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The sleep characteristics of 37 military veterans and active-duty service members (17 with PTSD and 20 without PTSD) of recent wars were analyzed to determine if combat deployment, with its associated sleep restriction, may be an alternative explanation for the sleep complaints found among combat veterans with PTSD (as determined by PTSD Checklist Military Version scores). Over a 1-week period, sleep data were collected using sleep actigraphy and self-report. Across the entire sample, subjective and objective assessment methods of sleep were strongly correlated, although there were some notable within-group differences. Specifically, although sleep duration between groups did not differ based on actigraphy, veterans without PTSD reported sleeping 1 h and 11 min ($p = .002$) longer than did veterans with PTSD. In an effort to determine why individuals without PTSD might be overreporting sleep, we found that symptoms of emotional arousal (anger, anxiety, and nightmares) were significantly correlated with self-reported sleep duration, suggesting a pattern of higher autonomic arousal found in veterans with PTSD. Thus, although sleeping for 6 h, the higher levels of emotional arousal reported by veterans with PTSD may mean that they do not perceive their sleep as restful. Further research is necessary to determine if the sleep architecture of veterans with PTSD is actually different from that of combat veterans without PTSD and if such differences are actually amenable to standard behavioral treatments for this disorder.

Keywords: veterans, PTSD, sleep, actigraphy, OEF/OIF/OND

Posttraumatic stress disorder (PTSD) is common among Operation Iraqi Freedom (OIF), Operation Enduring Freedom (OEF), or Operation New Dawn (OND) combat veterans and active-duty service members; it constitutes the third most common reason for filing a disability claim (McNally & Frueh, 2013). Symptoms of PTSD such as numbing; hypervigilance; flashbacks; and avoidance of people, places, and events that remind them of their trauma not only create emotional distress but also lead to significant social and occupational impairment. Sleep disturbances, particularly nightmares and insomnia, are among the primary complaints of veterans with PTSD. Examining the sleep diaries of 105 Vietnam veterans, greater PTSD

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severity positively correlated with poorer sleep, including delayed sleep onset, reduced sleep duration, restlessness, and increased nightmares (Gehrman, Harb, Cook, Barilla, & Ross, 2015). Numerous studies have reported positive correlations with sleep difficulties and severity of PTSD symptoms; in addition, some studies suggest that sleep difficulties may exacerbate other distressing PTSD symptoms such as increasing overall irritability and reducing concentration (see Pace-Schott, Germain, & Milad, 2015, for a full review of sleep disturbance in the pathophysiology of PTSD).

When evaluating sleep studies, the manner in which sleep quantity and sleep quality is assessed merits consideration. In healthy samples, correlations between self-reported and actigraphy-derived total sleep time are as low as $r =$ .45 (Lauderdale, Knutson, Yan, Liu, & Rathouz, 2008), and, in that particular study, participants over self-reported by an average of 48 min. With respect to military populations, few studies have actually compared self-report with actigraphy sleep data in veterans and active-duty service members with (or without) combat-related PTSD. In one study, veterans of the Iran-Iraq war (1980–1988) with chronic PTSD underreported their sleep duration by a difference of 2.9 h as compared with actigraphy (Ghadami, Khaledi-Paveh, Nasouri, & Khazaie, 2015), whereas in another investigation (Westermeyer et al., 2007), Vietnam-era veterans underreported their sleep duration by 51 min. However, both of these studies had several limitations. First, both samples consisted of older veterans with a mean age of 50.4 and 54.76 years (range of 34–80), and sleep complaints are more common in older than young people (Foley, Ancoli-Israel, Britz, & Walsh, 2004), whether or not they served in the military or have a diagnosis of PTSD. Second, not all veterans were diagnosed with current PTSD at the time of the study; some only had a lifetime PTSD diagnosis. Third, when the sleep of veterans with PTSD is compared to that of veterans without PTSD, there is often no attention given to either the type of PTSD (combat-related, sexual assault, training accidents, etc.) or the specifics of the control group, such as combat history or deployment status. Lack of attention to these variables limits our understanding of self-reported sleep complaints in veterans, particularly in young veterans with PTSD.

When assessing sleep, the specific characteristics of the comparison group are critical because the more closely the comparison group resembles the group of interest, the more useful the comparison will be. Most sleep studies to date have been based on older samples, and the comparison group is typically described as "veterans without PTSD" but further undefined. However, although disturbed sleep is part of the diagnostic criteria for PTSD, standard military operations also might impact sleep patterns (e.g., Lewis, Creamer, & Failla, 2009). One such factor is deployment. In addition to reduced sleep opportunity when deployed, sleeping in an unfamiliar environment, hypervigilance for threat/attacks, hazardous working conditions, and inconsistent work hours may produce poor sleep quality overall (Miller, Matsangas, & Shattuck, 2008; Seelig et al., 2010). In fact, several investigations have found that, in comparison to veterans without a deployment history, combat veterans, both with and without PTSD, report inadequate sleep (e.g., because of difficulty falling or staying asleep) and a reduction in overall sleep quality (Miller, Matsangas, & Shattuck, 2008; Mysliwiec et al., 2013; Peterson, Goodie, Satterfield, & Brim, 2008). These data suggest that sleep disruption may not be specific to personnel with combat-related PTSD but may exist among deployed personnel regardless of incidence of trauma and highlight the need for carefully documented comparison groups.

Even among troops who are deployed, only a percentage will engage in combat operations. Even if it does not result in the symptom cluster known as PTSD, traumatic events can produce disturbed sleep, which may or may not remit with time. Thus, if we intend to truly understand sleep difficulties among veterans with combat-related PTSD, the most appropriate comparison group would be veterans who engaged in combat operations but who did not develop PTSD. To our knowledge, no such study has been conducted.

In addition to the heuristic value of using a comparison group closely matched in terms of deployment and combat experience, complaints of insomnia commonly persist after evidence-based treatment for PTSD in both veteran and active-duty populations (e.g., Pruiksma et al., in press). In that investigation, even among participants who no longer met diagnostic criteria for

PTSD at posttreatment, 57% still reported insomnia. Although these authors suggest that insomnia may be affected by factors such as poor sleep schedules, poor stimulus control, and dysfunctional beliefs about sleep ("If I don't sleep, I won't have nightmares"), another factor may be that sleep dysfunction (particularly insomnia) may be an aftereffect of deployment and combat operations and not simply a symptom of PTSD. In the case of combat-related PTSD, one way to begin to disentangle the relationship of sleep and PTSD is the use of a comparison group with similar deployment and combat experiences.

In summary, the presence of sleep complaints among armed services personnel returning from OIF/OEF/OND diagnosed with PTSD is well established, but understanding is limited in several important ways. First, whether and how the sleep patterns/disturbances of veterans with PTSD might differ from service members who also deployed, and in turn experienced similar sleep-related restrictions and stressors, but who do not meet criteria for PTSD, remains unknown. Second, even when treatment is successful in removing the diagnosis of combat-related PTSD, many individuals continue to report insomnia. Thus, it is unclear whether sleep complaints among combat veterans is simply a particularly intransient symptom or whether other aspects of military operations may impact sleep patterns, creating a long-lasting change in typical sleep patterns. Therefore, the present study had two primary aims. The first aim was to determine whether combat veterans with PTSD or without PTSD could accurately estimate their sleep duration by comparing their self-report to actigraphy. From a clinical perspective, understanding the relationship between self-report and objective report is important inasmuch as most randomized clinical trials and clinical practice rely on self-report of sleep as an indicator of therapeutic efficacy. Thus, knowing the accuracy of self-reported sleep duration when compared to actigraphy would inform clinicians of the utility of the information provided. We hypothesized that despite diagnostic category, self-reported sleep duration would be correlated with actigraphy data but that self-report would underestimate sleep duration.

The second specific aim was to compare sleep disruption (based on actigraphy and self-report variables) between veterans with and without PTSD, all of who had experienced life-threatening combat events during their OIF/OEF/OND deployment. We hypothesized that, although both groups would experience sleep disruption, individuals with combat-related PTSD would experience greater sleep disruption.

Method

Participants

Forty-eight military personnel who returned from deployment as part of OIF/OEF/OND operations participated in the study. Seven combat veterans with PTSD (PTSD group) and four without PTSD (no PTSD group) were not included in the analysis because they either failed to wear the actigraphy watch for at least 3 nights or they did not fill out the sleep self-report. Thus, the final sample consisted of 17 participants who met *Diagnostic and Statistical Manual of Mental Disorders* (*DSM*) criteria for current, combat-related PTSD and 20 participants who were combat deployed (see Table 1) but did not meet criteria for combat-related PTSD in their lifetime. No participants in either group had PTSD as a result of any other type of trauma. Participants with comorbid psychotic disorders or acute substance abuse disorders were excluded, and participants were excluded if they were taking benzodiazepines or other medications specifically to promote sleep or linked to excessive drowsiness (Ambien, Prazosin, and Trazodone) from this sleep study. Other exclusionary criteria included homelessness, substance abuse disorders, and major sleep disorders (sleep apnea, periodic limb movement) based on the participants' self-report.

Participants with PTSD were drawn from an ongoing clinical trial conducted at a specialized center for PTSD at the University of Central Florida (UCF RESTORES). Participants with PTSD met A1 criteria for a combat-related trauma and met all other criteria for *DSM–IV–TR* PTSD. In addition, given the high comorbidity rates of mild traumatic brain injury (mTBI), five veterans with PTSD who reported they were diagnosed with a mTBI were included; however, veterans were excluded if they were diagnosed with a moderate or severe TBI.

Table 1
Demographic Characteristics

Characteristic	With PTSD, *M* (*SD*)	Without PTSD, *M* (*SD*)	*t* tests/χ^2
Age (years)	34.29 (5.81)	29.40 (4.25)	$t = 2.96^{**}$
Time served in combat (months)	17 (6.96)	16.78 (4.95)	$t = 0.12$
Sex			$\chi(2) = 0.030$
Males	15	18	
Females	2	2	
Race/ethnicity			$\chi(5) = 2.479$
Caucasian	9	14	
Hispanic	5	2	
African American	1	2	
Asian	2	2	
Branch			$\chi(3) = 4.453$
Army	14	10	
U.S. Marine Corps	3	9	
Navy	0	1	
Employment status			$\chi(2) = 9.85^{**}$
Employed	9	12	
Unemployed	6	0	
Full-time college	2	8	
Highest rank obtained			$\chi(4) = 0.096$
E4	9	10	
E5	6	8	
E7	1	1	
O3	1	1	
Marital status			$\chi(4) = 5.04$
Single	5	10	
Married	7	9	
Separated	2	1	
Divorced	3	0	

** $p < .01$.

Participants without PTSD also were previously combat deployed OEF/OIF/OND veterans who documented their combat operational status by providing (a) their combat Military Occupancy Specialty (MOS) and/or (b) other evidence that they served in combat operations (e.g., qualification for a Combat Action Ribbon [CAR] or similar combat qualification). Specifically, to qualify for a CAR, the veteran "must have rendered satisfactory performance under enemy fire while actively participating in a ground or surface engagement . . . direct exposure to . . . [and/or took] direct action to disable, render safe, or destroy an active enemy-emplaced IED, mine, or scatterable munition" (www.marines.mil). Thus, this non-PTSD comparison group consisted of veterans who had engaged in combat operations similar (or identical) to the participants with combat-related PTSD. Although a full diagnostic interview was not administered for the non-PTSD group, none of the participants in this comparison group reported having TBI or treatment for any psychiatric condition, and none were taking any psychiatric medications.

Measures

Assessment for the presence of PTSD was determined by the Clinician-Administered PTSD Scale for *DSM–IV* (CAPS; Blake et al., 1995). The CAPS evaluates the frequency and intensity of the 17 *DSM–IV* PTSD symptoms on a 0 to 4 Likert scale. Specifically, it scores the symptoms derived from the three *DSM–IV* subscales—reexperiencing (Criterion B), avoidance and numbing (Criterion C), and hyperarousal (Criterion D)—by summing the frequency and intensity scores for relevant individual items. It is a widely used instrument with excellent psychometric properties (Weathers, Keane, & Davidson, 2001). The CAPS was administered either in person or via telephone by licensed clinical psychologists, postdoctoral fellows, or by supervised senior doctoral students to all veterans with PTSD; however, not all veterans without PTSD were administered the CAPS.

The severity of symptoms associated with PTSD was additionally obtained through the PTSD Checklist Military Version (PCL-M; Weathers, Litz, Herman, Huska, & Keane, 1993). It is a 17-item self-report measure that obtains how much the combat veteran was bothered by each symptom in the past month. A 5-point Likert-scale allows the participant to rate the symptom severity on a scale from 1 (*not at all*) to 5 (*extremely*). The PCL-M is highly correlated with the CAPS (.93; Blanchard, Jones-Alexander, Buckley, & Forneris, 1996) and has good reliability and validity (Wilkins, Lang, & Norman, 2011). Because not all participants were administered the CAPS, the PCL-M was used in the final analysis.

Micro Sleep Watch actigraphs (Ambulatory Monitoring, Inc., Ardsley, New York) were used to objectively measure sleep. The device is worn on the wrist and continually records movement. Data are then downloaded and analyzed using a validated computer-generated algorithm for detecting sleep versus wake periods. Actigraphy shows high correlation (.97) with polysomnography (Jean-Louis et al., 1996), and actigraphs are considered "valid and reliable devices for detecting sleep/wake diurnal patterns" (Cellini, Buman, McDevitt, Ricker, & Mednick, 2013). Specific sleep variables analyzed from actigraphy recordings included (a) total sleep minutes (amount of actual sleep time during the time in bed), (b) wake after sleep onset (WASO; total wake minutes from sleep onset to final morning awakening), (c) sleep efficiency (total sleep minutes divided by total time in bed), (d) sleep onset latency (time period from "lights out," or bedtime as indicated by event markers, to sleep onset), and (e) time in bed (minutes from bedtime to final morning awakening).

The Pittsburgh Sleep Quality Index Addendum (PSQI-A; Germain, Hall, Krakow, Shear, & Buysse, 2005) is a self-report instrument that assesses sleep quality and disturbances over a 1-month time interval, specifically assessing the disruptive nocturnal behaviors that are associated with PTSD to include hot flashes, general nervousness, trauma- and nontrauma-related nightmares, anxiety unrelated to trauma, awakening in terror, and acting out a dream (Germain et al., 2005). Overall, higher PSQI-A ratings are highly correlated with greater PTSD severity, and, when attempting to identify male military veterans with current PTSD, one study reported a 71% sensitivity rate and a 76% specificity rate (Insana, Hall, Buysse, & Germain, 2013).

Participants completed a paper-and-pencil sleep log (recording total sleep time in hours and minutes) and an activity log for 7 days. The activity log allowed the participants to record frequency of nightmares, flashbacks, verbal rage episodes, and physical rage episodes. The form also included global rating scales for anxiety and anger, which were rated on a 10-point scale ranging from 1 (*no anger*) to 5 (*moderate anger*) to 10 (*most angry you have ever been*). The frequency of verbal and physical rage episodes were also assessed via the activity log.

Power Analysis

An appropriate sample size was determined using GPower 3.1 software (Faul, Erdfelder, Buchner, & Lang, 2009; Faul, Erdfelder, Lang, & Buchner, 2007). On the basis of PSQI Global Sleep Scores from a previous study examining sleep in combat veterans (Lewis et al., 2009), an effect size of 1.1 was entered for the analysis of sleep differences in combat veterans. For an effect size of 1.10, $\alpha = .05$, power $(1\ \beta) = .80$, two groups, and five response variables (main indices for actigraphy), 20 total participants (10 in each group) will be needed for an independent sample t test to detect differences and reliably reject the null hypothesis. Therefore, this study has adequate power.

Procedure

All participants were recruited through flyers, radio advertisements, websites, and military-oriented outreach events. A telephone screen was used to determine eligibility. Those deemed eligible were invited to the clinic to participate in the study. The CAPS was used for all veterans with PTSD as part of a larger study occurring at the same research center; however, the CAPS was only used for some of the veterans without PTSD. Participants were administered the CAPS to confirm the presence or absence of PTSD. After completing the CAPS, the participant completed the PCL-M and the PSQI-A. If the participant did not complete the CAPS, then the PCL-M was used to confirm the presence or absence of PTSD. Participants were also instructed on the proper use of the actigraph and the daily self-report sleep log. After returning the actigraph, participants with PTSD began treatment and participants without PTSD were compensated with a $25 gift card for their participation. Veterans with PTSD were not given the $25 gift card because they receive $50 for completing a more comprehensive assessment before they began their treatment.

Results

Preliminary Analyses

An examination of sleep latency scores (amount of time spent in bed until asleep as determined by a consistent reduction of movement) indicated one significant outlier—one veteran had a sleep latency score of 57 min whereas all others were 7 min or less. Follow-up inquiry revealed that the long sleep latency was due to sleep training an infant. Therefore, that veteran's sleep latency score was not included in the analysis. Thus, a total of 37 combat veterans provided adequate data for inclusion; the 17 veterans with PTSD recorded sleep using actigraphy for 5.88 nights, whereas the 20 veterans without PTSD did so for an average of 6.75 nights. This difference was not statistically significant.

Demographics of the two groups are listed in Table 1. A series of *t* tests and χ^2 analyses revealed a significant group difference for age and employment. Specifically, veterans with PTSD were older ($M = 34.29$ years vs. $M = 29.40$ years; $t(35) = -2.96$, $p = .006$) and more likely to be unemployed (35% vs. 0%, $\chi(2) = 9.85$, $p = .007$) than the non-PTSD group. Preliminary analyses of covariance (ANCOVAs) determined that age and employment were not significant covariates for any of the dependent variables and thus, unadjusted data were used for the analysis than those without PTSD. All analyses were conducted with and without using age and employment as a covariate. There were no differences in outcome when covarying for age and/or employment, and the results are presented in Table 1 with age and employment as covariates.

As expected, an independent-sample *t* test indicated that PCL-M scores were significantly higher for the PTSD group ($M = 60.82$, $SD = 16.13$) than the non-PTSD group ($M = 25.45$, $SD = 8.01$; $t(37) = -8.648$, $p < .000$). Likewise, an independent-sample *t* test indicated that CAPS total scores were significantly higher for the PTSD group ($M = 82.59$, $SD = 26.57$) than the non-PTSD group ($M = 17.87$, $SD = 15.28$; $t(32) = -8.292$, $p < .000$, $d = .35$).

Aim 1: Determine extent to which sleep self-report corresponds with actigraphy in a sample of veterans with combat-exposure. The primary hypothesis was that despite diagnostic category, self-reported sleep duration would be correlated with actigraphy data but that self-report would underestimate sleep duration. Across all participants, the two methods were moderately correlated, $r = .49$, $n = 37$, $p < .01$. A paired-sample *t* test indicated that there was a significant difference in number of minutes of sleep duration when assessed by self-report ($M = 403.72$ min, $SD = 82.47$ min) versus actigraphy ($M = 366.61$ min, $SD = 52.20$ min; $t(36) = -3.10$, $p = .004$). Participants overestimated their sleep duration by an average of 37.1 min.

For veterans without PTSD, there was a significant, moderate correlation between self-report of sleep duration and actigraphy data, $r = .36$, $p < .01$. Self-reported sleep duration ($M = 440.2$ min, $SD = 43.8$) was significantly longer than duration recorded by actigraphy ($M = 371.4$ min, $SD = 38.3$; $t(19) = -6.591$, $p = .000$); they overestimated their sleep time by 1 h and 9 min. In contrast, for veterans with PTSD, sleep duration assessed via actigraphy ($M = 361.0$ min, $SD = 65.7$ min) was not significantly different from self-reports ($M = 360.8$ min, $SD = 97.0$ min; $t(16) = .005$, $p = .996$), and the two methodologies were not significantly correlated ($r = .361$). Finally, an *r* to z transformation for these two correlations found that they were not statistically significant, $z = .69$, $p = .25$.

Aim 2: Compare sleep disruption (based on actigraphy and self-report variables) in a sample of veterans, all of who had experienced life-threatening combat events during their OIF/OEF/OND deployment. The second hypothesis was that the veterans with PTSD would report more sleep disruption than veterans without PTSD. On the basis of actigraphy, there were no significant group differences on objective measures of sleep, including sleep duration, WASO scores (awake time in minutes that occurred between sleep onset and final awakening), sleep efficiency, or sleep latency for veterans with or without PTSD (see Tables 2 and 3).

In contrast, veterans with PTSD self-reported significantly less sleep than veterans without PTSD (M = 360.85 min, SD = 97.03 min vs. M = 440.16 min, SD = 43.77 min; $t(35) = 3.289$, $p = .002$); veterans with PTSD reported 6 h and 9 min of sleep compared with 7 h and 20 min reported by veterans without PTSD, a difference of 1 h and 11 min.

In addition to sleep duration, we examined group differences on the activity log and the PSQI-A (see Table 4). Veterans with PTSD reported significantly more nightmares and flashbacks per week and had significantly higher daily ratings of anxiety and anger than veterans without PTSD (see Table 4). Veterans with PTSD also had significantly greater scores on the PSQI-A, which is indicative of poorer overall sleep quality ($\mu = 10.65$, $SD = 4.42$) versus ($\mu = 2.70$, $SD = 2.64$; $t(35) = -6.76$, $p = .000$). An examination of the individual items comprising the PSQI-A revealed significant group differences for all items except for two questions: Question 1-e, which was a question about how many bad dreams not related to traumatic memories did the rater have in the past month, and Item 2-c, which was what time of night did most memories/nightmares occur (see Table 4).

Exploratory Analysis of Sleep Report Accuracy and Emotional Arousal

The fact that the group with PTSD accurately estimated their sleep duration whereas the group without PTSD overestimated their sleep duration merits further consideration. One hypothesis is that the emotional arousal that is part of the PTSD symptom picture creates a state of hypervigilance with respect to somatic states. To examine whether emotional arousal was related to the ability to accurately estimate sleep duration, we first constructed an index of sleep estimation by subtracting self-report of sleep duration from actigraphy sleep duration. Thus, scores closer to zero indicated an accurate estimation of one's sleep duration, higher scores on this index represented overestimation of actual sleep, and negative scores represented underestimation. We then correlated this index with the items on the PSQI-A (many of which question difficulty sleeping due to emotional arousal) and to the following behaviors on the activity log related to arousal: total nightmares, global anger, global anxiety, and flashbacks (see Table 5). Groups were collapsed to allow for sufficient number of participants for correlational purposes.

The results indicated several statistically significant, and negative, correlations between sleep estimations and emotional arousal. On the PSQI-A, Items 1-b (trouble sleeping because feeling general nervousness; $r = -.32$, $p = .05$), 1-c (trouble sleeping because of nightmares of a traumatic experience; $r = -.43$, $p < .00$), 1-d (trouble sleeping because had severe anxiety or panic not related to traumatic memories; $r = -.32$, $p = .05$), 2-a (how much anxiety due to trauma-related nightmares/memories; $r = -.38$, $p = .02$), and the PSQI-A Total ($r = -.32$, $p = .05$) were significantly and negatively correlated with the estimates of sleep duration. With respect to items from the activity log, global anxiety was the only significant negative correlation with sleep estimates found, $r = -.33$,

Table 2
Sleep Duration

Sleep duration	With PTSD (N = 17), M (SD)	Without PTSD (N = 20), M (SD)
Sleep actigraphy	360.96 (65.74)	371.42 (38.34)
Sleep self-report	360.85 (97.03)	440.16 (43.77)
Self-report and actigraphy	Pearson correlation $r = .556^{**}$	Pearson correlation $r = .361$

** $p < .01$.

Table 3
Sleep Actigraphy Variables

Actigraph sleep variables	With PTSD (N = 17), M (SD)	Without PTSD (N = 20), M (SD)	t tests
WASO	34.10 (28.89)	37.34 (28.89)	$t(35) = .366$
Sleep efficiency	90.85	91.12	$t(35) = .14$
Sleep latency	.0	.37	$t(34) = .352$

$p = .05$. In each case, individuals who overestimated their sleep duration had the lowest levels of emotional arousal as assessed by these various symptom complaints.

Discussion

Combat veterans experience a significant decrease in their total nightly sleep time in their training and during their combat deployments (Miller et al., 2008; Mysliwiec et al., 2013; Peterson et al., 2008). Thus, one purpose of this study was to determine if a reduction in total sleep time persists in combat veterans (not just veterans with PTSD) after their combat experiences. The results of this investigation reveal that, overall, OIF/OEF/OND veterans without PTSD report sleeping 7 h and 20 min per night (see Figure 1). This figure is not significantly different from the National Sleep Foundation recent national poll that, on average, adults older than 18 years of age report sleeping 7 h and 6 min (Knutson, 2015; $t(19) = 1.45$, $p = .16$). These data suggest that, overall, the sleep restriction that combat veterans endure during military deployments may not, in itself, have significant lasting effects on sleep duration once the veteran returns home. However, when PTSD is present, self-report of sleep is significantly different from the national average of adults, $t(16) = -2.77$, $p = .01$, which is not surprising given that sleep difficulties are one of the criteria for PTSD.

The first aim of this study was to determine the consistency of sleep duration reports when assessed by self-report or actigraphy. Such assessment is important inasmuch as many clinicians treating veterans with PTSD will not have access to objective measures of sleep such as actigraphy and polysomnogra-

Table 4
Comparison of Combat Veterans on Various Sleep Variables

Variable	With PTSD, M (SD)	Without PTSD, M (SD)	t tests
PSQI-A			
PSQIA Total	10.65	2.70	$t(35) = -7.95^{***}$
PSQI-A 1-a	1.41	0.20	$t(35) = -3.88^{***}$
PSQI-A 1-b	2.53	0.85	$t(35) = -5.82^{***}$
PSQI-A 1-c	2.06	0.50	$t(35) = -5.11^{***}$
PSQI-A 1-d	1.47	1.23	$t(35) = -3.94^{***}$
PSQI-A 1-e	1.24	0.65	$t(35) = -1.81$
PSQI-A 1-f	0.71	0.00	$t(35) = -2.87^{**}$
PSQI-A 1-g	1.24	0.20	$t(35) = -3.62^{***}$
PSQI-A 2-a	2.35	0.45	$t(35) = -6.36^{***}$
PSQI-A 2-b	2.12	0.40	$t(35) = -5.24^{***}$
PSQI-A 2-c	1.18	1.35	$t(35) = -0.412$
Activity log			
Nightmares	4.31	0.75	$t(34) = -3.08^{***}$
Anger ratings	4.79	2.19	$t(34) = -3.67^{***}$
Anxiety ratings	5.73	2.45	$t(33) = -3.70^{***}$
Flashbacks	8.69	0.40	$t(34) = -2.50^{*}$

Note. PSQI-A = Pittsburgh Sleep Quality Index Addendum.
$^{*} p < .05$. $^{**} p < .01$. $^{***} p < .005$.

Table 5
Self-Report of Physiological Arousal and Accuracy of Sleep Duration Estimates

Variable	Estimates of sleep duration
PSQI-A 1-a	−.026
PSQI-A 1-b	−.317*
PSQI-A 1-c	−.429**
PSQI-A 1-d	−.321*
PSQI-A 1-e	−.048
PSQI-A 1-f	−.169
PSQI-A 1-g	.114
PSQI-A 2-a	−.377*
PSQI-A 2-b	.181
PSQI-A 2-c	.543
PSQI-A Total	−.323*
Nightmares	−.307
Global anger	−.261
Global anxiety	−.334*
Flashbacks	−.192

Note. PSQI-A = Pittsburgh Sleep Quality Index Addendum.
* $p < .05$. ** $p < .01$.

phy. The results of this investigation highlight the difference when assessing sleep duration via self-report and objective methods of sleep assessment. When compared to actigraphy data (which indicated an average of 6 h and 7 min of sleep per night), participants in this investigation (collapsed across groups) overestimated their sleep duration by an average of 37 min. This finding is consistent with another sample of young adults who overreported their sleep duration by an average of 48 min (Lauderdale et al., 2008). In contrast, older veterans (Westermeyer et al., 2007) underreported their sleep by an average of 51 min compared with actigraphy. Although it is not clear why some samples underreport and others overreport, it appears that all adults are able to assess their sleep duration within 1 h of objective measures. In this investigation, compared with combat veterans without PTSD, veterans with PTSD were more accurate self-reporters of their sleep duration, a finding consistent with the depressive realism hypothesis in which "depressed individuals exhibit more accurate and realistic perception and less prone to biases of judgement than their non-depressed counterparts" (Hussain, 2012). Given the high frequency with which self-report data are used to assess outcome of PTSD treatment, this study provides documentation that self-report data are consistent with objective measures; thus, they can be used with confidence for diagnostic assessment, treatment planning, and determination of treatment outcome.

Why the group with PTSD more accurately estimated their sleep duration than their fellow combat veterans is unclear, but one hypothesis is that the emotional arousal that is part of the PTSD symptom picture creates a state of hypervigilance with respect to physiological cues. Therefore, those individuals who are more vigilant may be more aware of all somatic behaviors, including sleep. In this investigation, an exploratory analyses found a significant relationship between overestimation of sleep duration and low scores on measures of emotional arousal as measured by the activity log and the PSQI-A. Stated differently, those individuals who were the least likely to overestimate their sleep duration (i.e., primarily those in the PTSD group) reported the highest levels of emotional arousal. Consistent with this interpretation, a meta-analysis (Kobayashi, Boarts, & Delahanty, 2007) of polysomnography studies suggested that the sleep of adults with PTSD (but not necessarily combat PTSD) is characterized by more stage 1 sleep, less slow wave sleep, and great rapid-eye movement (REM) sleep density. These three sleep characteristics are suggested to reflect hyperarousal of the central nervous system during the sleep of patients with PTSD (Mellman, Kumar, Kulick-Bell, Kumar, & Nolan, 1995; Woodward, Murburg, & Bliwise, 2000). Although we did not assess sleep via polysomnography, our results are consistent with the results of this meta-analysis (Kobayashi et al., 2007). Further studies, using larger samples of combat veterans with and without PTSD, are needed to more clearly delineate these relationships.

Limitations

There are several limitations to this investigation that need to be highlighted. First, the sample size was reduced because several veterans were not compliant with instructions regarding actigraphy or self-monitoring. Although there was still sufficient power for the primary purpose of the investigation, more frequent communication with the participants (re-

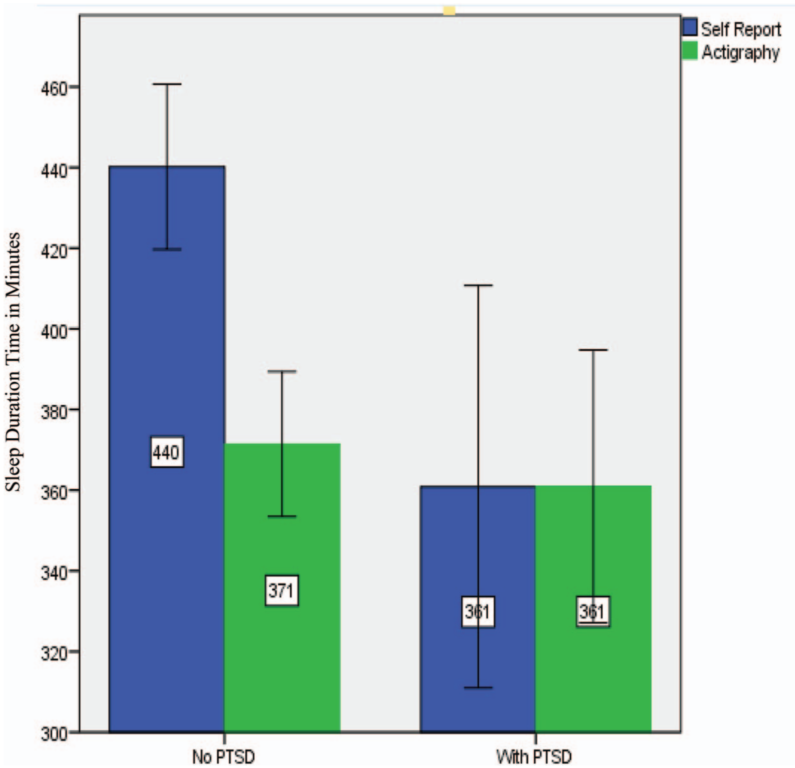

Figure 1. Self-report duration compared with sleep actigraphy sleep duration between OEF/OIF combat veterans with and without PTSD. See the online article for the color version of this figure.

garding self-monitoring and reminders to wear the actigraph) would improve behavioral compliance.

In addition, although actigraphy is well correlated with polysomnography for total sleep time, the validity and reliability of actigraphy is "less useful for documenting sleep-wake in individuals who have long motionless periods of wakefulness . . ." (Acebo, 2005; Sadeh, & Acebo, 2002; in other words, one could lie awake motionless, leading to the interpretation that one was asleep). Although that is clearly a possibility, it is unlikely that such a scenario played out in this investigation because our results do not reveal higher sleep duration based on actigraphy (when compared with self-report). We do agree with the conclusions of Acebo (2005) that combining actigraphy with another measure of sleep duration would provide the best estimate of sleep duration.

Further studies with larger sample sizes could more rigorously assess, and perhaps control for, the length of time since the last deployment because that may be an important factor in assessing sleep complaints. With regards to the sleep estimation index created by subtracting self-report of sleep duration from actigraphy sleep duration, groups were collapsed to allow for a sufficient number of participants for correlational purposes; however, adding the PTSD group likely creates a confounding variable in that analysis since veterans in the with-PTSD group were more likely to report sleep arousal items. A more detailed assessment of each individual may also serve to reveal what other variables may influence one's perception of their sleep. For example, future studies should record participants' alcohol intake, work schedules, physical health, and perception of sleep quality and daytime sleepiness and give a detailed account of their work schedules. Because this study contained a significant number of full-time students, the relationships between traditional employment and college sleep schedules could not be adequately addressed; however, this is an important population comparison because many veterans returning from war are enrolling into college.

A longitudinal sleep assessment study of veterans' sleep before combat, during combat, after combat deployment, and postservice sleep would also help researchers better elucidate the long-term effect of combat-related sleep restriction. In addition, expanding the sleep log to include more specific questions such as "How many times do you remember waking up?" and "If you woke up, how long did it take you to fall back asleep?" may further elucidate the subjective, but important variable of sleep quality. With regards to hyperarousal, assessment of salivary cortisol, which is a well-documented way to measure stress, could objectively measure stress, further elucidating the role of physiological/emotional arousal and sleep. In addition, given the high comorbidity of anxiety and depressive disorders in populations with PTSD, other mental health disorders were included in this sample and not controlled for. Therefore, it is imperative that future studies utilize a thorough mental health assessment to rule out other mental health disorders in both the with-PTSD and without-PTSD samples.

Conclusion

To our knowledge this is the first study to assess the sleep of veterans with combat-related PTSD by including a control group of veterans who also experienced combat but did not have PTSD. Thus, it serves as an important advance in understanding the role of typical combat-deployment conditions such as sleep restriction on returning veterans and in understanding the sleep complaints typically found among veterans with PTSD. Understanding the relationship between sleep and PTSD is critical because it could directly affect clinical conceptualization and treatment planning. The results of this study suggest that veterans with PTSD report less sleep than veterans without PTSD, but this difference was not confirmed by objective assessment using actigraphy. Furthermore, veterans without PTSD overreport their sleep duration to a significant degree when compared with actigraphy data. Finally, the results of this investigation revealed that those veterans who were the most accurate reporters of sleep duration reported the highest levels of emotional arousal and had significantly higher scores on the PSQI-A. In conclusion, these results suggest that sleep quality and sleep quantity are both impacted by the presence of PTSD. Specifically, this study adds to the literature by raising intriguing questions about the role of hyperarousal as a factor in the sleep quality of returning veterans with PTSD. Because sleep complaints are one of the primary complaints among combat veterans with PTSD and assessment of treatment outcome is most commonly assessed by self-report of sleep, continued investigation examining its etiology and treatment outcome are necessary.

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