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SCIENTIFIC INVESTIGATIONS

Predicting Attentional Impairment in Women With Posttraumatic Stress Disorder Using Self-Reported and Objective Measures of Sleep

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Study Objectives: There is growing evidence to support sleep impairment as a core feature of posttraumatic stress disorder (PTSD). Sleep impairment in PTSD is associated with severe distress and poorer treatment outcomes. Therefore, specific attention to this symptom of PTSD is warranted and accurate assessment of sleep impairment is critical. The current study investigated the association between self-reported and objective assessment of sleep and sustained attention in women with PTSD.

Methods: Study participants include 50 treatment-seeking, female, interpersonal violence survivors who have PTSD. Nocturnal sleep duration was measured with self-report sleep diaries and objective actigraphy assessment over the course of 7 nights. Sustained attention during daytime was measured by the Psychomotor Vigilance Task (PVT).

Results: Results indicated that self-reported nocturnal sleep duration, but not objective or global sleep quality measures, best predicted attentional deficits as indicated by lapses and inverse reaction time on the PVT. Daily sleep diaries predicted 19% and 14% of the variance in attentional lapses and inverse reaction time, respectively.

Conclusions: In a sample of women with PTSD, self-reported nocturnal sleep duration predicted deficits in sustained attention. Conversely, sleep duration as measured by actigraphy and global sleep quality, did not predict sustained attention. Findings suggest that assessing sleep impairment on a daily basis may provide clinically relevant information in evaluating daytime symptoms and provide guidance in targeting this particularly troublesome symptom in the treatment of PTSD.

Keywords: posttraumatic stress disorder, attention, actigraphy, Psychomotor Vigilance Task

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BRIEF SUMMARY

Current Knowledge/Study Rationale: Sleep impairment has been cited as the most-often reported symptom of posttraumatic stress disorder (PTSD). It is associated with severe distress, impaired attention and concentration, and poorer treatment outcomes. The primary study aim was to assess the relative contributions of objective and self-reported measures of nocturnal sleep duration to objectively measured deficits in sustained attention in a sample of female interpersonal violence survivors with PTSD.

Study Impact: Results revealed that self-reported, daily estimations of sleep, but not objectively or globally measured sleep impairment, is directly related to attention in this PTSD sample. Assessing sleep impairment on a daily basis throughout treatment may provide clinically relevant information in evaluating daytime symptoms and guiding treatment decisions.

INTRODUCTION

Sleep impairment has been linked to deficits in a number of domains of cognitive functioning, including attention, concentration, and memory in otherwise healthy individuals.[1–3] An estimated 50–70 million Americans are diagnosed with a sleep disorder and sleep disturbance is now considered a public health epidemic.[4] Sleep disturbance and pathology is endorsed at even higher rates in those presenting with psychiatric disorders. For instance, within the posttraumatic stress disorder (PTSD) population, reports of clinically significant sleep disturbance range from 70% to 87% and sleep impairment is the most frequently endorsed symptom following exposure to a traumatic event.[5–7] Sleep disturbance often persists in this population even after the conclusion of successful trauma-focused therapy.[8] Some researchers consider sleep disturbance experienced after a trauma to be transient,[9] while others have suggested that sleep impairment is, in fact, the hallmark feature of PTSD.[10]

Sleep can be assessed objectively with polysomnography (PSG) and actigraphy, as well as with self-reported daily sleep diaries or global standardized measures. In community samples, self-reported and objective reports of sleep are only moderately correlated. When compared to objective assessments, individuals' self-reports tend to overestimate nighttime awakenings and underestimate total sleep time.[11] Similar discrepancies exist between self-reported and objectively measured sleep within the PTSD population.[12] Elevated levels of self-reported sleep disturbance in individuals with PTSD have been consistent across studies.[13] However, objective assessment of sleep

disturbance in PTSD populations has not corroborated self-reported sleep impairment.[14–16] When self-reported and objective sleep are assessed simultaneously in PTSD, self-reports of sleep impairment are often not associated with objective assessment; individuals tend to report more sleep impairment than what is recorded through objective measurement.[9,17–19] In our own research investigating sleep impairment in women with PTSD, we found no relationship between self-reported sleep impairment measured with daily sleep diaries and objective sleep impairment measured with actigraphy. Participants reported more sleep impairment via daily sleep diaries as compared to objective actigraphy recording.[20] This lack of correlation across self-reported and objective measures of seemingly similar constructs highlights the importance of utilizing a multimodal assessment of sleep when attempting to understand the effects of sleep impairment among individuals with PTSD.

While an independent symptom in Cluster E of the PTSD symptom constellation, sleep deficits are hypothesized to exacerbate other PTSD symptoms, such as concentration and attention.[21] In healthy individuals, chronic sleep loss has been associated with daily and cumulative reductions in sustained attention as measured by reaction time and performance lapses on the Psychomotor Vigilance Task (PVT).[22–24] Sustained attention is a basic requirement for information processing and daytime cognitive functioning. Compromised sustained attention can impact individuals' ability to engage with their environment or modify behaviors to successfully function in a dynamic world.[25] In the case of PTSD, impairments in sleep and concentration are not only symptoms of the disorder, but could deleteriously effect treatment engagement to address the disorder.[21]

Both self-reported and objective measured sleep disturbance have been associated with deficits in sustained attention.[26,27] However, Sugerman and colleagues[26] found that otherwise healthy participants who reported sleep difficulty on self-report measures showed impairments in daytime functioning even when sleep deficits were not objectively apparent. These findings suggest that perception of sleep disturbance may be a stronger predictor of daily cognitive functioning than objective sleep impairment.

To date, no research has directly investigated the relationship between self-reported or objective assessments of sleep impairment and attention in individuals with PTSD. The current study sought to investigate the relationship between three different measures of sleep disturbance (a standardized self-report measure of overall sleep quality, a daily diary report of nocturnal sleep duration, and an objective actigraphy assessment of actual time spent asleep) and performance on the PVT, an objective measure of sustained attention.[28] The primary study aim was to assess the relative contributions of each of these measures of sleep loss to objectively measured deficits in sustained attention in a sample of female interpersonal violence (IPV) survivors with PTSD.

METHODS

Participants

Fifty participants who completed daily sleep diaries, actigraphy, and PVT assessments during a baseline assessment were drawn from a larger study focusing on sleep-directed treatment as a complement to cognitive processing therapy (CPT) for female IPV survivors with PTSD. All participants were at least 18 years old and met full criteria for PTSD, including endorsement of clinically significant sleep impairment (defined as a total score of 3 or higher on symptom D1 [trouble initiating or falling asleep] on the Clinician-Administered PTSD Scale [CAPS][29]). Exclusion criterion for this study included current psychosis, mental retardation, active suicidality, current dependence on drugs or alcohol, and living in an ongoing traumatic situation (eg, current domestic violence). Psychotropic medication usage was not excluded, but participants were required to be stabilized on their medication during the study. Sleep medication use was also not excluded, though frequency of use was assessed and included as a covariate in analyses. Current diagnosis of any independent sleep disorders (eg sleep apnea, primary insomnia, narcolepsy) was also an exclusionary criteria as the goal of the parent study was to evaluate the efficacy of CPT on trauma-related sleep impairment and not sleep disorders of an unrelated origin. Participants could not receive any outside trauma- or sleep-focused psychotherapy during the study.

Participants were recruited through victim assistance agencies, newspapers, and flyers posted to communal areas, including, but not limited to, restaurants, college campuses, grocery stores, and community bulletin boards. All participants were clinically assessed for psychopathology by MA and PhD-level clinicians. All participants gave written informed consent prior to beginning the study and were monetarily compensated for their participation in this portion of the trial.

Measures

Participants completed a locally constructed trauma interview to collect demographic information, information about their index trauma, prior trauma history, and treatment history. In addition, participants completed the following battery of standardized instruments.

PTSD Diagnosis and Symptom Severity Measure

CAPS[29] is a 22-item semistructured interview used to assess current PTSD. This study used CAPS-IV, which contains separate 5-point frequency and intensity rating scales (0–4) for symptoms identified with PTSD in the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (range 0–136).[30] CAPS has demonstrated excellent reliability and validity[31] and internal consistency in the current study was acceptable ($\alpha = .71$). Total CAPS frequency and intensity score was used in the current study.

Self-Reported Sleep Measures

The Pittsburgh Sleep Quality Index (PSQI) was used to assess global sleep quality in the past month.[32] The PSQI is a self-report measure that contains 19 individual items scored from 0 to 3 that query seven sleep characteristics: self-reported sleep quality, sleep latency, sleep duration (total sleep time), habitual sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction. The sum of the subscores generates one global score with total scores of 5 or above indicating poor

sleep. The PSQI shows good internal consistency (α = .83) and acceptable reliability in the current sample (α = .60).

Sleep diaries were used to assess participants' daily report of the previous night's sleep. These diaries allowed for a daily assessment of sleep and disturbance compared to the PSQI that queried sleep characteristics across the last month. The diaries were adapted from previous research, included questions to assess a range of sleep characteristics, and required approximately five to seven minutes to complete.[34] The sleep diaries were completed each morning for one week. Though sleep diaries assessed several aspects of self-reported sleep quality, the primary variable of interest for the current study was total nocturnal sleep time (ie, daily diary total sleep time [TST]).

Objective Sleep Measure

Objective sleep disturbance was assessed utilizing a wrist worn sleep watch and basic motion-logger technology, also known as actigraphy (basic motion logger model 26.000, Ambulatory Monitoring Inc., Ardsley, New York). Actigraphy is a noninvasive method of monitoring rest/activity cycles during sleep that allows for a daily measure of objective sleep and sleep disturbance in the home environment, and can be worn for several days at a time. Actigraphy is a less invasive objective sleep measure than PSG. Minimally invasive sleep assessment is particularly important for those with PTS symptoms and enables assessment of sleep quality in the individual's natural environment. Although, actigraphy does not allow for investigation of sleep architecture or stages, it provides a good measure of general sleep characteristics including total nocturnal sleep time (ie, objective TST).[35] Actigraphy measurement has been validated as an objective measure of sleep/wake cycles compared to PSG,[36] and a strong correlation has been observed (r = .70) between actigraphy and PSG sleep recordings.[37] The actigraph in this study was programmed to sample movement at 30-second epochs and measurements were recorded over the course of seven days/nights (completed concurrently with daily sleep diaries).

Cognitive Measure of Attention

The PVT monitor (PVT-192 Palm Logger Software 21.PALM, Ambulatory Monitoring, Inc.) is a stand-alone device for measuring the ability to sustain attention and respond to external signals. The device acts as a continuous measure of attention over the course of a 5-minute period. A small digital display lights up at random intervals and measures elapsed time until a button is pressed (ie, simple reaction time). When no response to the light is detected within 500 ms this is coded as a lapse. Although originally developed as a cognitive test of alertness, performance on the PVT has been widely used in the literature as a measure of sustained attention.[28,38] The 5-minute PVT has been shown to be sensitive to many manipulations, including sleepiness.[1,23,24]

Procedure

Study procedures were approved by the Institutional Review Board at the University of Missouri – Saint Louis as part of a larger treatment study entitled Sleep-directed Hypnosis as a Complement to Cognitive Processing Therapy in Treating PTSD (1R21AT004079-01; Principal Investigator: Tara Galovski, PhD). Participants meeting study inclusion criteria were given daily sleep diaries to complete at home for 7 days. Individuals completing at least 3 out of 7 assessments were included in the study (mean ± standard deviation 6.49 ± 1.13). Each participant also was fitted with the actigraphy equipment on their nondominant wrist to take home and wear daily for 7 days. Participants were instructed to wear the actigraphy equipment 24 hours per day for 7 days and to remove the device only when an activity could possibly damage the device (immersion in water for long periods of time, strenuous activity, etc.). They were instructed to press a marker button twice when getting out of bed in the morning and twice again when getting into bed at night to indicate time to bed and time awakened. An average of 6.3 ± 2.9 nights of actigraphy data were collected from each participant.

Participants were also provided with instructions regarding the completion of the PVT. Specifically, each participant received written instructions to take home, as well as verbal direction from an assessor about how to complete the PVT task. Participants were instructed to complete the PVT task at home in a quiet environment with minimal distraction 3 times daily (within 30 minutes of waking, in the afternoon, and within 30 minutes of going to bed). Therefore, participants were asked to complete the PVT a total of 21 times across the 7-day period. Actual completion rates were on average 11.6 ± 5.9 trials, and the total trials completed by each participant ranged from 3–21. After 7 days, each participant returned to the clinic at which time the daily diary measures were collected and actigraphy data were downloaded from the watch.

Data Analysis

TST in minutes was used as the primary sleep measure for both the daily sleep diary and actigraphy assessments. The Action–W analysis software (version 2.0, Ambulatory Monitoring, Inc.) was used for scoring of actigraphy data and allowed for automated scoring by computing a down interval and estimates of normal sleep and wake time parameters. For the current study, the Action–W software was used to calculate objective total sleep time values for each night of recording. The proportional integrating mode (PIM) data collection method, which provides an estimation of the intensity of movement, was used in this investigation and the actigraphy scoring was completed utilizing the University of California – San Diego (UCSD) algorithm. The UCSD algorithm can be used with PIM collection and allows for scoring of actigraphy data to indicate when the participant is asleep and awake. The PIM data collection and UCSD algorithm and scoring method have been validated as a robust analysis tool of actigraphy recordings compared to PSG recordings.[35]

The primary PVT outcome variables used in this study were inverse reaction time (1 / reaction time) and the frequency of lapses (the number of times that a participant failed to respond to the signal within 500 milliseconds). Inverse reaction time and frequency of lapses were found to have large effect sizes in a recent meta-analysis of PVT outcome measures and were indicated as a reliable measures of attention.[39] To yield the most robust findings, all completed trials for each participant on each day were averaged to yield total average lapses as well as total average reaction time (inverse). However, exploratory analyses

also examined PVT outcomes separately for assessments completed in the morning, afternoon, and at night.

Covariates of interest included CAPS PTSD frequency and intensity total score, use of sleep medication, and global sleep quality as measured by the PSQI. To reduce covariance of PTSD severity with sleep measures, PTSD overall symptom severity minus the sleep item "difficulty falling or staying asleep" was considered in analyses. Sleep medications clinically reduce alertness during night-time hours to encourage sleep; however, these effects can continue into the daytime and have a negative impact on a person's ability to function and concentrate. Therefore, sleep medication use, as reported on the PSQI on a 4-point Likert scale, was included as a covariate. Lastly, the PSQI minus the sleep medication question was included in the last step of analyses to ensure any associations between daily sleep assessment and attention were not mediated by global, chronic sleep impairment.

Statistical analyses were performed using IBM SPSS Statistics for Windows, Version 20.0 (IBM Corp., Armonk, New York, United States). Tests for normality, multivariate outliers, linearity, and homogeneity were completed for all variables used in the main analyses. Data were not found to violate any assumptions. Missing data also were examined prior to main analyses and were found to comprise 7.3% of the total data. Missing data were determined to be missing completely at random (MCAR; Little's MCAR test: $\chi^2 = 11.492$; $P = .321$) and the maximum likelihood estimates procedure using the expectation maximization algorithm was employed to compute missing values.[40]

Primary analyses consisted of two hierarchical linear regressions, one examining the frequency of lapses and a second examining inverse reaction time on the PVT. Across these two models, step 1 included CAPS total scores (minus sleep item) and an estimation of sleep medication use from the PSQI. At step 2, objective TST was added to the model. At step 3, daily diary TST was added to the model. Finally, in step 4, PSQI total global sleep quality scores were accounted for. Exploratory *post hoc* analyses examined similar models with PVT outcomes broken down by time of day (morning, afternoon, night).

RESULTS

Initial Analysis

Participants were predominately Caucasian (54%) and African-American (44%) and from low-income households (72% less than $20,000 yearly income). Ages ranged from 18 to 59 years with an average age of 36.3 ± 12.0 years. Most participants were single (52%) and had received an average of 13.7 ± 2.6 years of education.

Overall, participants experienced severe levels of PTSD symptoms as measured by total score on the CAPS (78.1 ± 16.8). The cohort endorsed poor global sleep quality over the past month as reflected by PSQI total score (13.9 ± 3.5). Fifty percent of the cohort endorsed taking sleep medication to help with sleep at least once in the month leading up to the assessment: 28% (n = 14) reported usage three or more times a week, 14% (n = 7) reported use once or twice in a week, 8% (n = 4) reported using medication to help with sleep less than once a week. Fifty percent (n = 25) reported no use of medication to help with sleep during the past month.

Regression Analyses

Prior to main analyses, assumptions for hierarchical multiple regression were checked and multicollinearity assumptions had not been violated. In addition to correlational relationships between sleep variables, as well as PTSD severity previously reported,[20] moderate correlations between daily diary TST and PVT outcomes were found (**Table 1**).

The first hierarchical model examined the frequency of mean lapses on the PVT as the outcome of interest. Results for the complete model are presented in **Table 2**. The model was found to be significant after step 3 ($F_{4,45} = 3.18$, $P = .022$) and remained significant after adjusting for PSQI global sleep quality in step 4 ($F_{5,44} = 2.49$, $P = .045$). The adjusted R^2 value indicated that 22% of the variability in total PVT lapses was predicted by the overall model. In step 1, CAPS total scores (minus sleep) and sleep medication use did not significantly add to the prediction of lapses on the PVT ($F_{2,47} = .31$, $P = .74$). Objective TST was added in step 2, but also did not significantly add to the prediction of PVT lapses ($F_{3,46} = .44$, $P = .73$). Daily diary TST was considered in step 3 and accounted for 19.3% of the variance in PVT lapses, ($F_{4,45} = 3.18$, $P = .002$). PSQI global sleep quality, added in the final step, did not significantly increase the explained variance and did not contribute any additional variance explained by the overall model. However, daily dairy TST remained a significant predictor of PVT lapses (**Table 2** and **Figure 1**).

The second hierarchical linear regression model examined inverse reaction time on the PVT as an outcome of interest. Results of the complete model are presented in **Table 3**. The overall model was marginally nonsignificant after step 3 ($F_{4,45} = 2.18$, $P = .086$), but did not maintain statistical significance after step 4 ($F_{5,44} = 1.71$, $P = .15$). Despite this, a similar pattern emerged when examining individual predictors. In step 1, CAPS total scores and sleep medication were not significantly predictive of PVT inverse reaction time ($F_{2,47} = .34$, $P = .71$). When objective TST was added in step 2, it also did not predict PVT inverse reaction time ($F_{3,46} = .34$, $P = .80$). Daily diary TST was considered in step 3 and was found to account for 14.1% of the variance in PVT inverse reaction time values. Finally, PSQI global sleep quality scores were included in step 4 and the inclusion of this measure did not significantly increase the explained variance nor contribute additional variance to the overall model. Again, in step 4, daily diary TST remained a significant predictor of PVT inverse reaction time scores (**Table 3** and **Figure 1**).

In exploratory *post hoc* analyses we examined six additional hierarchical linear regression models for PVT lapses and PVT inverse reaction time by time of day (ie, morning, afternoon, and nighttime assessments). The pattern of effects was consistent regardless of time of day, with daily diary TST being the only significant predictor of sustained attention outcomes (all $P < .05$). The one exception was the model examining afternoon assessments of PVT inverse reaction time. Though daily diary TST was significant in step 3 ($\beta = .35$, $P = .03$) and explained 10.0% of the variance in PVT inverse

Table 1—Mean, SD, and correlation of attention, PTSD, and sleep variables.

Variable	Mean	SD	1	2	3	4	5	6
1 PVT lapses	10.1	9.2	–	−.91	.10	−.10	−.45***	.21
2 PVT inverse reaction time (ms)	0.002	0.0007		–	−.10	−.07	.39**	−.20
3 CAPS severity minus sleep item	70.7	16.6			–	.16	−.27*	.55**
4 Objective TST (minutes)	410.4	69.6				–	.22	.09
5 Daily diary TST (minutes)	352.8	77.7					–	−.37**
6 Global sleep quality	13.89	3.49						–

n = 50. * P < .05, ** P < .01, *** P < .001. CAPS = Clinician Administered PTSD Scale, PTSD = posttraumatic stress disorder, PVT = Psychomotor Vigilance Task, SD = standard deviation, TST = total sleep time.

Table 2—Hierarchical regression model predicting PVT lapses with objective and self-reported sleep measures.

	R^2	ΔR^2	β
Dependent variable: PVT lapses			
Step 1	.01		
CAPS total symptom score (no sleep)			.10
Sleep medication use			.06
Step 2	.03	.00	
CAPS total symptom score (no sleep)			.12*
Sleep medication use			.06
Objective TST			−.12
Step 3	.22*	.19**	
CAPS total symptom score (no sleep)			−.04
Sleep medication use			.13
Objective TST			.00
Daily diary TST			−.48**
Step 4	.22*	.00	
CAPS total symptom score (no sleep)			−.04
Sleep medication use			.12
Objective TST			.00
Daily diary TST			−.48**
Global sleep quality			.01

n = 50. * P < .05, ** P < .01. CAPS = Clinician Administered PTSD Scale, PTSD = posttraumatic stress disorder, PVT = Psychomotor Vigilance Task, TST = total sleep time.

reaction time scores, the association was reduced to a nonsignificant trend (β = .32, P = .06) in step 4 after controlling for PSQI global sleep quality scores. Results for each of these six models are included in the supplemental material (**Table S1**, **Table S2**, **Table S3**, **Table S4**, **Table S5**, and **Table S6**).

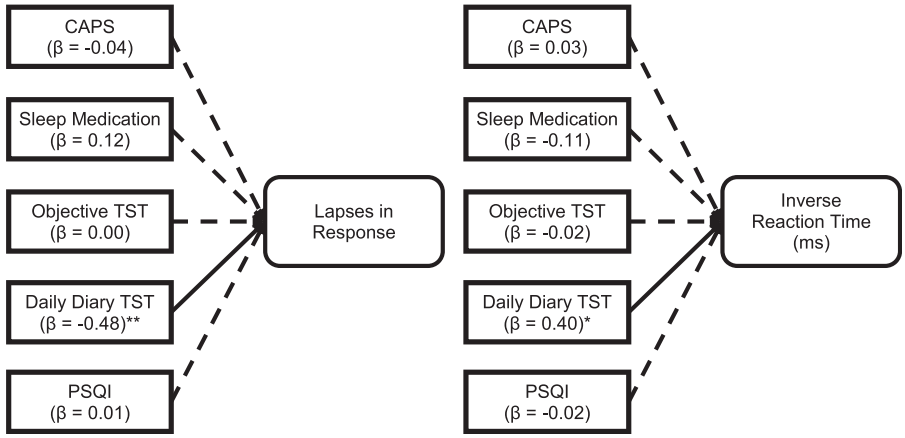
DISCUSSION

This is the first study to investigate the contribution of self-reported and objectively measured sleep impairment to deficits in sustained attention (determined by a cognitive task) in a PTSD cohort. Results revealed that self-reported daily diary reports of sleep predicted the ability to sustain attention during the day above and beyond PTSD severity, sleep medication use, objectively measured sleep, and global sleep quality. Specifically, decreases in total sleep time reported on daily diaries, and not objectively measured sleep duration, were associated with decreases in sustained attention (as measured by PVT lapses and inverse reaction time) experienced during the morning, afternoon, and nighttime across the same 7-day time frame. These results are consistent with previous research in individuals with insomnia but are inconsistent with findings in police recruits.[3,26,27] The added effect of PTSD symptomatology did not appear to contribute uniquely to the attentional deficits. Interestingly, sleep impairment as measured by actigraphy also did not predict attentional deficits. Thus, the self-report description of poor sleep of participants with PTSD mapped most closely onto objectively measured daytime attentional deficits.

Inconsistencies in the measurement of sleep impairment across self-report and objective measurement may be partially explained by the high levels of self-reported distress associated with PTSD. In fact, the emotionality and physiological arousal inherent in the disorder itself may be exhausting. This chronic experience of exhaustion (mental, emotional, and physical) may contribute to the overall perception that one did not get a good night's rest. Theoretically then, the self-reported sleep loss may be influenced by the current wakeful, and distressed, state of the reporter. However, this study found that self-reported sleep impairment—in contrast to objective measures of sleep impairment—emerged as a significant predictor of daytime attentional impairment measured objectively with the PVT, suggesting that participants' estimation of their recent sleep loss is most closely linked to actual performance in their ability to sustain attention. This observed relationship cannot necessarily be attributed to an artifact of reporting style, as the attentional impairment was measured objectively. Further, the ability to sustain attention is critical in participation in psychotherapy; attentional impairments may negatively impact a patient's ability to fully engage in treatment and ultimately result in less than optimal outcomes.

Alternatively, perhaps the sleep impairment experienced in the context of PTSD is distinct and more nuanced than the domains captured by our study constructs. The lack of correlation between the sleep measures and the differential associations with attentional deficits may be the result of specific measurement of unique aspects of sleep. Some recent research

Figure 1—Fully adjusted model predicting PVT lapses and inverse reaction time with objective and self-reported sleep measures.



In both fully adjusted models, self-reported TST was the only significant predictor of deficits in sustained attention. * $P < .05$, ** $P < .01$. CAPS = Clinician Administered Posttraumatic Stress Disorder Scale, PSQI = Pittsburgh Sleep Quality Index, PVT = Psychomotor Vigilance Task, TST = total sleep time.

Table 3—Hierarchical regression model predicting PVT inverse reaction time with objective and self-reported sleep measures.

	R^2	ΔR^2	β
Dependent variable: PVT inverse reaction time			
Step 1	−.03		
CAPS total symptom score (no sleep)			−.10
Sleep medication use			−.06
Step 2	−.04	.007	
CAPS total symptom score (no sleep)			−.11
Sleep medication use			−.07
Objective TST			.09
Step 3	.09	.14	
CAPS total symptom score (no sleep)			.02
Sleep medication use			−.12
Objective TST			−.02
Daily diary TST			.41 **
Step 4	.07	.00	
CAPS total symptom score (no sleep)			.03
Sleep medication use			−.11
Objective TST			−.02
Daily diary TST			.40 *
Global sleep quality			−.02

n = 50. * $P < .05$, ** $P < .01$. CAPS = Clinician Administered PTSD Scale, PTSD = posttraumatic stress disorder, PVT = Psychomotor Vigilance Task, TST = total sleep time.

has suggested trauma-related sleep impairment should be considered distinct from insomnia.[41,42] Indeed PTSD related sleep disturbance is not limited to sleep impairment but also includes traumatic nightmares, although examination of nightmares has proven difficult.[41,42] Regardless, our results suggest that assessing and addressing sleep impairment may, in turn, serve to improve sustained attention which would, in turn, improve daytime functioning. That is, daily monitoring of sleep with self-reported measures may prove useful, particularly as it pertains to the patient's ability to focus and fully engage in treatment. This supposition is supported by research findings in healthy adults suggesting improvements in the ability to sustain attention have been associated with improved working memory and executive functioning.[43] Further study to examine a conceptual model of trauma related sleep impairment, may help to reconcile discrepancies between objectively identified aspects of sleep impairment with those being reported consistently by patients with PTSD. This level of specificity would most certainly inform clinical intervention for the substantial and debilitating sleep impairment reported in the PTSD population.

There are several limitations to the study. The cognitive task used in the current study assessed simple attention and vigilance and did not serve as a measure of other cognitive domains known to be impaired in PTSD. Development of additional portable cognitive tasks to query executive function, memory, and more emotionally relevant attention tasks would further extend our understanding of the role of sleep impairment in cognitive functioning. In addition, the PSQI does not provide information pertaining to the type of sleep medication used. As some medications are known to produce cognitive impairments directly, further research should attempt to more precisely capture the exact medications and dosages used by participants each night. Lastly, while current diagnoses of sleep disorders such as obstructive sleep apnea were excluded from this study, the absence of any the disorders was not confirmed via polysomnography and, therefore sleep disruption and cognitive impairments related to diagnosable concurrent sleep disorders (although unlikely) cannot be ruled out.

In summary, results indicate daily self-reported sleep disturbance predict objective deficits in attention above and beyond PTSD severity, sleep medication use, and objectively measured

sleep. Self-reported sleep disturbance can have measurable effects on the ability to sustain attention which, in turn, may affect daytime functioning. Sleep impairment has wide-ranging and deleterious effects on physical and mental health as well as functioning. Understanding the role of sleep impairment in a disorder such as PTSD may enhance larger treatment outcomes. In line with previous recommendations,[15,44,45] these results suggest that self-reported sleep impairment is directly related to attention. The extent to which trauma-focused and sleep-directed treatment impact sleep impairment as assessed across these methodological approaches remains unknown. From a clinical utility perspective, questions also remain as to which measurement approach is most accurate in tracking symptomatology and functioning over time. Future research may consider utilizing non-PTSD and/or an insomnia comparison groups to assess the role of trauma-related sleep impairment versus more generalized sleep loss in attention. This may partial out the anxiety and distress that may be contributing to the self-report of sleep loss. If after accounting for these related constructs the sleep impairment remains, more specified approaches examining and targeting trauma related sleep impairment could be warranted. Additionally research might also consider how sleep improvement might directly affect related symptoms of PTSD, such as concentration difficulty as well as assess the influence of sleep improvement on the ability to engage in psychotherapy designed to remediate PTSD itself.

ABBREVIATIONS

CAPS, Clinician Administered Posttraumatic Stress Disorder Scale
CPT, cognitive processing therapy
IPV, interpersonal violence
PIM, proportional integrating mode
PSG, polysomnography
PSQI, Pittsburgh Sleep Quality Index
PTSD, posttraumatic stress disorder
PVT, Psychomotor Vigilance Task
TST, total sleep time
USCD, University of California – San Diego

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