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Physiological and Psychological Measurement of Sleep Disturbance in Female Trauma Survivors with PTSD and Major Depression

Kimberly Borkowski Werner
University of Missouri-St. Louis

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Physiological and Psychological Measurement of Sleep Disturbance in Female
Trauma Survivors with PTSD and Major Depression

Kimberly B. Werner

M.A, Psychology – Behavioral Neuroscience, University of Missouri – St. Louis, 2009

B.A., Psychology, Saint Louis University, 2006

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Advisory Committee:

Dr. Michael G. Griffin, Ph.D.
Chairperson

Dr. Tara E. Galovski, Ph.D.

Dr. Joseph M. Ojile MD, D.ABSM, FCCP

Dr. George Taylor, Ph.D.

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Abstract

Sleep disturbance is often reported after a traumatic event and is included in the American Psychiatric Association Diagnostic and Statistical Manual criteria for posttraumatic stress disorder (PTSD). Subjective reports from trauma survivors have consistently indicated difficulties in sleep onset, sleep maintenance, overall quality and quantity of sleep. However, objective physiological research has yielded inconsistent findings in PTSD-related sleep impairment. Studies investigating subjective and objective assessments concordantly support a theory of sleep state misperception – subjective over-estimation of sleep disturbance – in PTSD. The majority of these previous investigations have been limited to male, veteran cohorts and have not accounted for the effects of psychiatric comorbidity, such as major depression. The current study examines PTSD-related sleep disturbance in a female interpersonal violence cohort (N=51) assessing subjective and objective physiological (actigraphy) sleep measures concurrently. Specific aims of the study addressed the presence of sleep state misperception in a female PTSD cohort and the effect of comorbid depression symptoms and diagnosis on PTSD-related sleep impairment.

Analyses revealed an overall subjective over-reporting of sleep disturbance when compared to objective physiological measurement. Subjective reports of sleep onset latency were significantly higher than objective measures ($t(50) = 4.59, p < .001$), and subjective sleep quality ($t(50) = 6.03, p < .001$) and sleep quantity ($t(50) = 4.52, p < .001$) were significantly lower than objective assessment. No significant differences were displayed between PTSD-only and PTSD/MDD groups across subjective, objective and sleep state misperception scores for any of the target sleep parameters. However, 24% of the variability in sleep state misperception was predicted by the regression model including re-experiencing

symptoms and depressive symptoms as significant contributors ($p < .01$). Re-experiencing symptoms accounted for 13% of the variance in sleep state misperception, and depressive symptoms contributed a unique 9% of variance ($p < .05$). Avoidance and, surprisingly, hyperarousal symptoms, were not significant predictors of sleep state misperception.

Overall, findings support the existence of sleep state misperception in a PTSD-positive female cohort. Results also point to the importance of accounting for depressive and re-experiencing symptoms as predictors of subjective sleep impairment in a PTSD cohort. Findings are discussed in terms of implications for understanding sleep impairment in PTSD.

Physiological and Psychological Measurement of Sleep Disturbance in Female Trauma
Survivors with PTSD and Major Depression

Introduction

Sleep is a natural reoccurring state of reduced consciousness that has been linked to cell rejuvenation, immune functioning, and memory consolidation (Gumustekin, et al., 2004; Turner, Drummond, Salamat, & Brown, 2007; Zager, Andersen, Ruiz, Antunes, & Tufik, 2007). Optimizing time spent asleep is crucial as too little and too much sleep has been associated with increased mortality rate (Patel, et al., 2004). Deficits in sleep can occur in otherwise healthy individuals as well as within pathological cohorts. Insomnia, loosely described as difficulty falling or staying asleep, can be both a disorder itself and/or a symptom of a larger syndrome.

In population-based studies, approximately 30% - 45% of adult samples endorse at least one symptom of insomnia as described in the *Diagnostic and Statistical Manual of Mental Disorders – Text Revision (DSM-IV-TR*; American Psychiatric Association (APA), 2000). When additional criteria of impairment in daytime functioning or distress were included, a prevalence rate of 10% was reported in an adult population (National Institute of Health (NIH), 2005). Impairments in sleep can be very distressing to individuals and can lead to health problems if disturbances continue over time. Sleep deprivation can precipitate a number of psychological and physiological difficulties including irritability, cognitive impairment, decreased reaction time, impaired judgment, decreased immune functioning, and reduced ability to react to stress (Dinges et al., 1997; Irwin et al., 1996).

Investigation of the effects of insomnia in pathology has become an important field of research; understanding the relationship between sleep and pathological disorders is

important for etiological, developmental, and clinical applications. Insomnia has been associated with stress, and increases in sleep disturbance are common after traumatic stress occurs. Insomnia, as well as other sleep impairments, is commonly displayed in psychopathology including mood disorders and anxiety disorders such as posttraumatic stress disorder (PTSD; Morin & Ware, 1996).

Trauma-Related Sleep Impairment

Sleep disturbance may be the most frequently endorsed impairment after a trauma with one study reporting 100% of the traumatized sample suffering from sleep impairments (Rosen, Reynolds, Yeager, Houck, & Hurwitz, 1991). Current rates of experiencing trauma are high with two-thirds of the population experiencing at least one traumatic event during their lifetime (*DSM-IV-TR*; APA, 2000). Trauma here is defined as it is in the *DSM-IV-TR* as an “event or events that involve actual or threatened death or serious injury, or a threat to the physical integrity of oneself or others” (*DSM-IV-TR*; APA, 2000). Of those that experience trauma, epidemiological studies have found rates of posttraumatic stress disorder (PTSD) development to be between 1 and 10% (APA, 2000; Breslau et al., 1998). Some researchers argue sleep disturbance experienced after a trauma is transient (Lavie, 2001), but sleep impairments are common in psychopathology in general and have been suggested as a hallmark feature of PTSD (Ross, Ball, Sullivan, & Caroff, 1989).

Although sleep disturbance in the acute aftermath of trauma is common, persistent sleep impairment has been displayed in those who go on to develop PTSD. Koren, Arnon, Lavie & Klein (2002) prospectively assessed motor vehicle collision (MVC) survivors and found that participants who go on to develop PTSD reported more sleep complaints as early as one month post trauma compared to MVC survivors who did not develop PTSD.

Participants were assessed for sleep complaints, including insomnia, at 5 time points as well as PTSD at 12 months. Although most MVC survivors complained of sleep problems directly after the accident, larger impairments were endorsed by those who went on to develop PTSD with significant differences continually displayed through 1, 3, 6, and 12 month assessment points. Participants who did not develop posttraumatic pathology returned to comparably normal sleep scores as early as 3 months post trauma, while sleep complaints in those who developed PTSD persisted. Findings support the theory of persistent disordered sleep after a trauma as a possible contributor to post-traumatic pathological development, but it remains unclear whether impairments in sleep contribute to the etiology or are a symptom of post-traumatic pathology.

Sleep disturbance is included in diagnostic criteria for both acute stress disorder and posttraumatic stress disorder (APA, 2000). Sleep problems are included as criterion in two symptom clusters of PTSD: re-experiencing (recurrent or distressing dreams) as well as hyperarousal (difficulty falling or staying asleep) and are endorsed by most participants with the disorder (Neylan et al., 1998). Studies utilizing subjective sleep measures to query sleep difficulties have displayed higher levels of sleep disturbance associated with PTSD compared to healthy controls (Ohayon & Shapiro, 2000), trauma survivors without PTSD (Neylan et al., 1998), and non-traumatized elective surgery controls (Koren et al, 2002). Researchers have also employed objective tools to explore sleep and sleep complaints of patients with PTSD to obtain clinical and diagnostic quality information. However, objective findings of PTSD-related sleep disturbance yield inconsistent results and have not always replicated subjective reports. Disparities are also commonly displayed between concurrently measured subjective and objective PTSD-related sleep disturbance.

Subjective findings, objective findings, and studies comparing subjective and objective assessment of sleep disturbance in PTSD will be systematically reviewed.

Limitations of these studies and an attempt to overcome some of these limitations in the current study are also discussed.

Sleep Variables and Measures

Sleep has been a topic of investigation in many scientific areas, therefore, there are a wide variety of sleep measures and sleep variables utilized to assess, diagnose, and describe sleep characteristics and sleep impairments. Subjective measures, as well as objective assessments, query similar sleep variables to describe features of insomnia: sleep quantity, sleep onset insomnia, sleep maintenance insomnia, and sleep quality. A measure of sleep quality, total sleep time (TST) identifies the total amount of sleep actually experienced throughout the night. Although the total amount of sleep required by each individual differs, research suggests the optimal amount of TST for an adult is seven to nine hours per night (National Sleep Foundation, 2010). Reduction in TST can be a result of sleep onset or maintenance insomnia. Sleep onset latency (SOL) describes the amount of time that passes in the transition from fully awake to sleep and is the most commonly reported measurement of sleep onset insomnia in the current literature. Increased SOL at night prior to sleep indicates greater sleep dysfunction and increases in SOL prior to bedtime decrease TST. In addition to onset difficulties, one can experience sleep maintenance insomnia that is measured as wake after sleep onset (WASO) – the total amount of wake time after initial sleep onset. The amount of time lost is summed across all mid-sleep awakenings to give a total WASO value. A more qualitative measure, sleep efficiency (SE) is the percent of time asleep divided by total time spent in bed multiplied by 100. Therefore, increases in time lost through SOL and

WASO values decrease quality/efficiency of sleep. Normal, sufficient sleep efficiency for healthy adults is defined as 90% (Brzezinski et al, 2005), with many pathological populations, including PTSD, reporting decreases in sleep efficiency and sleep quality. Table 1 includes these sleep variables and the corresponding acronyms for reference use.

Table 1

Sleep Variable Acronyms

Sleep Variable	Acronym
Total sleep time	TST
Sleep onset latency	SOL
Wake after sleep onset	WASO
Sleep Efficiency	SE

Subjective measures. Subjective sleep measures assess the person's own perspective of their sleep disturbance and give researchers a non-invasive method of examination. Measures are easily collected and require little time or effort to complete. Subjective measurement tools include two main types: self report questionnaires and daily diaries. The largest categorical distinction between assessment groups is the time period queried, as self-report questionnaires are specific to general sleep patterns across a longer period of time while daily diaries track sleep characteristics over individual nights. The Pittsburgh Sleep Quality Index (PSQI; Buysse, Reynolds, Monk, Berman, & Kupfer, 1989) and Insomnia Severity Index (ISI; Bastien, Vallieres, & Morin, 2001) are examples of self-rated questionnaires that assess sleep over a set time interval. They rely on individual self-report of sleep characteristics to describe symptoms of insomnia and overall sleep disturbance. The

PSQI describes seven distinct variables of sleep: sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbance, use of sleep meds, and daytime dysfunction using a 0-3 likert scale. The PSQI is a useful tool for initial sleep assessment and general sleep measures with acceptable reliability and validity (Buysse et al., 1989). However, retrospective design and query of sleep disturbance over an extended period of time can limit the application of this measure when comparing subjective and objective sleep.

Sleep questionnaires are an acceptable assessment of general sleep hygiene but may not be the best tool when nightly monitoring is the goal. Daily symptom monitoring diaries rely on a daily report of sleep and sleep disturbance. Although the number and wording of questions may differ across studies, reports of total sleep time, sleep quality, awakenings after sleep onset and sleep latency each night allow for symptoms to be reported more precisely from night to night over long periods. Daily diaries are also extremely useful when tracking symptoms across time as well as comparing subjective and objective assessment.

Objective measures. Objective techniques allow for clinical investigation and diagnosis of sleep disturbance devoid of subjective interpretation. Where sleep disturbance is common and assessment of sleep is a primary aim, objective measures of sleep such as polysomnography (PSG) and actigraphy are employed to investigate sleep disturbance physiologically. Objective measures are somewhat more invasive and sometimes require the participant to sleep in a laboratory setting. PSG is considered the gold standard for sleep assessment and employs measurements of electroencephalograph (EEG), electrocardiograph to monitor heart rate (EKG) as well as electromyograph and other monitors of physiological activity. Changes in neural activity, or brain waves, indicate changes in consciousness and are used to identify when a patient is asleep and transitioning through sleep stages. PSG

allows researchers and clinical professionals to monitor sleep and sleep architecture to identify any anomalies or impairments that may be present.

A less invasive option to PSG, actigraphy has a number of advantages including smaller, less cumbersome equipment, comparatively low-cost, and less burdensome multiple night use in the home environment. It is considered an objective behavioral indicator of sleep and has frequently been used in studies of insomnia (Edinger, Means, Stechuchak, & Olsen, 2004; Sadeh, Hauri, Kripke & Lavie, 1995). An actigraphy is usually attached to the non-dominant wrist and can be worn 24 hours a day for days or weeks at a time. Although the actigraphy provides minimal data regarding sleep architecture, it does provide an objective assessment of sleep by monitoring sleep/wake cycles and may be used to assess insomnia and sleep impairments which are indicated by total sleep time (TST), sleep efficiency (SE), sleep onset latency (SOL), and wakening after sleep onset (WASO). Actigraphy has been found to be a valid objective assessment tool for sleep/wake cycles in comparison to assessment through the gold-standard PSG (Littner et al., 2003; Edinger et al., 2004; Ancoli-Israel et al., 2003) and strong correlations between PSG and actigraphy data have been shown in participants with insomnia ($r = .88$; Shaver, Lentz, & Landis, 1996).

Subjective Sleep Impairment in PTSD

Seminal literature in PTSD-related sleep dysfunction heavily relied on subjective, individual reports of sleep disturbance to investigate sleep characteristics utilizing global sleep questionnaires and occasionally nightly sleep diaries. Findings of subjective PTSD-related sleep impairment have been relatively consistent across studies and cohorts. Overall, studies of subjective assessment of sleep in PTSD have found significant impairment in sleep quality and quantity as well as delayed sleep onset and poor sleep maintenance.

Sleep onset insomnia, as measured by increases in sleep onset latency (SOL), has been reported in 41% - 44% of individuals with PTSD compared to 6% of combat veterans without PTSD and 5-13% of civilians (Neylan et al., 1998; Ohayon and Shapiro, 2000). Frequent or very frequent difficulty falling asleep was found exclusively in combat veterans with PTSD, and a high correlation between non-sleep PTSD symptom scores and sleep onset insomnia was also reported (Neylan et al., 1998). Similar findings were reported by Mellman Kulick-Bell, Ashlock and Nolan (1995) in a Vietnam veteran cohort and other studies report consistent findings across veteran populations (Brown & Boudewyns, 1996; Hurwitz, Mahowald, Kuskowski & Engdahl, 1998). Sleep onset insomnia has also been endorsed in community PTSD samples (Ohayon & Shapiro, 2000) but importantly is not reported by all persons suffering with PTSD. In a study of natural disaster survivors, no evidence for sleep onset difficulty was found (Mellman, David, Kulick-Bell, Hebding, & Noland, 1995); a veteran study by Hurwitz and colleagues (1998) reported only 6 of 18 participants with PTSD endorsed sleep onset insomnia issues (13 reported difficulty falling asleep) while all 18 participants with PTSD reported waking during the night, pointing to a concern for sleep maintenance disruption in addition to sleep onset difficulties.

Prevalence of sleep maintenance insomnia, as measured by waking after sleep onset (WASO), has also been reported at a much higher rate in participants with PTSD (91%) than non-PTSD combat veterans (63%) and healthy civilian controls (53%) (Neylan et al., 1998). Findings of subjectively reported sleep maintenance impairment have been consistent across studies with PTSD patients endorsing more disturbance, awakenings, and time spent awake than controls (Ohayon & Shapiro, 2000). Brown and Boudewyns (1996) reported

sleep maintenance insomnia as the most endorsed sleep impairment within Vietnam combat veterans with PTSD.

A number of theories have been posed regarding why those with PTSD report sleep onset and maintenance insomnia ultimately reducing sleep quality and quantity. Researchers suggest sleep maintenance insomnia is often a product of nightmares experienced by those with PTSD. Nightmares can be re-enactments of the trauma or non-trauma related, both resulting in loss of sleep as identified by sleep maintenance insomnia (WASO) and decreases in sleep quality (SE) and quantity (TST). Increased anxiety of experiencing nightmares during sleep may also contribute to reports of sleep onset insomnia (Inman, Silver & Doghramji, 1990; Krakow et al., 2001). Individuals with PTSD may attempt to avoid sleep to avoid re-experiencing through traumatic dreams. Sleep impairment can also proliferate through the development of negative coping strategies: sleeping with the lights on, getting out of bed, sleeping in less conventional places, and other behaviors (Krakow, Hollified, & Shrader, 2000; Spoomaker & Montgomery, 2008).

Subjective sleep disturbance has also been highly correlated with the non-sleep related PTSD symptoms and daytime PTSD symptoms alone were found to predict 48% of the variance in sleep onset difficulties (Neylan et al., 1998) supporting the idea that non-sleep related PTSD symptoms contribute to subjectively reported impairments in sleep. More specifically, research suggests sleep difficulties are directly related to the hypervigilance and hyperarousal symptoms as indicated by increased activity in the noradrenergic system (Pillar, Malhotra & Lavie, 2000). This suggests the individual is at a continually increased state of vigilance and cannot reduce arousal enough to effectively fall asleep – contributing to hyperarousal symptomatology included in the *DSM-IV-TR* criteria for PTSD. Interestingly,

objective research utilizing polysomnography to investigate the strength of stimuli required to awaken participants with PTSD found that a louder auditory stimulus is required to awaken those with PTSD from sleep and arousal response is longer as compared to healthy controls. These objective reports support a decrease in overall arousal and the researchers suggested this could be due to an active process to block external or internal stimuli from interrupting sleep (Dagan, Lavie, & Bleich, 1991; Lavie, Katz, Pillar, & Zinger, 1998).

Regardless of the underlying mechanism, research consistently reports subjective sleep onset, maintenance, quality, and quantity impairments in those with PTSD. Although these findings support inclusion of sleep related symptoms in the *DSM-IV-TR* criteria for PTSD, concerns of relying solely on subjective reports are widespread in the literature (Harvey, Jones, & Schmidt, 2003). Subjectively reported sleep impairments may differ from objective assessments of the same variables as participant's perceptions and cognitive appraisals of sleep experience may introduce report bias in the subjective assessments (Van Den Berg et al., 2008). Subjective reports allow for assessment of the participant's perception of sleep disorder, but do not serve as direct objective recordings of sleep impairment. Utilizing objective tools such as polysomnography (PSG) and actigraphy allows for a distinct, more physiological perspective to assess and diagnose PTSD-related sleep disturbance.

Objective Sleep Impairment in PTSD

Polysomnography. Polysomnography (PSG) has been employed frequently to investigate sleep related impairments within PTSD and trauma populations. In contrast to subjective findings, PSG studies focused on capturing sleep-related disturbance within a PTSD population have been inconsistent. Much of the objective research has reported at least

one type of sleep impairment in PTSD, but the impairments displayed differ across studies (Table 2).

Table 2

Previous Investigations of PTSD-related Sleep Impairment with Objective Measures

Study	Measure	Trauma Type	%male	TST	SL	WASO	SE
Breslau et al. (2004)	PSG	Civilian	33.9	ns	ns	ns	ns
Dow et al. (1996)	PSG	Combat	100	-	ns		ns
Engdahl et al. (2000)	PSG	Combat	100	ns	ns	ns	ns
Fuller et al. (1994)	PSG	Combat	100	ns	ns	ns	ns
Glaubman et al. (1990)	PSG	Combat & Civilian	100	ns	ns	+	-
Habukawa, et al. (2007)	PSG	Civilian	50	ns	ns	+	-
Herbst, et al. (2010)	PSG	Combat & Civilian	56.7	ns		ns	ns
Hurwitz et al. (1998)	PSG	Combat	100	ns	ns	ns	ns
Klein et al. (2002)	PSG	MVC	57.1	ns	ns	ns	ns
Lavie et al. (1979)	PSG	Combat	100	-	ns	+	-
Lavie et al. (1998)	PSG	Combat	100	ns	ns	ns	ns
Mellman, David, et al. (1995)	PSG	Hurricane Andrew	47.4	ns	ns	ns	ns
Mellman, Kulick-Bell, et al (1995)	PSG	Combat	100	ns	ns	+	-
Mellman, Kumar, et al.	PSG	Combat	100	ns		+	-

(1995)

Mellman et al. (1997)	PSG	Combat	100	-	ns	+	-
Mellman et al. (2002)	PSG	Civilian	74.2	-	ns	+	
Neylan et al. (2003)	PSG	Combat	100	ns		ns	ns
Otte et al. (2007)	PSG			ns			ns
Ross et al. (1994)	PSG	Combat	100	ns	ns	ns	ns
Woodward et al. (2000)	PSG	Combat	100	ns		ns	ns
Yetkin, et al. (2010)	PSG	Combat & Civilian	100	-	+	ns	-
Calhoun, et al. (2007)	Actigraphy	Civilian	0	ns	+	ns	-
Dagan, et al. (1997)	Actigraphy	Combat	100	ns			ns
Klein et al. (2003)	Actigraphy	MVC	71	ns			ns

Note: ns = Non-significant difference between PTSD and control group; + = significantly increased levels in PTSD group as compared to controls; - = significantly decreased levels in PTSD group as compared to controls

The most common significant sleep impairment in objectively measured sleep reported in PTSD samples is sleep maintenance insomnia as indicated by increases in WASO in combat (Lavie, Hefez, Halperin & Enoch, 1979; Mellman, Kulick-Bell et al, 1995; Mellman, Kumar, Kulick-Bell, Kumar & Nolan, 1995; Mellman, Nolan, Hebding, Kulick-Bell, & Dominguez, 1997), civilian (Germain & Nielsen, 2003; Habukawa, Uchimura, Maeda, Kotorii & Maeda, 2007; Mellman, Bustamante, Fins, Pigeon, & Nolan, 2002) and mixed cohorts (Glaubman, Mikulincer, Porat, Wasserman, & Birger, 1990). Sleep onset

insomnia is also reported, as indicated by significant increases in SOL (Yetkin et al., 2010; Calhoun et al., 2007). Studies have also displayed decreases in quantity and quality of sleep for those with PTSD, as indicated by decreases in sleep efficiency (Germain & Nielsen, 2003; Glaubman et al., 1990; Habukawa et al., 2007; Lavie et al., 1979; Mellman, Kulick-Bell et al., 1995; Mellman, Kumar et al., 1995; Mellman et al., 1997; Yetkin, Aydin & Ozgen, 2010) and decreases in TST across all cohorts (Lavie et al., 1979; Mellman et al., 1997; Mellman et al., 2002; Yetkin et al., 2010). Other studies have not replicated findings of sleep impairments in PTSD reporting those with PTSD show no difference in sleep as compared to healthy controls (Breslau et al., 2004; Herbst et al., 2010; Hurwitz et al., 1998; Klein, Koren, Arnon, & Lavie, 2002; Lavie et al., 1998; Mellman, David et al., 1995).

In a recent meta-analysis, Kobayashi and colleagues (2007) analyzed the findings of 20 studies investigating PTSD-related sleep disturbance with PSG. Researchers computed mean effect size and confidence intervals for multiple sleep parameters and found only small effects overall. A small negative effect was displayed for TST ($d+ = -.17$; 95% CI = $-.39$ to $.05$), indicating across studies, participants with PTSD showed only a small deviation from control groups in the reduction of sleep quantity. Overall effect for SOL was also small but positive ($d+ = .13$; 95% CI = $-.04$ to $.39$), suggesting participants with PTSD experienced an increase in sleep onset insomnia as compared to control groups across studies. No significant effect size was revealed for WASO, and SE was not investigated. The effects reported in the meta-analysis were only small, and findings across studies were inconsistent suggesting further research is needed in order to better develop this area of study.

Actigraphy. Recent studies have employed the use of ambulatory monitoring, specifically actigraphy recording, in the home environment to objectively assess sleep

disturbance within traumatized and PTSD samples. Actigraphy serves as a non-invasive method of monitoring rest/activity cycles, can be worn for several days at a time, and is used to determine sleep patterns while less expensive and less intrusive than PSG. Similar to overall findings in the PSG literature, actigraphy studies investigating sleep disturbance in participants with PTSD have reported inconsistent results. The seminal study in the investigation of PTSD-related sleep disturbance with actigraphy utilized male combat veterans with chronic PTSD compared to age and gender matched veteran controls without PTSD in their homes for 5 consecutive nights using the ambulatory monitoring technique (Dagan, Zinger & Lavie, 1997). Although those with PTSD showed a trend for lower sleep quality, no significant differences were reported in TST, SE, activity, or sleep wake transitions (Dagan et al., 1997). In the published findings, Dagan and colleagues (1997) reported no objective evidence of sleep disturbance in veterans with PTSD as compared to traumatized controls without PTSD. However, a more recent paper analyzed these data including effect size and confidence intervals more closely and discovered PTSD had a large negative effect on SE (*Cohen's d* = -.84; 95% CI = -1.61 to -.02) and a large increase in restlessness (*Cohen's d* = .91; 95% CI = .08 to 1.68) (Calhoun et al., 2007) suggesting PTSD has a malignant effect on the quality of sleep.

In a prospective study of hospitalized motor vehicle collision (MVC) survivors, actigraphy was used as an objective measure of sleep in PTSD patients in their home environment (Klein, Koren, Arnon & Lavie, 2003). Twenty-six patients went on to develop PTSD at the 12-month assessment and those data were used for analyses. Nineteen surgical patients were used as the non-traumatized comparison group and the longitudinal design investigated sleep disturbance at 1 week, 3 month and 12 month assessments by recording

actigraphy for 48 hours at each assessment. A significant difference in sleep quantity as measured by TST at 3 months was revealed between MVC survivors who went on to develop PTSD compared to those who did not. However, both traumatized groups, regardless of PTSD status, slept significantly longer than the comparison surgical patient group at the 12-month assessment. Overall, the study concluded a lack of objective evidence for sleep disturbance in PTSD within MVC survivors in their natural environment.

Calhoun and colleagues (2007) investigated PTSD-related sleep disturbance in an all female, mixed trauma cohort. Participants included individuals with PTSD and without PTSD or major depressive disorder (MDD) as controls. Actigraphy data were averaged across 3 nights of monitoring for each participant and results indicated women with PTSD experienced increased SOL, decreased SE and more restless sleep as defined by fragmented sleep and mean activity score (Calhoun et al., 2007). These findings are in contrast to the conclusions discussed in previous research that reported no significant objective sleep disturbance in veterans or MVC survivors.

Comparison of Subjective and Objective Sleep Impairment in PTSD

Mixed findings from subjective and objective assessment of sleep pose new questions as to what is actually occurring in those with PTSD. Although individuals with PTSD subjectively report sleep impairments and disturbance, objective assessments with both PSG and actigraphy have not always been in agreement. In a review, Lavie (2001) describes that objective sleep laboratory findings do not corroborate subjective reports of deficits in sleep. He suggests those with PTSD may not be aware of their actual sleep. Studies investigating both subjective and objective PTSD-related sleep disturbance have consistently displayed discrepancies in perceived and actual sleep impairment. Overall, these investigations have

reported subjective over-estimation of sleep disturbance when compared to objective assessment in participants with PTSD. This occurrence has been labeled “subjective insomnia”, sleep state misperception, and most recently was called paradoxical insomnia for diagnostic purposes (American Academy of Sleep Medicine, 2005).

The first study comparing self-report and objectively measured sleep disturbance in participants with PTSD found an overall underestimation of total sleep time and overestimation of sleep onset latency in self-report measures as compared to PSG (Carskadon et al., 1976). Subsequent studies utilizing PSG compared to subjective measures have displayed similar results in veterans (Dagan et al., 1991; Hurwitz et al., 1998; Engdahl, Eberly, Hurwitz, Mahowald, & Blake, 2000) and mixed trauma cohorts (Lavie, 2001; Herbst et al., 2010).

Dagan and colleagues (1991) investigated PTSD-related sleep disturbance in 19 combat veterans several years post trauma compared to 6 healthy male controls. Each participant’s sleep was monitored with electroencephalogram (EEG), electromyogram (EMG), electrooculograph (EOG), and electrocardiogram (EKG) for 2 nights of uninterrupted sleep. PTSD patients during clinical interviews widely endorsed sleep impairments such as difficulty falling asleep, multiple awakenings, and disturbing dreams, however, objectively measured sleep was within normal limits. No formal statistical comparisons were made between subjective and objective sleep disturbance, however the authors commented that they were expecting to observe more disordered sleep within the objective recordings.

Hurwitz and colleagues (1998) conducted a study to directly investigate sleep disturbance associated with PTSD with both objective and subjective tools. Because sleep

impairment is so frequently endorsed in PTSD, the researchers wanted to objectively investigate sleep by utilizing sleep questionnaires (subjective report) as well as clinical PSG recordings (objective report). Consistent with previous subjective research, participants with PTSD reported significantly higher levels of sleep disturbance as compared to those without PTSD. However, PSG recordings completed over 2 successive nights in a laboratory setting revealed no significant group differences. Subjective reports of participants with PTSD significantly underestimated sleep quantity and overestimated sleep onset insomnia as compared to objective assessment. This study was the first to suggest that PTSD patients may have a distorted perception of their sleep, known as sleep state misperception in the insomnia literature (American Sleep Disorder Association, 1997).

Engdahl and colleagues (2000) found similar results to Hurwitz and colleagues (1998) in an investigation of elderly male combat prisoners of war ($N = 59$) with and without PTSD. Uninterrupted sleep was monitored with PSG for 2 successive nights in a laboratory setting and upon awakening, each participant was asked to subjectively rate the quality and quantity of sleep the previous night. The study noted discrepancies in concordantly measured subjective sleep and objective sleep. Sleep observed with PSG revealed no significant differences between those with and without PTSD; even though participants with PTSD reported more awakenings and more restless sleep than those without PTSD. Although the subjective sleep measure utilized in this study differed from Hurwitz and colleagues (1998), findings and conclusions are consistent indicating incongruence between subjective perception of sleep and objective measurement in PTSD and suggest the possibility of sleep state misperception within PTSD cohorts.

Previous studies have investigated all male veteran cohorts, while Herbst and colleagues (2010) aimed to investigate mixed gender participants with combat and civilian traumas ($N = 60$). This study also made a methodological change from previous research exploring PTSD-related sleep disturbance both in a laboratory and home environment. Herbst and colleagues utilized PSG in both locations for objective sleep assessment. Subjective sleep measures included the Pittsburgh sleep quality index (PSQI), a global sleep measure, and a visual analog self report rating scale of sleep quality. Participants with PTSD reported lower ratings of sleep quality than controls in both the laboratory and home environment on the visual analog scale. However, no group differences were found in objective sleep measures as recorded by PSG across all nights in the laboratory or at home. This discrepancy again suggests sleep misperception as opposed to actual objective sleep impairment in participants with PTSD.

Comparison studies with actigraphy technology have reported similar results to PSG investigations for PTSD-related sleep. Dagan and colleagues (1997) also investigated PTSD-related sleep disturbance with actigraphy in combat veterans in their home environment. Dagan and colleagues found male veterans suffering from PTSD overestimate subjective sleep disturbance compared to healthy controls. Veterans with PTSD experienced objective sleep within normal limits and did not significantly differ from healthy controls on any objective sleep measures using actigraphy recordings. The authors suggest patients with PTSD may experience “subjective insomnia,” that is, they subjectively misperceive sleep problems while objectively recorded sleep is not impaired – essentially another name for sleep state misperception.

Klein et al. (2003) investigated motor vehicle collision (MVC) survivors ($N = 102$) with actigraphy and compared objective findings with the subjective reports previously described. Although subjective reports were predictive of PTSD development, objective assessment was not found to be predictive or significantly related to PTSD. Consistent with previous PSG and actigraphy findings, the study suggests that the sleep problems experienced in PTSD are misperceptions in sleep and not objective impairment.

Westermeyer and colleagues (2007) reported results supporting the idea of participants displaying sleep state misperception in a study of combat veterans with PTSD. Total sleep time was significantly underestimated by participants; specifically, participants subjectively reported 51 minutes less of total sleep time as compared to actigraphy measurement of sleep. However, the study also indicated those with PTSD underreported WASO in diary measures as compared to actigraphy with 3.6 times fewer wake episodes reported than were recorded by actigraphy. These findings suggest that even when concurrently reported, sleep logs underestimate awakenings in PTSD patients when compared to objective recordings.

In the only objective study of PTSD-related sleep disturbance consisting of female trauma survivors, women with mixed trauma histories ($N = 52$) were found to subjectively underestimate PTSD-related sleep disturbance as indicated by reporting more TST and less time lost to WASO as compared to objective actigraphy assessment of sleep on the same night (Calhoun et al., 2007). In contrast to previous research, actigraphy measures were moderately correlated with self-report sleep assessment in the form of daily sleep diary data, but were not related to scores on the self-report inventory of the PSQI. This study provides the first evidence in an all female cohort and is the first to report those with PTSD have

objectively measured sleep disturbance in their normal home environment. Calhoun and colleagues also suggest sleep diaries are more consistent with objective sleep measures than a more global sleep measure such as the PSQI. Calhoun and colleagues (2007) suggest research should not simply attribute sleep disturbance to distortions in perception; instead, tangible objective sleep disturbance is occurring and must be assessed, accounted for, and treated.

Findings of objective sleep impairment in female trauma survivors with PTSD are inconsistent with the previous research in mixed gender cohorts and all male veteran cohorts that report only subjective but no objective sleep disturbance. In contrast to subjective overestimation of sleep impairment previously reported, not only were objective impairments reported by Calhoun and colleagues (2007), but an underestimation of sleep disturbance was subjectively endorsed. Further evidence sleep disturbance in females may be differentially displayed was reported by Humphreys, Lee, Neylan & Marmar (1999) in an investigation of female survivors of domestic violence in a battered women's shelter. Actigraphy recordings revealed a significant increase in SOL and WASO when compared to subjective reports collected on the same nights. Thirty four percent of participants objectively experienced a sleep efficiency of less than 80% while subjectively reporting better overall sleep. Although PTSD was not assessed in this cohort, findings suggest poorer objectively measured sleep in women who have experienced chronic trauma such as domestic violence. These findings are in contrast to the subjective overestimation of disturbance found in most prior research and suggest sleep state misperception may take multiple forms – with a misperception of over or underestimation of sleep disturbance occurring in different cohorts. Discrepancies in findings

warrant further investigation to better understand sleep disturbance in female samples and to illuminate the relationship between subjective and objective reports in this cohort.

Limitations of Previous Research on Sleep Impairment in PTSD

As the review of the current literature illustrates, there are a number of limitations that should be addressed. Methodological inconsistencies in both subjective and objective measures across studies make it difficult to compare data and generalize findings to various trauma and PTSD populations. The method of investigation for PTSD-related sleep disturbance has been greatly limited, with a few exceptions, to laboratory PSG assessment of male combat veterans with little analysis of the effects of comorbid disorders. Researchers and clinicians are aware that differences in gender and trauma type, as well as comorbid disorders, can have a significant effect on PTSD symptom presentation as well as co-existing secondary symptoms (Galovski, Mott, Young-Xu & Resick, 2010). Further research is needed to generalize findings to a broad range of cohorts, including female survivors of interpersonal violence.

A recent meta-analysis of PSG-measured sleep abnormalities in PTSD by Kobayashi and colleagues (2007) identified sex and comorbid disorders as possible moderating variables in the relationship of PTSD and sleep disturbance. PSG studies with all male cohorts displayed lower sleep quantity (TST) and increased SOL as compared to investigation including mixed gender cohorts. Investigations with lower rates of comorbid depression were found to display decreased sleep quantity as measured by PSG. Although Kobayashi and colleagues (2007) did not review actigraphy assessed sleep disturbance, these findings point to a need for further investigations to address the variables of gender and comorbidity. The present study attempts to add to the literature and address the inconsistencies and

methodological limitations of the current literature by investigating PTSD-related sleep disturbance both subjectively and objectively in an all female cohort with and without comorbid major depressive disorder.

Cohort. Most PTSD sleep studies have utilized all male combat veteran cohorts leaving female survivors greatly under investigated (see Table 2). Males are twice as likely to experience a traumatic event in their lifetime; however, women are twice as likely to develop PTSD after a traumatic event (Breslau et al., 2004). Reasons for this discrepancy have been suggested including that women are more likely to experience sexual traumatization which produces the highest rates of PTSD development (Stein, Walker, & Forde, 2000; Macmillian et al., 1997) and differences in coping strategies, cognitive appraisals, biological and psychological stress responses also have been hypothesized. Although women and men have been found to present with similar PTSD symptoms once diagnosed, they also report secondary non-pathological symptoms differentially including health outcome and state anger (Galovski et al., 2011).

Gender differences in sleep patterns have been noted in otherwise healthy individuals that may result in differential findings between genders across PTSD-related sleep disturbance. Sleep patterns in community samples have been found to differ across gender: males show poorer, lighter sleep overall as compared to females in PSG studies and men have reduced sleep efficiency compared to women (Redline et al., 2004; Roehrs, Kapke, Roth, & Breslau, 2006). Kobayashi and colleagues' (2007) meta-analysis revealed that male participants with PTSD sleep less than male participants without PTSD while studies including female and mixed cohorts displayed only a small difference in sleep quantity across PTSD status. Similarly, all male studies display large effect sizes for sleep onset

insomnia. Studies including an all male cohort reported longer SOL times in PTSD individuals compared to non-PTSD males while studies including females and mixed cohorts did not show any difference in sleep onset between PTSD groups (Kobayashi, 2007). This moderating effect is limited by possible effects of trauma type: all male cohorts were also all veteran while mixed cohorts included veteran and civilian trauma such as MVC.

Recent findings in female trauma survivors show discrepancies in comparison to previous research in male cohorts for PTSD-related sleep disturbance. Calhoun and colleagues (2007) reported significant objective sleep disturbance in an all female cohort as indicated by decreased SE, increased SOL, and increased restlessness, while studies in male cohorts have reported little to no objective sleep disturbance. Differences in subjective versus objective assessment were also reported by Calhoun and colleagues who found an underestimation of sleep disturbance in women in contrast to overestimation in male and mixed cohorts. These gender differences both in PTSD and sleep disturbance point to the importance for further investigation of sleep disturbance in female traumatized cohorts as findings in male populations may not be generalizable to female survivors.

Assessment tools. When aiming to compare subjective and objective sleep reports, assessment tools must monitor sleep over concurrent nights and comparable sleep variables such as TST, SOL, WASO, and SE. Although findings from subjective assessments have consistently reported impairments in PTSD, subjective measures have not been consistent across studies. Discrepancies between subjective reports and objective assessment of sleep disturbance in PTSD populations have been displayed. Based on these findings, the possibility of perceived sleep disturbance and subjective insomnia has been implicated in PTSD populations. These findings and conclusions may be limited by reliance on global

sleep measures instead of daily sleep logs for subjective assessment in comparison studies. Global sleep inventories are useful for assessing general complaints over time. However, when investigating both subjective and objective sleep disturbance, global sleep disturbance measures do not allow for comparison across nights, thus hindering the researcher's ability to deduce the mechanism of impairment. Some previous experiments have utilized a nightly measure of sleep disturbance but do not assess specific sleep variables, instead focusing on general subjective sleep quality. Daily sleep diaries questioning subjective sleep onset insomnia, sleep maintenance insomnia, sleep quality, and sleep quantity variables allow for direct comparison with objective findings which are reported using the same variables.

With the focus of investigating sleep disturbance specifically in PTSD, assessments tools must address special limitations that may confound findings in traumatized populations. Some studies have used PSG in a laboratory setting, while others have utilized actigraphy in a home environment. Although the PSG is the gold standard in sleep architecture investigation, PSG in a laboratory environment may be too invasive for participants with PTSD and may result in sleep inconsistent with the participant's actual daily experience. PSG is usually completed in a controlled and safe laboratory setting and may remove environmental factors that play a role in the sleep disturbances experienced on a nightly basis by those suffering from PTSD. Some researchers argue that PTSD-related sleep disturbance in a laboratory setting may be compromised due to participants' perception of a more secure (Sheikh, Woodward, & Leskin, 2003; Calhoun et al., 2007) or novel sleeping environment (Woodward, Bliwise, Friedman & Gusman, 1996). Studies also suggest it may not only be the environment in which the investigation takes place but also acclimation to the PSG equipment itself. The phenomenon of the first night effect describes the alteration of sleep in

an unfamiliar environment reflecting an increase in vigilance to a new situation where sleep latency is increased and sleep efficiency is decreased (Agnew, Webb, & Williams, 1966).

Actigraphy allows for a reliable, non-invasive, extended assessment of objective sleep disturbance in the home environment and is ideal for participants with PTSD. Although actigraphy does not assess sleep architecture variables, it does allow for the investigation of sleep characteristics important to understanding impairments within PTSD cohorts. However, the method by which actigraphy sleep characteristics are analyzed is also potentially important to consider. Existing studies of actigraphy findings may not have utilized the most reliable analytic technique. Previous research investigating PTSD-related sleep disturbance with actigraphy has typically utilized zero crossing mode (ZCM) for analysis (Dagan et al., 1997; Westermeyer et al., 2007), but recent investigation into the most accurate scoring method for comparison to PSG was found to be proportional integrating measure (PIM) which is a more reliable method for analysis of sleep/wake cycles (Blackwell et al., 2008; Ancoli-Israel et al., 2003).

Comorbidity of major depressive disorder. In addition to methodological and gender limitations, few studies in the current literature directly investigate the impact of comorbid pathology on PTSD-related sleep impairment. Kessler, Sonnega, Bromet, Hughes, and Nelson (1995) report major depressive disorder (MDD) occurring with PTSD has comorbidity rates of nearly 48% in men and 49% in women. Research suggests comorbid disorders, such as major depressive disorder, may be a likely cause of sleep disturbance in PTSD (Dow, Kelsoe, & Gillin, 1996). Although most studies of PTSD-related sleep disturbance comment on comorbidity in the sample – as high as 100% (e.g. Dow et al., 1996) - most do not address the issue of comorbidity in data analyses. Some studies have excluded

those with comorbid periodic leg movement, sleep apnea, and MDD, possibly eliminating a large subset of people suffering from PTSD-related sleep disturbance and reducing generalizability of findings to the true PTSD population.

MDD has independently been associated with subjective and objective sleep impairment (Kupfer, 1999; Sheikh et al., 2003). A large majority of MDD patients (90%) report sleep disturbances such as insomnia (Tsuno & Besset, 2005). Sleep disturbances are included in the diagnostic criteria for MDD as defined by the *DSM-IV-TR* (APA, 2000). Utilizing objective assessment tools, MDD has been associated with sleep impairments including sleep onset and maintenance insomnia and decreased sleep quantity and quality as compared to healthy individuals (Argyropoulos & Wilson, 2005; Germain, Nofzinger, Kupfer, & Buysse, 2004; Hatzinger, Hemmeter, Brand, Ising, & Holsboer-Trachsler, 2004; Nofzinger et al., 2005).

Consistent reports of sleep impairment in MDD and the high comorbidity rates of PTSD and MDD both contribute to the interest in investigating sleep characteristics in those with comorbid PTSD/MDD. Woodward, Friedman, and Bliwise (1996) found no difference in TST, SE, or WASO between veteran in-patients with PTSD-only and those with comorbid PTSD/MDD. However, this study was limited by a small sample size ($N = 27$) and half of the PTSD-only group had a history of MDD. There is some evidence to suggest comorbid diagnoses have a differential effect on sleep disturbance in a PTSD population. Leskin, Woodward, Young & Sheikh (2002) reported higher rates of nightmares in those with comorbid PTSD/MDD as compared to participants with only PTSD. Yetkin and colleagues (2010) found differential sleep impairment as measured by PSG in veteran in-patients with PTSD-only and PTSD/MDD as compared to controls. Although no significant differences

were displayed between the PTSD-only and PTSD/MDD group, those with PTSD-only displayed more profuse objective sleep impairment than the comorbid PTSD/MDD group as compared to normal controls. Kobayashi and colleagues (2007) compared effect sizes across studies with less than or greater than 30% comorbid MDD/PTSD and found studies with a lower rate of comorbid MDD displayed more sleep disturbance than controls as compared to studies with higher rates of MDD comorbidity. That is, the difference between participants with and without PTSD in a higher comorbid MDD cohort showed smaller differences across sleep variables (Kobayashi et al., 2007).

These results are somewhat unexpected as sleep disturbance has independently been associated with both PTSD and MDD and, therefore, one might expect to observe increased sleep disturbance in those with both disorders. The report that sleep impairments are more prominent in samples with lower comorbidity may be a product of more selective inclusion criteria for the studies including lower rates of comorbidity (Kobayashi et al., 2007). However, both MDD symptoms and comorbid diagnosis may have a measurable effect on sleep impairment in PTSD populations and should be further investigated.

Summary

The relationship between trauma, pathology, and sleep has yet to be fully explained in the literature. There are discrepancies in the current research findings particularly between subjective and objective tools used to assess sleep disturbance, a bias toward studying male participants, and a lack of research focused on the effects of comorbid pathology on PTSD-related sleep disturbance. Thus, there are a number of important research questions remaining. At a basic level, how does sleep disturbance manifest in a female PTSD cohort?; does sleep disturbance actually exist or are there subjective cognitive factors that lead to a

misperception of sleep disturbance?; and finally, does comorbid psychopathology have an effect on the relationship of PTSD and sleep?

Purpose of the Current Study

The present study aimed to add to the current understanding of PTSD-related sleep disturbance by addressing limitations within the current literature and asking new questions to further advance the field. The current study investigated subjective and objective sleep disturbance in a home environment within a cohort of female interpersonal violence survivors diagnosed with PTSD, some with comorbid major depressive disorder. Female survivors of trauma were assessed for psychopathology and global sleep impairment. Sleep disturbance was specifically investigated across a seven-day assessment period employing both subjective and objective measures. Daily sleep diaries were used to measure subjective sleep disturbance. Use of actigraphy monitoring allowed for a minimally invasive objective physiological investigation of sleep in the participants normal home environment over an extended period of time. The current aims were addressed and hypotheses posed based on the current state of the literature and understanding of sleep and psychopathology.

Aim 1. Investigate subjective and objective physiological measures of PTSD-related sleep impairment within a female interpersonal violence cohort on the same nights of assessment.

- Hypothesis 1: Subjective reports of sleep, as measured with daily sleep logs, will produce an overestimation of sleep onset and maintenance insomnia and an underestimation of sleep quality and quantity compared to objectively measured sleep impairment in participants.

Aim 2. Investigate the effects of comorbid major depressive disorder on objective and subjective sleep disturbance in a female IPV cohort with PTSD.

- Hypothesis 2: Differential objective and subjective sleep impairments will be displayed across individuals with PTSD-only and comorbid PTSD/MDD.

Aim 3. Investigate the distinct contribution of each PTSD symptom cluster (hyperarousal, re-experiencing, and avoidance) and depressive symptoms to sleep state misperception in a female IPV cohort with PTSD.

- Hypothesis 3: PTSD hyperarousal and re-experiencing symptoms as well as depressive symptoms will uniquely contribute to the prediction of sleep state misperception.

Methods

Participants. Participants were drawn from a larger treatment-outcome study ($N = 92$) focusing on sleep-directed treatment as a complement to cognitive processing therapy. The sample consisted of treatment-seeking female interpersonal violence (IPV) survivors who completed up to seven nights of actigraphy monitoring ($n = 55$) with PTSD ($n = 29$) and comorbid PTSD/MDD ($n = 26$). Inclusion criteria included a PTSD diagnosis with sleep impairment as defined as a total score of 3 or higher for frequency and intensity on symptom D1 (trouble initiating or falling asleep) on the Clinician-Administered PTSD Scale (CAPS; Blake et al. 1990) and an age of 18 years or older. Exclusion criterion for this study included current psychosis, mental retardation, active suicidality, current addiction to drugs or alcohol, and living in an ongoing traumatic situation (e.g., domestic violence). Psychotropic medication usage was not excluded, but the participants were required to be stabilized on their medication during the course of the study. Sleep medication use was not excluded and

frequency of use was assessed. Participants could not receive any outside trauma- or sleep-focused psychotherapy throughout the course of the study and were not receiving any study-related treatment at the time of the sleep assessments reported in the current investigation.

The following protocol was approved by the Institutional Review Board at the University of Missouri –Saint Louis as part of a larger treatment grant entitled: Sleep-directed Hypnosis as a Complement to CPT in Treating PTSD (1R21AT004079-01; Principal Investigator Tara Galovski, PhD). 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 clinically trained M.A. and Ph.D. level psychologists. All participants gave written informed consent prior to beginning the study and were paid \$30 for their participation.

Measures. All participants completed a standardized trauma interview to collect demographic information, information about the crime, prior trauma history, and treatment history. Each participant's assault type was coded as physical or sexual assault based on the information provided in the trauma interview. Participants were assessed for PTSD symptoms using the Clinician-Administered PTSD Scale (CAPS; Blake et al. 1990). The CAPS is a 22-item scale with three associated features – avoidance, re-experiencing, and hyperarousal – assessing frequency and intensity of symptoms. The CAPS contains separate 5-point frequency and intensity rating scales (0-4) for symptoms identified with PTSD in the *DSM-IV* (American Psychiatric Association, 1994). Good internal consistency has been reported for all three subscales using intensity ratings ($\alpha = .87$) (Weathers, Keane & Davidson, 2001).

Participants were assessed for other psychopathology including major depressive disorder using the Structured Clinical Interview for DSM-IV-Patient Version (SCID: First, Spitzer, Gibbon, & Williams, 1996). The SCID is a diagnostic interview based on symptoms outlined in the DSM-IV and was used to diagnose major depression in the current investigation. Those with current MDD were considered in-group comparisons. The SCID has acceptable reliability for major depressive disorder ($\alpha = .66$; Lobbestael, Leurgans, & Arntz, 2010).

Participants completed the Beck Depression Inventory-II (BDI-II; Beck, Steer, & Brown, 1996) a self-report measure of depressive symptoms. The BDI-II consists of 21-items assessing depressive symptoms as outlined by the DSM-IV criteria for major depressive disorder (APA, 1994). Items are scored on a scale value of 0 to 3 resulting in a total scores that can be clinically evaluated using cutoff scores: *0-13 = minimal depression; 14- 19 = mild depression; 20-25 = moderate depression; 26-63 = severe depression*. The BDI-II was utilized as an indicator of depressive symptom severity and has been found to be reliable in this capacity ($\alpha = .92$; Beck et al., 1996).

Two subjective sleep measures were used to assess general sleep disturbance experienced over time prior to the assessment. The Pittsburgh Sleep Quality Index was utilized to assess sleep disturbance variables in the past month (PSQI; Buysse et al., 1989). The PSQI is a self-report, subjective assessment that contains 19 individual items scored from 0 to 3 that query seven sleep characteristics: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. The sum of the sub-scores generates one global score with total scores of 5 or above indicating poor sleep. The PSQI shows good internal consistency ($\alpha = .83$).

Subjective sleep disturbance over the past week was also assessed with the Insomnia Severity Index (ISI; Bastien et al., 2001): a seven item measure that assesses perceived insomnia severity and daytime distress caused by insomnia yielding a total score ($0-7 = no\ clinically\ significant\ insomnia$, $8-14 = sub-threshold\ insomnia$, $15-21 = moderately\ severe\ clinical\ insomnia$, $22-28 = severe\ clinical\ insomnia$). The ISI has shown good internal consistency ($\alpha = .74$) in a clinical sample. The aforementioned global sleep measures were used as descriptive measures to indicate the severity of sleep disturbance across groups and the overall sleep impairments experienced by all participants.

Although these general subjective measures allow for comparison across groups, daily sleep diaries were the primary subjective sleep assessment used in analyses for the present study. Sleep diaries allowed for a daily assessment of sleep and disturbance as opposed to more general self-report sleep measures that query sleep characteristics across weeks, months or longer. The diaries included questions to assess sleep loss, PTSD and depression symptoms, physical complaints, social activities, alcohol consumption, medication compliance, and health care utilization and required approximately five to seven minutes to complete daily. The diary was adapted from previous research (Galovski & Blanchard, 1998; Galovski & Blanchard, 2002) and has been found in these studies to show good sensitivity to treatment effects. The sleep diaries were completed nightly for one week. The questions utilized to query subjective sleep in the current study include: total hours of sleep (total sleep time; TST), number of minutes required to fall asleep (sleep onset latency; SOL), number of times wakened during the night, and total number of minutes of sleep loss when awakened (wakening after sleep onset; WASO). Sleep efficiency was also computed from these scores as calculated by total sleep time minus total number of minutes of sleep

loss to sleep onset latency and WASO divided by total sleep time; this score multiplied by one hundred will produce a percent of sleep efficiency (See Table 1).

Objective sleep disturbance was assessed utilizing a sleep watch and basic motion-logger technology - also known as an actigraphy (Ambulatory Monitoring Inc., Ardsley, NY). Actigraphy recordings allow for a daily measure of objective sleep and disturbance in the home environment with minimal amount of disruption in normal sleep patterns. Although, actigraphy does not allow for investigation of sleep architecture and sleep stages, it is a good measure of sleep quality, efficiency, total sleep time, latency to sleep, and awakenings after sleep onset (Ancoli-Israel et al., 2003). Actigraphy has been validated as an objective measure of sleep/wake cycles as compared to PSG (Edinger et al., 2004; Sadeh et al., 1995) and a high correlation has been displayed ($r = .88$) between actigraphy and PSG sleep recordings in females with insomnia (Shaver et al., 1996). The strength of the actigraphy is that recordings can be collected for long periods of time while being minimally invasive. A minimally invasive objective sleep measure is particularly important in those with PTSD to study sleep disturbance in the participant's natural environment. Actigraphy measurements were recorded over the course of seven days/nights. The actigraphy was programmed prior to the participant's arrival to record in "tri-mode" which collects three data modes simultaneously, proportional integrating mode (PIM), time above threshold (TAT) and zero crossing mode (ZCM). The actigraphy was programmed to sample and record movement at 30-second epochs. Data recorded includes the sleep variables previously described (TST, WASO, SOL, and SE) in each mode.

Procedure. Participants were assessed with the CAPS, the SCID, and other interview and subjective assessment tools by trained M.A and Ph.D. level clinicians supervised by a

licensed clinical psychologist. At the end of their assessment, participants who met study inclusion criteria were given daily diary measures to complete at home for seven days. At the initial assessment, each participant was fitted with the actigraphy equipment on their non-dominant wrist to take home and wear daily for seven days. Each participant was instructed to wear the actigraphy 24 hours per day for seven days and to remove the device only when an activity could possibly damage the device (emersion in water for long periods of time, strenuous activity, etc.). Each participant was 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. After seven days, each participant returned to the laboratory at which time the actigraphy and diary measures were collected.

Data Analyses

The Action–W analysis software (version 2.0) provided by the actigraphy manufacturer was utilized 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 utilized to calculate estimates of sleep onset and maintenance, sleep quality and sleep quantity by computing sleep latency (SOL), total sleep time (TST), wake after sleep onset (WASO) and sleep efficiency (SE) 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 as compared polysomnography recordings (Ancoli-Israel et al., 2003). Once scored, actigraphy data, as well as sleep diary data, were averaged across nights of monitoring for each participant and mean scores for each variable were analyzed.

Statistical assumptions testing and missing data. Statistical analyses were performed using SPSS version 20 for evaluation of statistical assumptions, univariate and multivariate statistical analyses. Analyses designed to address the current aims of the study are outlined below. Tests for normality, multivariate outliers, linearity, and homogeneity were completed for all variables used in the main analyses. Missing data were also examined prior to main analyses. Maximum likelihood estimates procedure using the expectation maximization algorithm was employed to compute values for the missing data (Allison, 2001).

Initial analyses. Descriptive statistics for the total sample were investigated to report overall PTSD symptom severity as measured by the CAPS and MDD symptom severity through the BDI-II as well as global sleep impairment as measured by the PSQI and ISI. An independent samples t-test to assess differences in PTSD symptom scores between those with PTSD-only and comorbid PTSD/MDD were examined and PTSD symptom severity was used in the main analyses as a covariate.

Main statistical analyses. To investigate each aim, multiple analyses were utilized. Adjustment for multiple analyses was completed using the false discovery rate (FDR; Benjamini & Hochberg, 1995). FDR provides an adjusted p value to protect the alpha value when conducting multiple tests. To address Aim 1, correlations between subjective sleep impairment parameters including total PSQI score, total ISI score and daily sleep diary variables TST, SOL, WASO, and SE and objective sleep assessment including TST, SOL,

WASO, and SE as assessed with actigraphy were explored. In addition, repeated measures *t*-tests were used to examine differences between subjective and objective sleep measures (independent variable) across dependent variables of TST, SOL, WASO, and SE. Effect size statistics, as measured by Eta squared (η^2) and 95% confidence intervals (CI) were analyzed to report on the strength and impact of relationships between variables.

Aim 2 of the study investigated group difference in sleep between those with PTSD-only and those with comorbid PTSD/MDD. Separate MANCOVAs were utilized to assess group differences (PTSD-only vs. PTSD/MDD) in subjective reports (sleep diary) and objective physiological assessment (actigraphy) of sleep variables including TST, SE, WASO, SOL while controlling for PTSD symptom severity minus sleep item (item D1 on the CAPS “difficulty falling or staying asleep”). Finally, difference scores between subjective and objective variable values were calculated by subtracting sleep log scores from actigraphy measures and compared between diagnostic groups using MANCOVA again controlling for PTSD symptom severity minus sleep item D1. This allowed for comparison of discrepancies in subjective reports and objective physiological measures across groups and served as an index of sleep state misperception.

The current investigation uses the term sleep state misperception to describe subjective sleep impairments not corroborated by objective assessment, as opposed to the diagnostic label “paradoxical insomnia”. Participants included in the current study were not assessed for a diagnosis of paradoxical insomnia as polysomnography testing is required for this diagnosis. Also, psychiatric conditions are exclusionary for a diagnosis of paradoxical insomnia and all current participants were diagnosed with PTSD.

Aim 3 investigated the unique contribution of each PTSD symptom – re-experiencing, avoidance, and hyperarousal – as well as depression symptoms to the prediction of sleep state misperception. To assess the independent predictive value of each, hierarchical linear regression modeling was used to predict differences between objective and subjective sleep quality scores. Sleep quality (SE) was chosen as the target variable because it takes the other considered sleep variables – TST, WASO, and SOL – into account by definition. To reduce any possible co-linearity or inflation of relationship, sleep items were removed from the hyperarousal cluster (item D1 on the CAPS “difficulty falling or staying asleep”) and the depression symptoms (item 16 on the BDI-II “changes in sleep patterns”) for the regression analyses. The complete model for predicting sleep state misperception was as follows: At Step 1, re-experiencing symptom total score; at Step 2, avoidance symptom total score; at Step 3, hyperarousal symptoms total score (minus sleep item); and at Step 4, depression total score (minus sleep item). To also ensure complete consideration of symptoms scores and confirm the contribution of depressive symptoms above and beyond PTSD symptoms, additional analyses including sleep parameters in hyperarousal and depression total scores were included in separate analyses and also will be reported.

Results

Statistical assumptions and missing data. After completing data abstraction of actigraphy data, four participants were removed from the sample ($N = 55$) because the actigraphy data were not able to be analyzed or were not recorded (the participant took the device off) leaving a total $N = 51$ for the main analyses. Univariate investigations of normality and univariate outliers were examined for all variables used in main analyses including subjective and objective measures of sleep variables of TST, SOL, WASO, SE as

well as BDI-II symptom scores, total CAPS symptom score and CAPS re-experiencing, avoidance, and hyperarousal symptom scores. One univariate outlier was found in the total BDI-II score with a total score of zero depressive symptoms reported. Because this score is within range of possible scores on the BDI-II and the participant did not meet diagnosis for current MDD on the SCID, the score was deemed valid and was included in analyses.

Examination of normality statistics indicated distributions did not violate assumptions of normality and did not warrant transformation. After checking for univariate assumptions, missing data from subjective target variables were found to be 2.0% of the total data and missing completely at random (Little MCAR $\chi^2(48) = 48.03, p = .472$). Therefore, the maximum likelihood estimates procedure using the expectation maximization algorithm (Allison, 2001) was appropriate and applied to replace missing values. Tests of multivariate normality, outliers, and additional assumptions testing for each aim are reported in the appropriate subsection below.

Initial analysis. Participants ($N = 51$) were predominately Caucasian (50%) and African-American (46%) and from low-income households (71% less than \$20,000 yearly income). Ages range from 18 to 59 years with an average age of 36.1 years ($SD = 12.0$ years). Most participants were single (53%) and had received an average education of 13.7 years ($SD = 2.6$ years). Group comparisons revealed participants with PTSD-only did not significantly differ from the comorbid PTSD/MDD group on any demographic characteristics including age ($t(49) = .52, p = .60$), race ($\chi^2(2, N = 51) = .65, p = .52$), education ($t(49) = .06, p = .95$), marital status ($\chi^2(2, N = 51) = 1.2, p = .21$) or income ($\chi^2(2, N = 51) = .83, p = .361$). See Table 3 for demographic and initial statistics.

Table 3*Demographic and Initial descriptive statistics for PTSD only and PTSD/MDD groups*

	Overall	PTSD only	PTSD/MDD	
	<i>N</i> = 51	<i>n</i> = 29	<i>n</i> = 22	
	<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)	<i>Statistic</i>
Age	36.1 (12.0)	36.8(12.4)	35.1(11.7)	<i>t</i> (49) = .52
Education	13.7 (2.6)	13.7(2.2)	13.7(3.0)	<i>t</i> (49) = .06
Race				$\chi^2 = .65$
White	54.9%	37.9%	50.0%	
African American	43.1%	62.1%	45.5%	
Other	2.0%	0.0%	4.5%	
Marital Status				$\chi^2 = 1.2$
Single	52.9%	58.6%	45.5%	
Married/living with someone	17.6%	20.7%	13.6%	
Separated/divorced/widowed	29.4%	20.7%	40.9%	
Income				$\chi^2 = .83$
< 20,000	70.6%	65.5%	77.3%	
> 20,000	29.4%	34.5%	22.7%	
CAPS total	77.8(16.7)	72.5(15.7)	84.8(15.5)	<i>t</i> (49) = 2.800**
Cluster B – Re-experiencing	21.4(7.7)	20.4(5.7)	22.7(9.7)	
Cluster C – Avoidance	31.3(8.8)	28.6(9.1)	34.8(7.1)	<i>t</i> (49) = 2.67*
Cluster D – Hyperarousal	25.1(5.1)	23.5(5.1)	27.3(4.3)	<i>t</i> (49) = 2.85**
BDI-II	32.6(11.2)	29.9(11.9)	36.1(9.3)	<i>t</i> (49) = 2.03*

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ISI	19.06(5.43)	17.49(5.04)	21.14(5.32)	$t(49) = 2.498^*$
PSQI	13.84(3.48)	13.48(3.43)	14.31(3.55)	$t(49) = .844$
Sleep med use past month				$\chi^2 = .325$
Three or more times a week	27.50%	22.90%	33.30%	
Once or twice a week	13.70%	14.80%	14.30%	
Less than once per week	7.80%	11.10%	4.80%	
No use	45.10%	48.10%	47.60%	

Note: $N = 51$; CAPS (Clinician-Administered PTSD Scale); BDI-II (Beck Depression

Inventory – II); PSQI (Pittsburgh Sleep Quality Index); ISI (Insomnia Severity Index)

* $p < .05$; ** $p < .01$; *** $p < .001$

Overall, participants experienced high levels of PTSD symptoms as measured by total score on the CAPS ($M = 77.8$; $SD = 16.6$) and severe levels of depressive symptoms on the BDI-II ($M = 32.6$; $SD = 11.2$). This is not surprising because a PTSD diagnosis was required for inclusion into the study and symptoms of MDD are commonly comorbid in trauma survivors. Overall, participants displayed high re-experiencing ($M = 21.4$; $SD = 7.7$), hyperarousal ($M = 25.1$; $SD = 5.1$), and avoidance symptoms ($M = 31.3$; $SD = 8.8$). The complete cohort endorsed poor global sleep over the past month on the PSQI ($M = 13.8$; $SD = 3.5$) and moderately severe insomnia over the past week as indicated by ISI total score ($M = 19.1$; $SD = 5.4$). Fifty-five percent of the cohort endorsed taking medication to help with sleep at least once in the month leading up to the assessment: 27.5% ($n = 14$) reported three or more times a week, 13.7% ($n = 7$) reported use once or twice a week, 7.8% ($n = 4$)

reported using medications to help with sleep less than once a week. Forty-five percent ($n = 23$) reported no use of medication to help with sleep during the past month.

The comorbid PTSD/MDD diagnosis group reported significantly higher scores on the BDI-II ($t(49) = 2.03, p = .048; M = 36.1; SD = 9.3$) as compared to the PTSD-only group ($M = 29.9; SD = 11.9$). A significant difference was displayed across groups on CAPS total symptoms score ($t(49) = 2.80, p = .007$) indicating participants with comorbid PTSD/MDD diagnosis reported increased PTSD symptoms ($M = 84.8; SD = 15.5$) as compared to those with a PTSD-only ($M = 72.5; SD = 15.7$). This difference was driven by the avoidance ($t(49) = 2.67, p = .010$) and hyperarousal symptom clusters ($t(49) = 2.85, p = .006$). CAPS total score was used as a covariate when comparing the PTSD/MDD and PTSD-only groups. No significant difference between groups was reported for PSQI total scores ($t(49) = .844, p = .403$), or sleep medication use $\chi^2(2, N = 51) = .325, p = .745$. Increased levels of insomnia were reported by the PTSD/MDD group ($M = 21.1, SD = 5.3$) on the ISI as compared to the PTSD-only group ($M = 17.5; SD = 5.0; t(49) = 2.50; p = .016$).

Aim 1 Results. Preliminary univariate assumption testing was conducted prior to analyses to ensure normality and homogeneity of variance and no violations were observed; difference scores were found to be normally distributed meeting the additional assumption required for repeated measure t -tests. All alpha values were adjusted for multiple comparisons using the FDR algorithm to protect against Type 1 error.

Target sleep impairment variables including measures of sleep onset disturbance (sleep onset latency; SOL), sleep maintenance (wakening after sleep onset; WASO), sleep quantity (total sleep time; TST), and sleep quality (sleep efficiency; SE) were compared across subjective reports and objective assessment with no significant correlations displayed

between objective physiological measures (actigraphy) or any subjective variables (Table 4). Indices of subjective sleep impairment including global sleep impairment and insomnia (PSQI and ISI) as well as sleep diary measures of sleep quality, sleep quantity, sleep maintenance and sleep onset were found to be unrelated to objectively assessed sleep parameters as indicated by non-significant correlations between subjective and objective variables.

Table 4

Correlations between Objective Actigraphy Variables and Subjective self-report Variables

	Actigraphy Variables			
	Total Sleep Time	Sleep Onset latency	WASO	Sleep Efficiency
ISI	.00	-.07	.05	-.03
PSQI	.11	-.06	.07	-.03
Daily Sleep Diaries				
TST	.22	-.09	-.12	.16
SOL	-.09	-.21	.12	-.07
WASO	.11	-.08	-.02	.06
SE	.01	.16	-.14	.10

Note: $N = 51$; SOL (Sleep onset latency in minutes); WASO (Wakening after sleep onset in minutes); TST (Total sleep time in minutes); SE (Sleep Efficiency in minutes); PSQI (Pittsburgh Sleep Quality Index); ISI (Insomnia Severity Index)

* $p < .05$, ** $p < .01$, *** $p < .001$

Supporting hypothesis one, repeated measures *t*-tests investigating target sleep variables revealed significant differences across SOL, TST, and SE (see Table 5 and Figure 1). Subjective reports of SOL were significantly higher ($t(50, 1) = 4.59, p < .001; \eta^2 = .30$) than objective measures of SOL indicating subjective sleep onset impairment. Subjective reports of SE ($t(50,1) = 6.03, p < .001; \eta^2 = .42$) and TST ($t(50,1) = 4.52, p < .001; \eta^2 = .29$) were also significantly more impaired as compared to objective assessment with actigraphy further supporting an interpretation of sleep state misperception in this sample. No significant differences were found between subjective reports and objective assessment of WASO ($t(50, 1) = 1.26, p = .213; \eta^2 = .03$).

Table 5

Comparisons across Subjective Reports and Objective Physiological Sleep Variables

	Subjective		Objective		<i>t</i>	η^2	95% CI
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			
SOL	36.0	23.1	18.0	11.6	4.59***	.30	10.1-25.8
WASO	38.5	28.2	45.3	25.4	1.26	.03	-17.6-4.0
TST	352.8	76.9	410.6	68.9	4.52***	.29	-83.4- -32.1
SE	76.9	14.8	89.9	5.8	6.03***	.42	-17.3- -8.7

Note: $N = 51$; SOL (Sleep onset latency in minutes); WASO (Wakening after sleep onset in minutes); TST (Total sleep time in minutes); SE (Sleep Efficiency in minutes)

* $p < .05$, ** $p < .01$, *** $p < .001$

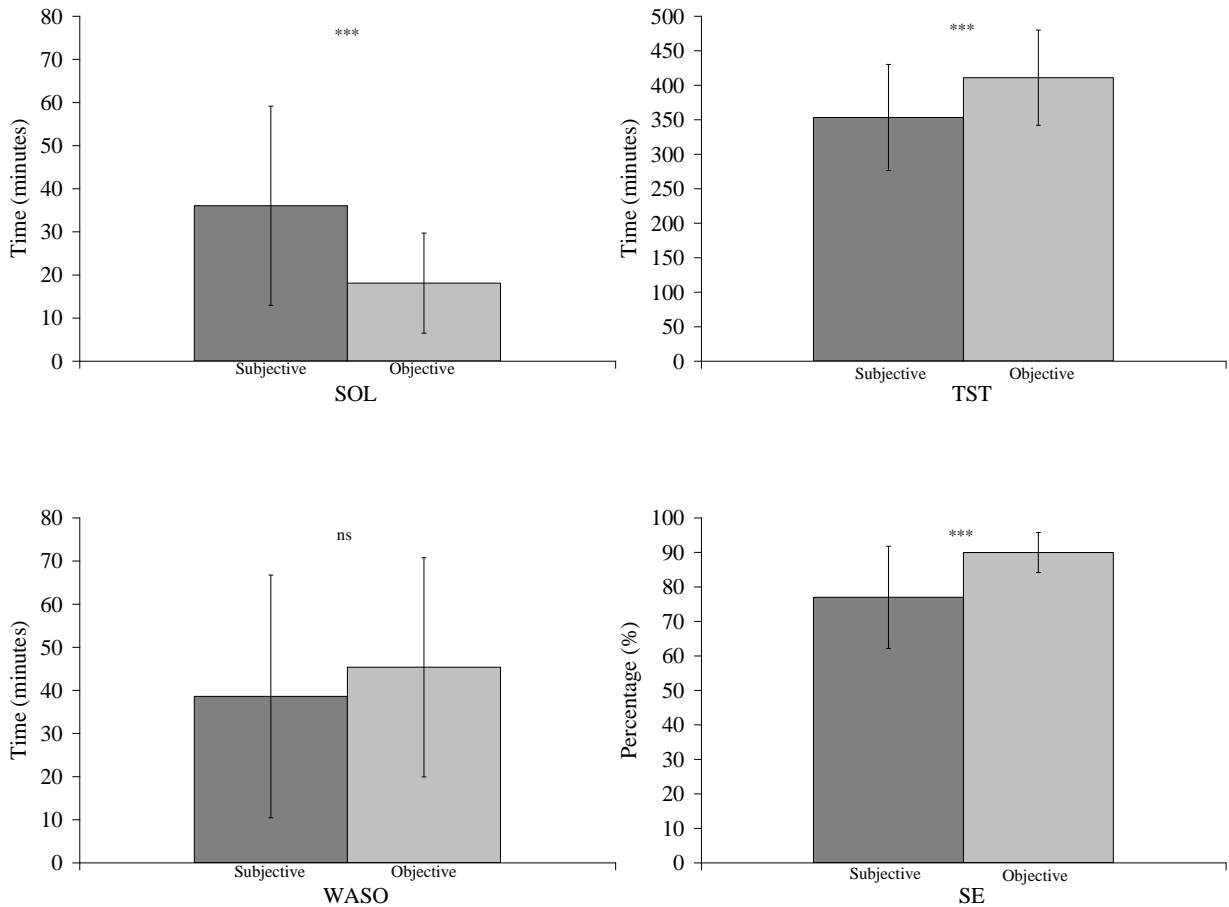


Figure 1. Comparison of Subjective and Objective Assessment of Sleep Parameters. (Error bars represent standard deviation) Graphic shows significant subjective overestimation of sleep impairment as compared to objective physiological assessment with actigraphy for 3 of 4 target sleep variables.

Note: $N = 51$; SOL (Sleep onset latency in minutes); WASO (Wakening after sleep onset in minutes); TST (Total sleep time in minutes); SE (Sleep Efficiency in minutes)

*** $p < .001$

Aim 2 Results. To address Aim 2, three separate multiple analyses of covariance (MANCOVAs) were utilized to investigate subjective report, objective assessment, and sleep state misperception difference scores between a PTSD-only group and a comorbid PTSD/MDD group across the four target sleep variables, SOL, WASO, TST, and SE

controlling for PTSD symptom severity minus sleep item D1. Preliminary assumption testing was performed to check for normality, linearity, multivariate outliers, homogeneity of variance-covariance matrices, and multicollinearity for each of the three analyses performed. Table 6 includes the main statistical analyses addressed in Aim 2.

Aim 2 statistical assumption testing. Linearity was assessed by generating scatter plots of between pairs of variables overall and separately for the PTSD-only and the PTSD/MDD group; no indication of non-linearity was observed for subjective, objective, or sleep state misperception variables and therefore the assumption of linearity was satisfied. Assumptions testing revealed one multivariate outlier for the subjective report of sleep impairment (Mahalanobis Distant = 20.02) and one multivariate outlier in sleep state misperception scores (Mahalanobis distant = 21.12) which exceeded the Chi-square critical value with an alpha value of $p = .001$. These single values are not exceedingly high and did not cause enough problems with the distribution to warrant transformation. No multivariate outliers were revealed in objective measures (maximum Mahalanobis distant = 17.54). Multicollinearity and homogeneity of variance-covariance were assessed for each of the analyses and assumptions were not violated for objective, subjective, or sleep state misperception MANCOVA.

Levene's test of equality of error variance indicated the variables of subjective SOL ($F(1, 49) = 4.47, p = .040$) and sleep efficiency misperception ($F(1, 49) = 6.64, p = .013$) violated the assumption of equality of variance. Therefore a more stringent alpha value of .025 was used for subjective SOL and sleep efficiency misperception univariate contributions in MANOVA analyses. All other subjective, objective, and sleep state misperception variables satisfied the assumption of equality of variance.

MANOVA results: difference between PTSD-only and PTSD/MDD groups. There were no statistically significant differences between the PTSD-only and the PTSD/MDD group overall when comparing subjective reports ($F(4, 45) = 1.87, p = .133$; Wilks' Lambda = .86; $\eta^2_{partial} = .14$), objective assessment ($F(4, 45) = .53, p = .713$; Wilks' Lambda = .96; $\eta^2_{partial} = .05$) of sleep impairment, or sleep state misperception (difference scores) ($F(4, 45) = 1.38, p = .257$; Wilks' Lambda = .89; $\eta^2_{partial} = .11$). After correcting for assumption violations and using FDR adjusted alpha levels no significant differences between groups were revealed when considering each subjectively reported sleep variable for SOL ($F(1, 48) = .45, p = .505$), TST ($F(1, 48) = 2.04, p = .160$), WASO ($F(1, 48) = .43, p = .514$), or SE ($F(1, 48) = .01, p = .909$), objectively measured sleep variable for SOL ($F(1, 48) = .79, p = .378$), TST ($F(1, 48) = .18, p = .675$), WASO ($F(1, 48) = .63, p = .431$), or SE ($F(1, 48) = .24, p = .629$), or sleep state misperception scores for SOL ($F(1, 48) = .03, p = .855$), TST ($F(1, 48) = .78, p = .381$), WASO ($F(1, 48) = 1.05, p = .310$), or SE ($F(1, 48) = .01, p = .939$).

Table 6

Comparison of Subjective and Objective Sleep Indicators across PTSD only and PTSD/MDD Groups

	PTSD		PTSD/MDD		<i>F</i>	$\eta^2_{partial}$	95% CI
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			
Subjective Measures					1.87	.14	
SOL	33.0	18.4	39.9	28.2	.45	.01	-18.8 to 9.4
WASO	39.2	24.0	37.7	33.5	.43	.01	-11.5 to 22.8
TST	347.1	54.8	360.3	99.8	2.04	.04	-77.0 to 13.1
SE	78.2	12.1	75.2	17.9	.01	.00	-8.4 to 9.4

Actigraphy					.53	.05	
SOL	16.3	12.9	20.3	9.5	.79	.02	-10.2 to 3.9
WASO	44.0	24.7	47.1	26.8	.63	.01	-21.7 to 9.4
TST	403.8	68.9	419.5	69.5	.18	.00	-51.0 to 33.3
SE	90.0	5.8	89.8	6.0	.24	.01	-2.7 to 4.4
Mean Difference Scores					1.38	.11	
SOL	-16.7	24.5	-19.6	32.5	.03	.00	-15.7 to 18.9
WASO	4.8	34.5	9.4	43.7	1.05	.02	-34.8 to 11.3
TST	56.70	87.5	59.2	98.1	.78	.02	-29.5 to 75.8
SE	11.8	12.0	14.6	19.1	.01	.00	-8.8 to 9.5

Note: $N = 51$; SOL (Sleep onset latency in minutes); WASO (Wakening after sleep onset in minutes); TST (Total sleep time in minutes); SE (Sleep Efficiency in minutes); Mean difference scores (actigraphy – daily sleep diary)

* $p < .05$, ** $p < .01$, *** $p < .001$

Aim 3 Results. Aim three examined the unique contribution of each of three PTSD symptom clusters – re-experiencing, avoidance, and hyperarousal – as well as depressive symptoms to sleep state misperception. It was hypothesized that re-experiencing, hyperarousal, and depressive symptoms would significantly predict sleep state misperception in this cohort. Prior to main analyses, assumptions for hierarchical multiple regression were addressed. Multicollinearity was considered by investigating tolerance and variance inflation factor (VIF) values and the correlations between predictor variables. Tolerance values ranged from .80 to .67 for each predictor variable and VIF values ranged from 1.48 to 1.25

indicating that the multicollinearity assumption had not been violated as tolerance was well above zero and VIF was well below four (Rogerson, 2001). Correlation analyses indicated some significant relationships between variables included in the regression analysis (Table 7) no correlations were observed that would indicate a possible problem with multicollinearity as no correlation exceeded $r = .8$ (Leahy, 2000). Of the significant relationships, strong positive correlations were reported between depressive symptoms and avoidance and hyperarousal symptom total scores respectively. A strong correlation between avoidance and hyperarousal scores was also displayed. Moderate relationships were found between all other variables with the exception of sleep state misperception score and avoidance and hyperarousal total scores respectively.

Table 7

Means, Standard Deviations, and Correlations of Sleep State Misperception, PTSD and MDD symptoms

Variable	<i>M</i>	<i>SD</i>	1	2	3	4	5
1 Sleep State Misperception	12.99	15.38	-	.36**	.17	.06	.37**
2 CAPS Cluster B	21.39	7.69		-	.31*	.40**	.35**
3 CAPS Cluster C	31.25	8.80			-	.44**	.47***
4 CAPS Cluster D (no sleep)	18.18	4.95				-	.46***
5 BDI-II (no sleep)	30.76	11.08					-

Note. $N = 51$; Sleep State Misperception = Objective – Subjective Sleep Efficiency Scores;

CAPS (Clinician-Administered PTSD Scale); BDI-II (Beck Depression Inventory – II)

* $p < .05$; ** $p < .01$; *** $p < .001$

No multivariate outliers were revealed as indicated by a maximum Mahalanobis distant value of 10.25 well below the Chi-square critical value. No outliers were revealed upon inspection of the residuals scatter plot as identified by all data points falling within approximately +/- 2 standard deviations of the mean. Normality, linearity, homoscedasticity, and independence of residuals were all examined using the residual scatter plot and the normal probability plot of regression standardized residuals (Normal P-P plot) and all assumptions were satisfied.

For main statistical analyses, the complete linear hierarchical regression model was found to be significantly different from zero at each step, and after Step 4, with all variables entered, $F(4,46) = 3.62, p = .012$ (Table 8). The adjusted R^2 value indicated that 24% of the variability in sleep state misperception was predicted by the overall model. In step 1, re-experiencing symptoms accounted for 13% of the variance in sleep state misperception, $F(1, 49) = 7.48, p = .009$. Avoidance symptoms were added in Step 2 but did not significantly add to the prediction of sleep state misperception, $F(1, 48) = .23, p = .637$. Hyperarousal symptoms were considered in Step 3 but also did not significantly add to the prediction of sleep state misperception, $F(1, 47) = .90, p = .348$. Depressive symptoms minus the sleep question added in the final step resulted in a significant addition to the explained variance, $F(1, 46) = 5.25, p = .027$. These results indicate re-experiencing and depressive symptoms independently and modestly added to the prediction of sleep state misperception. Re-experiencing symptoms added a unique 13% of variance and depressive symptoms contributed a unique 9% of variance to the model. Avoidance and, in contrast to the hypothesis, hyperarousal were not significant predictors.

Table 8*Linear Hierarchical Regression Model Predicting Sleep State Misperception*

	R^2	ΔR^2	B	$SE B$	β
Dependent Variable: Sleep State Misperception					
Step 1	.13*				
CAPS Cluster B total score – Re-experiencing			.728	.27	.36*
Step 2	.14*	.00			
CAPS Cluster B total score – Re-experiencing			.69	.29	.34*
CAPS Cluster C total score – Avoidance			.12	.25	.07
Step 3	.15*	.02			
CAPS Cluster B total score – Re-experiencing			.77	.30	.39*
CAPS Cluster C total score – Avoidance			.21	.27	.12
CAPS Cluster D total score – Hyperarousal (no sleep)			-.46	.50	-.15
Step 4	.24*	.09*			
CAPS Cluster B total score – Re-experiencing			.67	.29	.34*
CAPS Cluster C total score – Avoidance			.01	.27	.01
CAPS Cluster D total score – Hyperarousal (no sleep)			-.76	.49	-.25
BDI-II total score (no sleep)			.50	.22	.36*

Note. $N = 51$; Sleep State Misperception = Objective – Subjective Sleep Efficiency Scores;

CAPS (Clinician-Administered PTSD Scale); BDI-II (Beck Depression Inventory – II)

* $p < .05$

Predictor variables also were considered with sleep items to assess any possible covariance that may reduce the predictive value of additional variables. The second model considered predictor variables in the same steps; however, the sleep item of the hyperarousal cluster was not removed from step 3. Step 4 remained the same as the primary analysis, taking into account depressive symptoms minus the sleep item. Consistent with the primary findings for aim 3, the hierarchical regression model, including the hyperarousal sleep item, was significantly different from zero at each step, and after Step 4, with all variables entered was significant, $F(4,45) = 3.56, p = .013$ (Table 9). The addition of the sleep item to hyperarousal symptoms produced no significant predictive value for sleep state misperception $F(1, 47) = .99, p = .342$. Inclusion of the sleep item did not affect the predictive value of depressive symptoms minus the sleep item which remained a significant predictor of sleep state misperception $F(1, 46) = 5.00, p = .030$. Depressive symptoms accounted for 8.3% of the variance in sleep state misperception above and beyond all three complete PTSD symptom clusters of re-experiencing, avoidance, and hyperarousal.

Table 9

Hierarchical Regression Model Predicting Sleep State Misperception with Hyperarousal Sleep Item

	R^2	ΔR^2	B	$SE B$	B
Dependent Variable: Sleep State Misperception					
Step 1	.13**				
CAPS Cluster B total score – Re-experiencing			.73	.27	.36**
Step 2	.14*	.00			
CAPS Cluster B total score – Re-experiencing			.69	.29	.34*

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CAPS Cluster C total score – Avoidance		.12	.25	.07
Step 3	.15*	.02		
CAPS Cluster B total score – Re-experiencing		.79	.30	.40*
CAPS Cluster C total score – Avoidance		.21	.26	.12
CAPS Cluster D total score – Hyperarousal		-.48	.48	-.16
Step 4	.24*	.08*		
CAPS Cluster B total score – Re-experiencing		.69	.29	.35*
CAPS Cluster C total score – Avoidance		.01	.27	.01
CAPS Cluster D total score – Hyperarousal		-.73	.48	-.24
BDI-II total score (no sleep)		.49	.22	.35*

Note. $N = 51$; Sleep State Misperception = Objective – Subjective Sleep Efficiency Scores;

CAPS (Clinician-Administered PTSD Scale); BDI-II (Beck Depression Inventory – II)

* $p < .05$, ** $p < .01$

In the third model, all predictor variables were entered into the same steps and sleep items were considered in both the hyperarousal and depressive symptoms. The addition of the sleep item to depressive symptoms in step 4 produced significant predictive value for complete depressive symptoms above and beyond PTSD symptom clusters $F(1, 46) = 5.79, p = .020$, accounting for 9.4% of the variance in sleep state misperception. Consistently, the overall model was significant when taking into account all predictors ($F(1, 46) = 3.81, p = .009$). Again, re-experiencing and depressive symptoms remained the significant contributors to sleep state misperception (Table 10).

Table 10

Hierarchical Regression Model Predicting Sleep State Misperception with Hyperarousal and Depression Sleep Items

	R^2	ΔR^2	B	$SE B$	B
Dependent Variable: Sleep State Misperception					
Step 1	.13**				
CAPS Cluster B total score – Re-experiencing			.73	.27	.36**
Step 2	.14*	.00			
CAPS Cluster B total score – Re-experiencing			.69	.29	.34*
CAPS Cluster C total score – Avoidance			.12	.25	.07
Step 3	.15*	.02			
CAPS Cluster B total score – Re-experiencing			.79	.30	.40*
CAPS Cluster C total score – Avoidance			.21	.26	.12
CAPS Cluster D total score – Hyperarousal			-.48	.48	-.16
Step 4	.25**	.09*			
CAPS Cluster B total score – Re-experiencing			.66	.29	.33*
CAPS Cluster C total score – Avoidance			.01	.27	.01
CAPS Cluster D total score – Hyperarousal			-.74	.47	-.24
BDI-II total score			.51	.21	.37*

Note. $N = 51$; Sleep State Misperception = Objective – Subjective Sleep Efficiency Scores;

CAPS (Clinician-Administered PTSD Scale); BDI-II (Beck Depression Inventory – II)

* $p < .05$, ** $p < .01$

Discussion

This study examined the relationship between subjectively assessed (diaries and questionnaires) and objective physiological measures (actigraphy) on sleep parameters while taking into consideration the role of depression in this PTSD cohort. The results of the current study add unique insight into PTSD-related sleep impairment in a female cohort as earlier investigations have predominately focused on male, veteran cohorts. Initial results are consistent with this previous research with male combat veterans (Carskadon et al., 1976; Dagan et al., 1991; Hurwitz et al., 1998; Engdahl et al., 2000; Lavie, 2001; Herbst et al., 2010) indicating “subjective insomnia” or sleep state misperception in PTSD. The present female cohort subjectively over-reported sleep onset difficulties and under-reported sleep quality and quantity as compared to concurrent physiological actigraphy recordings over multiple nights of monitoring.

This investigation was the first to directly assess the impact of comorbid major depressive disorder (MDD) on subjective sleep reports, objective sleep measures, and any discrepancy between subjective and objective indices in a PTSD cohort. Although those with PTSD and comorbid MDD diagnosis did not show a significant difference across sleep variables as compared to those with PTSD-only, depressive symptom scores did significantly predict sleep state misperception above and beyond PTSD symptom cluster scores. Re-experiencing also contributed to the variance explained in sleep state misperception pointing to the unique contribution of both re-experiencing and depressive symptoms to this phenomenon. The present findings indicate that depressive symptoms may play a contributing role to misperceptions associated with sleep and should be further addressed.

Aim 1 was to illuminate the relationship between subjective reports and objective physiological measures of PTSD-related sleep disturbance in a female cohort with PTSD. It was hypothesized that subjective reports of sleep would produce an overestimation of sleep onset latency and maintenance insomnia and an underestimation of sleep quality and quantity as compared to objective physiological measurements with actigraphy. Subjective assessments included the PSQI, the ISI, and daily diary reports of four sleep characteristics: TST, WASO, SE, and SOL. Each of the investigated sleep measures represented a unique sleep characteristic vulnerable to actual impairment as well as subjective perception bias.

Consistent with previous reports, subjective parameters of habitual subjective sleep impairment (PSQI and ISI) were not correlated with objective actigraphy assessment (Dagan et al., 1997; Klein et al., 2003; Calhoun et al., 2007). Daily sleep diary parameters also were not correlated with objective measurement across concurrent nights of reporting on any sleep variable under investigation in the present study. These findings are in contrast to previous reports of moderate correlations between objective measures and sleep logs in females with PTSD (Calhoun et al., 2007). Based on their findings, Calhoun and colleagues suggested daily sleep logs are a more reliable tool than global sleep measures to assess actual sleep impairments. Although daily sleep logs are useful tools as they may be more appropriate for monitoring sleep impairment over time as well as for use in comparison to nightly objective assessment, the current data suggest reports on daily diary measures are not consistent with the actual sleep as assessed through physiological assessment. The current findings do suggest that subjective and objective sleep should be considered as unique parameters and both should be assessed.

More specifically, the present study also investigated the relationship of subjective and objective sleep through repeated measures analyses indicating significant differences across subjective and objective measures between sleep onset (SOL), sleep quantity (TST), and sleep quality (SE). Significantly more sleep impairment was endorsed through subjective reports compared to actigraphy: sleep onset difficulties were significantly over-estimated and sleep quantity and quality were significantly under-estimated on daily sleep diaries in this female IPV cohort. This over-estimation of sleep impairment by subjective assessment displayed in the present investigation is in agreement with the majority of previous research comparing subjective and objective sleep disturbance as well as the supposition of sleep state misperception in PTSD. Previous examinations of PTSD-related sleep disturbance revealed subjective sleep impairment not corroborated by objective measurement including but not limited to difficulty falling asleep (Carskadon et al., 1976; Dagan et al., 1991; Hurwitz et al., 1998), difficulty staying asleep (Dagan et al., 1991; Engdahl et al., 2000; Westermeyer et al., 2007), reduced sleep quality (Herbst et al., 2010), and reduced sleep quantity (Carskadon et al., 1976; Hurwitz et al., 1998). Although the current data do show an overestimation of sleep onset latency and an underestimation of sleep quantity and quality in PTSD, no difference in subjective and objective reports of sleep maintenance were revealed.

A potentially important difference between the present study and previous reports is that earlier investigations focused on sleep impairment in male combat veterans and mixed cohorts in contrast to the females studied in the current investigation. The only previous study investigating PTSD-related sleep impairment in an all female cohort, Calhoun and colleagues (2007) reported subjective daily sleep diary over-estimation of sleep quantity and underestimation of sleep maintenance as compared to actigraphy assessment. Conversely, the

present findings showed an under-estimation of sleep quantity and no difference between subjective and objective sleep maintenance in the current cohort of females with PTSD.

Although both studies investigated females with daily sleep diaries and actigraphy, the discrepancy between study findings could be due to methodological differences. The current study utilized female survivors of interpersonal violence while only 64% of Calhoun and colleagues (2007) participants fit this criterion, with the remaining participants endorsing witnessing/experiencing death as a child or adult and other non-specified traumas.

Interpersonal violence has been associated with the highest PTSD rates (Stein, Walker, & Forde, 2000) and may be associated with more sleep disturbance compared to other traumas. PTSD severity was not reported by Calhoun and colleagues (2007), but the current cohort reported severe PTSD symptoms ($M = 77.8$, $SD = 16.7$) overall. The implication is that disturbances in sleep may vary by trauma type and PTSD severity may have an impact on both subjective and objective sleep changes. Additional research is needed to address the impact of trauma type and PTSD severity on sleep parameters.

Another methodological difference in the current study is the inclusion of participants using sleep medication. Calhoun and colleagues (2007) excluded participants taking medications with effects on sleep that may have provided a more homogeneous sample for analysis, but also reduced the generalizability of findings to those using sleep medications. As would be expected, PTSD-positive participants excluded for sleep medication use in Calhoun and colleagues who reported increased sleep impairment as measured by total PSQI ($M = 12.8$) as compared to PTSD participants not using sleep medications included in the study ($M = 9.4$). Thus, exclusion of those taking sleep-medication also removed participants with more severe sleep disturbance possibly contributing to an underestimation of subjective

PTSD-related sleep impairment in the Calhoun and colleagues (2007) investigation. This may contribute to the contrary finding in the present study as the current participants endorsed high levels of global sleep disturbance on the PSQI ($M = 13.84$).

Most previous data does support a general overestimation of sleep disturbance in participants with PTSD compared to objective assessment of sleep parameters and has been described as “subjective insomnia” or sleep state misperception in this cohort (Hurwitz et al., 1998; Dagan et al., 1997). The current findings lend further support to the existence of sleep state misperception by displaying subjective underestimation of sleep quality and quantity and significant overestimation of sleep onset latency in females with PTSD. Findings suggest objective and subjective sleep impairments are distinct sleep parameters that do not necessarily directly co-vary and should be assessed independently when symptoms of sleep impairment are of concern. One possibility is that negative cognitive appraisal may contribute to subjective sleep impairment in a PTSD cohort as sleep does not seem to be physiologically impaired but only reported as such. This theory is supported by previous research that suggests the importance of negative cognitive biases in self-report measures (Buckley et al., 2000). Future research should examine the contribution of cognitive variables to subject reports of PTSD related sleep disturbance.

The second aim investigated the effects of comorbid major depressive disorder on objective and subjective sleep disturbance in a female IPV cohort with PTSD. It was hypothesized that different objective and subjective sleep impairments would be displayed across individuals with PTSD-only compared to those with comorbid PTSD/MDD. Analyses did not support this hypothesis as comorbid MDD diagnosis had no effect on sleep onset, sleep maintenance, sleep quality or sleep quantity across subjective reports, objective

assessment and sleep state misperception difference scores (objective – subjective). This finding was somewhat unexpected as a previous meta-analysis suggested that MDD was a moderating variable for the effects of PTSD on objective sleep disturbance (Kobayashi et al., 2007). This meta-analysis reported that study cohorts which included more than 30% of participants with co-morbid MDD displayed less sleep disturbance than controls as measured by PSG when compared to studies with less than 30% co-morbid PTSD/MDD.

Other research suggests more abundant objective sleep disturbances in those with PTSD some with comorbid MDD, but no significant differences when directly comparing PTSD only and PTSD/MDD groups (Yetkin et al., 2010). In a small study, Yetkin and colleagues reported 24 men with PTSD (six with PTSD-only, 15 with PTSD/MDD) experienced greater impairment in sleep quantity and sleep onset as well as reduced sleep efficiency compared to controls. However, when comparing participants with PTSD-only to those with PTSD/MDD no significant differences were displayed across sleep characteristics. Findings were also in agreement with a report from Hurwitz and colleagues (1998) who commented in their study that they found no differences between participants with PTSD-only and comorbid PTSD/MDD on any PSG measures although no formal analyses were reported. As the current study did not include a healthy control group, no conclusions can be drawn about what this comparison would reveal.

Still, the lack of significant differences in this study between diagnostic groups could be attributed to the high levels of depressive symptoms reported across both groups. High levels of depressive symptoms are commonly endorsed by IPV survivors with PTSD (Nixon, Resick, & Nishith, 2004). In this study, the total cohort reported severe levels of depressive symptoms on the BDI-II with only a small differences across PTSD-only ($M = 29.9$) and

PTSD/MDD ($M = 36.1$) diagnostic groups. The groups were not statistically significant after controlling for multiple comparisons ($t(49) = 2.03, p = .048$). Future research should include an MDD-only cohort to shed light on possible discrepancies not revealed through comparisons within a PTSD population.

Another consideration is the dual nature of sleep changes that may present in MDD that could account for non-significant difference between diagnostic groups. The *DSM-IV-TR* includes experiencing “insomnia or hypersomnia nearly every day” as a combined symptom in the diagnostic criteria for MDD (APA, 2000). The BDI-II also combines increases or decreases in sleep under the same category of “changes in sleep pattern” (Beck et al, 1996). Although sleep changes are commonly endorsed in MDD, not all patients with MDD endorse insomnia as some patients experience hypersomnia or too much sleep and others may not endorse sleep disturbance at all since impaired sleep is not required for diagnosis. An examination focusing on differences between patients who subjectively endorse symptoms of insomnia, hypersomnia, or no sleep impairment in MDD should be considered in future investigations.

It also may be beneficial to attempt to reduce the sub-threshold depressive symptoms in the PTSD participants by selecting those who endorse low depressive symptoms. By doing so, investigations could control for the contribution of MDD in PTSD-related sleep impairment. This may be difficult, however, because MDD symptoms are often reported by those with PTSD. Although findings may not be generalizable to a large population, investigations may clarify the involvement of depression and depressive symptoms in PTSD-related sleep impairment. The literature would also benefit by investigating the impact of

MDD symptom severity as a dimensional variable instead of only as a diagnosis/categorical label that was the goal of aim 3.

The final aim sought to take depressive symptom severity into account by investigating the distinct contribution of PTSD symptoms (hyperarousal, re-experiencing, and avoidance) and depressive symptoms to sleep state misperception. The existence of sleep state misperception in PTSD and in this female IPV cohort was supported by findings in aim 1. No research to date has investigated the impact of PTSD and continuously scored depressive symptoms on sleep impairment in a PTSD cohort. It was hypothesized that PTSD hyperarousal and re-experiencing symptoms as well as depressive symptoms would contribute to the prediction of sleep state misperception.

Hierarchical regression analyses partially supported this hypothesis. Depressive symptoms, independent of diagnosis status, were observed as a significant contributor to sleep state misperception above and beyond the PTSD symptom clusters: re-experiencing, hyperarousal, and avoidance. Depressive symptoms added a moderate but significant amount of explained variance (9%) above and beyond all three PTSD symptom clusters while re-experiencing symptoms (13%) also predicted a moderate amount of variance in sleep state misperception. The finding of re-experiencing symptoms as a significant predictor of sleep state misperception agrees with previous research indicating increases in anxiety of experiencing nightmares during sleep as a possible contributor to “subjective insomnia” (Inman, Silver & Doghramji, 1990; Krakow et al., 2001). Re-experiencing symptoms have long been linked to sleep impairment as Van der Kolk and colleagues (1984) describe nightmares as a prototypical symptom of PTSD and sleep disturbance shortly after trauma has also been associated with frightening nightmares (Hefez et al., 1987).

Interestingly, hyperarousal symptoms did not contribute to sleep state misperception in this cohort. This is surprising considering the research suggesting sleep difficulties in PTSD are directly related to the hyperarousal symptoms as driven by increased noradrenergic activity (Pillar, Malhotra & Lavie, 2000) but parallels PSG research reporting hypo-arousal in PTSD during sleep (Dagan, Lavie, & Bleich, 1991; Lavie, Katz, Pillar, & Zinger, 1998). In the present study, hyperarousal symptoms were considered with and without the “difficulty falling or staying asleep” item in the analysis and produced the same outcome: non-significant contribution to the model.

The findings from the present study must be interpreted carefully and conservatively. Re-experiencing and depressive symptoms were found to contribute to sleep state misperception as defined by subjective overestimation of sleep disturbance. Therefore, depression and re-experiencing symptoms seem to predict the overestimation of sleep disturbance and should not be interpreted as predictors of objective sleep impairment. The fact that hyperarousal symptoms were not found to contribute to sleep state misperception does not exclude these symptoms from having legitimate effects on PTSD-related sleep impairment. Hyperarousal may be associated with impairments of objective sleep which would limit the contribution of hyperarousal symptoms to sleep state misperception. It should be noted, post hoc analysis in the current investigation revealed no significant relationship between hyperarousal and objective sleep impairment.

The impact of depressive symptoms on sleep perception in PTSD points to the importance of considering sub-threshold diagnostic symptoms apart from co-morbid depression diagnosis and in addition to PTSD, as a contributor of sleep impairment in a PTSD cohort. Depression severity has been linked to subjective sleep impairment separate

from PTSD diagnosis (Kupfer, 1999) and the severity of depressive symptoms has been associated with increased severity of subjective sleep impairment (Gupta, Dahiya, & Bhatia, 2009). Therefore it is not surprising that depressive symptoms, regardless of diagnosis, would contribute to sleep state misperception in the current PTSD cohort.

Conclusions

The current findings have significant implications for understanding PTSD-related sleep disturbance and have clinical relevance for treatment of PTSD and related symptoms. Findings support the existence of sleep state misperception in a PTSD-positive female cohort suggesting subjective but not objective sleep is impaired in this population. As this study is only the second study to investigate subjective and objective sleep disturbance in females with PTSD and does not support all previous findings, further research is needed in this area. The use of daily sleep logs and actigraphy allowed for minimally invasive yet precise nightly assessment of both subjective and objective sleep impairment. However, actigraphy does not allow for investigation of sleep characteristics or other parasomnias such as periodic leg movement and sleep apnea. Parasomnias such as sleep related breathing disturbance and periodic leg movement have been reported in PTSD cohorts (Brown & Boudewyns, 1996; Krakow, et al., 2000). Future investigations may want to screen for parasomnias as these may contribute to the development or increased severity of subjective and/or objective insomnia.

Certain limitations exist that should be taken into account when considering the current findings. The cohort included in this investigation reported severe sleep impairment over the past month and severe insomnia over the past week on global self-report sleep measures which may limit the generalizability of the findings to less sleep impaired cohorts. Although, studies suggest the majority of participants with PTSD endorsed some sleep

impairment (Neylan et al, 1998; Harvey et al., 2003). The current study did not employ the use of a control group for comparison of subjective reports and objective assessments.

Therefore, no conclusions can be made as to the degree of sleep disturbance above a non-PTSD population. Future research should include non-traumatized as well as traumatized PTSD-negative control groups to compare to PTSD populations. The goal of the present study was to examine sleep state misperception in an under-investigated cohort of PTSD-positive female IPV survivors as well as account for the contribution of depressive symptoms and diagnosis. Findings should not be generalized to male cohorts as significant differences in healthy female and male sleep patterns have been reported (Redline et al., 2004).

This is the first study of PTSD-related sleep disturbance to directly investigate and report the effects of major depression in a female cohort. Although MDD diagnosis was not found to affect sleep impairment when considered as a dichotomous variable, depressive symptoms were observed as a unique predictor of sleep state misperception above and beyond PTSD symptom clusters. The largest amount of variance in the regression was explained by re-experiencing symptoms which are effectively reduced through cognitive and trauma focused therapy. Reductions in depressive symptoms are commonly displayed after trauma-focused therapy as well. It stand to reason if cognitive and trauma focused therapy can reduce or eliminate PTSD and/or depressive symptoms, subjective sleep complaints may also improve as a result. Future research should also address the effect of treatment on subjective and objectively measured sleep as well as sleep state misperception in a PTSD cohort.

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