The Relation between PTSD Symptoms in Veterans Diagnosed with PTSD and their Daily Sleep Quality: A Systematic Review

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Abstract

Post-Traumatic Stress Disorder or PTSD is a mental disorder in which individuals suffering from it have experienced or witnessed traumatic events. As a result of this, many symptoms develop in the individual that cause emotional distress. For example, symptoms such as having recurring, vivid and intrusive memories of the traumatic event are common in PTSD. A population that is more likely to suffer from PTSD are veterans that have been deployed in war or war-like environments, making them prone to witnessing or experiencing traumatic events. Another important symptom of PTSD is the sleep disturbances that these symptoms will inevitably cause. For the purpose of this systematic review, eleven studies illustrating the link between veterans' PTSD symptoms and their daily sleep quality will be assessed and common sleep disturbances were identified along with their correlations to the PTSD symptoms. In addition to this, current treatment option available for the treatment of these sleep disturbances were evaluated and propositions for future directions concerning these treatments were proposed. The evidence from the literature showed a link between Trauma Related Nightmares, Sleep Onset Latency, Total Sleep Time, Wake After Sleep Onset, Hypervigilance and Insomnia and symptoms of PTSD. Evidence also showed that research on treatment options raise inconsistent findings and there is limited amount of effective treatments concerning the sleep disturbances associated with PTSD.

Keywords: PTSD symptoms, veterans, daily sleep quality, sleep disturbance

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Sleep disturbances are very challenging symptoms that are associated with post-traumatic stress disorder (PTSD) (So et al., 2023). Insomnia, trauma related nightmares, intense anxiety, and hypervigilance are just a few of the sleep disturbances that an individual with PTSD could suffer from (So et al., 2023). In fact, the APA definition of sleep disturbances is "a persistent disturbance of typical sleep patterns (including the amount, quality, and timing of sleep) or the chronic occurrence of abnormal events or behaviour during sleep" (APA Dictionary of Psychology, n.d.).

Understanding and then further treating these disturbances would be a very important improvement to the daily lives of people with PTSD since its impact on daily life is an important aspect of sleep disturbances and can cause very serious physical and mental harm to individuals suffering from it (Palmer et al., 2022; Bellesi, 2019). Moreover, poor sleep even worsens the daytime symptomatology of PTSD and makes it even more resistant to treatment (Remadi et al., 2023). Another finding suggests that sleep problems, if not treated, tend to become independent problems over time and may warrant sleep focused assessment and treatment away from the initial PTSD treatment (Gehrman, 2014)

Unfortunately, the treatment of the sleep disturbances specifically, away from the general treatment of PTSD symptoms is fairly scarce. Oftentimes, sleep disturbances are overlooked compared to other PTSD symptoms in treatment and the treatments that are available are not effective enough and individuals with PTSD continue to experience residual sleep difficulties (Ulmer et al., 2011). Residual sleep difficulties concern the persistent sleep difficulties that remain even after the successful therapy for PTSD (Belleville et al., 2011). Research has demonstrated that 70% of people who report baseline sleep difficulties will report significant sleep problem even after treatment (Belleville et al., 2011). This is a

concerning finding, because, individuals reporting posttreatment sleep difficulties may experience even more residual posttraumatic, depression and anxiety symptoms than individuals who did not report any residual sleep difficulties (Belleville et al., 2011).

In order to develop effective treatment for sleep disturbances, the first step is to understand the relation between PTSD symptoms and sleep disturbance. This review will focus specifically on the investigation of the relation between PTSD symptoms and daily sleep disturbance in populations that are known to be prone to suffering from PTSD symptoms: veterans.

Veterans, a population who serve in the active military and are often deployed to serve in war or war-like environments, are more likely to witness or be involved in dangerous or life-threatening situations. These situations are a risk factor for developing PTSD since, according to the DSM-5 criteria A for PTSD, the individual needs to have been exposed to either death, threatened death, actual or threatened serious injury, or actual or threatened sexual violence. As reported by Richardson et al. (2009), the prevalence of PTSD in US military veterans since the Vietnam War ranges from 2% to 17% and nearly 90% of veterans diagnosed with PTSD will report significant sleep complaints (Miller et al., 2023).

The relationship between PTSD and sleep disturbance has been subject to research throughout the years. So far, research has been relatively consistent in associating PTSD with sleep difficulties to the point where nightmares and problems falling or staying asleep are symptoms listed in the fourth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) criteria for PTSD (Belleville et al., 2011). Whether it is research done on veterans with war trauma or research done on individuals with other types of trauma, PTSD and sleep difficulties are consistently linked. For example, a study on the association of PTSD and sleep quality in individuals experiencing high threat of the COVID-19 pandemic done by Straus et al., (2022) noted that worse sleep quality was associated with

more severe PTSD symptoms. In addition, Biggs et al. demonstrated, in 2020 and in 2021, that sleep disturbances are common symptoms with post-traumatic stress disorders. Even though PTSD and sleep disturbance are often linked in many different contexts, Biggs et al. (2020) also found that the correlation between night time sleep characteristics and next day post-traumatic stress symptoms was not well researched. This is interesting as this review is aiming to investigate the relationship between PTSD symptoms in veterans and daily sleep quality, specifically.

Regarding the current state of treatment for sleep disturbances in PTSD, the literature suggests promising findings in terms of cognitive behavioural therapies and rather unsuccessful findings for pharmacological treatment (Gehrman, 2014). Often, research on sleep disturbances and PTSD focus on insomnia symptoms and nightmares, therefore, aim to reduce these. The main sleep disturbance symptom that is researched with PTSD is insomnia because it is the most prevalent with an estimate up to 80-90% of patients experiencing it (Koffel et al., 2016). The most researched therapy producing the most positive outcomes is Cognitive Behavioural Therapy for Insomnia (CBT-I) (Gehrman, 2014). This therapy can be administered individually or in groups and is generally shown to improve insomnia symptoms even after 6 months (Gehrman, 2014). However, sleep medications have not been found to be helpful in treating sleep disturbances as they carry many negative side effects, are recommended for short term use and there are few clinical trials examining the safety of these medications (Koffel et al., 2016). These medications will initially promote sleep but the patients will often develop a tolerance and their continued use will be reinforced by a desire to avoid withdrawal symptoms (Gehrman, 2014).

As far as treatment goes when sleep disturbances are not the target specifically, but rather PTSD symptoms are, sleep related symptoms of PTSD should usually be alleviated during the treatment of the underlying disorder itself, however, research has found that this is

not necessarily the case (Walters et al. 2020). In fact, this is disconcerting because, as seen previously, sleep impairment is extremely prevalent in people diagnosed with PTSD and it suggests that PTSD treatments need to focus on day and night relief of symptoms, as opposed to only day time symptoms, hence the focus on ambulatory sleep quality measurements in this review (Walters et al. 2020).

The benefits of looking at daily sleep quality and not sleep quality in general, is so that it is possible to pinpoint exactly what the disturbances are on a day to day basis to have a better overall view of the possibilities of treatment. The use of daily diary methodology, and ecological momentary assessment (EMA) have multiple benefits and add interesting information to cross sectional methodology (Schneider et al. 2016). Some of these benefits include: the fact that they capture individuals' experiences in their natural environment which increases ecological validity, the individuals will record their symptoms as they occur rather than reporting them from memory later on which increases the accuracy of the report (Schneider et al. 2016). Other benefits include the data being fine grained and capturing the within day changes and contextual information, it can also be paired with objective measures like actigraphy or physiological measures (Schneider et al. 2016).

In addition to this, research about the relation between daily sleep characteristics and PTSD is scattered, which is why this review's aim is to summarise the findings in line with this relation and to get a better picture of the literature (Biggs et al., 2021). Specifically, this review is set to examine the daily relationship between PTSD and sleep disturbances, which opens a new area of research to be summarised, looking at the daily variation of these sleep disturbances and their treatment. An essential aspect of the relation between daily sleep disturbances and PTSD symptoms is the effectiveness of the treatments that have been researched up until now to treat this specific type of sleep disturbance.

Methods

The present study is part of a larger project titled Stress in Action (Weverling, 2023). This project is a collaboration between multiple universities, focused on reviewing research on daily measures of stress dynamics with the overarching goal of creating a more stress-resilient population. The present study was designed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) statement (Page et al., 2021). The study was also pre-registered (https://osf.io/24auc).

2.1 Eligibility criteria

To be included in the overall study, the articles needed to meet a set of eligibility criteria. Firstly, only studies involving human participants are considered eligible for inclusion. However, studies incorporating animals as intervention agents, such as those investigating the impact of canine companionship on daily mental distress among humans, are also included, given the focus on human participants. Additionally, single-participant case studies (N=1) are excluded from consideration.

Secondly, empirical studies are simply included for inclusion, while non-empirical sources such as dissertations, reviews, comments, opinion articles, books (chapters), and similar publications are excluded. Nevertheless, protocols detailing the methodologies of empirical studies are included to optimise selection of relevant articles.

Thirdly, selected studies must incorporate daily measures that are recorded at least once a day for several consecutive days (≥2 days in a row). These measures could be subjective self-reports, reported by others, or objective measures of physiology or activity. However, studies reporting daily treatments without accompanying measures, Intensive Care Diaries (ICD) documenting the status and treatments of unconscious patients in intensive care units, or daily measures unrelated to human experiences, such as emotional word searches or crime reports, were excluded. These criteria serve to ensure the selection of studies that

directly contribute to understanding daily measures of stress and mental well-being in human populations while excluding irrelevant sources

2.2 Search strategy and information sources

The search was conducted in Web of Science with Core Collection and MEDLINE searched and PsycINFO (through EBSCOhost) on December 15th, 2023. For these electronic databases, the search string was developed on three core components: a) stress concept (context); AND b) mental health outcome; AND c) the design of the study (daily measurements). The search was conducted in the title or abstract. The first component "stress concept" used : a) stress* or "life event*" or "negative event*" or hassles or trauma* or abuse or neglect or *child* maltreatment" or "child* experiences" or violence or disaster*. The second component used: b) psychopathol* or "mental disorder*" or anxiet* or depress* or "CIDI" or "DSM" or phobia* or "ptsd" or "panic disorder*" or "GAD" or "MDD" or "MDE". The last component used: c) diary or daily or "time series" or "time-series" or "experience sampling" or "ESM" or "ecological momentary assessment*" or "EMA" or "intensive longitudinal" or ambulatory or "micro-longitudinal".

2.3 Selection process

A preparation stage was conducted, in addition to a pilot screening of 1200 hits, an update on selection criteria and continuation of work on screening, pilot extraction, extraction and synthesis stage. After removing duplicates using RStudio and Rayyan, abstract screening was conducted using ASReview available at https://asreview.nl/ (van de Schoot et al., 2021). This software uses active learning to prioritize abstracts based on the similarity of included articles. The software was trained using 400 records as signifiers of articles that should be included or excluded (200 each). The prioritized records were then screened by four individuals, each looking at a different subset of abstracts. Only the title and abstract of the record were displayed on the screen with two decision options (relevant/irrelevant). The

screening process continued until fifty records in a row were marked as irrelevant, after which, the criteria was met to stop semiautomatic screening, the remaining articles were not included and not seen by reviewers. Another round of screening of the excluded records was done by a different reviewer, also using ASReview. For the purpose of this review, we only included published articles in peer-reviewed journals.

2.4 Data collection process and items

A data extraction sheet in Excel was set up to be used for the primary data extraction phase. Twelve extractors were given instructions on how to code the articles, with each of them coding approximately 100 articles in five weeks. The coding was supervised and assisted by one of the project leaders, to ensure extraction reliability. From the included articles, the following data was extracted regarding the population characteristics: year of publication, sample country, sample size, mean age, population, physical health, and mental health diagnosis. The data extraction sheet was separated into two blocks: for ambulatory measurements and cross-sectional measures. sampling frequency per day, as well as type of report (subjective, objective, or mixed) was collected for the ambulatory measurements part, and the following variables were extracted when measured either ambulatory or cross-sectionally: stress response (stressor, stress, affect/emotions, cognitions, physiology, behaviour), and mental health symptoms (coping, mental health concept, measurement). Additionally, there was an 'other' column, where variables that do not fit into the other categories, could be coded. Each study was coded as either including an intervention (1) or not (0). Information that was unavailable in the articles was referred to as non-available (N/A).

2.4 Studies selection form the database

In regard to the research question which will be addressed throughout the review, it was formulated using Population, Exposure and Outcome, or PEO. The population that was focused

on was veterans diagnosed with PTSD, the exposure was trauma and PTSD symptoms, and the outcome was daily sleep disturbance and quality. Sleep disturbances are operationalized as daily subjective ratings of different indices of sleep (e.g., self-reported sleep onset latency, waking after sleep, daily sleep logs, sleep diaries, and nightmare reports,) and objective measures through actigraphs, dream headbands, heart rate and other physiological measures that give information about sleep disturbance or quality.

The process to select the relevant articles for the research question "What is the relation between PTSD symptoms in veterans diagnosed with PTSD and daily sleep quality?" was as follows. Firstly, filters on the Excel database were applied to find all the articles that could be used to answer the research question. The first filter that was applied concerned the population that was addressing. A filter for "population subtype" as only showing the populations: "veterans", "adult veterans", "combat veterans", "military veterans", "Vietnam veterans", "OIF/OEF veterans", "US veterans", and "veterans suffering from combat -related PTSD" was used. Then, a refinement of the search of the population by filtering the "mental health diagnosis (CIDI, SCID, ICD, MINI, DSM, CAPS (for PTSD)" column and included only articles where the population had been diagnosed with "PTSD" was performed. Then, a filter concerning the "Variable measure Ambulatory" section, more specifically the "stress response - behaviour" column to include either terms: "sleep, sleep cycle, sleep disturbances, sleep duration, sleep efficiency, sleep onset latency, sleep quality" was added. For the "variable measured cross sectionally" section, more specifically the "MH-concept-C" column, there was an application of the filter for "PTSD" or "PTSD Sx"…

A series of articles were then selected from the database based on these filters and exclusion criteria including:

a) non-veterans

b) no cross-sectional measure of PTSD,

c) substance use disorders that could explain the sleep disturbances,

d) sleep not measured daily,

e) participants under 18 years old,

f) articles that were not available in full.

Through snowballing, from these articles, another article was found another article that complied to all the criteria and other articles through a search on PsycINFO making sure to respect all eligibility criteria.

Results

Literature search

Fig 1 depicts the PRISMA flow chart of the literature search. Web of Science Core Collection, MEDLINE and PsycINFO databases identified 4195 records to be screened, of which 1159 remained to be included in the database. Of these, 38 studies were assessed for eligibility, 30 were excluded, leaving a total of 11 studies included in the review (8 from the database and 3 from snowballing).

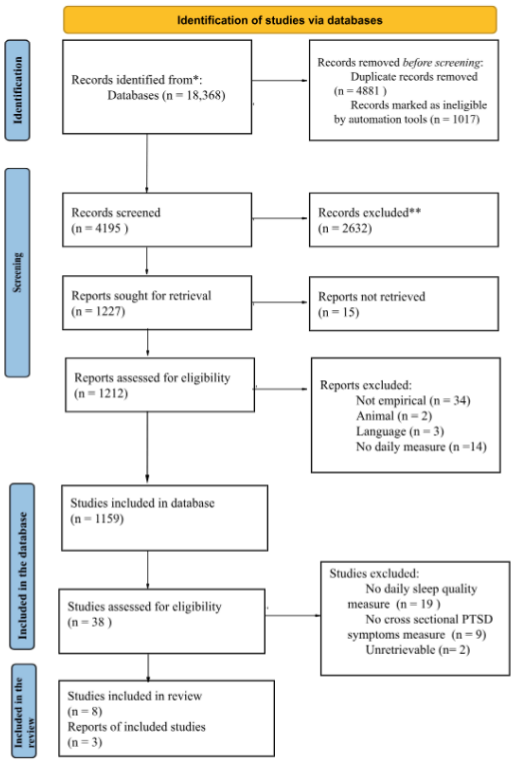

Fig 1. Flow chart of literature search adapted from PRISMA guidelines

Table 1

Sample Characteristics and Measures

Author (year)	Population			Measures		
	Country	Sample size	Mean Age	PTSD symptoms measure	Daily objective sleep quality measure	Daily subjective sleep quality measure
Haynes et al. (2020)	US	37	56	CAPS	Actigraph	sleep diary; insomnia assessment
David et al. (2006)	US	20	54	CAPS	-	sleep/dream diary; PSQI
Westermeyer et al. (2010)	US	26	18+	PCL; CAPS	Daily sleep actigraph	PSQS; daily sleep log
Saguin et al. (2023)	FR	60	43	PCL-S	Dream 2 headband (DH) device; empatica E4 wristband	nightmare reports
Slightam et al. (2018)	US	120	54	CAPS	Actigraph	self-reported sleep quality
Ulmer et al. (2011)	US	22	46	PCL-M	-	DSISD; ISI; Electronic sleep diary; PSQI
Miller et al. (2023)	US	190	36	CAPS-5	Mattress actigraphy systems	ISI
Walters et al. (2020)	US	45	35	CAPS; PTSD-CS; PHQ-9	Actigraph; Actiwatch	sleep diary; nightmare log; ISI; PSQI
Krystal et al. (2016)	US	267	18+	CAPS; DSM-IV PTSD diagnosis	-	PSQI

Biggs et al. (2021)	US	157	42	PCL-5	-	20 item sleep disturbance; daily sleep diary; PSQI; SLEEP-50
Gehrman et al. (2014)	US	105	60	SCID-IV; CAPS; PCL-M	-	PSQI; sleep diaries

Note. CAPS: Clinician Administered PTSD Scale, PCL-M: PTSD Checklist Military Version, PCL- 5: PTSD Checklist DSM-V version, SCID-IV: Structured Clinical Interview for DSM Disorders (DSM-IV version), PCL-S: PTSD checklist, PSQI: Pittsburgh Sleep Quality Index, DSISD: semi structured interview designed to detect the presence of sleep and circadian problems, ISI: Insomnia Severity Index, SLEEP-50: questionnaire designed to detect sleep disorders

Table 2

Analysis and Outcome Data

			Outcomes		
Author (year)	Type of statistical estimate	Estimate type	Corresponding Estimate	Significance	Result
Haynes et al. (2020)	Correlation; percentage	CAPS change scores and therapy dose association	r = 0.09	p= .61	27 out of 32 veterans reported nightmares
		participants with PTSD met criteria for insomnia disorder	79%	-	no improvement of sleep disturban after treatment large part of the veterans with PTS the criteria for insomnia
		greater reduction in CAPS scores from pre-to post treatment associated with greater improvement in sleep quality	(γ11 = − .03, 95% CI [−.05, −.00])	p= .02	no significant association between severity of sleep indices at post treatment and length time since completion of the CPT.
David et al. (2006)	differences pre-and post- treatment (t value)	PSQI awakenings and bad dreams after treatment with risperidone	t = 1.7 and t =1.1	NS	PSQI awakenings and bad dreams r significant result after treatment wi risperidone
		CAPS total pre-and post-treatment	t = 2.3	NS	CAPS total and sleep items concer distressing dreams and difficulty fa asleep were improved significantly
Westermeyer et al. (2010)	correlation	PTSD score, total ESS	r = 0.40	p= .05	significant association between PT checklist score total and hypervigilance with
		r of PTSD checklist, hypervigilance	r = 0.44	p= .03	Sleepiness Scale Scores.

Saguin et al. (2023)	Correlation; percentage; frequency	Percentage of participants having had at least one nightmare during 5 recorded nights		64.91%		-	A large majority of patients suffer f Trauma Related Nightmares (TRN)
		200 nightmares over 91 nights in 37 patients out of 43 in REM and NREM		-		-	TRNs present in both REM and NF sleep in patients with severe PTSD
		Correlations between subjective and objective sleep measures of TST, SOL and TRNs		r_{TST} = 0.422 r_{SOL}=0.624 r_{TRN}=0.467		p<0.0001	Positive correlation between subjec and objective measures of sleep parameters (total sleep time, sleep latency, TRNs)
Slightam et al. (2018)	Percentage; means	NAW for PTSD measured with actigraphy	NAW for PTSD measured with diary	mean= 4.28	mean= 3.56	-	
		NAW for control measured with actigraphy	NAW for control measured with diary	mean= 3.61	mean= 2.61	-	Self-reported measures showed tha individuals with PTSD reported wo sleep than controls but this was not with the objective measures
		SOL measured through diaries for PTSD	SOL measured through diaries for control	mean= 35.74	mean= 20.58	-	
		WASO measured through diaries for PTSD	WASO measured through diaries for control	mean= 54.36	mean= 29.25		In PTSD participants, there was significantly higher WASO and SC and significantly lower TST compa controls
		TST measured through diaries for PTSD	TST measured through diaries for control	mean= 393.79	mean= 420.51	-	
Ulmer et al. (2011)	Difference statistic; F-statistic	SOL difference between SIP and Treatment as usual		$F_{1,21}$ 10.17		p= 0.004	The significant differences after

		SE difference between SIP and Treatment as usual	$F_{1,21}$ 14.61	p= 0.001	SIP: a reduction in nightmare frequ greater improvements on diary mea of SOL, higher sleep efficiency
		nightmare frequency difference between SIP and Treatment as usual	$F_{1,21}$ 5.03	p= 0.04	
		SIP produced significantly greater improvements in insomnia severity (ISI)	$F_{1,21}$ 11.80	p= 0.003	Significant improvements in insom PTSD symptoms and Sleep quality SIP
		PTSD symptoms (PCL-M) after SIP	$F_{1,21}$ 22.72	p= 0.0001	
		Sleep quality (PSQI) after SIP	$F_{1,21}$ 17.31	p= 0.0005	No significant difference between g for PTSD specific sleep quality (PS A), and WASO.
		WASO: SIP vs. Usual Care	F=0.71	p = 0.41	
		PSQI-A: SIP vs. Usual Care	F=0.76	-	
Miller et al. (2023)	descriptive	3 longitudinal profiles during treatment: stable (56%); decreasing (35%); increasing (8%)	-	-	3 longitudinal profiles during the treatment of PTSD, stab increasing and decreasing.
		Comparing decreasing and stable SP class means	Mean decreasing SP= 5.7 Mean stable SP= 6.3	p= 0.03	Compared to the stable SP class, individuals in the decreasing SP cla reported fewer PTSD avoidance symptoms
Walters et al. (2020)	Difference pre-and post- treatment; percentage of change in sleep quality	effect of PE on SE	76% had SE <85%	p= 0.98	practically no significant change in quality before and after treatment
		percentage of veterans continuing to experience at least 2 nightmares per week	80%	-	

		total number of nightmares after PE	t= -2.76	p=0.006	total number of nightmares does nc decrease significantly
		total sleep time after PE	t= -0.22	p= 0.83	total sleep time does not increase significantly after PE
		sleep latency after PE	t= -1.06	p=0.29	sleep latency doesn't improve
Krystal et al. (2016)	correlation; percentage; main effect	Percentage of participants having impaired sleep	88%	-	correlation between sleep disturban and PTSD symptoms
		correlation between PTSD symptoms and severity of sleep disturbances	-	significant	
		Risperidone main effect on PSQI scores	F1,228=4.57	p=0.034	main effect quite small but signific the risperidone
Biggs et al. (2021)	T value; correlation coefficients	People with PTSD reported significantly shorter sleep duration compared to controls (mean)	5.33 vs 5.98, t=3.20	p<0.001	group with PTSD suffered more fr sleep quality issues than group witl PTSD on all sleep characteristics during the weekdays and weekends
		lower sleep quality in PTSD patients vs. controls (means)	1.40 vs 1.64, t=3.09	p=0.007	
		more trouble falling asleep in PTSD patients vs. controls (means)	0.54 vs 0.25, t=-6.52	p<0.001	
Gehrman et al. (2015)	correlations	PCL-M and number of awakenings	r=0.34	p=0.0007	greater PTSD severity was correlat with more awakenings, shorter sleep time, longer sleep late and more nightmares
		PCL-M and number of hours slept	r=-0.3	p=0.002	
		PCL-M and minutes to fall asleep	r=0.27	p=0.006	
		PCL-M and number of nightmares	r=0.33	p=0.0005	
		CAPS and number of awakenings	r=0.16	-	

CAPS and number of hours slept	r=0.16	p=0.012	Greater severity of PTSD as assess the CAPS was
CAPS and minutes to fall asleep	r=0.17	-	associated with shorter sleep time, awakenings, higher SOL, more
CAPS and number of nightmares	r=0.15	-	nightmares.

Note. NS: Not Significant, PHQ-9: patient health questionnaire, PE: Prolonged Exposure, SE: sleep efficiency, NAW: number of awakenings, SIP: Sleep Intervention for PTSD, ESS: Epworth Sleepiness Scale Score, SP: sleep period, defined as the hours of lying down in bed and quiescence between 20:00–10:00

Population

The population focused on in this review consisted exclusively of samples of veterans that were mainly from the United States, with one study having a sample of veterans from France. The mean age range was 18 to approximately 60 years old and the sample sizes ranged from the smallest being 20 participants and the largest being 267 participants.

Sleep measures

The most common method of measuring daily subjective sleep is found to be sleep diaries, which are employed in approximately 64% of articles used in this review, e.g. Biggs et al. (2021); David et al. (2006); Gehrman et al. (2014); Haynes et al. (2020); Walters et al. (2020); Westermeyer et al. (2010). Another common subjective measure of daily sleep is the insomnia assessment or the ISI, which is employed in around 36% of articles, e.g. Haynes et al. (2020); Miller et al. (2023); Ulmer et al. (2011); Walters et al. (2020). Then, there is the use of nightmare or bad dream reports, which are found in about 27% of the articles used, e.g. Saguin et al. (2023); Walters et al. (2020). And finally, the use of the PSQI, which has been employed in around 64% articles used in this review, e.g. Biggs et al. (2021); David et al. (2006); Gehrman et al. (2014); Krystal et al. (2016); Ulmer et al. (2011); Walters et al. (2020); Westermeyer et al. (2010). The most common measure of daily objective sleep is the actigraph, which was found to be used in 83.3% of articles that employ objective sleep measures, e.g. Haynes et al. (2020); Miller et al. (2023); Slightam et al. (2018); Walters et al. (2020); Westermeyer et al. (2010).

PTSD measures

PTSD was either measured using the CAPS or different versions of the PCL (PCL-M, PCL-5, PCL-S). There were also articles making use of the SCID-IV, DSM IV PTSD diagnosis, and PHQ-9. Some sources made use of scales to measure symptoms and their relation to sleep and other sources compared PTSD participants with control participants with

no PTSD in order to identify a difference in sleep disturbances in veterans with PTSD while looking at a baseline of sleep disturbances in veterans with no PTSD. Sources also compared PTSD treatment to control groups with no treatment.

Objective and Subjective measures of daily sleep

Six studies (Haynes et al. (2020); Miller et al. (2023); Saguin et al. (2023); Slightam et al. (2018); Walters et al. (2020); Westermeyer et al. (2010)) make use of objective and subjective sleep measures together to reduce the biases that would accompany self-reporting sleep quality. Researchers found positive correlations between subjective and objective sleep parameters (total sleep time, sleep onset latency and TRNs frequency) (Saguin et al., 2023). However, some researchers found that self-reported items of sleep tend to overestimate or worsen the symptoms of bad sleep quality when compared to objective sleep measures (Slightam et al., 2018).

Types of Sleep Disturbances

In a study done by Krystal et al. (2016), researchers found that 88% of the veterans with PTSD who participated in the study reported impaired sleep which correlated with their PTSD symptoms. Indeed, the most common sleep disturbances that have been identified are: trauma related nightmares (TRNs) (David et al. 2006; Gehrman et al. 2014; Haynes et al. 2020; Saguin et al. 2023; Ulmer et al. 2011; Walters et al. 2020), sleep onset latency (SOL) (Biggs et al. 2021; David et al. 2006; Gehrman et al. 2014); Slightam et al. 2018; Ulmer et al. 2011; Walters et al. 2020), total sleep time (TST) (Gehrman et al. 2014; Slightam et al. 2018; Ulmer et al. 2011; Walters et al. 2020), wake after sleep onset (WASO) (David et al. 2006; Gehrman et al. 2014; Slightam et al. 2018; Ulmer et al. 2011), hypervigilance (Westermeyer et al. 2010) and insomnia (Haynes et al. 2020; Ulmer et al. 2011).

Trauma Related Nightmares (TRNs)

TRNs were reported in Haynes et al. (2020) as affecting 84.4% of veterans in the study who were diagnosed with PTSD. Daily correlational studies (Haynes et al., 2020; Saguin et al., 2023) have found a significant positive correlation between veterans' CAPS and PCL-M scores and the number of nightmares they experienced. They also found that in patients with severe PTSD, TRNs are present in both REM and NREM sleep.

In terms of treatment, the daily experimental studies included in this review (David et al., 2006; Ulmer et al. 2011; Walters et al., 2020) found that using Risperidone, there was no significant improvement in bad dreams and found no significant decrease in total number of nightmares after prolonged exposure (PE) therapy, where 80% of veterans continued to experience at least 2 nightmares per week. They have, however, found a significant reduction in nightmare frequency after Sleep Intervention for PTSD (SIP).

Sleep onset latency (SOL)

In daily comparative studies (Biggs et al., 2021; Gehrman et al., 2014; Slightam et al., 2018) participants with PTSD reported significantly more trouble falling asleep than the control group with no PTSD indicating that veterans with PTSD had significantly higher SOL compared to control groups. In terms of comparative treatment, it was found that SOL improved significantly after SIP but did not improve after Prolonged Exposure (PE). Daily correlational studies (Gehrman et al., 2014) found a positive correlation between severity of PTSD and sleep latency.

Total sleep time (TST)

When comparing PTSD groups with control groups, studies have found that participants with PTSD have significantly lower total sleep time compared to controls with no PTSD (Biggs et al. 2021; Slightam et al. 2018). In a longitudinal study (Miller et al., 2023), three profiles of treatment to increase sleep time in veterans with PTSD were found: the most common being stable, followed by decreasing and increasing, the decreasing class

constituted participants who had less severe pre-treatment PTSD avoidance symptoms. The decreasing group was also acclaimed to be the most advantageous sleep period because decreasing sleep is a good intervention for sleep consolidation, according to the treatment of insomnia by restriction of time in bed (Speilman et al., 1987). With respect to treatment, experimental studies have shown that Prolonged Exposure had no significant improvement on TST (Walters et al. 2020).

Wake after sleep onset (WASO) and hypervigilance

In studies comparing PTSD groups with controls (Slightam et al., 2018), found that veterans with PTSD had significantly higher wake after sleep onset. In daily correlational studies about WASO and hypervigilance as a consequence of WASO (Gehrman et al. 2014; Westermeyer et al., 2010), researchers found that CAPS and PCL-M scores were significantly correlated with WASO and scores on the PTSD checklist were correlated with hypervigilance. For treatment, SIP made no significant improvement on WASO.

Insomnia

In daily descriptive study designs (Haynes et al., 2020) it was found that 79% of participants with PTSD met criteria for insomnia disorder. In treatment, Sleep Intervention for PTSD seemed to produce significant improvements for insomnia severity in participants with PTSD (Ulmer et al. 2011).

Discussion

This paper was carried out through means of a systematic review of the current literature available about the topic aiming to investigate the relation between PTSD symptoms in veterans diagnosed with PTSD and their daily sleep quality. Within this paper, articles using objective and subjective sleep measures were utilised to measure PTSD in veterans diagnosed with PTSD and their daily sleep quality. A link was then made between PTSD and specific sleep disturbances. Different types of treatment of these sleep

disturbances were reviewed and their efficacy were detected. Overall, this review explored the way that PTSD symptoms in veterans diagnosed with PTSD affected daily sleep quality. Through measures of daily sleep using subjective and objective measures, this review was able to identify the most researched common sleep disturbances in daily sleep associated with PTSD in veterans. These common sleep disturbances included: trauma related nightmares (TRNs), sleep onset latency (SOL), wake after sleep onset (WASO), hypervigilance, Total Sleep Time (TST) and insomnia. All of these symptoms were clearly linked with PTSD in research exclusively done on veterans. Another conclusion drawn from this review is that there are few effective treatments for these sleep disturbances. Indeed, there is a small amount of treatment that improves the daily sleep quality of veterans with PTSD. The only treatment that seemed to have a positive significant effect on sleep latency, trauma related nightmares and insomnia was Sleep Intervention for PTSD (SIP) and there is little research on this intervention. However, SIP did not have a significant effect on WASO. Risperidone had no significant effect on TRNs and Prolonged Exposure (PE) had no significant effect on TST, SOL or TRNs.

It is important for veterans with PTSD, or any individual suffering from PTSD to benefit from a 24-hour relief of their symptoms, but so far, research on treating daytime PTSD symptoms has received more attention than research on night time symptoms. This trend suggests that sleep disturbances become more extreme the more severe the PTSD symptoms are in veterans, or vice versa. There is an association between both constructs but it is challenging to predict in which direction the trend goes. A possible explanation for the co-occurrence of sleep disturbances and PTSD symptoms, is that possible PTSD symptoms include “recurring, involuntary, and intrusive distressing memories of the traumatic event(s)”, “recurring distressing dreams in which content and/or affect of the dream are related to the traumatic event(s)” (Substance Abuse and Mental Health Services Administration, 2014),

which shows a relation between sleep disturbances and symptoms of PTSD, their measures being redundant. There are also a number of symptoms including emotional distress and flashbacks, which link PTSD symptoms directly to involuntary thoughts and dreams of traumatic events (Kwassman, 2007; Seixas et al., 2015). The link between unhealthy sleep and emotional distress, a core symptom of PTSD, is also shown in a National Health Interview survey, where researchers found that emotional distress increased the chances of individuals reporting unhealthy sleep by 1.5 (Seixas et al., 2015). This shows that, whether the individual suffered from trauma related nightmares directly or not, a major symptom of PTSD, namely, emotional distress, is still linked to poor sleep quality. This is important to note because, the link between PTSD and sleep disturbances is clearly researched cross sectionally, however, this review brings about new information about the ambulatory measures of sleep and what their findings bring to the subject. Indeed, through the ambulatory measures, this review was able to identify more specific sleep disturbances associated with PTSD and look at treatment targeting those specific sleep disturbances.

Strengths of the selected studies

There are a number of strengths associated with this review. Given that it is an analysis of the current body of knowledge and literature around PTSD in veterans and their sleep quality, articles that were selected from the original database were peer reviewed and their findings supported and extended to each other. Findings from study to study were rather consistent in linking PTSD in veterans to sleep disturbances. Another strength of the selected studies in the review concerns the daily measures of sleep quality. Indeed, EMA was used to measure sleep quality in veterans at least once a day and for at least two consecutive days. This is advantageous because EMA offers high ecological validity as the participants are able to answer survey questions in their regular environments, therefore the data is able to be generalised to real life settings, thus improving its quality. EMA also accounts for biases

associated with participants being measured in artificial settings and instead being measured in the comfort of their own home or during their regular schedules. This also decreases the risk of misinformation effect, where participants get notified and have to answer survey questions as the notifications appear, therefore reducing the amount of time between the recollection and the event so the memory of it is more accurate. It is important to note that data was sometimes collected at specific times in the night or in the morning as the participants had just woken up or were in the middle of their night sleep, which constitutes a strength since the memory of their sleep quality was often fresh and more precise. PTSD symptoms were also measured cross sectionally at baseline and at the end of the studies to account for variations in severity in parallel to the daily sleep quality measures in all the articles. An advantage of these articles is that they are quite recent, four of them being conducted after 2020 and the oldest dating from 2006. Finally, a strength of this review includes the study of both objective and subjective measures of sleep quality to account for potential discrepancies of the participants over or under reporting their sleep disturbances. Studies used objective sleep quality measures in addition to subjective sleep quality measures and found that participants often misinterpreted their sleep disturbances, which was a variable to consider when interpreting the results of the studies.

Limitations of the selected articles

Limitations of this paper include the lack of diversity in the samples used in the articles. Ten out of the eleven articles used American participants and half of these samples included less than a hundred participants. This is a limitation to the generalisability of the findings. It is often discussed in the studies that they do not always account for comorbid mental disorders such as depression or substance use disorders that could mediate the relationship between PTSD and sleep quality. Finally, a limitation concerning the findings of the review concerns the insignificant findings concerning treatment efficacy of the sleep

disturbances as there is not enough research on the topic. This brings about another important discussion topic, which are future directions.

Future directions

These findings, consistent as they are concerning PTSD in veterans and the clear link with sleep disturbances, open a new direction which has been researched but has not found significant results, which is their treatment.

Options of treatment so far include: Prolonged Exposure (PE), Sleep Intervention for PTSD (SIP), and Risperidone. As discussed previously, PE produced no significant improvement on daily sleep disturbances and Risperidone produced only a small effect on reducing PTSD symptoms. As for SIP, findings are more promising as it produced a significant reduction in nightmare frequency, greater improvements on diary measures of total sleep time, greater improvements in insomnia severity, and higher sleep efficiency (Ulmer et al., 2011). Future directions opportunities would evidently need to include better treatment options for PTSD related sleep disturbances. I would suggest going further into treatment options targeting specifically the most common PTSD related sleep disturbances. This would permit the most common sleep disturbances to be reduced and, since these correlated positively with the severity of PTSD symptoms, the treatment could/has the potential to alleviate the day time PTSD symptoms.

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