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Subjective and objective sleep disturbances following trauma-focused treatment

Salomé Porten [a], Franziska Friedmann[b], Nikola Schoofs[a], Charlotte Barth[a], Kristina Meyer[c], Philip Santangelo[d,e], Ulrich Ebner-Priemer[d,f], Meike Müller-Engelmann[h,i], Regina Steil [h], Nikolaus Kleindienst[g], Frank Enning[g], Thomas Fydrich[b] and Kathlen Priebe[a,b]

[a]Department of Psychiatry and Neuroscience, Charité – Universitätsmedizin Berlin, corporate member of Freie Universität Berlin and Humboldt-Universität zu Berlin, Berlin, Germany; [b]Department of Psychology, Factulty of Life Sciences, Humboldt-University Berlin, Berlin, Germany; [c]Institute of Medical Psychology, Charité – Universitätsmedizin Berlin, corporate member of Freie Universität Berlin and Humboldt-Universität zu Berlin, Berlin, Germany; [d]Mental mHealth Lab, Institute of Sport and Sport Sciences, Karlsruhe Institute of Technology, Karlsruhe, Germany; [e]Department of Behavioural and Cognitive Sciences, Luxembourg University, Luxembourg, Luxembourg; [f]Department of Psychiatry and Psychotherapy, Central Institute of Mental Health, University of Heidelberg, Medical Faculty Mannheim, Mannheim, Germany; [g]Institute of Psychiatric and Psychosomatic Psychotherapy, Central Institute of Mental Health Mannheim, Medical Faculty Mannheim, Heidelberg University, Heidelberg, Germany; [h]Department of Clinical Psychology and Psychotherapy, Goethe University Frankfurt, Frankfurt am Main, Germany; [i]Department of Psychology, Faculty of Human Sciences, Medical School Hamburg, Hamburg, Germany

ABSTRACT

Background: Most individuals with posttraumatic stress disorder (PTSD) report sleep disturbances. Yet, results on the impact of trauma-focused therapy on subjective and objective sleep disturbances are inconsistent.

Objectives: This study conducted secondary analyses from a randomized controlled trial (RCT; German Clinical Trials Registration: DRKS00005578) to investigate changes in both subjective and objective sleep over the course of trauma-focused therapy and whether these changes differed for dialectical behaviour therapy for PTSD (DBT-PTSD) or cognitive processing therapy (CPT).

Methods: Women with PTSD related to childhood abuse were randomized to receive DBT-PTSD or CPT. Sleep was assessed in $n = 180$ women using the Pittsburgh Sleep Quality Index (PSQI), sleep diaries, and actigraphy at baseline, 6 and 12 months into treatment, with sleep monitoring for 1 week at each assessment.

Results: Subjective sleep disturbances improved significantly from pre- to post-treatment, reflected in better PSQI scores ($d = 0.76$), sleep quality ($d = 0.69$), and total sleep time ($d = 0.11$) in sleep diary entries with no differences between treatment groups. No significant changes were observed in actigraphy measures. In total, 76% of participants still met the clinical cut-off of 5 on the PSQI, indicating clinically significant subjective sleep disturbances.

Conclusions: PTSD treatments were linked to improvements in subjective sleep quality, but objective sleep measures remained unaffected. A high percentage of participants with persistent clinical sleep disturbances after treatment highlight the need for further research on the efficacy of PTSD treatments on sleep disturbances. To reduce the burden of sleep disturbances, sleep-specific treatment components may need to be added to trauma-focused treatments.

Trastornos subjetivos y objetivos del sueño tras el tratamiento centrado en el trauma

Antecedentes: La mayoría de las personas con trastorno de estrés postraumático (TEPT) reportan trastornos del sueño. Sin embargo, los resultados sobre el impacto de la terapia centrada en el trauma en los trastornos subjetivos y objetivos del sueño son inconsistentes.

Objetivos: Este estudio realizó análisis secundarios de un ensayo controlado aleatorizado (RCT por sus siglas en ingles); registro de ensayos clínicos alemanes: DRKS00005578) para investigar los cambios subjetivos y objetivos en el sueño a lo largo de una terapia centrada en el trauma y si estos cambios diferían para la terapia conductual dialéctica para el TEPT (DBT-PTSD por sus siglas en inglés) o la terapia de procesamiento cognitivo (CPT por sus siglas en inglés).

Métodos: Se asignó aleatoriamente a mujeres con TEPT relacionado con abuso infantil a recibir DBT-PTSD o CPT. Se evaluó el sueño en $n = 180$ mujeres mediante el Índice de Calidad del Sueño de Pittsburgh (PSQI por sus siglas en inglés), diarios de sueño y actigrafía al inicio, a los 6 meses y a los 12 meses de tratamiento, con monitorización del sueño durante una semana en cada evaluación.

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Posttraumatic stress disorder; borderline personality disorder; sleep disturbances; insomnia; actigraphy; trauma-focused therapy; CPT; DBT

PALABRAS CLAVE
Trastorno de estrés postraumático; trastorno límite de la personalidad; trastornos del sueño; insomnio; actigrafía; terapia centrada en el trauma; CPT; DBT

HIGHLIGHTS

- Trauma-focused therapies were associated with moderate subjective, but no objective improvements in sleep.
- Sleep changes did not differ between individuals undergoing 12 months of cognitive proccessing therapy versus dialectical behaviour therapy for PTSD.
- The majority of patients (76%) still displayed clinically significant subjective sleep disturbances after PTSD treatment, whereas objective measures did not detect disturbed sleep from the start.

CONTACT Salomé Porten salome-marie.porten@charite.de Department of Psychiatry and Neuroscience, CCM, Charité – Universitätsmedizin Berlin, corporate member of Freie Universität Berlin and Humboldt-Universität zu Berlin, Charitéplatz 1, 10117, Berlin, Germany

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Resultados: Las alteraciones subjetivas del sueño mejoraron significativamente entre el pretratamiento y el postratamiento, lo que se reflejó en mejores puntuaciones del PSQI (d = 0,76), la calidad del sueño (d = 0,69) y el tiempo total de sueño (d = 0,11) en los apuntes del diario de sueño, sin diferencias entre los grupos de tratamiento. No se observaron cambios significativos en las mediciones actigráficas. En total, el 76% de los participantes seguía cumpliendo el valor de corte clínico de 5 en el PSQI, lo que indica alteraciones subjetivas del sueño clínicamente significativas.
Conclusiones: Los tratamientos para el TEPT se asociaron con mejoras en la calidad subjetiva del sueño, pero las mediciones objetivas del sueño no se vieron afectadas. El alto porcentaje de participantes con trastornos clínicos del sueño persistentes después del tratamiento destaca la necesidad de más investigación sobre la eficacia de los tratamientos para el TEPT en los trastornos del sueño. Para reducir la carga de los trastornos del sueño, podría ser necesario añadir componentes terapéuticos específicos para el sueño a los tratamientos centrados en el trauma.

1. Introduction

Individuals affected by posttraumatic stress disorder (PTSD) frequently experience difficulties initiating or maintaining sleep (Weber & Wetter, 2021). Insomnia is a common issue, occurring in 70% – 90% of individuals with PTSD due to factors such as distressing dreams, sleep avoidance to prevent nightmares, and heightened autonomic arousal (Lancel et al., 2021; Weber & Wetter, 2021). Accordingly, sleep disturbances are listed as part of the diagnostic criteria for PTSD (APA, 2013), highlighting their role as a core feature of PTSD symptomatology. Sleep disturbances have consistently been linked to reduced psychosocial functioning (DeViva et al., 2005), long-term somatic health issues (Medic et al., 2017), lower quality of life (Ishak et al., 2012) and an increased risk for suicidal thoughts and behaviours in patients with PTSD (Cox et al., 2017). In addition, sleep disturbances are a risk factor for developing PTSD after trauma exposure and strongly linked to the maintenance of PTSD (Cox et al., 2017; DeViva et al., 2005).

The effectiveness of PTSD treatments in reducing sleep disturbances remains an area of ongoing research. Some studies have demonstrated positive effects of first-line treatments for PTSD on subjective sleep outcomes. Treatments such as cognitive processing therapy (CPT) (Galovski et al., 2009; Galovski et al., 2016; Gutner et al., 2013; Haynes et al., 2020; Mathersul et al., 2023; Pruiksma et al., 2016; Sullan et al., 2021; Woodward et al., 2017; Zalta et al., 2020), prolonged exposure therapy (Galovski et al., 2009; Gutner et al., 2013; Sexton et al., 2017), present-centered therapy (Pruiksma et al., 2016), and cognitive therapy or cognitive behavioural therapy (CBT) for PTSD (Belleville, 2010; Lommen et al., 2016; Woodward et al., 2017) have been associated with improvements in subjective sleep. However, effect sizes were often small and the majority of patients continued to meet the criteria for clinically significant sleep disturbances (Belleville, 2010; Gutner et al., 2013; Haynes et al., 2020; Pruiksma et al., 2016; Zalta et al., 2020).

Self-report measures are essential tools in sleep research and clinical practice (Riemann et al., 2023), as they closely reflect the individual´s perceived suffering and are correlated with quality of life (Lee et al., 2021). Despite their importance, subjective assessments are susceptible to biases such as social desirability and recall bias (Mathersul et al., 2023). Discrepancies between subjective and objective sleep assessments are common. Individuals with mental disorders were found to report their sleep disturbances as more severe than what is objectively measured, a phenomenon known as *sleep state misperception* (Arditte Hall et al., 2023). Therefore, while subjective measures are crucial for capturing the experienced burden, complementing them with objective measurement instruments, such as actigraphy or polysomnography allows for a more comprehensive understanding of the complexity of sleep disturbances (Lehrer et al., 2022; Silva et al., 2007).

Studies objectively assessing sleep throughout trauma-focused treatment are scarce and results have been inconsistent. Studies on CPT found conflicting results: one study found small effects of treatment on all actigraphy measures (Haynes et al., 2020), two others did not find any effect on actigraphy data (Arditte Hall et al., 2021; Mathersul et al., 2023). Similarly, for CBT for insomnia (CBT-I), a significant effect on sleep was only observed in total sleep time (TST) measured by polysomnography. However, TST measured by actigraphy, as well as wake after sleep onset (WASO) and sleep maintenance measured through both polysomnography and actigraphy, showed no improvement throughout treatment (Talbot et al., 2014). The limited number of studies, coupled with the inconsistencies in the results, underscores the need for further research using objective sleep measures.

Most studies evaluating the effectiveness of PTSD treatments did not include sleep as a secondary outcome in the first place. Efficacy studies that do address sleep have some limitations. The majority have been relatively short in treatment duration, typically consisting of 12 therapy sessions, with the longest of the above mentioned studies extending to 19 sessions

(Belleville, 2010). Investigating the impact of longer treatments on sleep disturbances is valuable, not only because sleep issues often persist after standard-length treatments, but also because more extended treatments resemble real-world clinical practice in some countries (Flückiger et al., 2020). Additionally, to our knowledge all but two studies (Lommen et al., 2016; Woodward et al., 2017) were conducted in the United States with a primary focus on veterans (Haynes et al., 2020; Mathersul et al., 2023; Pruiksma et al., 2016; Sexton et al., 2017; Sullan et al., 2021; Zalta et al., 2020), which may restrict the generalizability of findings to other populations. Given recent evidence on mixed trauma populations, individuals having experienced sexual trauma as well as childhood abuse may be particularly affected by sleep disturbances (Cox et al., 2017; Kajeepeta et al., 2015), sleep research in this population should be expanded. Hence, there is need for research on sleep disturbances in PTSD among more diverse patient groups (Lancel et al., 2021). In summary, the infrequent use of objective sleep assessments to complement subjective sleep assessments, the scarcity of research on extended treatment durations, and the predominance of U.S. samples highlight the need for further advancement in sleep research within PTSD treatments.

To address these gaps, the current study conducts a secondary analysis of a RCT that demonstrated superior efficacy of dialectical behaviour therapy for PTSD (DBT-PTSD) over CPT in women with PTSD related to histories of childhood abuse (Bohus et al., 2020). In a cross-sectional subsample of our study, patients with PTSD reported more subjective sleep disturbances compared to healthy controls but actigraphy only measured an objective difference in sleep interruptions, not in sleep duration (Friedmann et al., 2021). By examining both subjective and objective sleep measures over 12 months of outpatient treatment, this study aims to contribute to the existing literature currently indicating mixed findings on objective and subjective sleep disturbances in PTSD. Furthermore, we explore whether the sleep outcomes differ in two trauma-focused therapy groups (CPT vs. DBT-PTSD). Although DBT-PTSD demonstrated superior effects on overall PTSD outcomes (Bohus et al., 2020), the analysis remains exploratory, as neither treatment includes a dedicated sleep module.

2. Materials and methods

2.1. Participants and procedures

Data were drawn from a multicenter RCT primary investigating the effect of CPT and DBT-PTSD on PTSD symptoms in women with PTSD who experienced childhood abuse (RELEASE, German Clinical Trials Registration: DRKS00005578). Results indicated that PTSD symptoms decreased in both intervention groups, with DBT-PTSD showing superior efficacy compared to CPT (Bohus et al., 2020). Of the 193 participants in the primary RCT, a subset of 180 women aged 18–62 took part in the sleep assessments for the present study. Participants were recruited at three assessment sites in Germany: Mannheim, Frankfurt, and Berlin.

To be eligible, female participants in both gender and sex identity needed to meet the criteria for a PTSD diagnosis related to abuse-related trauma under the age of 18 and present with emotion regulation difficulties, operationalized as at least three DSM-5 criteria of borderline personality disorder, one of which needed to be affective instability. Exclusion criteria were a lifetime diagnosis of schizophrenia, bipolar I disorder, intellectual disability, severe psychopathology requiring immediate treatment in another setting (e.g. BMI <16.5), current substance dependence, life-threatening suicide attempts within the last two months, medical conditions that contraindicated the use of exposure therapy (e.g. pregnancy), highly unstable living conditions (e.g. homelessness), or previous participation in DBT-PTSD or CPT within the last year (Bohus et al., 2020). The study was approved by the ethics committees of the three participating institutions: the Medical Faculty Mannheim at Heidelberg University, Goethe-University Frankfurt, and Humboldt University Berlin. All participants gave informed consent prior to the study.

In the present study, sleep was assessed alongside other measures, including PTSD severity, at three time points: month 0 (before therapy), month 6, month 12. At each time point, sleep was measured over six consecutive nights using both subjective (sleep diary) and objective (actigraphy) methods. On the final day of each assessment period, participants completed the Pittsburgh Sleep Quality Index (PSQI) for the past week.

2.2. Measures

2.2.1. Psychopathology measures

2.2.1.1. Clinician-Administered PTSD Scale for DSM-5 (CAPS-5). PTSD symptom severity was evaluated using the German version of the CAPS-5 (Müller-Engelmann et al., 2020; Weathers et al., 2018). The CAPS-5 is a structured clinical interview that assesses 20 PTSD symptoms on a 5-point Likert scale, ranging from 0 (no impairment) to 4 (severe impairment). In the RCT sample, the CAPS-5 demonstrated acceptable internal consistency, with a Cronbach's alpha of .65 and high Interrater reliability, with intraclass correlation coefficients ranging from 0.81 to 0.89 (Bohus et al., 2020).

2.2.1.2. Beck´s Depression Inventory (BDI-II). Depressive symptom severity was assessed at baseline

using the German version of the BDI-II (Hautzinger et al., 2006). The BDI-II is a 21-item self-report inventory assessing the severity of depression on a four-point scale. The German form reached high internal consistency (α≥0,84) (Kühner et al., 2007).

2.2.1.3. Structural Clinical Interview for DSM (SCID-IV). The SCID-IV for Axis I is a semi-structured interview that was used to assess whether participants met criteria for any co-occurring Axis I DSM-IV disorder at baseline (First et al., 1997).

2.2.2. Subjective sleep

2.2.2.1. Sleep diary. Daily sleep assessments were taken at month 0, 6, and 12 for six consecutive days in form of an e-diary using the movisensXS application (movisens GmbH, Karlsruhe, Germany). For this purpose, every participant received a smartphone (Samsung Galaxy S3 mini) which prompted participants at 9 AM every morning to report their TST ('How long was your total sleep time (in hours)?') and rate their sleep quality ('How was your sleep last night?' on a scale from 1 = very bad to 4 = very good).

2.2.2.2. Pittsburgh Sleep Quality Index (PSQI). The PSQI (Buysse et al., 1989) was administered on the final day of diary assessments at each of the three measurement points, assessing participants' sleep over the previous week. The PSQI was adapted in this study to assess sleep over one week. The 19-item questionnaire is divided into seven components: sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbances, use of sleep medication, and daytime functioning. The global score ranges from 0 to 21, with scores above 5 indicating clinically significant sleep disturbances. The PSQI with sleep assessments over the past four weeks has demonstrated good internal consistency, with Cronbach's alpha ranging from 0.70 to 0.83, and test-retest reliability between $r = 0.81$ and $r = 0.86$ across various populations (Mollayeva et al., 2016).

2.2.3. Objective sleep

2.2.3.1. Actigraphy. An activity sensor (move 2, movisens GmbH, Karlsruhe, Germany) was worn for 6 consecutive days and nights for each measurement time point to assess sleep based on movement parameters. The three-axis accelerometer device recorded raw acceleration data at 64 Hz with a measurement range of ±8 g. Participants were instructed to wear the sensor on their nondominant wrist and only remove it for showering.

Actigraphy data were processed using the *DataAnalyzer* software (Version 1.18.3, movisens GmbH, Karlsruhe, Germany), which employs an algorithm that has demonstrated high accuracy: a median sensitivity of 0.92 and specificity of 1.00 for detecting non-wear periods; a median sensitivity of 0.90 and specificity of 0.94 for identifying sleep; and a median sensitivity of 0.93 and specificity of 0.90 for detecting wakefulness (Barouni et al., 2020). For more information on the algorithm, see Barouni et al. (2020).

Subsequent data processing was conducted using Python's NumPy package (Harris et al., 2020). To calculate TST, WASO, sleep efficiency, sleep fragmentation index, and non-wear time, the sleep period (SLP) was identified and assessed first. For each night, sleep onset was defined as the starting time of the first continuous block of at least 20 minutes of sleep with no more than 1 min of interruption occurring after 8 pm. Sleep offset was defined as the start of the last 20 minutes of uninterrupted wakefulness in the morning before 12 pm (noon the following day) (Fekedulegn et al., 2020). SLP was determined as the time between sleep onset and sleep offset.

TST referred to the total hours of sleep occurring within the SLP. WASO was defined as the total number of minutes awake during the SLP. Sleep efficiency indicated the percentage of time spent asleep during the SLP, obtained by dividing the TST by the SLP and multiplying by 100. Finally, the sleep fragmentation index was defined as the ratio of the number of awakenings to the SLP (Fekedulegn et al., 2020).

2.3. Treatments

Detailed descriptions of the interventions can be found elsewhere (Bohus et al., 2020). DBT-PTSD is a multicomponent treatment programme incorporating components of standard DBT (Linehan, 2014), trauma-focused CBT components such as exposure (Ehlers et al., 2005), acceptance and commitment therapy (Hayes et al., 2011) and compassion-focused therapy (Gilbert, 2010). CPT (Resick, 2016) is a trauma-focused treatment addressing dysfunctional cognitions and emotions related to traumatic experiences. Both interventions were delivered in an outpatient setting by trained psychotherapists. Therapy adherence was independently rated based on videotapes. Participants attended up to 45 weekly sessions over 12 months, followed by 3 monthly booster sessions.

2.4. Data analysis

Analyses were performed using IBM SPSS Statistics, Version 29.0.1.0, and visualizations were generated in python with the seaborn package (Waskom, 2021). Actigraphy and sleep diary data were averaged across the recorded days to calculate the mean values of the respective sleep measures for each time point (month 0, 6, 12). Independent t-tests were conducted to assess baseline differences in sleep quality and psychopathology measures between the two treatment

groups. For each sleep measure, only participants with data from at least one time point were included in the corresponding analysis. Linear mixed models were used for each sleep measure, as they are well-suited for longitudinal data and can handle missing values without resorting to case-wise deletion.

To evaluate sleep changes over time, each sleep measure was treated as the dependent variable, with time (month 0, 6, 12) entered as a fixed effect. A random intercept was included to account for individual differences at baseline. A first-order autoregressive structure with homogenous variances was chosen to take into account the dependencies between neighbouring measurements. Parameter estimates were obtained using restricted maximum likelihood estimation.

To determine whether the effect of time varied between the two treatment groups (CPT vs. DBT-PTSD), group and its interaction with time were included as fixed effects. Separate models were fitted for each subjective sleep measure: PSQI score, sleep diary assessments (sleep quality, TST) and actigraphy measures (sleep efficiency, WASO, TST and fragmentation index).

To quantify the effect size, Cohen's *d* was calculated by dividing the estimated fixed effect of timepoint (Mean Difference month 0 and month 12) by the standard deviation, which was derived as the square root of the sum of the variance components, including the residual variance and the random intercept variance.

2.5. Missing data

The amount of missing data varied throughout measurement instruments. Specifically, 26.8% of the data points were missing for the PSQI, 26.0% for the sleep diary, and 37% for actigraphy. Reasons for missing data included treatment dropout and technical issues with actigraphy. Detailed missing value patterns are displayed in the supplementary material.

3. Results

3.1. Descriptive statistics

Sleep was assessed in 180 women, each of whom completed at least one sleep measure at one or more time points. The participants had a mean age of 35.9 years ($SD = 10.9$), with an age range of 18–62 years. The reported onset of abuse occurred at a mean age of 7.8 years ($SD = 4.2$), while the average end of abuse was at 14.5 years ($SD = 4.8$). In 94% of the cases (n = 169), the perpetrator was a relative. Most women in the sample ($n = 133$; 74%) were single (including divorced, separated, or widowed). Baseline scores for sleep quality and psychopathology in the CPT and DBT-PTSD treatment group are summarized in Table 1.

Table 1. Sleep and psychopathology measures at baseline.

	CPT		DBT-PTSD		
	n	*M (SD)*	*n*	*M (SD)*	*p*
Sleep measures[a]					
Subjective sleep					
PSQI global score	75	11.97 (3.88)	84	11.95 (3.73)	.63
Sleep quality (sleep diary)	86	2.25 (0.55)	90	2.26 (0.53)	.97
TST (hrs; sleep diary)	86	5.82 (1.40)	90	5.69 (1.52)	.94
Objective sleep					
Sleep efficiency (%)	63	82.17 (11.79)	66	81.67 (12.67)	.81
WASO (min)	63	101.67 (68.89)	66	99.81 (79.94)	.78
TST (hrs)	63	7.50 (2.14)	66	6.87 (1.49)	.11
Fragmentation index	63	1.08 (0.51)	66	1.12 (0.52)	.81
Non-wear time outside SLP (min)	63	38.71 (36.51)	66	42.01 (35.54)	.88
Psychopathology measures[b]					
CAPS total score	80	41.36 (9.15)	89	40.09 (10.68)	.09
BDI	80	33.09 (10.82)	89	33.31 (10.86)	.73
Number of SCID-1 diagnoses (current)	80	3.44 (1.52)	89	3.04 (1.34)	.14

Note. CPT = cognitive processing therapy; DBT-PTSD = dialectical behaviour therapy for posttraumatic stress disorder; PSQI = Pittsburgh sleep quality index; WASO = wake after sleep onset; TST = true sleep time; SLP = sleep period; CAPS = clinical administered PTSD scale for DSM-5; BDI = becks depression inventory; BPD = borderline personality disorder; SCID-IV = structured clinical interview. [a] Participants with a baseline measure of the corresponding instrument are displayed in the table. [b] Participants included in the linear mixed model assessing the PSQI are displayed in the table.

3.2. Sleep over the course of treatment across groups

Before therapy (month 0), 97% of patients scored above 5 on the PSQI, indicating clinically significant sleep disturbances, which decreased to 89% at month 6 and 76% at month 12. The estimates from the linear mixed models are presented in Table 2. A significant improvement in subjective sleep quality, as measured by the PSQI, was observed from pre to post treatment with a medium effect size ($d = 0.76$). Similarly, sleep quality ($d = 0.69$) and TST ($d = 0.11$), reported in sleep diaries, showed significant improvements with medium and small effect sizes respectively. No significant effects of time were found for any actigraphy measures, namely sleep efficiency, WASO, TST, and fragmentation index (Table 2).

3.3. Change in sleep for treatment groups

The interaction of group and time did not reveal significant effects on any sleep measures (see Figure 1). Specifically, no significant interaction was found for the subjective sleep measures PSQI ($F = 0.24$, $df = 204.19$, $p = .79$), sleep quality ($F = 1.73$, $df = 217.12$, $p = .18$), TST ($F = 0.93$, $df = 137.33$, $p = .40$), and the actigraphy measures sleep efficiency ($F = 1.38$, $df = 127.99$,

Table 2. Results of linear mixed model of treatment on sleep across groups.

		Fixed effect time, estimates (*SE*)					Random effects	
Sleep measure	*n*	Month 0	Month 6	Month 12	*p*	*d*	Intercept	SE
Subjective sleep								
PSQI	169	11.92 (0.40)	10.29 (0.40)	8.84 (0.38)	<.001	0.76	6.72	1.85
Sleep quality	178	2.26 (0.06)	2.42 (0.06)	2.66 (0.05)	<.001	0.69	0.16	0.03
TST (hrs)	178	6.08 (0.11)	5.99 (0.45)	6.49 (0.30)	<.001	0.11	7.55	0.87
Objective sleep (actigraphy)								
Sleep efficiency	154	81.22% (1.43)	81.47% (1.29)	82.66% (1.39)	.32	0.17	74.66	36.80
WASO	154	103.98 (9.07)	101.56 (8.43)	91.34 (8.42)	.17	0.11	2212.06	1036.95
TST (hrs)	154	7.13 (0.22)	6.83 (0.22)	6.82 (0.21)	.17	0.21	1.50	0.42
Fragmentation index	154	1.14 (0.05)	1.20 (0.05)	1.16 (0.06)	.81	0.17	0.24	0.03

Note. PSQI = Pittsburgh sleep quality index; WASO = Wake after sleep onset; TST = Total sleep time.

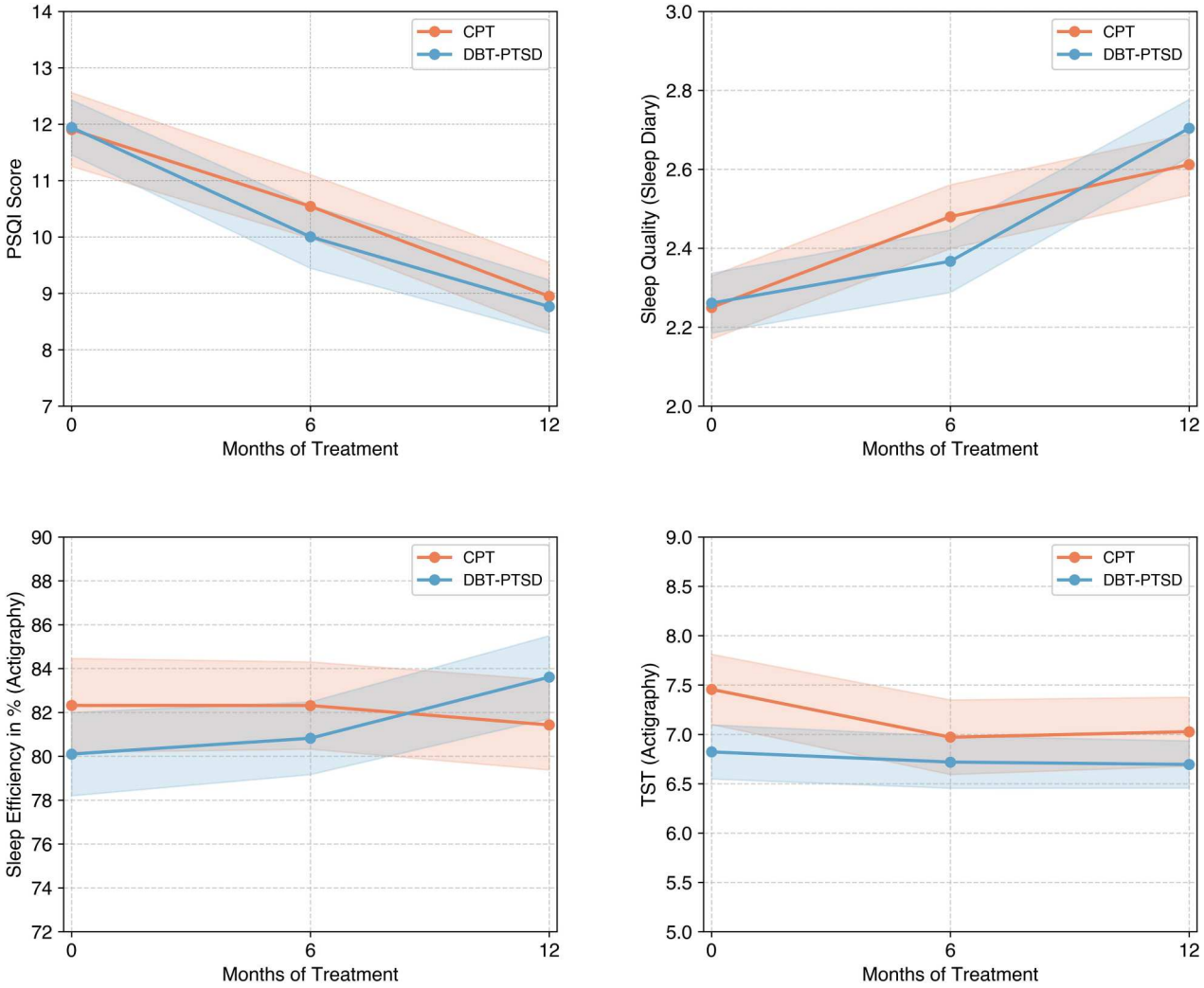

Figure 1. Changes in sleep at month 0, 6 and 12 in treatment groups.

Note. Fixed effect estimates (solid line) and standard error (shaded area). CPT = cognitive processing therapy; DBT-PTSD = dialectical behaviour therapy for posttraumatic stress disorder; PSQI = Pittsburgh sleep quality index; TST = total sleep time.

$p = .29$), WASO ($F = 1.27$, $df = 139.95$, $p = .28$), TST ($F = 0.54$, $df = 150.17$, $p = .59$), or sleep fragmentation ($F = 0.79$, $df = 122.51$, $p = .46$).

4. Discussion

The main objective of this study was to explore the change in objective and subjective sleep following two trauma-focused psychotherapies (CPT and DBT-PTSD). Our results showed that after 12 months of treatment, patients with PTSD significantly improved in all subjective sleep measures: the PSQI, sleep quality and TST measured in sleep diaries. Despite these gains, a large portion of participants (76%) continued to experience clinically significant sleep disturbances after treatment as indicated by PSQI scores above the clinical cut-off of 5. No changes in any objective sleep parameters were measured by actigraphy. Additionally, no significant differences in any sleep measure were found between the CPT and DBT-PTSD treatment groups.

Consistent with previous research on trauma-focused interventions (e.g. Haynes et al., 2020; Mathersul et al., 2023; Pruiksma et al., 2016), patients reported some improvements in subjective sleep (d = 0.76). The vast majority (76%) of participants however, continued to experience clinically significant sleep disturbances (PSQI > 5). For comparison, the mean PSQI score of women in a community sample was 4.21 (Hinz et al., 2017), which is substantially lower than the mean post-treatment score of 8.84 observed in our sample. Thus, a higher number of trauma-focused sessions and longer overall duration of treatment as applied in our study does not seem to have a benefit over shorter treatments applied in previous studies in sleep improvements. Only 21% of participants showed remission of clinically significant sleep disturbances, in contrast to the 49.7% of the total intention to treat sample who achieved PTSD symptom remission (Bohus et al., 2020). Although direct comparisons should be made cautiously, given that sleep disturbances are generally more prevalent in the general population than PTSD (Hinz et al., 2017), the markedly lower rate of sleep improvement may oppose the classical model of PTSD suggesting insomnia as a symptom of PTSD. Instead, it supports the idea that sleep disturbances may represent a distinct condition requiring targeted insomnia treatment, rather than being fully recovered through PTSD specific therapy alone (Weber & Wetter, 2021). According to Spielman's 3P model of insomnia, the factors that perpetuate insomnia (e.g. excessive time spent in bed), are distinct from the precipitating factors (e.g. trauma exposure) and are not directly addressed in treatments like CPT or DBT-PTSD (Perlis et al., 2010).

CBT-insomnia (CBT-I), a six to eight sessions multi-component treatment based on the 3P model, produced effective results in treating insomnia (Rossman, 2019). As an add-on with first line trauma-focused interventions, CBT-I may be a promising treatment approach. A recent network meta-analysis (Huang et al., 2024) examining RCTs of psychotherapeutic interventions on PTSD and sleep found that CBT-I combined with Imagery Rehearsal Therapy (IRT) was the most effective in reducing PTSD symptom severity, while CBT-I alone was the most effective for improving sleep. However, they did not include standalone first-line PTSD treatments such as CPT or prolonged exposure, making it difficult to compare the effectiveness of adjusted sleep interventions against standard PTSD treatments, especially when it comes to improvements in PTSD symptoms. Some research also showed promising findings in using physical exercise to improve sleep (Pieper et al., 2024). Further research is needed to investigate the non-inferiority of new approaches such as sleep-specific or exercise interventions compared to first-line PTSD treatments, in terms of both sleep and PTSD outcomes.

In line with previous research (Arditte Hall et al., 2021; Mathersul et al., 2023), we did not observe any significant changes in objective sleep. This may be due to a ceiling effect: at baseline, sleep efficiency was on average at 82%, exceeding the 80% threshold for healthy sleep (Berger et al., 2005), which limits room for further improvement during the intervention. For comparison, similarly aged individuals without psychiatric diagnoses typically show sleep efficiencies ranging from 74% to 87% (Evans et al., 2021). The same holds true for total sleep time, with a baseline average of 7 hours, falling within a healthy range. This aligns with previous actigraphy research, including a meta-analysis that reported a weighted mean sleep efficiency of 79.9% in individuals with PTSD, which did not significantly differ from healthy controls (Lewis et al., 2020). These results raise concerns about whether actigraphy effectively captures the sleep-related burden experienced by individuals with PTSD. The distress may stem less from insomnia itself and more from their subjective perceptions and fear of sleep (Weber & Wetter, 2021). Alternatively, as actigraphy relies on acceleration, it may not be suitable for capturing nightmares, which are a significant aspect of sleep-related burden in PTSD. A recent study conducted in healthy individuals found that neither subjective nor objective sleep measures predicted nightmares on the same night. Similarly, nightmare occurrence did not predict objective sleep (Balch et al., 2024). This suggests that nightmares may contribute to the perception of sleep disturbances in a way that objective sleep measures fail to capture. Further research is needed to better understand the factors underlying the mismatch between objective and subjective sleep measures.

A key strength of the current study is the multi-method approach used to assess sleep over an extended period, combining both subjective (sleep diaries and PSQI) and objective (actigraphy) measures. Additionally, the study benefited from a well-diagnosed sample of participants and a relatively large sample size, enhancing the reliability of findings.

4.1. Limitations and future directions

Our study was not conducted without limitations. Due to the lack of an inactive control group, we cannot make any causal inference on the effects of the interventions on sleep. Additionally, we encountered a relatively high amount of missing data, particularly in the actigraphy measures. Furthermore, large random effects were observed in our sample, which may be caused by missing data or substantial individual differences, which may have prevented the detection of overall changes in objective sleep. Another limitation was the lack of

evening diary entries (e.g. exact bedtime) or event makers (e.g. 'lights out'), which prevented cross-verification of actigraphy-derived sleep onset and offset times with self-reports and limited accurate assessment of sleep onset latency, which may have introduced systematic biases. Lastly, we only included women in this sample, which may impede generalization of our findings to men with PTSD.

Considering sleep disturbances were consistently found to contribute to the persistence of PTSD, it is essential to further investigate their role and treatment options. Future methodological and conceptual research should examine the distinct aspects that contribute to the divergence of objective sleep measures and subjective sleep perceptions. Additionally, potential differences in sleep disturbances generally and after treatment between complex PTSD, borderline personality disorder, and PTSD alone have yet to be explored. There is a growing trend in research to enhance standard PTSD treatments with sleep-specific interventions. These approaches should be evaluated against gold-standard treatments for their effectiveness in addressing both PTSD and sleep. In this context, if sleep-specific components are implemented, it is important to explore whether the timing of targeting sleep during the treatment trajectory influences outcomes.

4.2. Conclusion

In conclusion, this study found that while trauma-focused therapies were associated with improvements in subjective sleep quality, many participants continued to report significant sleep disturbances, and no changes were observed in objective sleep measures. The discrepancy between subjective and objective sleep outcomes underscores the need for further research into the measurements and perceptions of sleep in PTSD.

Author contributions

KP, FF, PS, and U-EP were involved in the conception and design of the study. KP, FF, PS and MM-E were responsible for data collection, and FE and TF supported data collection. SP preprocessed the data, ran analyses, interpreted results, drafted, and finalized this paper. CB, KM, and NK contributed to the analyses. KP and NS contributed to the interpretation of the data and drafting the paper. FF, NS, CB, KM, PS, U-EP, MM-E, RS, NK, and KP revised and edited this paper.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Data availability statement

The data that support the findings of this study are available from the corresponding author, SP, upon reasonable request.

ORCID

Salomé Porten http://orcid.org/0009-0007-8210-8806
Regina Steil http://orcid.org/0000-0002-5367-5664

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