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CLINICAL RESEARCH ARTICLE

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The relationship between sleep disturbances and post-traumatic stress disorder symptomatology in university students

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ABSTRACT

Background: A complex bidirectional relationship exists between sleep and post-traumatic stress disorder (PTSD). Previous research reporting a strong association between sleep and PTSD has largely examined older military veteran populations, with military-related confounders potentially magnifying this effect. Less is known whether this association remains strong in younger civilian adults.

Objective: This study examined the relationship between sleep disturbances, PTSD symptoms and PTSD symptom clusters in a young adult population with mixed trauma histories, while investigating the role of sex, chronotype and trauma chronicity in moderating this relationship.

Method: In this cross-sectional study, 337 trauma-exposed undergraduate students (269 females, 68 males) aged 17–66 ($M = 20.24$, $SD = 5.20$) completed a battery of online questionnaires measuring trauma history, PTSD symptom severity, sleep disturbances, chronotype, mood state and alcohol use.

Results: Trauma-exposed participants with and without probable PTSD demonstrated a significant positive relationship between sleep disturbances and PTSD symptom severity, $F(3, 333) = 58.24$, $p < .001$, $R^2 = .34$, although this relationship was not significantly moderated by any of the hypothesised factors. Additionally, sleep quality was significantly and positively associated with all four PTSD symptom clusters (re-experiencing, hyperarousal, avoidance, and negative mood).

Conclusions: The sleep–PTSD relationship in a mixed-trauma, young adult population is consistent with what has been found in military veteran populations. The strong association between sleep and PTSD highlight the potential for targeted sleep interventions to also benefit young adults with PTSD and may reduce PTSD risk in those who have recently experienced a traumatic event.

Relación entre alteraciones del sueño y sintomatología de trastorno de estrés postraumático en estudiantes universitarios

Antecedentes: Existe una relación compleja y bidireccional entre el sueño y el Trastorno de Estrés Postraumático (TEPT). Investigaciones anteriores que reportan una fuerte asociación entre el sueño y el TEPT, han evaluado en gran medida a militares veteranos de mayor edad, con factores relacionados al ejército, los que pueden ser potencialmente confundentes al magnificar este efecto. Se sabe menos si esta asociación sigue siendo fuerte en adultos civiles más jóvenes.

Objetivo: Este estudio examinó la relación entre los trastornos del sueño, los síntomas de TEPT y los grupos de síntomas de TEPT, en una población de adultos jóvenes con antecedentes de trauma mixto mientras se investigaba el papel del sexo, el cronotipo y la cronicidad del trauma, en la moderación de esta relación.

Metodología: En este estudio transversal, 337 estudiantes universitarios expuestos a trauma (269 mujeres, 68 hombres) de entre 17 y 66 años ($M = 20{,}24$, $DE = 5{,}20$) completaron una batería de cuestionarios en línea que medían la historia de trauma, la severidad de los síntomas del TEPT, las alteraciones del sueño, el cronotipo, el estado de ánimo y el consumo de alcohol.

Resultados: Los participantes expuestos a trauma, con y sin probable TEPT, demostraron una relación positiva significativa entre las alteraciones del sueño y la gravedad de los síntomas de TEPT, $F(3,333) = 58.24$, $p < .001$, $R^2 = 0.34$, aunque esta relación no fue moderada significativamente por ninguno de los factores hipotetizados. Además, la calidad del sueño se asoció de manera significativa y positiva con los cuatro grupos de síntomas de TEPT (reexperimentación, estado hiperalerta, evitación y estado de ánimo negativo).

Conclusiones: La relación sueño-TEPT en una población de adultos jóvenes con trauma mixto es consistente con lo que se ha encontrado en poblaciones de veteranos militares. La fuerte asociación entre el sueño y el trastorno de estrés postraumático resalta la posibilidad de que las intervenciones específicas en el sueño también beneficien a los adultos jóvenes con trastorno de estrés postraumático y que puedan reducir el riesgo de trastorno de estrés postraumático en aquellos que han experimentado recientemente un evento traumático.

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Young adults; mixed-trauma; sleep quality; PTSD symptom cluster; insomnia; chronotype; trauma chronicity

PALABRAS CLAVE
Adultos jóvenes; trauma mixto; calidad del sueño; grupo de síntomas de TEPT; insomnio; cronotipo; cronicidad del trauma

HIGHLIGHTS

- Sleep disturbances including worse sleep quality, increased insomnia symptom severity and excessive daytime sleepiness are associated with increased PTSD symptom severity in young, trauma-exposed undergraduate students with and without probable PTSD.
- Despite previously reported significance, sex, chronotype (morningness and eveningness) and trauma chronicity (time since trauma) do not moderate the sleep–PTSD relationship here.
- Re-experiencing, avoidance, hyperarousal and negative mood PTSD symptom clusters are individually associated with lower sleep quality.

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1. Background

Post-traumatic stress disorder (PTSD) is a debilitating neuropsychiatric disorder underpinned by four core symptom clusters: re-experiencing of the trauma through recurring memories, avoidance of trauma reminders, physiological hyperarousal and negative alterations in cognitions and mood (American Psychological Association, 2013). Sleep disturbances are a hallmark symptom of PTSD (Germain, 2013), with recurring nightmares (re-experiencing symptom) and insomnia (i.e. difficulty falling and/or staying asleep; hyperarousal symptoms) among criteria for diagnosis (APA, 2013). PTSD symptoms are strongly and bidirectionally associated with poor sleep (Slavish et al., 2022; Zhang et al., 2019). Disturbed sleep both preceding and following trauma exposure is predictive of PTSD symptoms and development (Chinoy et al., 2022; Fan et al., 2017; Koffel et al., 2013; van Liempt et al., 2013; Wang et al., 2019). On the other hand, PTSD symptoms are linked to an increased risk for comorbid sleep disruptions (Chinoy et al., 2022; Cornelius et al., 2024). These findings suggest that sleep is an aetiological factor underlying the development of PTSD (Germain, 2013) and a maintaining factor once PTSD is established (Pace-Schott et al., 2015; Saguin et al., 2021).

Although PTSD can arise at any life stage in any population, the research literature investigating its relationship with sleep is dominated by primarily male US military veteran samples above 30 years of age (Sareen, 2014). To illustrate, 13 out of 20 studies describing sleep in PTSD investigated combat trauma in a meta-analysis (Kobayashi et al., 2007). The majority of participants in combat trauma studies were male, while non-combat trauma studies featured predominantly female participants (Kobayashi et al., 2007). Another meta-analysis reported that studies investigating sleep in PTSD including combat veterans assessed participants largely aged between 30 and 70, while non-combat studies examined participants aged between 22 and 48 (Zhang et al., 2019). Many characteristics of military populations, such as combat-exposure, rotating and irregular work schedules, environmental disruptors (e.g. noise), and health-related issues (e.g. alcohol or drug use) impact on sleep and may be catalysts behind the strong sleep–PTSD relationship (Good et al., 2020; Mantua et al., 2019; Osgood et al., 2019). Therefore, it is unclear whether the magnitude of the association between sleep and PTSD remains that large in young, civilian populations. Preliminary evidence suggests a similar relationship, however, only limited research exists investigating these associations within young adults who have not experienced a military-related trauma. For example, Wang et al. (2022) found that college students with disturbed sleep were more likely to have PTSD but did not assess the strength of this association. Similarly, weak to moderately strong associations have been found between sleep quality and PTSD symptoms, but these studies either did not capture the full extent of PTSD symptomatology (Lind et al., 2017; Pickett et al., 2016) or studied a predominantly non-clinical sample with low PTSD symptom severity (Lehinger et al., 2023). Therefore, the overarching aim of this study is to further investigate the relationship between sleep and PTSD symptomatology, specifically assessing whether this relationship remains strong in a young, non-veteran population in the absence of military-related confounders, while accounting for potentially important trauma-specific and individual factors.

1.1. Trauma-specific factors

Trauma chronicity (the time since exposure to a traumatic event) may alter sleep quality in individuals with PTSD. Two studies observed that more recent traumas were associated with increased night-time awakenings and nightmares, compared to when more time had passed since the traumatic event (Hefez et al., 1987; Lee et al., 2015; Rosen et al., 1991). Individuals that were assessed years after trauma exposure demonstrated these characteristics less severely. Similarly, more recent studies measuring sleep objectively observed a significant effect of time following PTSD diagnosis on sleep disruption with objective sleep disruptions reducing over time (Hurwitz et al., 1998; Klein et al., 2003; Mellman et al., 2002, 2014). However, self-reported sleep difficulties may persist, even years after experiencing the traumatic event (Klein et al., 2003). Nonetheless, most studies only investigated the sleep–PTSD relationship involving similar chronicity of trauma and when military personnel were studied, only tracked short periods of time following deployment (Kobayashi et al., 2007). Therefore, less is known about the effect of the various trauma chronicities found in young civilian adult populations and their effect on the sleep–PTSD association.

1.2. Individual factors

Emerging evidence suggests that men and women with PTSD exhibit different patterns of sleep disturbances (Kobayashi et al., 2012). Particularly women with PTSD presented with more disrupted sleep including longer wake after sleep onset compared to men (Zhang et al., 2019). Sex-specific differences have also been found in a meta-analysis investigating sleep-effects in fear conditioning paradigms, the experimental model examining the underlying mechanisms of PTSD (Schenker et al., 2021). Sex moderated the

association between sleep and the return of fear following extinction, where increases in certain sleep stages were protective in males (i.e. associated with lower fear response) but predicted higher fear responses in women. More recently, similar sex-specificity has been found in those with PTSD (Ney et al., 2022; Richards et al., 2022; Schenker et al., 2022). Although only a few studies have compared sex-specific patterns of sleep disturbances in PTSD participants, PTSD studies rarely report an even sex distribution among participants (Kobayashi et al., 2012; Schenker et al., 2023; Zhang et al., 2019), which hinders the possibility of further investigating sex-specific differences in the sleep–PTSD relationship.

Another factor that may affect the sleep–PTSD relationship is chronotype or the inherent preference of the body for sleep and wakefulness. However, the effect of participant chronotype on the sleep–PTSD relationship has been investigated in only two studies to date to our knowledge, and both in military populations (Harrison et al., 2021; Hasler et al., 2013). Self-reported eveningness was associated with greater lifetime sleep disturbance and higher symptom severity in combat veterans with various levels of post-traumatic stress symptoms (Hasler et al., 2013). Eveningness in U.S. sailors was also found to be associated with both PTSD symptoms and greater sleep disruption (Harrison et al., 2021). Studying the effects of chronotype on the sleep–PTSD relationship solely in military veterans poses an issue. Long-term sleep disruptions are extremely pervasive in these populations due to high proportions of shift work and the inability to maintain a consistent sleep schedule (Good et al., 2020). In young adults, evening-type has also been associated with both worse sleep quality and worse psychological well-being (Gulec et al., 2013; Romo-Nava et al., 2016; Walsh et al., 2022). Thus, effects of eveningness on the sleep–PTSD relationship should be investigated in young civilian adult cohorts.

Finally, sleep disturbances following trauma exposure may be more closely associated with symptom cluster severity than PTSD symptom severity overall. Prior research has reported that re-experiencing symptoms were related to issues with initiating and maintaining sleep (Babson et al., 2011), sleep continuity (Brownlow et al., 2022; Cox et al., 2018; Dietch et al., 2019), and sleep quality (Lee et al., 2015; Short et al., 2017), while hyperarousal symptoms were associated with lower sleep quality (Babson et al., 2011; van Wyk et al., 2016), sleep maintenance problems and nightmares (Babson et al., 2011). There is mixed or no support for sleep to be associated with avoidance or negative mood symptom clusters, respectively (e.g. Babson et al., 2011; Cox et al., 2018; Lee et al., 2015, but Dietch et al., 2019; Short et al., 2017). Prior research focused predominantly on older samples and military populations (Brownlow et al., 2022; Cox et al., 2018; Short et al., 2017) and research investigating the association between sleep disturbances and specific PTSD symptom clusters in young adults is limited. For example, Lee et al. (2015) found re-experiencing and hyperarousal symptoms, but not avoidance symptoms, to mediate the association between trauma exposure and sleep quality. Based on the previous research, it is therefore possible that re-experiencing and/or hyperarousal symptoms – the hallmarks of PTSD sleep problems – may be more strongly associated with sleep disturbances than avoidance and negative mood symptoms. Therefore, considering the effects of individual PTSD symptom clusters on sleep may result in a more comprehensive understanding of the sleep–PTSD relationship.

1.3. Aims and hypotheses

Based on the above, we aimed to investigate whether the magnitude and extent of the relationship between sleep disturbances and PTSD symptomatology remains large in a young, civilian population with a range of trauma exposures and symptoms, and without military-related confounders. Additionally, we explored individual and trauma-specific moderators of this relationship as well as PTSD symptom clusters. We hypothesised that: (1) a significant positive relationship will exist between sleep disturbances and PTSD symptom severity in young trauma-exposed individuals with a range of PTSD symptom severity; (2) this relationship will be significantly moderated by sex, chronotype and trauma chronicity; and (3) sleep disturbances will be associated with re-experiencing and hyperarousal symptom clusters, but not avoidance and negative mood clusters.

2. Method

2.1. Participants

720 undergraduate students were recruited via convenience sampling over a period of six months via the University of Melbourne (Australia). After excluding incomplete (i.e. missing sleep or PTSD data) and invalid data entries (see Figure 1), 634 participants remained and were grouped into trauma-naïve (N = 297), trauma-exposed without PTSD (N = 194) and probable PTSD (N = 143). The protocol was approved by The University of Melbourne Human Research Ethics Committee (#14544) and all participants gave informed consent.

2.2. Procedure

Data was collected between February and July 2021 and participants anonymously completed an online

survey. Trauma-exposed participants with and without probable PTSD were distinguished from trauma-naïve by scoring one or more on the Trauma Exposure Questionnaire (TEQ, see below; Vrana & Lauterbach, 1994) and individuals with probable PTSD were identified using the PTSD Checklist for DSM-5 (PCL-5, see below; Weathers et al., 2013).

2.3. Measures

2.3.1. Trauma variables

TEQ and PCL-5 were used to assess trauma exposure and PTSD symptomatology. The former lists a series of common criterion A trauma (APA, 2013) and participants respond whether they experienced it (*yes*) or not (*no*). The latter was used to measure PTSD symptom severity and total scores equal or greater than 33 indicated that a PTSD diagnosis was probable (Weathers et al., 2013). Cluster item scores were summed to obtain re-experiencing, avoidance, hyperarousal, and negative mood scores. PTSD symptomatology was assessed in trauma-naïve participants by completion of the PCL-5 considering their most stressful experience to date (Ney et al., 2021). Trauma chronicity was calculated using the years elapsed since participants' most recent trauma exposure on the TEQ.

2.3.2. Sleep variables

Sleep quality was assessed using the Pittsburgh Sleep Quality Index (PSQI; Buysse et al., 1989), while insomnia and daytime sleepiness were assessed using the Insomnia Severity Index (ISI; Bastien et al., 2001) and the Epworth Sleepiness Scale (ESS; Johns, 1991), respectively. A PSQI score >5 is considered as the cut-off score to differentiate between good and poor sleep quality (Buysse et al., 1989). Higher scores on the ISI and ESS are indicative of more severe insomnia and greater daytime sleepiness, respectively, with ISI $\geq$ 15 used as the clinical cut-off for insomnia (Morin et al., 2011). Chronotype was assessed using the Morningness–Eveningness questionnaire (MEQ; Horne & Östberg, 1976).

2.3.3. Demographic variables

Demographic measures included age and sex as well as depressive, anxiety and stress symptoms assessed on the 21-item Depression, Anxiety and Stress Scale (DASS-21; Lovibond & Lovibond, 1995) and alcohol used measured by the Alcohol Use Disorder Identification Test (AUDIT; Saunders et al., 1993). Summary scores on each DASS subscale can be interpreted on a continuum of severity (Lovibond & Lovibond, 1995). Finally, AUDIT total scores gave an indication for risk drinking behaviour (Saunders et al., 1993).

2.4. Data analysis

To test hypothesis 1, the relationship between sleep disturbances and PTSD symptomatology in trauma-exposed participants with and without probable PTSD was assessed using hierarchical multiple regression with sleep quality (PSQI), insomnia (ISI) and daytime sleepiness (ESS) as independent variables and PTSD symptom severity (total PCL-5 score) as the outcome. Hypothesis 2 was assessed in trauma-exposed individuals with three moderation analyses to investigate the possible effects of sex, chronotype and trauma chronicity on the sleep–PTSD relationship. Finally, the relationship between individual PTSD symptom clusters and sleep quality (hypothesis 3) utilised separate linear regressions with each cluster score as an independent variable and sleep quality as the outcome variable.

In prior studies, the type of control population used (trauma-exposed or trauma-naïve) significantly moderated the relationship with sleep quality when compared to PTSD (Zhang et al., 2019). Disturbed sleep is not solely associated with a PTSD diagnosis and is frequently observed in trauma survivors without PTSD (Milanak et al., 2019). Thus, including both trauma-exposed and trauma-naïve individuals as controls and assessing the relationship between sleep and PTSD symptoms dimensionally may enhance our comprehension of their interaction. Therefore, we conducted the same analyses as outlined above and included trauma-naïve individuals to assess the relationship between sleep and PTSD symptoms dimensionally across the full sample. The results are included in the appendix.

Effect sizes were calculated as Cohen's R^2 (Cohen, 1988) and Green's ΔR^2 (Green, 1991) and bootstrap was applied to all regression models with confidence intervals obtained from 10,000 resamples (Davison & Hinkley, 1997). Assumptions were checked prior to running tests and where assumptions were not met, values fell within bootstrapped limits. A flowchart of data processing and sample size for each hypothesis is reported in Figure 1. All statistical analyses were conducted in R version 4.3.1 (R Core Team, 2023).

3. Results

Means and standard deviations of study questionnaires are reported in Table 1. The total sample consisted of 491 females and 143 males, with the age ranging between 16 and 66 years of age. Both the full and trauma-exposed samples had a mean total PCL-5 score below the clinical cut-off of 33. Regardless of whether trauma-naïve individuals were included, reduced self-reported sleep quality was observed.

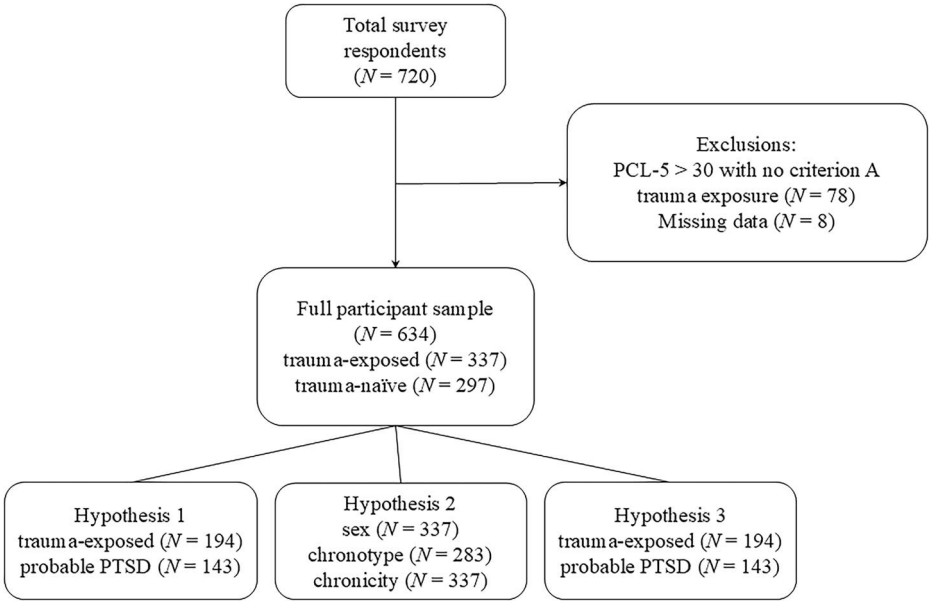

Figure 1. Participant flow in study hypotheses.

Mean MEQ scores demonstrated an intermediate chronotype, ranging from morning, intermediate to evening types. In the trauma-exposed sample, the average number of trauma exposures was almost two, and on average, the most recent trauma occurred a little over two years before testing. Mild and moderate depression symptoms, mild stress symptoms, and mild and moderate anxiety symptoms were observed in the full and trauma-exposed-only samples, respectively. Finally, low risk for harmful patterns of alcohol use was observed. To assess hypotheses 1, 2 and 3, the results from the trauma-exposed subgroup ($N = 337$) are reported here and from the full sample are included in the supplement (S1, S2, S4). Sixteen individuals were older than 30. They were excluded for sensitivity analyses, but results remained unchanged, see supplementary table S5.

Table 1. Participant demographics.

	Full sample (N = 634)		Trauma-exposed sub-sample (N = 337)	
Variable	*M*	*SD*	*M*	*SD*
Age	19.83	4.71	20.24	5.20
PCL-5	20.30	17.00	28.73	18.14
PSQI	6.44	3.27	7.49	3.51
ISI	8.88	5.55	10.65	5.74
ESS	7.60	4.51	8.48	4.67
MEQ	45.68	8.67	44.78	8.70
TEQ			1.81	1.19
Chronicity (years)			2.55	3.33
DASS-depression	5.94	4.32	7.26	4.67
DASS-stress	7.48	4.01	8.79	4.14
DASS-anxiety	5.54	3.81	6.70	4.01
AUDIT	4.66	5.38	5.45	5.99

Notes: PCL-5: PTSD checklist for DSM-V, PQSI: Pittsburgh Sleep Quality Index, ISI: Insomnia Severity Index, ESS: Epworth Sleepiness Scale, MEQ: Morningness–Eveningness Questionnaire, TEQ: Trauma Exposure Questionnaire, DASS: Depression, Anxiety and Stress Scale, AUDIT: Alcohol Use Disorder Identification Test.

3.1. Hypothesis 1: the sleep–PTSD relationship

The best-fitting model of sleep disturbances predicting PTSD symptom severity in trauma-exposed individuals with and without probable PTSD was determined using hierarchical multiple regression with sleep quality as measured by the PSQI, insomnia (ISI) and daytime sleepiness symptoms (ESS) entered according to the strength of their associations with disturbed sleep in PTSD found in previous studies (Ahmadi et al., 2022; Westermeyer et al., 2010). Models were significant at each step of the regression ($p < .001$). At the final step, all measures of sleep disturbance together were significantly associated with PTSD symptom severity, $F(3, 333) = 58.24$, $p < .001$, accounting for 34%, 95% CI [.26, .43] of variance in the PCL-5 score (a large effect; Cohen, 1988). ΔR^2 suggests significant improvements in model fit after including ISI, $F(1, 334) = 28.97$, $p < .001$, and ESS, $F(1, 333) = 19.41$, $p < .001$. Standardised beta coefficients indicated that insomnia symptoms were the strongest predictor of PTSD symptom severity followed by sleep quality, then daytime sleepiness. See Table 2 for model details. The model including the full sample can be found in the supplementary table S1 and yielded similar results.

3.2. Hypothesis 2: moderation analyses including sex, chronotype and trauma chronicity

In the trauma-exposed sub-sample with and without probable PTSD, 269 were female and 68 were male. Overall, the model including sex, sleep quality as well as their interaction was significant, $F(3, 333) = 40.83$, $p < .001$. However, sex was not a significant predictor ($p = .22$) nor moderator of the sleep–PTSD

Table 2. Hierarchical multiple regression model summary.

	b (95% CI)	*β*	SE	*t*	R^2 (95% CI)	ΔR^2	AIC
Step 1					.25 (.17, .33)		2818.19
Constant	9.43 (5.45, 13.41)		2.02	4.66***			
PSQI	2.58 (2.10, 3.06)	0.50	0.24	10.53***			
Step 2					.31 (.22, .39)	.06***	2793.57
Constant	7.38 (3.47, 11.28)		1.99	3.71***			
PSQI	1.32 (0.66, 1.98)	0.26	0.37	3.92**			
ISI	1.01 (0.67, 1.48)	0.34	0.21	5.24***			
Step 3					.34 (.26, .43)	.04***	2776.48
Constant	3.11 (−1.14, 7.37)		2.16	1.44			
PSQI	1.31 (0.66, 1.85)	0.25	0.33	3.99**			
ISI	0.84 (0.43, 1.24)	0.26	0.21	4.02***			
ESS	0.82 (0.45, 1.18)	0.21	0.19	4.41***			

Notes: $N = 337$. PSQI: Pittsburgh Sleep Quality Index, ISI: Insomnia Severity Index, ESS: Epworth Sleepiness Scale. β = standardised beta estimates. ΔR^2 = increase in model variance explained. AIC = Akaike information criterion. **$p < .01$. ***$p < .001$.

relationship ($p = .89$, see Figure 2(A)). Likewise, the model including chronotype was significant, $F(3, 279) = 30.00$, $p < .001$, but individually did not predict PTSD symptom severity ($p = .67$) nor moderate the sleep–PTSD relationship ($p = .85$, see Figure 2(B)). The majority ($N = 162$) had an intermediate chronotype, 15 self-reported a preference for morning, and 106 were evening-type. Data of 54 were missing. Lastly, trauma chronicity (years since the most recent trauma) was not a significant predictor ($p = .23$) nor moderator of the sleep–PTSD relationship ($p = .81$), despite the model overall reaching significance, $F(3, 333) = 41.43$, $p < .001$ (Figure 2(C)). In all three models, sleep quality as measured by the PSQI score was a significant predictor of PTSD symptom severity as measured by the PCL-5 ($p < .05$). Table 3 includes summaries of all moderation models. Moderation analyses for sex and chronotype in the full sample can be found in supplementary table S2 with similar results.

3.3. Hypothesis 3: the dimensional sleep–PTSD symptom cluster relationship

PTSD symptom clusters including re-experiencing, avoidance, hyperarousal, and negative mood symptoms were all independently associated with lower sleep quality with medium effects. Firstly, greater re-experiencing symptom severity was significantly associated with lower sleep quality, $F(1, 335) = 71.18$, $p < .001$ (Figure 3(A)), explaining 17.5%, 95% CI [.10, .25], of its variance (medium effect; Cohen, 1988). For every standard unit increase in re-experiencing symptom severity, there was a corresponding standard unit increase in PSQI score of 0.42. Similarly, avoidance symptom severity was significantly related to sleep quality, $F(1, 335) = 55.26$, $p < .001$ (Table 4, Figure 3(B)). It explained 14%, 95% CI [.07, .21], of variance in sleep quality (medium effect; Cohen, 1988) and every standard unit increase in avoidance symptom severity was accompanied with a 0.38-

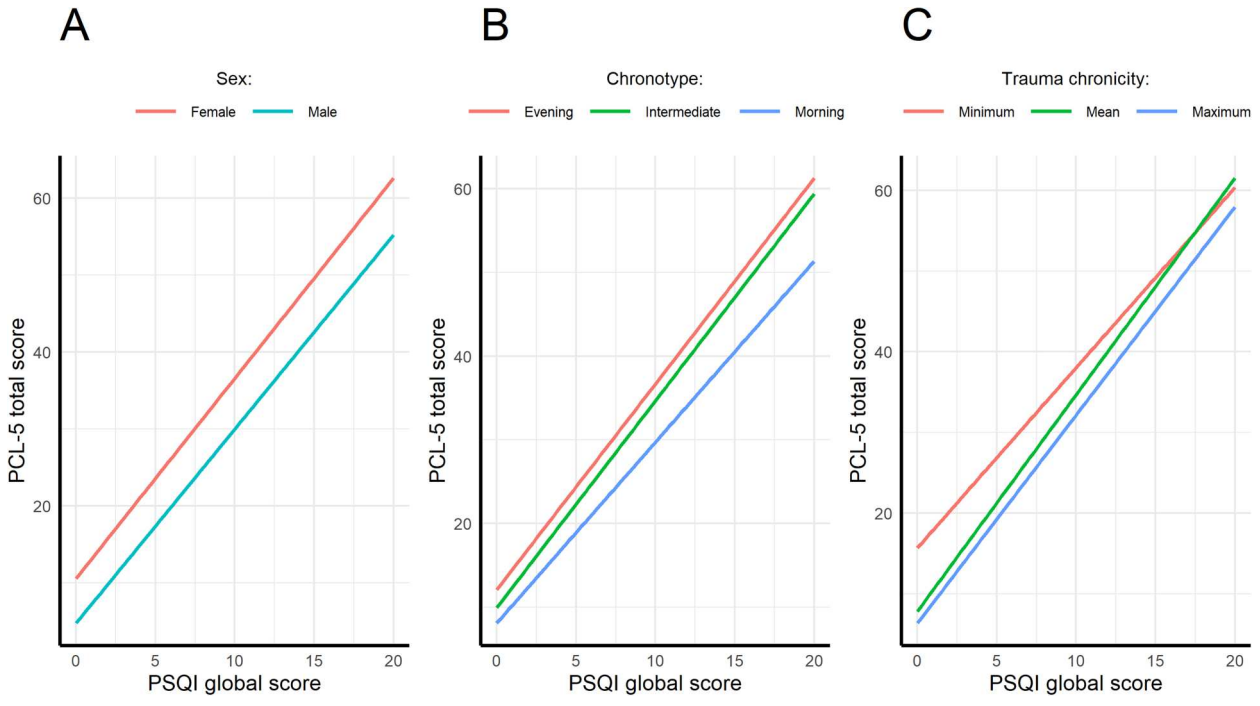

Figure 2. Mean PTSD symptom score by sleep quality score depending on biological sex, chronotype and trauma chronicity.

Table 3. The moderating effect of biological sex, chronotype and trauma chronicity.

	b (95% CI)	*β*	SE	*t*	R^2	(95% CI)
Sex					.27	(.17, .34)
Constant	10.54 (6.03, 15.06)		2.30	4.59***		
PSQI	2.60 (2.05, 3.15)	0.50	0.28	9.30***		
Sex	−5.79 (−15.04, 3.46)	−0.13	4.70	−1.23		
PSQI × Sex	−0.08 (−1.18, 1.02)	−0.02	0.56	−0.14		
Chronotype					.24	(.16, .33)
Constant	15.65 (−7.56, 38.86)		11.79	1.33		
PSQI	2.69 (0.01, 5.36)	0.52	1.36	1.98*		
MEQ	−0.11 (−0.61, 0.39)	−0.05	0.26	−0.42		
PSQI × MEQ	−0.01 (−0.07, 0.05)	−0.05	0.03	−0.19		
Chronicity						
Constant	11.67 (6.64, 16.71)		2.56	4.56***	.27	(.19, .35)
PSQI	2.56 (1.95, 3.17)	0.50	0.31	8.26***		
Years since trauma	−0.67 (−2.03, 0.69)	−0.12	0.69	−0.97		
PSQI × Years	−0.02 (−0.21, 0.16)	−0.03	0.09	−0.24		

Notes: $N = 337$ ($N = 283$ for chronotype). PSQI: Pittsburgh Sleep Quality Index, MEQ: Morningness–Eveningness Questionnaire. β = standardised beta estimates. *$p < .05$, ***$p < .001$.

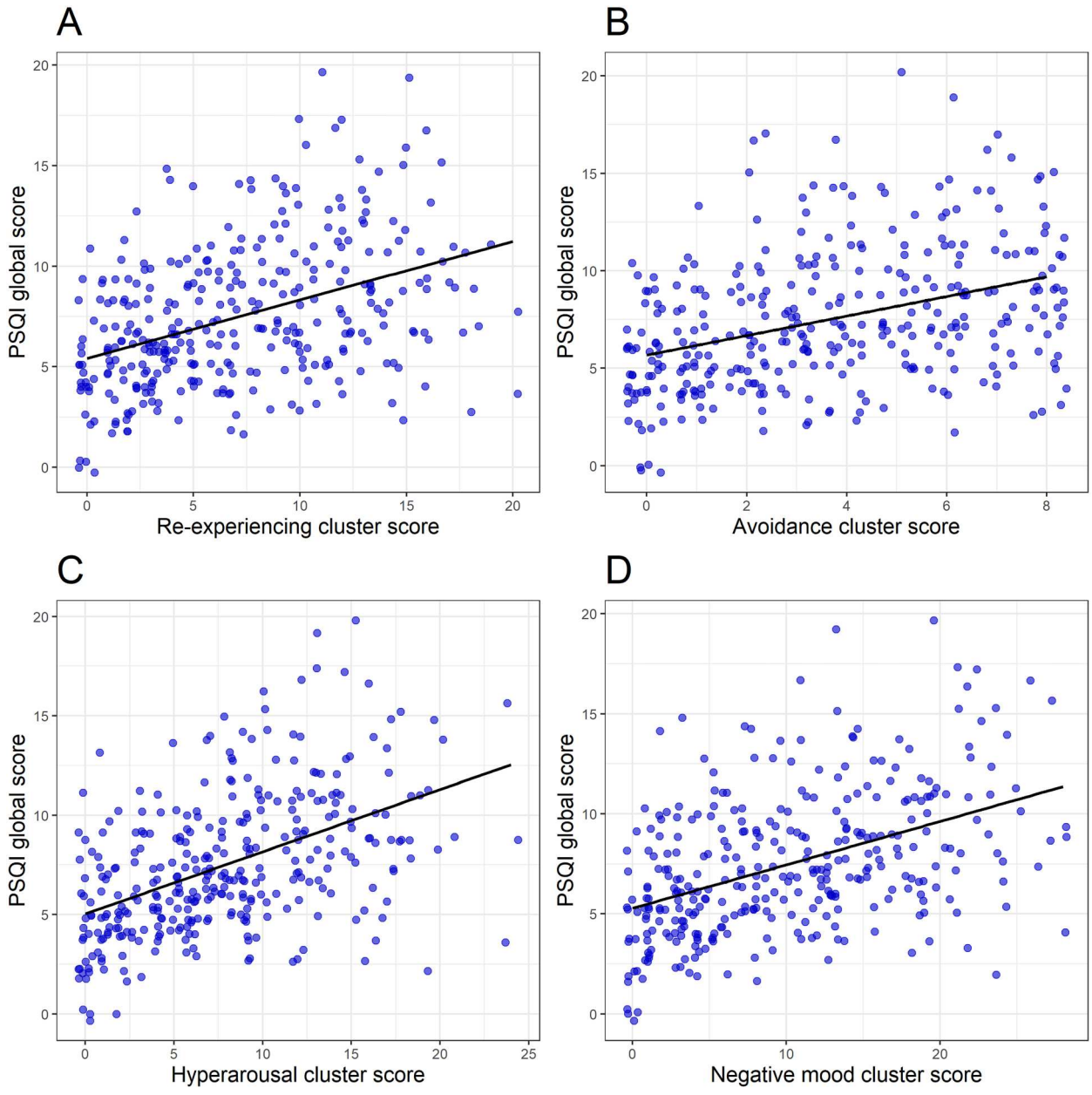

Figure 3. Lines of best fit for PTSD symptom cluster severity predicting sleep quality.

Note: $N = 337$. (A) Severity of re-experiencing trauma reminders associated with sleep quality. (B) Severity of avoidance behaviours associated with sleep quality. (C) Severity of physiological hyperarousal associated with sleep quality. (D) Severity of negative mood associated with sleep quality. Data points represent individual participants.

Table 4. Exploratory analyses.

	b (95% CI)	*β*	SE	*t*	R^2	(95% CI)
Constant	4.62 (3.92, 5.31)		0.35	13.04***	.21	(.13, .28)
Avoidance	0.33 (0.19, 0.48)	0.25	0.07	4.60***		
Anxiety	0.25 (0.15, 0.34)	0.28	0.05	5.22***		
Constant	4.84 (4.21, 5.47)		0.32	15.10***	.23	(.15, .30)
Negative mood	0.14 (0.08, 0.21)	0.30	0.03	4.43***		
Depression	0.16 (0.06, 0.26)	0.22	0.05	3.24**		

Notes: $N = 337$. Anxiety: DASS-21 anxiety subscale, Depression: DASS-21 depression subscale. β = standardised beta estimates. $^{**}p < .01$, $^{***}p < .001$.

point increase in PSQI score. Next, greater hyperarousal symptom severity was significantly associated with worse sleep quality, $F(1, 335) = 104.6$, $p < .001$ (Figure 3(C)). It explained 24%, 95% CI [.61, .32], of the variance in sleep quality, which constituted a medium to large effect (Cohen, 1988). For every standard unit increase in hyperarousal symptom severity, there was a corresponding increase in PSQI score of 0.49. Finally, negative mood symptom severity was also significantly related to sleep quality, $F(1, 335) = 85.19$, $p < .001$ (Figure 3(D)), which explained 20%, 95% CI [.13, .82], of variance in sleep quality (medium to large effect; Cohen, 1988). Every standard unit increase in negative mood symptom severity was associated with a 0.45-point increase in the PSQI score. Results from the trauma-exposed and full sample are included in supplementary table S3 and S4, respectively, with comparable results.

As avoidance behaviour in PTSD is hypothesised to predict anxiety (Bardeen et al., 2015; Sareen, 2014) and negative mood overlaps highly with depression symptoms (Elhai et al., 2015), exploratory analyses were conducted to further investigate the unexpected significance of avoidance and negative mood in relation to sleep quality in two multiple regression models (Table 4). Both avoidance and anxiety symptoms were significantly associated with sleep quality, $F(2, 334) = 43.42$, $p < .001$. Beta coefficients were 0.28 and 0.25 for anxiety and avoidance respectively, indicating anxiety symptoms had a stronger association with sleep quality than avoidance. Both negative mood and depression symptoms similarly showed significant associations with sleep quality, $F(2, 334) = 49.04$, $p < .001$. Conversely, beta coefficients for negative mood (0.30) and depression (0.22) indicated that negative mood had a stronger association with sleep quality than depression symptoms.

4. Discussion

The aim of this study was to assess the strength of the relationship between sleep disturbances and PTSD symptomatology in a relatively understudied sample of young civilian adults with a range of trauma histories and without military-related confounders. As expected, there was a positive association between sleep disturbances and PTSD symptom severity. The results were in line with the limited literature in the field (Lehinger et al., 2023; Lind et al., 2017; Pickett et al., 2016; Wang et al., 2022). Contrary to our expectations, sex, chronotype and trauma chronicity did not moderate the sleep–PTSD relationship. Finally, although re-experiencing and hyperarousal PTSD cluster scores were positively associated with sleep disturbances as hypothesised, avoidance and negative mood were also significantly related to poor sleep. Exploratory analyses highlighted that the effect of avoidance on sleep was independent from anxiety symptoms and the effect of negative alterations in mood was independent from depressive symptoms.

The observed strong, positive relationship between sleep disturbances and PTSD symptomatology in the trauma-exposed sample is consistent with previous research, despite considerable demographic differences between our sample and commonly researched veteran populations including younger in age, type of trauma exposure, low risk of deleterious alcohol use and lack of other military-related confounders (Germain, 2013; Good et al., 2020; Kobayashi et al., 2007; Mantua et al., 2019; Sareen, 2014; Zhang et al., 2019). One surprising finding was the high rate of probable PTSD detected within the trauma-exposed participants (42%) compared with 20% of the general population and 25% of military populations (Seedat et al., 2003; Wellman et al., 2016). This may be partially explained by the higher rate of psychopathology experienced by Australian university students compared with the general population (Larcombe et al., 2016; Stallman, 2010). Young adults also experience poorer sleep than the general population, which may predispose them to heightened PTSD responses following trauma (Cusack et al., 2019). Clarifying rates of probable PTSD in young adult populations is critical in future research investigating the sleep–PTSD relationship in this population.

Sex, chronotype and trauma chronicity did not moderate the sleep–PTSD relationship, unlike previous research (Harrison et al., 2021; Hasler et al., 2013; Hefez et al., 1987; Mellman et al., 2014; Rosen et al., 1991; Schenker et al., 2021; Schenker et al., 2022; Schenker et al., 2023). While PTSD is about twice as common in women compared to men (Kessler et al., 2017), female participants were overrepresented in our sample. The unbalanced sample size resulted in reduced power to detect the moderation effect for sex, and particularly to detect

a slope significantly different from zero in male participants. Additionally, it should be noted that the small interaction effects were incredibly difficult to estimate via moderation analyses, especially when compared with strong main effects (Gelman et al., 2020). To illustrate, the association between sleep quality and PTSD symptom severity ($\beta = 0.50$) in the current study was much larger than the interaction effect between sex and sleep quality ($\beta = -0.02$). The effect of chronotype on the sleep–PTSD relationship may also not be as robust as previously suggested (Harrison et al., 2021; Hasler et al., 2013). The adverse effect of eveningness on PTSD symptomatology may be stronger in military populations, who commonly report long-term sleep disruptions, which may not be found in young civilian populations (Good et al., 2020).

Finally, all four PTSD symptom clusters – re-experiencing, hyperarousal, avoidance, negative mood – were significantly associated with poor sleep. Interestingly and against our expectations, higher avoidance and negative alterations in mood symptoms were associated with greater sleep disruptions. A recent review proposed that fear of sleep, which consists of dysfunctional beliefs about loss of control and safety (a symptom of the negative mood and cognition cluster) during sleep due to nocturnal re-experiencing symptoms (e.g. nightmares), may lead to a maladaptive behaviour including avoiding going to sleep (Werner et al., 2021). Therefore, anxiety may underlie avoidance symptoms (Bardeen et al., 2015; Sareen, 2014), which has been found to be linked to sleep disturbances (Hoffman & Grossman, 2017; Spoormaker & van den Bout, 2005). Similarly, negative mood and cognition have been found to be indirectly related to sleep disturbances through depressive symptoms (Zhen et al., 2018). Although we accounted for anxiety and depression, the avoidance-sleep and negative mood–sleep relationships were not accounted for by anxiety or depression levels, respectively, in our sample. This finding may be due to our conceptualisation of PTSD symptom clusters as separate constructs. Network analysis of symptom cluster associations demonstrated that all were causally associated and covaried over time as PTSD developed following trauma (Bryant et al., 2017). Our cross-sectional regression models did not account for such covariance. It may be that mainly re-experiencing and hyperarousal symptom clusters drive poor sleep but this was not accurately estimated due to inter-cluster covariance.

4.1. Clinical implications

Our findings have practical implications for supporting the implementation of sleep in targeted interventions to prevent and treat PTSD in young adults. Emerging research investigating sleep interventions in PTSD patients show promising results (Carlson et al., 2022; Pigeon et al., 2022; Raskind et al., 2013; Walters et al., 2020). Targeted sleep therapy in addition to current gold-standard trauma-focused cognitive therapy has been found to address poor sleep that may be interacting with and maintaining PTSD symptomatology and improve the efficacy of trauma-focused cognitive therapy (Pigeon et al., 2022; Walters et al., 2020). In turn, the increased efficacy of trauma-focused cognitive therapy may reduce premature drop-out rates and increase treatment adherence. Our observation that 34% of variance in PTSD symptom severity was explained by disturbed sleep in trauma-exposed participants strongly supports the notion that sleep intervention for PTSD may also be beneficial for young civilian adults with PTSD. Our results indicate that such a two-pronged treatment strategy may therefore be an attractive option for restoring normal sleep and reducing PTSD symptom severity in young adults.

We found that sleep disturbances were associated with PTSD symptomatology regardless of trauma-exposure and probable PTSD diagnosis, with the greatest sleep disturbances reported in those with probable PTSD, followed by participants exhibiting subsyndromal PTSD. Trauma-naïve participants reported comparatively normal sleep quality. The strong relationship between sleep and PTSD symptomatology emphasised that sleep disturbances may not just be an issue for those who have likely PTSD but may already be an issue for those who have experienced a traumatic event and have not yet developed PTSD. These findings highlight possible opportunities for preventative PTSD interventions using sleep treatments in the acute post-trauma phase. Individuals with subsyndromal PTSD symptoms are at significant risk for later disorder development (Pietrzak et al., 2014). Despite much research, preventative interventions following trauma exposure demonstrate low efficacy and disorder prevalence has remained stable over the past 40 years (Kilpatrick et al., 2013). Sleep as a modifiable factor presents opportunities for targeted sleep interventions as a potential means to minimise rates of PTSD development by addressing dysregulated sleep in the immediate aftermath of trauma. Even where PTSD development is not prevented, early sleep interventions have the potential to prevent significant functional impairment (Freedman et al., 2015) and are particularly important in populations at risk for disturbed sleep prior to trauma, such as emergency service personnel (Huang et al., 2022), military veterans (Osgood et al., 2019) and possibly even university students (Schlarb et al., 2017; Seelig et al., 2010).

4.2. Limitations

Despite its strengths, this study was not devoid of limitations. One important contextual factor is the COVID-19 pandemic and associated lockdowns which occurred at the time of data collection. This pandemic has been shown to increase stress, depression and anxiety levels in young adults (Varma et al., 2021; Wang et al., 2022) and may have artificially inflated PTSD symptomatology in our sample. Pandemic and lockdown environments have also been shown to alter sleep patterns in young adults, resulting in increased sleep duration but poorer sleep quality and increased nightmares (Socarras et al., 2021). In the future, this study may be replicated in a non-lockdown environment to eliminate effects of pandemic-related factors on rates of disturbed sleep and PTSD, and the sleep–PTSD relationship as a whole.

Additionally, although our sample demonstrated a robust sleep–PTSD relationship, the cross-sectional nature of our research design did not allow us to determine the directionality or causality of this association. Prior studies have found that sleep disturbances can increase the risk of developing PTSD, and PTSD, in turn, may predict future sleep difficulties (Cornelius et al., 2024; Wang et al., 2022). However, it remains unclear whether sleep disturbances precede the onset of PTSD symptoms or if PTSD symptoms lead to subsequent sleep disturbances particularly in the immediate aftermath of trauma in young adults who have not experienced military-related trauma. Our analysis did not explore mechanisms underpinning our observations, which would be required for translation of our research findings into clinical practice (McFarlane et al., 2017). Therefore, future studies should incorporate longitudinal investigations of PTSD symptomatology after trauma-exposure and co-occurring changes in sleep in young adults.

5. Conclusion

This study provides strong evidence for a positive relationship between sleep disturbances and PTSD symptomatology in a young adult, civilian cohort with mixed trauma histories and without military-related confounders. Increasing severity of sleep disturbances was associated with increasing PTSD symptom severity, confirming that the sleep–PTSD relationship previously observed in military populations also exists in young adults, including – to a lesser extent – in individuals with subsyndromal PTSD. Although causality cannot be established, the significant association between poor sleep and PTSD symptom severity suggests that sleep disturbances may also play a role in the maintenance of PTSD in young adults. PTSD is associated with a range of impairments across various domains, and our findings highlight the potential of targeting poor sleep for PTSD prevention and treatment in young adults. Finally, although young adults have historically been largely overlooked in the PTSD literature, our results emphasise the critical need for future research in this cohort.

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Disclosure statement

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

Data availability statement

The data that support the findings of this study are available on request from the corresponding author (MTS). The data are not publicly available due to containing information that could compromise the privacy of research participants.

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