The Association Between Sleep Disturbances and Perceived Stress in Substance Use Disorder Treatment

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Abstract

Introduction: Sleep disturbances and elevated stress levels are commonly reported among individuals seeking treatment for substance use disorders (SUDs). However, it remains unclear whether the relationship between sleep and stress differs based on the primary substance of use or if there are commonalities across different substances. This study aimed to investigate the association between sleep disturbances and perceived stress among individuals in SUD treatment and examine whether primary substance influences this relationship.

Method: A sample of 4,201 individuals from 59 SUD treatment programs completed assessments including the Insomnia Severity Index and Perceived Stress Scale in 2021. Cross-sectional and longitudinal analyses were conducted to evaluate the relationship between sleep and stress across different primary substances during treatment.

Results: The results demonstrated that higher stress was associated with more severe insomnia, and vice versa, both at treatment intake and over the course of treatment, regardless of primary substance. Persons using heroin/fentanyl evidenced a stronger association of sleep on stress, and persons using cocaine evidenced a stronger relationship of stress on sleep.

Discussion: The findings suggest that sleep/stress associations are ubiquitous across different classes of drugs, although sleep might have more influence on stress in persons primarily using heroin/fentanyl, and stress might have more influence on sleep in persons primarily using cocaine, relative to other substances. Interventions targeting either sleep or stress could have positive effects on SUD outcomes, but further research is needed to investigate the underlying neurobiological mechanisms and inform the development of effective interventions for sleep and stress in SUD populations.

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Substance use disorders (SUDs) can be conceptualized, in part, as stress surfeit disorders, and sleep disturbances including insomnia are prevalent in individuals seeking treatment for cannabis use disorder,[1,2] alcohol use disorder (AUD),[3–6] opioid use disorder (OUD),[7] and other SUDs.[8] Persistent sleep disturbances have been associated with return to use among those seeking treatment for these specific SUDs[1,3,9,10] and are recognized as a major challenge to achieving and maintaining abstinence.[11]

Koob and Colrain[12] proposed a feed-forward allostatic model of sleep disturbances in AUD such that increased sleep disturbances can affect drinking behaviors and vice versa; importantly, sleep health seems to partially recover during prolonged abstinence, yet this phenomenon has not been thoroughly evaluated in other SUDs. Similarly, sleep disturbances during early abstinence have been studied within the context of a single substance, but there is a dearth of research examining the similarity or differences in the relationship between stress and sleep disturbances in persons who use different substances.

Variations in sleep disturbances among individuals with different SUDs may result from the distinct physiological effects of these substances and/or the specific withdrawal syndromes associated with each.[13–15] For example, sleep disturbances may be more persistent in OUD compared to other SUDs, as previous research in outpatient OUD treatment consistently shows poor sleep quality.[16] Additionally, while sleep seems to recover during inpatient treatment for those in treatment for OUD and AUD, the improvement is

Clinical Points

- The research fills a critical gap by examining sleep and stress associations across various substance use disorders, revealing consistent bidirectional relationships crucial for treatment strategies.
- The study underscores the universality of sleep disturbances in substance use disorders, emphasizing the need to integrate sleep interventions into standard substance use treatment for improved outcomes.

notably smaller for those with OUD relative to AUD at discharge.[17]

In addition, chronic alcohol, cannabis, cocaine, and opioid use affect the same neuroanatomical regions that regulate sleep, including the locus ceruleus, hypothalamus, thalamus, and prefrontal cortex, as well as neurotransmitters that affect sleep including corticotropin-releasing factor and orexin/hypocretin.[4,12,16,18] The overlap in neurobiology between addiction and sleep coupled with psychosocial factors that are common regardless of primary substance suggests that sleep disturbances are a universal feature of SUD. This opens the possibility of incorporating universal sleep disturbance treatments into SUD therapy, rather than tailoring treatments by primary substance.[11,19–22] Though sleep disturbances have been studied in persons with specific SUDs, there have been no large sample naturalistic studies examining if sleep disturbances are a single phenomenon across SUDs or have differences that are substance-specific.

Previous research has indicated that the relationship between stress and sleep is bidirectional (ie, poor sleep may be caused by high stress and high stress may be caused by poor sleep),[23–25] and just as the relationship between primary substance and sleep disturbances has not been evaluated thoroughly, neither has the relationship between sleep and stress by drug class. SUDs also cause/exacerbate psychosocial stress,[3,16,26–28] which could be a factor in the prevalence of sleep difficulty during SUD treatment. Increased tonic stress and stress reactivity are hallmark features of SUDs,[29] and individuals often seek SUD treatment because of stressful life events, including legal trouble, family conflicts, or job loss.[30] Thus, the influence of stress on sleep at the start of SUD treatment may be different than later in treatment as substance-use-related stress may abate.

Finally, the relationship between sleep and stress may change during the course of treatment as many of the changes in sleep quality and architecture that are associated with substance use are reversed by abstinence; though, sleep disturbances persist in a subgroup of individuals.[11,16,18,31–33] To increase internal validity, the current study sample was limited to individuals in residential treatment, which is a period of controlled abstinence; thus, the changes in sleep and stress may be largely attributable to the cessation of use. Additionally, the structured environment of residential SUD treatment reduces the heterogeneity in sleep hygiene and daytime napping, which may otherwise confound the effect of abstinence on sleep and stress.

This study aimed to address these specific research questions: Are there clinically meaningful differences in the association between sleep and stress among individuals endorsing different primary substances during early treatment? Over the course of treatment, are different primary substances associated with clinically meaningful differences in the association of sleep and stress? Finally, do sleep disturbances and heightened perceived stress abate over the course of treatment?

METHODS

Sample

The sample consisted of 4,201 individuals admitted to 59 SUD treatment programs in the United States in 2021. Sleep and stress assessments were delivered weekly to patients electronically (eg, on computer or tablet), and data were collected by Trac9, a third-party treatment outcomes provider. Trac9 partners with SUD treatment programs to collect outcome assessments on patients with the aim of improving treatment quality. The data used in this study were collected from all patients in these treatment programs who agreed to take weekly assessments. Deidentified data were provided for research through a data transfer agreement between Johns Hopkins University and Trac9, and this study was acknowledged by the Johns Hopkins School of Medicine Institutional Review Board.

During early treatment, defined as the first survey completed during the first 7 days of treatment, each participant was asked to report on which substance they considered their primary substance from 8 possibilities (alcohol, benzodiazepine, cocaine, heroin/fentanyl, marijuana, methamphetamine, prescription opioids, or prescription stimulants) as well as demographic information, including gender and age.

Insomnia

Insomnia was assessed using the Insomnia Severity Index (ISI), a 7-item self-report tool measuring a patient's experience of insomnia symptoms aligned with *DSM-IV* and International Classification of Sleep Disorders criteria.[34,35] The ISI evaluates the severity of sleep onset and maintenance disruptions, satisfaction with current sleep patterns, interference in daily life, and impairment due to sleep issues. Each item is scored from 0 (none) to 4 (very), and the scores are summed to yield a total score ranging from 0 to 28. Higher scores indicate more pronounced sleep disturbances, with scores of 15 or

higher indicating a clinical diagnosis of insomnia.[36] Bastien and Vallières[35] established the scale's reliability and concurrent validity by comparing it with sleep diaries and other sleep measurement tools. They also observed that it is responsive to changes in patients' perceptions of sleep quality and exhibits strong agreement between clinicians and patients in evaluating sleep quality. In our sample, the instrument demonstrated good reliability (α = 0.91 at intake and 0.94 longitudinally).

Stress

Stress was assessed using the Perceived Stress Scale 10-item version (PSS-10), a self-report questionnaire that quantifies an individual's perception of life situations as unpredictable, uncomfortable, and overloaded.[37] The PSS-10 has demonstrated reliability and validity across various populations and settings.[38,39] Each of the 10 items is scored from 0 (never) to 4 (very often) and summed for a total of 0–40, but unlike the ISI, there are no accepted, clinically relevant cutoff points that are correlated with a diagnosable condition; higher scores indicate higher degrees of stress, and research has found that the population mean of the PSS-10 rose from 1983 to 2009, with a 2009 average of 15.87 (SD = 7.51).[40] In this sample, the PSS-10 was found to have good internal consistency (α= 0.88 at intake and 0.92 longitudinally).

Covariates

Previous research has found that there may be differences in sleep quality and quantity based on gender[41,42] and age.[43–45] Similarly, there is evidence that reaction to stress differs based on gender, with women experiencing more somatic symptoms of stress than men, while men have more emotional inhibition related to stress than women.[46] Regarding age, younger individuals may have a more acute and severe reaction to stress than older individuals[47]; therefore, gender and age were included as covariates.

The physical effects of substance use typically resolve after cessation of use and the attendant withdrawal syndrome associated with the specific substance use; however, changes to the neurobiology associated with both sleep and substance use take longer to reverse, and while abstinence typically reverses many substance-related sleep quality and architecture changes, some remain resistant to restoration.[4,11,12,18,31] Thus, time measured as days in treatment was also included as a covariate.

Analyses

Cross-sectional. Group differences based on primary substance were assessed using analysis of variance followed by the Tukey post hoc test each (with $\alpha = 0.05$) for continuous variables. Categorical variables were compared with χ^2 tests. Given the preliminary nature of these tests, a full Bonferroni correction was not applied; instead, α was adjusted to 0.01 to mitigate type I error.

To explore the relationship between stress and sleep at intake among individuals endorsing different primary substances, 2 linear regressions were conducted. One had sleep as the dependent variable, while the other had stress as the dependent variable. The 8 primary substances were dummy-coded using alcohol as the reference group. Since dummy coding may hide comparisons between groups which are not the reference, our analyses were performed using each of the 8 primary substances as the reference group as well as using other coding schemes which do not require a reference group, and no substantial differences were observed; therefore, the dummy coding with primary alcohol use as the reference group was retained for ease of interpretation.

Longitudinal. Multilevel mixed-effects models were used to evaluate the association between sleep and stress for the different primary substance groups longitudinally. We evaluated differences in the association of stress with sleep (and sleep with stress) between individuals who endorsed the same primary drug and, secondarily, to ascertain if there were the patterns of within-person changes that were different based on primary substance. Analyses between mean effects (between-person) and momentary effects (within-person) were conducted by incorporating the individual's mean predictor variable (ie, stress or sleep) and a person-mean-centered variable in each model.[48,49] The analyses included individuals with 2 or more completed weekly surveys. An a priori power calculation was conducted to ensure that there was 80% power for all main effects and interactions, and details are described in Supplementary Appendix 1. The results indicated insufficient power to detect a medium effect in the groups with primary substances of benzodiazepine or prescription stimulants. Consequently, these groups were excluded from the final analyses. All analyses were run using the R programing language[50] and the lme4 package.[51]

RESULTS

Sample

The majority of the sample designated alcohol as their primary substance (45.2%, n = 1,902), followed by primary methamphetamine (17.7%, n = 744), and the smallest group endorsed prescription stimulants (1.8%, n = 77). The sample predominantly consisted of males (69.4%) and White individuals (79.4%). The mean age of the sample was 39 years (SD = 12.6). Notably, those endorsing alcohol (M = 43.0, SD = 12.6) and cocaine (M = 43.4, SD = 13.5) were significantly older compared to those endorsing other substances (M ≤ 35.0). Length of stay in treatment varied, ranging from an average of 27.8 days (SD = 23.0) for those with benzodiazepine as their primary substance to 19.6 days (SD = 19.0) for endorsing methamphetamine.

Table 1.

Demographic Characteristics of Participants in Substance Use Disorder Treatment by Primary Substance

	Alcohol (N = 1,902, 45.3%)	Benzodiazapine (N = 98, 2.3%)	Cocaine (N = 439, 10.4%)	Heroin/fentanyl (N = 367, 8.7%)	Marijuana (N = 171, 4.1%)	Methamphetamine (N = 744, 17.7%)	Prescription opioids (N = 403, 9.6%)	Prescription stimulants (N = 77, 1.8%)	Overall (N = 4,201)
Gender									
Female	530 (27.9%)	39 (39.8%)	111 (25.3%)	127 (34.6%)	40 (23.4%)	271 (36.4%)	114 (28.3%)	32 (41.6%)	1,264 (30.1%)
Male	1,367 (71.9%)	58 (59.2%)	328 (74.7%)	239 (65.1%)	128 (74.9%)	470 (63.2%)	289 (71.7%)	45 (58.4%)	2,924 (69.6%)
Other	5 (0.3%)	1 (1.0%)	0 (0%)	1 (0.3%)	3 (1.8%)	3 (0.4%)	0 (0%)	0 (0%)	13 (0.3%)
Race									
African American	175 (9.2%)	4 (4.1%)	184 (41.9%)	30 (8.2%)	29 (17.0%)	47 (6.3%)	36 (8.9%)	12 (15.6%)	517 (12.3%)
Asian	12 (0.6%)	6 (6.1%)	4 (0.9%)	1 (0.3%)	4 (2.3%)	2 (0.3%)	4 (1.0%)	2 (2.6%)	35 (0.8%)
Native American	17 (0.9%)	1 (1.0%)	6 (1.4%)	4 (1.1%)	6 (3.5%)	6 (0.8%)	4 (1.0%)	2 (2.6%)	46 (1.1%)
Native Hawaiian/Pacific Islander	8 (0.4%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	9 (1.2%)	1 (0.2%)	0 (0%)	18 (0.4%)
Other	96 (5.0%)	4 (4.1%)	30 (6.8%)	23 (6.3%)	16 (9.4%)	39 (5.2%)	36 (8.9%)	5 (6.5%)	249 (5.9%)
White	1,594 (83.8%)	83 (84.7%)	215 (49.0%)	309 (84.2%)	116 (67.8%)	641 (86.2%)	322 (79.9%)	56 (72.7%)	3,336 (79.4%)
Age, y									
Mean (SD)	43.0 (12.6)	33.3 (13.0)[a]	43.4 (13.5)[b]	33.7 (9.38)[a,c]	31.3 (11.6)[a,c]	35.0 (9.63)[a,c,d]	32.9 (10.4)[a,c]	33.8 (9.27)[a,c]	39.0 (12.6)
Median [Min, Max]	42.0 [18.0, 77.0]	29.0 [18.0, 71.0]	43.0 [18.0, 72.0]	32.0 [19.0, 69.0]	28.0 [18.0, 70.0]	34.0 [18.0, 65.0]	32.0 [18.0, 77.0]	33.0 [18.0, 63.0]	37.0 [18.0, 77.0]
Days in treatment									
Mean (SD)	25.9 (18.0)	27.8 (23.0)	21.8 (14.8)[a,b]	20.8 (17.0)[a,b]	23.5 (19.0)	19.6 (19.0)[a,b]	20.0 (17.6)[a,b]	20.4 (13.7)	23.2 (18.1)
Median [Min, Max]	25.0 [0, 126]	24.0 [0, 128]	22.0 [0, 94.0]	21.0 [0, 107]	21.0 [0, 128]	18.0 [0, 123]	19.0 [0, 128]	22.0 [0, 56.0]	22.0 [0, 128]
AMA									
AMA	170 (8.9%)	10 (10.2%)	66 (15.0%)	78 (21.3%)	31 (18.1%)	197 (26.5%)	76 (18.9%)	12 (15.6%)	640 (15.2%)
Perceived Stress Scale									
Mean (SD)	21.0 (8.12)	23.1 (7.60)	21.1 (7.57)	21.1 (7.21)	22.1 (7.89)	22.7 (8.41)	21.6 (7.96)	22.5 (8.97)	21.5 (8.04)
Median [min, max]	21.0 [0, 40.0]	23.0 [1.00, 39.0]	21.0 [1.00, 40.0]	21.0 [1.00, 40.0]	22.0 [0, 39.0]	23.0 [0, 40.0]	22.0 [1.00, 40.0]	22.0 [0, 40.0]	21.0 [0, 40.0]
ISI Total									
Mean (SD)	12.9 (7.38)	15.5 (7.63)	12.4 (7.44)	14.1 (7.17)	12.5 (7.25)	13.2 (7.47)	13.4 (7.17)	12.6 (7.37)	13.1 (7.38)
Median [min, max]	13.0 [0, 28.0]	15.0 [2.00, 28.0]	13.0 [0, 28.0]	14.0 [0, 28.0]	12.0 [0, 28.0]	14.0 [0, 28.0]	13.0 [0, 28.0]	12.0 [0, 28.0]	13.0 [0, 28.0]

Significant group differences: [a]Different than alcohol group. [b]Different than benzodiazepine group. [c]Different than cocaine group. [d]Different than marijuana.
Abbreviation: AMA = against medical advice.

Table 2.

Cross-Sectional Regression Analysis of Sleep and Stress Associations Among Substance Use Disorder Treatment Participants[a]

		Insomnia Severity Index			Perceived Stress Scale		
Predictors		Estimates	95% Confidence limit	*P* value	Estimates	95% Confidence limit	*P* value
Alcohol		Ref.			Ref.		
Benzodiazepine		0.75 (0.26)	−4.42, 5.93 (0.04 to 0.48)	.775	0.51 (−0.01)	−3.30, 4.33 (−0.23 to 0.21)	.792
Cocaine		−0.50 (−0.06)	−2.75, 1.74 (−0.17 to 0.04)	.659	1.21 (0.01)	−0.38, 2.81 (−0.09 to 0.11)	.135
Heroin/fentanyl		1.36 (0.17)	−1.20, 3.92 (0.05 to 0.28)	.297	−0.00 (−0.12)	−1.94, 1.93 (−0.23 to 0.00)	.998
Marijuana		−0.23 (−0.07)	−3.60, 3.14 (−0.23 to 0.09)	.893	0.49 (0.06)	−1.96, 2.93 (−0.10 to 0.21)	.696
Methamphetamine		−0.83 (−0.02)	−2.62, 0.95 (−0.11 to 0.07)	.359	−0.37 (0.07)	−1.74, 0.99 (−0.01 to 0.16)	.592
Prescription opioids		−0.03 (0.06)	−2.38, 2.32 (−0.05 to 0.17)	.978	−0.60 (−0.04)	−2.40, 1.20 (−0.15 to −0.07)	.513
Prescription stimulants		−1.85 (−0.03)	−6.19, 2.49 (−0.26 to 0.20)	.403	−3.15 (−0.03)	−6.72, 0.42 (−0.25 to 0.20)	.084
Perceived Stress Scale		**0.41 (0.44)**	**0.36, 0.45 (0.40 to 0.49)**	**<.001**			
ISI Total					**0.47 (0.44)**	**0.43, 0.52 (0.39 to 0.48)**	**<.001**
Age		**0.02 (0.04)**	**0.00, 0.04 (0.01 to 0.07)**	**.015**	**−0.07 (−0.11)**	**−0.09, −0.05 (−0.14 to −0.07)**	**<.001**
Gender	Women	Ref.			Ref.		
	Men	−0.26 (−0.04)	−0.76, 0.24 (−0.10, 0.03)	.306	**−1.76 (−0.22)**	**−2.29, −1.23 (−0.29 to −0.15)**	**<.001**
	Other	0.62 (0.08)	−3.30, 4.54 (−0.45, 0.62)	.757	−0.20 (−0.02)	−4.40, 4.01 (−0.55 to 0.50)	.927
Interaction			Substance x stress			Substance x sleep	
Benzodiazepine		0.06 (0.06)	−0.16, 0.27 (−0.17 to 0.29)	.614	−0.05 (−0.04)	−0.27, 0.18 (−0.25 to 0.16)	.680
Cocaine		0.00 (0.00)	−0.10, 0.10 (−0.11 to 0.11)	.979	−0.09 (−0.08)	−0.20, 0.02 (−0.18 to 0.02)	.118
Heroin/fentanyl		−0.01 (−0.01)	−0.12, 0.11 (−0.13 to 0.12)	.913	−0.07 (−0.07)	−0.19, 0.05 (−0.18 to 0.05)	.258
Marijuana		−0.01 (−0.01)	−0.16, 0.13 (−0.17 to 0.14)	.861	−0.00 (−0.00)	−0.17, 0.17 (−0.16 to 0.15)	.979
Methamphetamine		0.03 (0.03)	−0.04, 0.11 (−0.05 to 0.12)	.404	0.07 (0.07)	−0.02, 0.16 (−0.01 to 0.15)	.107
Prescription opioids		0.02 (0.02)	−0.08, 0.12 (−0.09 to 0.14)	.664	0.02 (0.02)	−0.10, 0.14 (−0.09 to 0.13)	.723
Prescription stimulants		0.08 (0.08)	−0.11, 0.27 (−0.12 to 0.29)	.422	0.22 (0.22)	−0.02, 0.47 (−0.02 to 0.43)	.073
Observations			3,314			3,314	
R^2/R^2 adjusted			0.209/0.205			0.231/0.227	

[a]Significance is set at <.05; boldface indicates statistical significance. Here, PSS and age are significant when ISI is the dependent variable, and age and men as gender are significant when PSS is the dependent variable.

At intake, the sample had a mean ISI score of 13.1 (SD = 7.38) with over 48% of the sample having an ISI score above the clinically significant cut point of 15. Similarly, the sample had a mean PSS-10 score of 21.5 (SD = 8.04) which is about 5 points above the 2009 national average[40] (see Table 1 for descriptive statistics).

Cross-Sectional Analyses

As expected, higher stress (PSS score) was associated with increased ISI scores (B = 0.41, $P < .001$), and vice versa (B = 0.47, $P < .001$). Older age correlated with slightly higher ISI scores (B = 0.02, $P = .015$) and slightly lower PSS scores (B = −0.07, $P < .001$). No gender differences were found in insomnia, but men scored significantly lower on PSS (B = −1.76, $P < .001$).

In the first week of treatment, there were no significant differences between primary substance on insomnia when controlling for stress and no significant differences between primary substances on stress when controlling for insomnia. Importantly, none of the drug classes nor any of the interactions between drug class and sleep or stress were significantly associated with differences in sleep or stress, indicating that the relationship between stress and sleep was consistent at intake regardless of primary substance, and addressing the first research question of establishing if there are clinically meaningful differences in the association between sleep and stress among individuals endorsing different primary substances during early treatment (see Table 2).

Longitudinal Analyses

Longitudinal analyses found that there was a significant association of stress on sleep as well as sleep on stress, indicating a bidirectional relationship between symptoms of insomnia and perceived stress. Between-person analyses indicated that people with higher PSS scores also had higher ISI scores (B = 0.50, β = 0.44, $P < .001$) and those with higher ISI scores had higher PSS scores (B = 0.60, β = 0.43, $P < .00$). Similarly, within-person analyses indicated that experiencing above average stress was also associated with increased insomnia symptoms (B = 0.37, β = 0.26, $P < .001$) and, conversely, higher ISI scores were associated with an increase in perceived stress (B = 0.54, β = 0.26, $P < .001$). Clinically, this indicated that an 8-point (approximately 1 standard deviation) reduction in PSS scores during a 30-day stay in treatment was associated with a 5.6-point reduction in ISI scores or 20% of the scale.

Table 3.

Longitudinal Analysis of Sleep and Stress Associations Among Substance Disorder Treatment Participants[a]

		Insomnia Severity Index			Perceived Stress Scale		
Predictors		Estimates (std β)	95% Confidence limit (std CL)	*P* value	Estimates (std β)	95% Confidence limit (std CL)	*P* value
Alcohol		Ref.			Ref.		
Cocaine		0.12 (0.02)	−1.27, 1.51 (−0.05 to 0.09)	.863	0.75 (0.00)	−0.32, 1.82 (−0.07 to 0.07)	1.68
Heroin/fentanyl		0.45 (0.13)	−1.06, 1.97 (0.05 to 0.21)	.557	0.66 (−0.03)	−0.49, 1.82 (−0.11 to 0.04)	.262
Marijuana		0.45 (0.03)	−1.71, 2.61 (−0.08 to 0.14)	.682	−0.14 (0.03)	−1.85, 1.58 (−0.08 to 0.14)	.875
Methamphetamine		0.17 (0.02)	−0.95, 1.28 (−0.04 to 0.09)	.772	−0.28 (0.03)	−1.18, 0.62 (−0.03 to 0.09)	.541
Prescription opioids		0.73 (0.04)	−0.71, 2.16 (−0.03 to 0.12)	.319	0.38 (0.01)	−0.76, 1.53 (−0.07 to 0.08)	.509
		PSS			**ISI**		
Person mean		**0.50 (0.44)**	**0.46, 0.53 (0.42 to 0.47)**	**<.001**	**0.60 (0.43)**	**0.56, 0.64 (0.40 to 0.46)**	**<.001**
Person mean centered		**0.37 (0.26)**	**0.35, 0.38 (0.25 to 0.28)**	**<.001**	**0.54 (0.26)**	**0.52, 0.57 (0.25 to 0.28)**	**<.001**
Days in treatment		**−0.06 (−0.15)**	**−0.06, −0.05 (−0.16 to -0.14)**	**<.001**	**-0.12 (-0.28)**	**−0.13, −0.11 (−0.29 to −0.26)**	**<.001**
Age		**0.04 (0.06)**	**0.02, 0.05 (0.04 to 0.08)**	**<.001**	**−0.06 (−0.09)**	**−0.08, −0.05 (−0.11 to −0.07)**	**<.001**
Gender	Women						
	Men	**−0.06**	**−0.06, −0.05**	**<.001**	**−0.75 (−0.09)**	**−1.14, −0.36 (−0.13 to −0.04)**	**<.001**
	Other	−1.12 (−0.15)	−3.90, 1.66 (−0.52 to 0.22)	.431	1.15 (0.13)	−1.95, 4.25 (−0.23 to 0.49)	.467
Between-person interactions		**Substance x PSS person mean**			**Substance x ISI person mean**		
Cocaine		0.00 (0.00)	−0.08, 0.08 (−0.08 to 0.08)	.950	−0.08 (−0.06)	−0.17, 0.01 (−0.12 to 0.01)	.083
Heroin/fentanyl		0.03 (0.03)	−0.05, 0.12 (−0.05 to 0.11)	.423	**−0.10 (−0.07)**	**−0.20, −0.01 (−0.14 to −0.00)**	**.035**
Marijuana		−0.01 (−0.01)	−0.13, 0.10 (−0.12 to 0.09)	.803	0.04 (0.03)	−0.10, 0.19 (−0.07 to 0.14)	.565
Methamphetamine		0.00 (0.00)	−0.06, 0.06 (−0.05 to 0.06)	.965	0.06 (0.04)	−0.02, −0.01 (−0.01 to 0.09)	.139
Prescription opioids		−0.03 (−0.02)	−0.11, 0.05 (−0.09 to 0.05)	.508	−0.04 (−0.04)	−0.13, 0.06 (−0.10 to 0.04)	.479
Within-person interaction		**Substance x PSS person mean centered**			**Substance x ISI person mean centered**		
Cocaine		**−0.04 (−0.03)**	**−0.08, −0.00 (−0.06 to −0.00)**	**.048**	−0.01 (0.00)	−0.07, 0.05 (−0.04 to 0.03)	.747
Heroin/fentanyl		0.02 (0.01)	−0.02, 0.06 (−0.02 to 0.05)	.379	**−0.09 (−0.04)**	**−0.15, −0.03 (−0.07 to −0.01)**	**.005**
Marijuana		−0.05 (−0.04)	−0.11, 0.01 (−0.08 to 0.01)	.085	−0.06 (−0.03)	−0.15, 0.03 (−0.07 to 0.02)	.216
Methamphetamine		0.02 (0.01)	−0.02, 0.05 (−0.01 to 0.04)	.317	0.02 (0.01)	−0.03, 0.07 (−0.02 to 0.03)	.472
Prescription opioids		−0.02 (−0.02)	−0.07, 0.02 (−0.05 to 0.01)	.261	−0.04 (−0.04)	−0.10, 0.02 (−0.10 to 0.02)	.230
Random effects							
σ^2		16.42			23.73		
τ_{00}		21.75			25.58		
N		4,296			4,296		
Observations		16,752			16,752		
Marginal R^2		0.530			0.558		

[a]Significance is set at <.05; boldface indicates statistical significance.

There were no significant main effects of substance on either sleep or stress, and as seen in Table 3, there were 3 interactions that were significant: the between-person interaction of primary heroin/fentanyl and sleep on stress (B = −0.10, β = −0.07, *P* = .035), the within-person interaction of primary heroin/fentanyl and sleep on stress (B = −0.09, β = −0.04, *P* = .005), and the within-person-interaction of primary cocaine and stress on sleep (B = −0.04, β = −0.03, *P* = .048) (see Figures 1 and 2).

As at intake, older age was significantly associated with higher ISI scores (B = 0.04, *P* < .001) and lower PSS scores (B = −0.06, −0.05, *P* < .001). Days in treatment were associated with lower ISI scores (B = −0.06, *P* < .001) and lower PSS scores (B = −0.06, *P* < .001). When compared to women, men had lower ISI scores (B = −0.06, *P* < .001) and lower PSS scores (−0.75, *P* < .001) over time in treatment.

DISCUSSION

Summary

This present study sought to examine the relationship between insomnia and perceived stress as a function of primary substance among individuals seeking treatment for SUDs.

Figure 1.

Predicted Values of the Perceived Stress Scale Compared to the Insomnia Severity Index (Person Mean Score and Scores Centered on Person Mean) for Those Who Identified Heroin/Fentanyl as Their Primary Substance Compared to Those Who Did Not

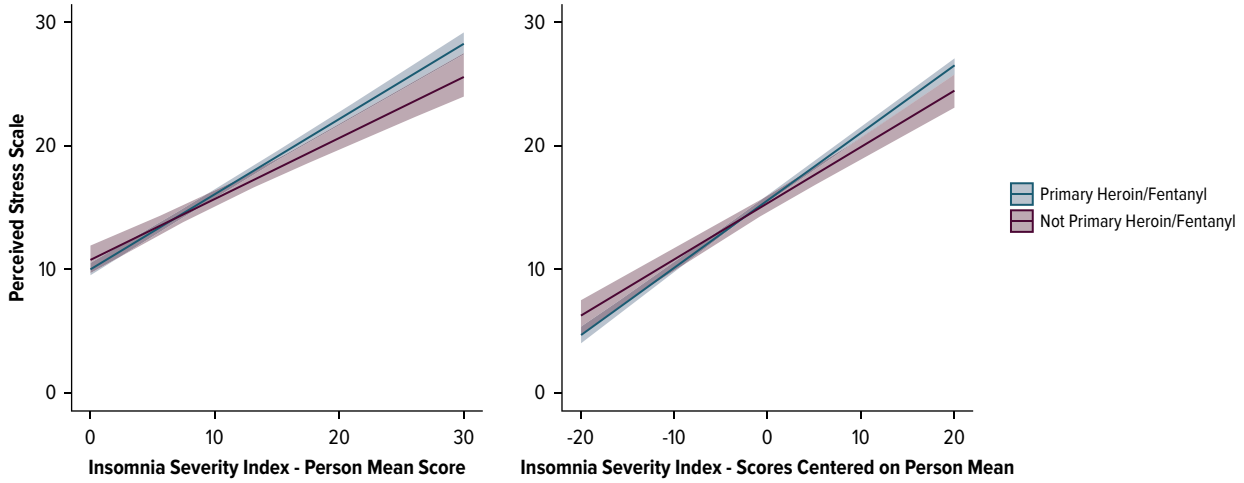
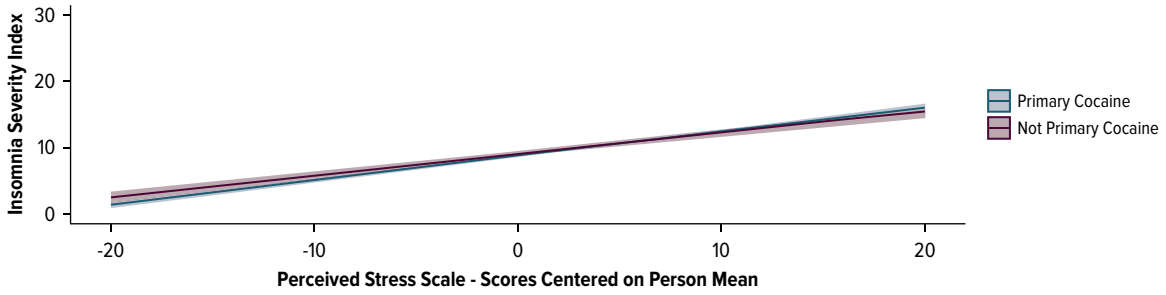


Figure 2.

Predicted Values of the Insomnia Severity Index Compared to the Perceived Stress Score (Scores Centered on Person Mean) for Those Who Identified Cocaine as Their Primary Substance Compared to Those Who Did Not



The findings underscore a clinically significant bidirectional connection between sleep and stress, where higher stress was associated with worse insomnia, and vice versa. Importantly, these associations held consistently across different primary substances and remained stable from intake throughout the treatment period. While SUDs have been conceptualized as stress surfeit disorders, it appears that sleep disturbances and sleep/stress associations are a consistent and universal feature across SUDs. Although some of the interactions were significant, the effect sizes, as measured by standardized beta, were small.[52–54] The findings that individuals who primarily use heroin/fentanyl might have stronger associations of sleep on stress and that individuals who primarily use cocaine might have stronger associations of stress on sleep could be further examined in preclinical or human behavioral pharmacology research. However, the results of this study suggest that individuals with different primary substances may not require distinct interventions to improve their sleep and stress outcomes.

Given the bidirectional link between sleep and stress in SUDs, interventions targeting one variable could positively influence the other. Moreover, this study reaffirms that sleep improvement during treatment coincides with reductions in perceived stress, aligning with previous work by Koob and Colrain.[12]

The finding that sleep disturbances are similar among many substances may be due to the overlap in brain structures and neurotransmitters that are associated with addiction and sleep disturbances.[18] Ek et al[18]

explain that these structures contain the primary reward system developed to encourage the most important life-preserving functions including seeking food, reproduction, and sleep and that this system is "hijacked by addiction and altered on a molecular level when chronically overstimulated."[18] Additionally, the same neurotransmitters (eg, corticotropin-releasing factor, norepinephrine, dynorphin, and orexin) contribute to irritability, anxiousness, and overarousal that typify both sleep deprivation and early abstinence from substance use for someone with SUD.[18,55] The possibility that sleep disturbances are due to neurological structures and neurotransmitters common to both addiction and sleep is further bolstered by the finding that sleep disturbances are common among those with process/behavioral addiction including gambling,[56] smartphone use,[57] gaming,[58,59] and binge eating disorder.[60]

Strengths/Limitations

This study utilized a large national sample in a real-world clinical environment using well-established measures of sleep and stress. Adding to the internal validity of the study is the fact that using a sample of individuals in the controlled environment of residential treatment removes the confounding factors of continued substance use and varied sleep/wake schedules.

Conversely, this study's finding that sleep disturbances and their relationship to stress are similar across substance class in residential treatment begs the question of what would have been the outcome in a less controlled environment, where the participants would have access to substances and were able to set their own sleep routine and schedule. Further research focused on individuals in outpatient treatment or those not in formal treatment but in early abstinence is warranted. Additional limitations of this study include the fact that stress and sleep were each measured using only one instrument and that, while participants were enrolled in substance use treatment, this study did not have access to the complete medical records of the individuals in treatment and therefore cannot assess exactly what treatments were administered for insomnia or stress nor how they varied between treatment providers.

While the methodology of null hypothesis testing does not lend itself to a definitive statement that there is no difference in sleep and stress between substances, this study had a large sample and had been tested and shown to have over 80% power to find a medium size effect for all main effects and almost all interactions, and it can be reasonably assumed that if a clinically meaningful difference existed, it would have been detected.

Implications

As established, sleep disturbance is a factor in return to substance use[1,3,9] and is characteristic of SUD regardless of primary substance. Incorporating sleep disturbance treatment into standard SUD treatment is essential. Early SUD treatment may require pharmacologic interventions, and a subset of individuals might require long-term pharmacotherapy.[7,61] Cognitive behavioral therapy for insomnia (CBTi) could offer long-term improvements in sleep, although there is limited evidence of the efficacy of CBTi across SUDs.[62–64] For those with more severe/persistent insomnia, CBTi could be a first-line and potentially efficacious long-term treatment.[63,65] In general, coaching SUD patients on proper sleep hygiene and the need for a regular sleep schedule during recovery can be beneficial, especially given the overlap in neural structures and neurotransmitter systems involved in both sleep and addiction.

Finally, mechanistic research on the neurological basis for sleep disturbances and addiction is highly important to identify sleep phenotypes during recovery, identify individuals who might respond well to behavioral interventions, and develop novel pharmacotherapeutic interventions that act on neural substrates common to both addiction and sleep.[7,66,67]

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