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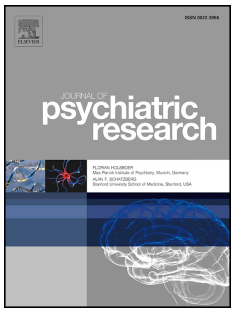

The relationship between sleep disturbance and self-harming behaviours in high-risk clinical adolescents

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Abstract

Emerging research has identified sleep disturbance as an important risk factor for predicting self-harming behaviours. However, the temporality of this relationship, particularly in clinical adolescent samples remains poorly understood. This study examines the relationship between sleep disturbance and self-harming behaviours (namely nonsuicidal self-injury and suicide attempts) in clinical adolescents engaging in risk-taking and self-harming behaviours using secondary analyses from a clinical cohort study. Cross-lagged structural equation modelling was used to determine whether baseline sleep disturbance and self-harming behaviours were predictors of each other over a one-year follow-up period in a sample of adolescents (n = 238, 89.5% female) attending and receiving treatment from an outpatient clinic specializing in risk-taking and self-harming behaviours. When controlling for age, sex and depressive symptoms, greater sleep disturbance (p = 0.001) at baseline independently predicted higher numbers of suicide attempts at follow-up. No bidirectional relationship was found when sleep disturbance was modelled with the frequency of nonsuicidal self-injury. This study adds to the growing evidence that sleep disturbance may predict suicidal behaviours. Clinicians should thus regularly assess for sleep disturbances when evaluating suicidal behaviours in high-risk adolescents. Further research and clinical trials should investigate whether sleep-based interventions may be efficacious in reducing the prevalence of suicidal behaviours.

Keywords*: sleep, suicide, suicide attempts, non-suicidal self-injury, depression, adolescence*

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Introduction

Suicide remains one of the leading causes of death worldwide in young people. While 6.04 in every 100,000 adolescents aged between 15 and 19 are estimated to die by suicide every year (Glenn et al., 2020), one population-representative American sample estimates that approximately 7.4% of adolescents have reported at least one suicide attempt in the preceding 12 months (Kann et al., 2018). Along with genetic and biological influences, common risk factors for suicidal behaviours include endorsing prior mental health problems (e.g., depression) (Gili et al., 2019), previous suicide attempts (Carballo et al., 2020) and nonsuicidal self-injury (NSSI) (Koenig et al., 2017). NSSI refers to the deliberate and self-inflicted damage of body tissue, without any social and cultural sanctioning or suicidal intent (Kaess et al., 2021). With prevalence estimates of 17.2% amongst adolescents, NSSI is a particularly important risk factor for suicide attempts, given that the onset and marked increase of both behaviours occurs during adolescence (Goldston et al., 2015; Swannell et al., 2014). Notably, prospective studies have also shown that NSSI may better predict suicide attempts than other risk factors such as prior suicide attempts (Asarnow et al., 2011; Wilkinson et al., 2011).

The onset of depressive and self-harming psychopathologies in adolescence coincides with the emergence of poor sleep, the latter being well established as a transdiagnostic factor for many common mental disorders (Harvey et al., 2011). Sleep disturbances often start to emerge during adolescence as teenagers begin to experience greater difficulties falling asleep, awaken early after falling asleep and sleep less hours overall (Gariepy et al., 2020). Biologically, it is thought that hormonal changes during puberty delays circadian rhythms (Crowley et al., 2018). Given the build-up of homeostatic sleep pressure is slower in comparison to prepubertal children, this enables adolescents to stay awake for longer and thus sleep for fewer hours (Gamble et al., 2014; Jenni et al., 2005). Moreover, early school start

times, less parental monitoring and greater use of electronic devices have also been found to be associated with shorter sleep durations (Bartel et al., 2015; Gamble et al., 2014).

Given the rise in sleep disturbances and self-harming behaviours during adolescence, current research suggests that there may be a relationship between sleep disturbance and self-harming behaviours. Liu and colleagues' meta-analysis of cross-sectional data revealed sleep disturbances in adolescents significantly increased the risk of suicidal ideation (OR = 2.35), plans (OR = 1.58) and attempts (OR = 1.92) (J.-W. Liu et al., 2019). Their meta-regression revealed sleep-related suicide attempts were more likely to occur in girls than in boys and a negative correlation between age and sleep-related suicide attempts (J.-W. Liu et al., 2019). Furthermore, Chiu and colleagues' meta-analysis revealed a curvilinear dose-response association between shorter sleep durations with suicidal ideation and attempts in adolescents, with 8-9 hours of sleep being associated with lower suicidal ideation and attempts (Chiu et al., 2018). Interestingly, depression did not moderate any of the associations reported in both meta-analyses (Chiu et al., 2018; J.-W. Liu et al., 2019). Moreover, cross-sectional data has generally shown that self-reported sleep disturbances (e.g. shortened sleep duration, insomnia, fatigue and nightmares) are associated with increased rates of NSSI in the adolescent population (Bandel and Brausch, 2020; Liu et al., 2017; X. Liu et al., 2019; McGlinchey et al., 2017). One longitudinal study also found that poor sleep only predicted NSSI prospectively in adolescent girls but not in boys (Lundh et al., 2013).

While the mechanisms underlying the relationship between sleep disturbances and self-harming behaviours remains unclear, many hypotheses have been proposed. Sleep loss is known to impair executive and cognitive functioning as such deficits (particularly in the areas of problem solving, impulse control and decision making) have been found in individuals who self-harm which may also be a potential risk factor for developing dysfunctional coping mechanisms such as NSSI (Bridge et al., 2012; Fernandes et al., 2021; Kearns et al., 2020;

Lundh et al., 2013). This supports existing neurobiological research demonstrating that youth with NSSI have reduced anterior cingulate cortex volumes as this area of the brain has also been linked with poor impulse control (Auerbach et al., 2021). Moreover, individuals who have attempted suicide synthesize less serotonin in the prefrontal cortex when compared to healthy controls (Leyton et al., 2006). Given the serotonergic system is most active during wakefulness and is less active during sleep, loss of sleep may lead to the dysfunction of postsynaptic serotonin receptor sensitivity and thus executive functioning which is associated with suicidal behaviours (Chiu et al., 2018). Lastly, stressful life events are associated with anxious thoughts which are thought to increase pre-sleep worry, delay bedtimes and consequently reducing sleep duration (Bartel et al., 2015; Lovato and Gradisar, 2014).

Only three studies have prospectively studied the relationship between sleep disturbances and suicidal behaviours in clinical samples with high-risk adolescents (Asarnow et al., 2020; Glenn et al., 2021; Hamilton et al., 2022). Asarnow and colleagues found self-reported sleep disturbances were contemporaneously associated with suicidal ideation and suicide attempts but not NSSI when controlled for depression in a sample of high-risk adolescents (n = 101) (Asarnow et al., 2020). They also reported that greater sleep disturbances predicted any form of self-harm (including NSSI) within a 30 day period but not over 60 or 90 days which may suggest that poor sleep may dysregulate executive functioning and lower the threshold to self-harm in the short term (Asarnow et al., 2020). After controlling for depressive symptoms, Glenn and colleagues (2021) similarly found self-reported sleep problems (e.g., longer time to fall asleep, nightmares, rumination) were associated with greater next-day suicidal thoughts in a sample of adolescents who had recently received psychiatric care (n = 48). However, this relationship was not found when comparing data collected on actigraphy (Glenn et al., 2021). In a sample of adolescents receiving outpatient care (n = 59), Hamilton and colleagues (2022) found no direct relationships between within-person sleep duration and

sleep quality fluctuations on next-day suicidal ideation (Hamilton et al., 2022). When covarying for prior-day depression, they found the occurrence and intensity of suicidal ideation was indirectly predicted by sleep duration and subjective sleep-quality via affective reactivity to interpersonal stress (Hamilton et al., 2022). However, no paper to date has investigated the link between sleep disturbance and self-harming behaviours in clinical samples of adolescents over a long-term period.

The present study aims to longitudinally evaluate the relationship between self-reported sleep disturbance, NSSI and suicide attempts in clinical adolescents engaging in risk-taking and self-harming behaviours over a one-year follow-up period, using secondary analyses from a clinical cohort study. Given the paucity of literature in this area and the high prevalence and psychiatric comorbidity of NSSI and suicide attempts in adolescents, it is important to elucidate whether sleep is a risk factor for suicide which may inform future suicide prevention strategies in high-risk adolescents. While controlling for age, sex and depressive symptoms, we hypothesized that sleep disturbance will be associated with higher rates of NSSI and suicide attempts in a clinical sample of adolescents engaging in high-risk behaviours.

Material and methods

Study sample and procedure

From June 2013 to December 2019, participants from this study were consecutively recruited from AtR!Sk (Ambulanz für Risikoverhalten und Selbstschädigung), a specialized outpatient clinic based at the University Hospital Heidelberg, Germany. The AtR!Sk clinic (Kaess et al., 2017) is a service that is designed for adolescents who engage in risk-taking (e.g. binge drinking and drug abuse) and self-harming behaviours (e.g. NSSI and suicide attempts). The AtR!Sk cohort study was approved by the Faculty of Medicine Ethics Committee at the University of Heidelberg, (IRB approval number S-449/2013).

Patients who received treatment at the AtR!Sk clinic, attended an initial appointment where a structured, diagnostic interview took place with a trained clinician. They were also required to complete several self-report questionnaires (described below), and provide basic sociodemographic data (e.g., educational level, relationship of parents). At the conclusion of the appointment, the psychologist provided a diagnosis and recommended appropriate treatment. Participants and their caregivers were then informed about the AtR!Sk cohort study and were asked to provide written consent if they were eligible and interested in participating. Participants subsequently attended follow-up appointments after one year (range 10-15 months) and completed the same interviews and questionnaires. They were also asked about the type and frequency of treatment that they were engaging in during this time.

Inclusion criteria for this study included adolescents aged 11-17 who engaged in risk-taking or self-harming behaviours. Exclusion criteria included insufficient German language skills, speech comprehension or intellectual function, current intentions to self-harm or harm others and a diagnosis of an acute psychotic disorder or bipolar disorder. A total of 627 patients consented to partaking in the AtR!Sk cohort study and completed baseline surveys. Of these,

341 participants (54%) had follow-up data, but 238 participants (38%) had completed all relevant follow-up surveys required for inclusion in the present study. On backward stepwise logistic regression (minimizing the Bayesian Information Criterion), there were no relevant group differences, except participants who only completed surveys at baseline or had incomplete data were significantly more likely to have a F9 diagnosis (behavioural and emotional disorders occurring in childhood and adolescence) according to the ICD-10 (OR=2.26, CI = [1.51, 3.38]) and were older (OR=1.32, CI = [1.16, 1.50]) than those with complete data. The variables for the sample characteristics were used as predictors.

Measures

Diagnostic Measures

The frequency of suicide attempts and NSSI over the last 12 and 6 months respectively were measured at both time points using the German version of the Self-Injurious Thoughts and Behaviours Interview (SITBI-G) (Fischer et al., 2014). NSSI was measured over a 6-month period as the prevalence of NSSI events was substantial in our sample and detecting changes in behavioural patterns would have been difficult if NSSI events were counted across the 1 year follow-up period. In contrast, the number of suicide attempts was lower and was assessed over a 12-month period to provide enough of a timeframe to detect any variances. The German version of the interview is comparable to the original version and demonstrates good psychometric properties (Fischer et al., 2014).

DSM-IV axis I and ICD-10 psychiatric disorders were assessed through the German version of the Mini International Neuropsychiatric Interview for Children and Adolescents (MINI-KID) which has demonstrated good reliability and validity (Sheehan et al., 2010). DSM-IV axis II psychiatric disorders were assessed through the German version of the Structured Clinical Interview for DSM-IV-Axis II (SCID-II; (Fydrich et al., 1997). The German version

of the SCID-II has been found to be suitable for use in adolescents (Fydrich et al., 1997; Salbach-Andrae et al., 2008).

Overall psychosocial and occupational functioning was assessed by clinicians at the end of the diagnostic interview using the Global Assessment of Functioning Scale (GAF). It is a numerical rating scale measured on Axis V of the DSM-IV that is scored between 1 and 100, where higher scores suggest better levels of current psychosocial and occupational functioning. It has been reported to have high interrater reliability and good validity (Hilsenroth et al., 2000).

Self-Report Measures

Self-reported depressive symptoms were assessed by the 26-item Depression Inventory for Children and Adolescents (DIKJ) (Stiensmeier-Pelster et al., 2000). The DIJK demonstrates excellent psychometric properties and is based off the DSM-IV criteria for depression (Stiensmeier-Pelster et al., 2000). For the present study, we used the total scores which were calculated as the sum of each 3-point, Likert scale-rated items, with a possible range from 0 to 52.

Sleep disturbances were assessed through three additional items in the validated German version of the SCL-90-R (Symptom Checklist List-90-Revised; Schmitz et al., 2000). These assess difficulty falling asleep, early morning awakening and restless or disturbed sleep on a scale of 0 (not at all) to 4 (extreme) over the last seven days. From these three items, a single latent variable was created to capture sleep disturbance overall.

Statistical Analysis

In this secondary analysis, means and standard deviations for the sample characteristics were calculated for continuous variables while the frequencies and percentages were recorded for categorical variables. Wilcoxon signed-rank tests were used to compare all psychological

variables from baseline to follow-up except for suicide attempts where mixed-effects ordered logistic regression was instead performed due to the larger number of variables. The association between sleep disturbance, NSSI, and suicide attempts was tested using two cross-lagged structural equation models, controlling for age, sex and depressive symptoms. The significance level was set to $\alpha = 0.05$. For data preparation and descriptive statistics, Stata 17.0 was used while R version 4.1.2 was used for the calculation of the structural equation models.

The first model looked the association between sleep disturbance at T0 and suicide attempts at T1 (and vice-versa). This model is depicted in Figure 1. Suicide attempts (SA) were modelled by the latent variable SA at timepoint T0 and T1. Because suicide attempts were measured as count data, we divided them into five categories (number of attempts within the past 12 months; 0, 1, 2, 3, >=4) and allowed for the construction of the latent variable SA. Sleep disturbance was modelled by the latent variable SLEEP at timepoint T0 and T1 using three indicator variables (difficulty falling asleep, early morning awakening, restless or disturbed sleep). We assumed weak measurement invariance between both timepoints and tested this using autoregressive models with and without constraints (i.e., likelihood ratio tests). We allowed the residuals between the sleep indicators to be correlated between T0 and T1. The cross-lagged model between the two latent variables at both timepoints was controlled by age, sex and depressive symptoms (total score of DIKJ) at time T0 and allowing for an autoregressive path between depression at T0 and T1. We allowed for further covariance between suicide attempts, sleep, and depression at timepoint T0. For model identification purposes, the residual error of suicide attempts at T1 was set to zero, and therefore covariance at T1 was only estimated between sleep and depression at timepoint T1. The model parameters were calculated using the weighted least squares mean and variance adjusted estimator (wlsmv) in lavaan 0.6-9 (Rosseel, 2012).

The second model determined the association between sleep disturbance at T0 and T1 with NSSI at T0 and T1, controlling for age, sex and depressive symptoms. The model is depicted in Figure 2. It has the same structure as the first model, but the latent structure of suicide attempts was replaced by NSSI which contains the log-transformed number of NSSI events within the past 12 months plus one. The addition of one circumvents numerical issues when transforming a participant who has not engaged in NSSI. The model parameters were calculated using the maximum likelihood method (mlm) in lavaan (Rosseel, 2012).

Results

In total, 238 participants met the criteria for inclusion into the study. Table 1 shows that the sample was predominantly female (n = 213, 89.5%) with the average age being 14.7 years (SD = 1.4). Table 2 reports on the sleep and psychological characteristics of the study sample. Paired t-tests revealed all three items used to assess sleep disturbance were significantly improved upon follow-up (all $p < 0.05$). At baseline, 39.5% of the sample had reported at least one suicide attempt in the past year and this dropped to 26.1% on follow-up. Mixed-effects linear regression revealed the number of suicide attempts significantly reduced at follow-up ($p < 0.001$). On average, the study sample endorsed 41.8 episodes of NSSI during the past six months at baseline which significantly dropped to 16.0 episodes at follow-up ($p < 0.001$). Depressive symptoms also improved significantly at follow-up ($p < 0.001$).

According to the ICD-10, the most prevalent psychiatric disorders in our sample included mood disorders (n = 155, 65.1%), followed by personality disorders (n = 99, 41.6%), anxiety, dissociative, stress-related and somatoform disorders (n = 83, 34.9%), behavioural and emotional disorders occurring in childhood and adolescence (n = 52, 21.8%). There was a mean of 2.2 psychiatric diagnoses per participant (SD = 1.5).

Table 1. Sample characteristics at baseline

Characteristic (n=238)	**Summary**
Age, M (SD)	14.7 (1.4)
Female sex, n (%)	213 (89.5)
School type, n (%) *	
Gymnasium	95 (40.1)
Realschule	88 (37.1)
Hauptschule	23 (9.7)
Other	31 (13.1)
Relationship of parents, n (%) *	
Live together	105 (44.3)
Separated	130 (54.9)
Unknown	2 (0.8)
Average number of psychiatric diagnoses, M (SD)	2.2 (1.5)
ICD-10 clinical diagnoses, n (%) †	
F1 - Mental and behavioural disorders due to psychoactive substance use	38 (16.0)
F3 - Mood [affective] disorders	155 (65.1)
F4 - Anxiety, dissociative, stress-related, somatoform and other nonpsychotic mental disorders	83 (34.9)
F5 - Behavioural syndromes associated with physiological disturbances and physical factors	31 (13.0)
F6 - Disorders of adult personality and behaviour	99 (41.6)
F8 - Pervasive and specific developmental disorders	1 (0.4)

F9 - Behavioural and emotional disorders with onset usually occurring in childhood and adolescence	52 (21.8)
Global Assessment of Functioning, M (SD)	49.6 (12.6)

*n=1 missing

†No participants had a diagnosis of F0 (mental disorders due to known physiological conditions), F2 (schizophrenia, schizotypal, delusional, and other non-mood psychotic disorders) or F7 (intellectual disorders) mental disorders

N.B. Gymnasium refers to the highest level/track of secondary education, Realschule is the middle level/track while Hauptschule is the lowest level/track.

Table 2. Psychological characteristics at baseline and follow-up

Characteristic	**Baseline (T0)**	**Follow-up (T1)**
Sleep disturbance, M (SD)		
Difficulty falling asleep	2.4 (1.6)	1.8 (1.5)
Restless or disturbed sleep	2.1 (1.5)	1.7 (1.5)
Early morning awakening	1.4 (1.4)	1.2 (1.4)
Suicide attempts in the past 12 months, n (%)		
0 attempts	144 (60.5)	176 (73.9)
1 attempt	53 (22.3)	40 (16.8)
2 attempts	18 (7.6)	6 (2.5)
3 attempts	9 (3.8)	4 (1.7)
4 or more attempts	14 (5.9)	12 (5.0)
NSSI in the last 6 months, M (SD), median, IQR	41.8 (47.2), 22, 60	16.0 (29.2), 3, 16
Depressive symptoms, M (SD)	28.3 (9.5)	21.9 (11.0)

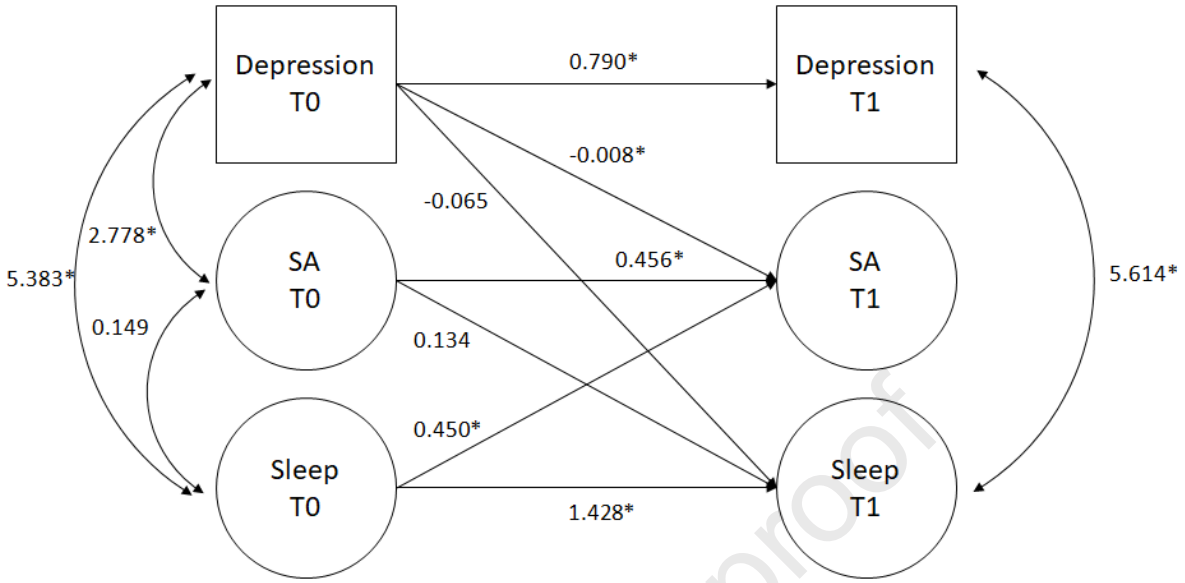
The cross-lagged model for suicide attempts in the past 12 months, sleep and depressive symptoms is reported in Table 3. As expected, all autoregressive analyses were statistically significant ($p \leq 0.001$). Suicide attempts ($p < 0.001$), sleep disturbance ($p = 0.001$) and depressive symptoms ($p = 0.015$) at baseline all predicted suicide attempts at the one-year follow-up. However, suicide attempts and depressive symptoms at baseline did not predict sleep disturbance at follow-up. The model demonstrated an acceptable goodness of fit as demonstrated in Table A of the Appendix.

Table 3. Autoregressive cross-lagged model for suicide attempts in the past 12 months, sleep and depressive symptoms, controlled by age and sex

Dependent variable	Independent variable	Estimate (SE)	z-value	p
Sleep (T1)				
	Sleep (T0)	1.428 (0.429)	3.326	0.001*
	SA (T0)	0.134 (0.155)	0.867	0.386
	Depression (T0)	-0.065 (0.035)	-1.834	0.067
SA (T1)				
	Sleep (T0)	0.450 (0.135)	3.333	0.001*
	SA (T0)	0.456 (0.083)	5.516	<0.001*
	Depression (T0)	-0.008 (0.003)	-2.421	0.015*
Depression (T1)				
	Depression (T0)	0.790 (0.113)	6.964	<0.001*

SA = suicide attempts in the past 12 months, SE = standard error, *$p < 0.05$

Figure 1. SEM for suicide attempts oriented on symbology of semPlot package.



N.B. *p < 0.05 and paths of residual covariances were omitted

The cross-lagged model for NSSI in the past six months, sleep and depressive symptoms is reported in Table 4. As expected, all autoregressive analyses were statistically significant (p < 0.001). While depression at baseline predicted frequency of NSSI at follow-up (p = 0.026), sleep disturbance did not exhibit the same relationship. NSSI and depressive symptoms at baseline also did not predict sleep disturbance at follow-up. The model also demonstrated an acceptable goodness of fit as demonstrated in Table B of the Appendix.

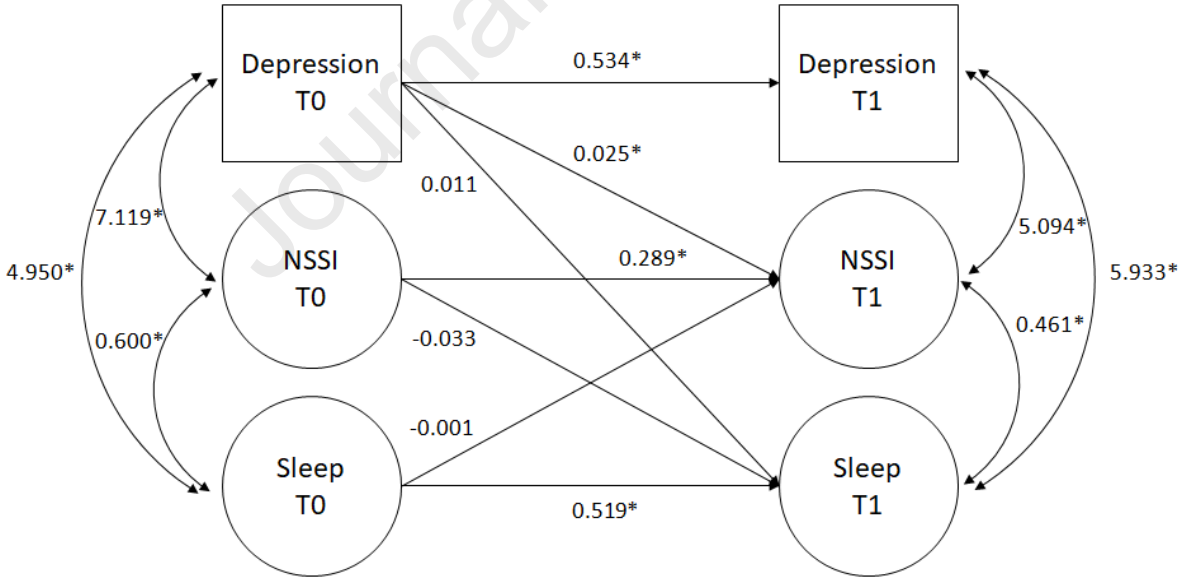
Table 4. Autoregressive cross-lagged model for nonsuicidal self-injury attempts in the past 6 months, sleep and depressive symptoms, controlled by age and sex

Dependent variable	**Independent variable**	**Estimate (SE)**	**z-value**	**p**
Sleep (T1)				
	Sleep (T0)	0.519 (0.072)	7.203	<0.001*

	NSSI (T0)	-0.033 (0.053)	-0.613	0.540
	Depression (T0)	0.011 (0.010)	1.114	0.265
NSSI (T1)				
	Sleep (T0)	-0.001 (0.085)	-0.016	0.987
	NSSI (T0)	0.289 (0.069)	4.166	<0.001*
	Depression (T0)	0.025 (0.011)	2.228	0.026*
Depression (T1)				
	Depression (T0)	0.534 (0.063)	8.484	<0.001*

NSSI = nonsuicidal self-injury attempts in the past 6 months, SE = standard error, *p < 0.05

Figure 2. SEM for log-transformed number of NSSI oriented on symbology of semPlot package.



N.B. *p < 0.05 and paths of residual covariances were omitted

Discussion

Using cross-lagged regression modelling, the present study investigated the relationships between sleep disturbance with suicide attempts and NSSI in a clinical high-risk sample of adolescents. Controlling for age, sex and depressive symptoms, we found suicide attempts after a one-year follow-up period were predicted by sleep disturbance, depressive symptoms and suicide attempts at baseline. However, our modelling found that NSSI was not predicted by sleep disturbance.

Notably, even at the one-year follow-up period where patients had received specialized psychotherapeutic treatment, 26.1% of the sample reported at least one suicide attempt in the past 12 months. This far exceeds the prevalence reported in one population-representative American sample which found 7.4% of adolescents had reported at least one suicide attempt in the preceding 12 months (Kann et al., 2018) and points to the high-risk nature of the clinical sample investigated. Episodes of NSSI amongst this clinical sample also remained high after one year of treatment. Given an estimated 70% of adolescents engaging in NSSI report at least one lifetime suicide attempt, these findings also reinforce the serious psychiatric comorbidity that high-risk adolescents encounter (Nock et al., 2006).

As hypothesized, we found that greater baseline sleep disturbances and depressive symptoms were associated with higher rates of suicide attempts on follow-up. These findings are of note, given this was assessed on three separate items assessing sleep disturbance, suggesting that greater baseline sleep disturbances may predict suicide attempts, independent of depressive symptoms. Our findings align with cross-sectional literature and one longitudinal study which found contemporaneous associations between sleep disturbance and suicide attempts as well as sleep disturbance predicting higher levels of self-harming behaviours within a thirty day follow-up period in a clinical sample of high-risk adolescents (Asarnow et

al., 2020). Our results extend from these findings and suggest that this prospective association may last for over one year, given our longer follow-up period and assessment of suicide attempts over the past 12 months. This converging evidence between sleep disturbance and suicidal behaviours (including suicidal ideation, attempts and completion) reinforces the need for clinicians to regularly assess their patients' sleep quality using validated psychometric tools (Glenn et al., 2021; Goldstein et al., 2008). While further research is needed to elucidate these underlying mechanisms, sleep disturbance in high-risk adolescents should be assessed to aid clinical decision-making for suicide risk assessment in the acute setting. Given sleep is a modifiable risk factor for suicide, further research should also evaluate interventions to help improve sleep in high-risk adolescents with sleep disturbances to develop more cost-efficient and potentially effective suicide prevention strategies that may also be more acceptable and less stigmatizing for young people.

Contrary to our hypotheses, we found higher rates of NSSI were only predicted by greater depressive symptomatology at baseline and not by sleep disturbance. Although this finding is in line with Asarnow and colleagues' (2020) study, these findings are in clear contrast with cross-sectional data which has shown that indicators for poor self-rated sleep quality (e.g. insomnia, daytime sleepiness, nightmares, fatigue and unrefreshed sleep) may be associated with increased levels of NSSI in adolescents (Liu et al., 2017; McGlinchey et al., 2017). While limited comparisons can be made with cross-sectional studies, longitudinal studies have presented more mixed findings. In one study, symptoms of insomnia were associated with NSSI after one year, but this trend was non-significant when adjusting for covariates (X. Liu et al., 2019). Notably however, this study did not measure the number of episodes of NSSI (X. Liu et al., 2019). Another study found poor sleep only predicted NSSI in adolescent girls and not boys which may be associated with the greater prevalence of females in their

sample (Lundh et al., 2013). Their findings may contrast with ours given sleep was only measured with a single item, whilst our study assessed sleep through three items.

Our study has several strengths. We used cross-lagged regression modelling to demonstrate the longitudinal relationship between sleep disturbance, NSSI and suicidal behaviours in a treatment-receiving sample over a 12-month period. We were also able to recruit a large and clinically high-risk sample and were able to collect detailed demographic and psychological characteristics using validated instruments. However, our study has a few limitations that must be noted. There was a substantial drop-out rate from the original sample who completed the baseline surveys which may affect the generalizability of our findings for high-risk adolescents who are older or may have behavioural and emotional disorders with onset in childhood and adolescence. However, it must be noted that past research has found that these groups are more likely to be lost to follow-up in outpatient mental health services (Block and Greeno, 2011; de Haan et al., 2013). We relied on a few self-report questions to assess for sleep disturbance over the past seven days, a measure that is inherently subject to recall bias and that does not capture potentially relevant indices of sleep disturbance (e.g., sleep duration, daytime sleepiness, or nightmares). Future research should employ more detailed subjective (e.g., sleep diaries) in tandem with objective as well as proximal measures of sleep quality such as actigraphy and polysomnography. Our sample was also predominantly female, though this reflects the general demographic of help-seeking individuals with self-harming behaviours. Whilst a previous meta-analysis which included cross-sectional studies and community samples found sleep-related suicide attempts were more likely in girls than in boys, these analyses could not be conducted in our sample due to the low numbers of suicide attempts reported by the small sample of male participants in our study. Further research should endeavour to recruit more males, given males are also more likely to die by suicide

than females. Lastly, we did not control for other potential confounding factors (e.g., medication use and psychiatric comorbidities).

Conclusion

In conclusion, we found greater sleep disturbance and depressive symptoms predicted higher numbers of suicide attempts in a one-year follow-up of clinical adolescents engaging in risk-taking behaviours. Moreover, we found depressive symptoms but not sleep disturbance predicted NSSI attempts at follow-up. Given the emerging and converging evidence suggesting that sleep disturbances may predict suicidal behaviours in the short term, sleep disturbances should be regularly assessed by clinicians in decision-making regarding suicide risk assessment for high-risk adolescents. Future clinical trials should consider integrating or evaluating sleep-based interventions for preventing suicide in high-risk adolescents.

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Appendix

Table A. Goodness of fit tests for Table 3

Test	**Standard**	**Robust**
Degrees of freedom	47	47
CFI	0.987	0.812
TLI	0.987	0.820
RMSEA	0.025	0.063

Table B. Goodness of fit tests for Table 4

Test	**Standard**	**Robust**
Degrees of freedom	39	39
CFI	0.956	0.963
TLI	0.926	0.938
RMSEA	0.065	0.061

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