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Original Article

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Sleep irregularity and nonsuicidal self-injurious urges and behaviors

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Abstract

Study Objectives: The objectives of this study were to examine the relationships between sleep regularity and nonsuicidal self-injury (NSSI), including lifetime NSSI history and daily NSSI urges.

Methods: Undergraduate students (*N* = 119; 18–26 years), approximately half of whom endorsed a lifetime history of repetitive NSSI, completed a 10-day actigraphy and ecological momentary assessment (EMA) protocol. A Sleep Regularity Index was calculated for all participants using scored epoch by epoch data to capture rapid changes in sleep schedules. Participants responded to EMA prompts assessing NSSI urge severity and negative affect three times daily over the 10-day assessment period.

Results: Results indicate that individuals with a repetitive NSSI history were more likely to experience sleep irregularity than those without a history of NSSI. Findings also suggest that sleep irregularity was associated with more intense urges to engage in NSSI on a daily basis, even after accounting for average daily sleep duration, sleep timing, negative affect, and NSSI history. Neither sleep duration nor sleep timing was associated with NSSI history nor daily NSSI urge intensity.

Conclusions: Findings suggest that sleep irregularity is linked with NSSI, including NSSI history and intensity of urges to engage in NSSI. The present study not only supports the growing evidence linking sleep disturbance with the risk for self-injury but also demonstrates this relationship using actigraphy and real-time assessments of NSSI urge severity. Findings highlight the importance of delineating the nuances in sleep irregularity that are proximally associated with NSSI risk and identifying targets for intervention.

Statement of Significance

The present study builds on evidence that sleep disturbance is associated with risk for nonsuicidal self-injury (NSSI). Findings suggest that sleep irregularity is associated with a history of NSSI as well as the severity of NSSI urges. The study adds to the literature based on its use of ecological momentary assessment methods as well as a novel actigraphy-based assessment of sleep regularity allowing for the capture of all sources of irregularity including changes in napping, night waking, sleep timing, and sleep duration. Future prospective research is needed to confirm the present findings and also should explore potential mechanisms, such as emotion dysregulation, underlying the association between sleep irregularity and NSSI.

Key words: nonsuicidal self-injury; nonsuicidal self-injury urges; self-harm; sleep regularity; sleep dysregulation; sleep disturbance; sleep problems; actigraphy; ecological momentary assessment

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Introduction

Nonsuicidal self-injury (NSSI) is the deliberate, self-inflicted damage of body tissue without suicidal intent and for purposes not socially or culturally sanctioned [1]. It is a growing public health problem among adolescents and young adults, with NSSI engagement becoming increasingly common [2–4]. NSSI behaviors often are preceded by urges or thoughts about NSSI [5]. Engagement in NSSI is associated with poor mental health outcomes, distress, and stigma [6, 7]. Critically, NSSI engagement predicts the future occurrence of both suicidal thoughts and behavior [8, 9]. Thus, identifying *modifiable* risk factors for NSSI is needed to prevent both nonsuicidal and suicidal self-injury.

One promising modifiable risk factor for NSSI is sleep disturbance. A small, but growing body of research suggests that sleep disturbance is associated with and prospectively predicts NSSI engagement [10–12]. Although most literature has focused on short sleep duration and insomnia symptoms in relation to NSSI [11, 13–15], sleep irregularity may be particularly important to consider in health risk behaviors such as NSSI [16]. Sleep regularity is defined as the extent to which individuals have consistent sleep/wake timing across days (i.e. *intra*individual sleep variability [17, 18]). Irregular sleep patterns are associated with short sleep, circadian misalignment, and poorer sleep quality [19], all of which have been associated with self-injury-related outcomes [20, 21]. One type of irregular sleep, the weekend-weekday difference or social jetlag, has been examined and linked to NSSI [15]. In addition, greater variability in *daily* sleep patterns across the entire week or longer periods of time have been associated with both poor physical and mental health outcomes [22], and may indicate a more chronic state of sleep variability.

Research examining sleep disturbances and NSSI is limited. Nearly all the research on this topic has relied exclusively on self-report measures to assess sleep and has employed designs that are either cross-sectional or longitudinal with recall periods spanning multiple weeks, months, or years [11, 12, 14, 23, 24]. Whereas self-report measures provide insight about perceptions of sleep quality, sleep difficulties, and insomnia symptoms, they only are modestly correlated with objectively-measured sleep [25, 26]. Furthermore, although sleep disturbance is thought to be a proximal predictor of NSSI risk, to our knowledge no study has examined these proximal relationships or evaluated regularity using more objective sleep methods. Intensive monitoring designs paired with actigraphy provide the opportunity to examine the relationships between sleep and NSSI in a shorter time interval while capturing the occurrence and intensity of NSSI urges as they unfold on a day-to-day basis.

Current study

This is the first study to use an intensive monitoring design paired with actigraphy to examine the relationship between sleep regularity and NSSI, including lifetime NSSI history and daily NSSI urges. Building on prior research, the current study aimed to examine differences in actigraphy-measured sleep irregularity between individuals with and without a history of repetitive NSSI. Further, the current study aimed to provide a more granular assessment of the relationship between sleep irregularity and daily NSSI urges assessed using ecological momentary assessment (EMA). Based on prior research examining sleep and NSSI [15], it was expected that individuals with greater actigraphy-measured sleep irregularity would have a greater likelihood of endorsing a history of NSSI and would experience greater severity of NSSI urges over a 10-day EMA period. Furthermore, we conducted exploratory follow-up analyses to examine if associations between actigraphy-measured sleep irregularity and daily NSSI urge severity differed between individuals with and without a history of NSSI.

Methods

Participants

The current study sample was drawn from a sample of 123 undergraduate students at a northeastern urban university. Individuals were recruited into two groups—those with a lifetime history of repetitive NSSI (NSSI+; n = 64) and those without a lifetime history of engagement in NSSI (NSSI–; n = 59). The inclusion criteria for the NSSI+ group was a minimum of two lifetimes NSSI acts as assessed by self-report and a clinician-rated interview. We chose a history of at least two lifetime acts to recruit participants with a repetitive self-injury history, rather than participants who may have only engaged in NSSI once experimentally and decided not to continue. Inclusion criteria also comprised: access to a smartphone, fluency in English, and normal or corrected vision for participants to perform computer-based cognitive tasks for larger study aims.

Only participants who had complete actigraphy data (n = 119) were included in the present study (a total of 62 NSSI+ and 57 NSSI– participants). Included participants were between the ages of 18–26 (M = 19.87 years; SD = 1.75) and the majority identified as female (n = 106; 89.1%). The racial composition of the sample identified as White (n = 76; 63.9%), Asian (n = 18; 15.1%), Black (n = 8; 6.7%), multiracial (n = 6; 5.0%), other (n = 10; 8.4%), and one participant preferred not to answer (0.8%). Approximately 8.4% (n = 10) of the sample identified as Hispanic. Participants identified as heterosexual (n = 89, 74.8%), bisexual (n = 21, 17.6%), lesbian, gay, or homosexual (n = 2, 1.7%) and other (n = 7, 5.9%).

Procedure

Screener. Participants were recruited from psychology classes utilizing the university's online research portal and in-person advertisements. Interested individuals were provided access to an online consent form and a brief questionnaire on the survey system, Qualtrics, to assess the history of NSSI (Deliberate Self-Harm Inventory [27], modified to assess self-injurious behaviors without suicidal intent) to determine potential study eligibility. Eligible individuals were invited to schedule an in-person session.

At the in-person session, participants provided informed consent and completed a clinician-administered interview to confirm inclusion criteria. After the in-person session, participants were trained on the ambulatory protocol, including procedures associated with wearing Actiwatches (Philips Healthcare, Bend, OR) and completing morning daily sleep and EMA surveys. A sample EMA survey was administered to ensure that participants understood the survey format and terminology. Research staff confirmed that participants accurately understood the meaning of NSSI and NSSI urges.

Participants then completed a 10-day ambulatory protocol that was initiated immediately after the in-person assessment. There were three main components of the ambulatory portion of the study: (1) daily morning survey, (2) EMA protocol, and (3) actigraphy protocol. On the first day following the in-person session, participants began receiving four links to surveys per day. The morning survey was sent to all participants at 8:00 am and included questions regarding participants' prior night's sleep; participants were able to complete this survey at any time within the day it was sent. Three questionnaire links then were sent throughout the day with identical signal-contingent questionnaires (e.g. questionnaires that use a signal, such as text message, to alert participants to respond to surveys). The scheduling of the signal-contingent questionnaires was randomized throughout a 12-hour period chosen by the participant (e.g. 10 am–10 pm). The participant received one survey at any point within three, evenly spaced 4-hour blocks across the 12-hour period. The distribution of surveys was engineered to ensure that any two surveys were not received within 90 min of each other. To encourage EMA compliance, participants were offered $15 or one additional course credit for completing 85% of the surveys within 30 min of receipt. To incentivize compliance for wearing the Actiwatches, after study participation, participants were given an automated report of their sleep data generated by the Actiwatch software. This research was approved by the university's Institutional Review Board.

Measures

Lifetime history of NSSI. The Self-Injurious Thoughts and Behaviors Interview (SITBI [28]) is a structured interview that assesses the presence, frequency, and characteristics of a wide range of self-injurious thoughts and behaviors, including NSSI, suicidal ideation, suicide plans, suicide gestures, and suicide attempts. This interview has been used in various clinical and nonclinical settings and has demonstrated strong psychometric properties [28]. The SITBI has demonstrated inter-rater reliability ($K = 0.99$), construct validity, and test-retest reliability ($K = 0.70$) [28]. In the present study, the SITBI was employed to measure history of NSSI to ensure correct group classification of study participants.

Ambulatory protocol

Momentary NSSI urge severity. The signal contingent surveys included prompts that measured the severity of NSSI urges in real-time. Each survey sent over the 10-day ambulatory assessment period asked participants to report the intensity of their urge to engage in NSSI "right now" on a Likert scale ranging from 0 (*none at all*) to 9 (*very intense*). Participants' daily maximum value was used to reflect daily maximum NSSI urge severity.

Momentary negative affect. The signal contingent surveys included questions that measured negative affect. Participants were asked to respond to the prompt, "Right now, to what extent are you feeling…" in the context of three negative affect-related states: "sad," "lonely," and "hopeless." Participants rated each item on a Likert scale from 0 (*not at all*) to 9 (*very much*) with higher scores indicating greater levels of negative affect. The sum of the three items generated a total score at each momentary assessment. Using this momentary sum, we additionally calculated daily averages within each person.

Self-reported sleep. The daily sleep survey inquired about sleep information from the night prior. The sleep diary asked participants what time they got into bed to go to sleep, what time they fell asleep, what time they woke up in the morning, and what time they got out of bed. These variables were used to assist with processing the actigraphy data.

Actigraphy. Actiwatches (Philips Healthcare, Bend, OR) were employed to objectively and reliably assess sleep irregularity through actigraphy. The Actiwatches sampled data in 1-minute epochs and stored the data digitally in the device. Research suggests that actigraphy is highly correlated with the field's gold standard measure of sleep, polysomnography [29]. Participants were instructed to wear the Actiwatch on their nondominant wrist for the entirety of a period of 10-days following the baseline assessment period (removing it only when it would get wet; e.g. when showering). Actigraphy scoring included verifying data against self-reported sleep diaries and utilizing the Cole-Kripke scoring algorithm [30]. Actigraphy data starting at 12:00 on the first day and ending at 12:00 on the eleventh day (capturing 10 nights of sleep) was used in the analysis. The current study utilized the following sleep variables generated by the Actiwatch software: sleep timing (onset of sleep) and sleep duration (duration of time between participants' main period of sleep onset and offset, after subtracting wake time after sleep onset). The Sleep Regularity Index (SRI [19]) was calculated using scored epoch by epoch data. The SRI was designed to capture rapid changes in sleep schedules by comparing one day's sleep to the previous and captures all sources of irregularity including changes in napping, night waking, sleep timing, and sleep duration. The index is a percentage probability of being in the same state (sleep vs. wake) at the same time from one day to the next. The index is scaled so that 1 indicates perfect alignment of sleep and wake epochs between days with 0 indicating a random pattern. The algorithm coded a within-person vector of epochs as 1 for wake and −1 for sleep, multiplied this vector by a 24-hour lagged vector, averaged the product across epochs and days. Missing epochs were handled by listwise deletion of the product if either the epoch or the lagged 24-hour epoch was missing.

Data analysis

All analyses were performed on the full analytic sample to provide representation of NSSI and sleep patterns in both NSSI+ and NSSI− groups. There were 1132 of 1190 days of data (4.87% missing) nested within 119 participants. Nesting was accounted for by first aggregating data within each day using the maximum value for NSSI urge severity and the average value for negative affect. Nesting of days within participant was addressed by either averaging across the 10 days within each person using observed data and assuming missing completely at random, or through generalized linear mixed effect models that assumes missing at random for missing data on the dependent variable.

We employed independent samples *t*-tests to examine whether there were differences between NSSI+ and NSSI− groups on SRI and sleep duration averaged across the 10 days of actigraphy. Generalized linear mixed effect models with a log link and Poisson distribution were used to account for nesting of days within-participant and examine whether SRI averaged across the 10 days was associated with daily maximum NSSI urge severity. To isolate the effects of sleep regularity on daily NSSI urges, the

Table 1. Means, standard deviations, and correlations with confidence intervals

Variable	*M*	*SD*	1	2	3	4
1. SRI	0.76	0.10				
2. Sleep duration	389.77	52.00	0.32** [0.15 to 0.47]			
3. Sleep timing	25.19	1.48	−0.41** [−0.55 to −0.25]	−0.32** [−0.47 to −0.15]		
4. Max daily NSSI urge	0.28	0.87	−0.26** [−0.42 to −0.08]	0.21* [0.03 to 0.38]	0.03 [−0.15 to 0.21]	
5. Mean daily NA	4.31	4.67	−0.30** [−0.46 to −0.13]	0.04 [−0.14 to 0.22]	0.12 [−0.07 to 0.29]	0.60** [0.47 to 0.70]

All values were averaged across the 10 days of assessment. *M* and *SD* are used to represent mean and standard deviation, respectively. Values in square brackets indicate the 95% confidence interval for each correlation. The confidence interval is a plausible range of population correlations that could have caused the sample correlation [50]. NA, negative affect; SRI, Sleep Regularity Index.
*$p < .05$; **$p < .01$.

model included as time-invariant fixed effects average sleep duration across the 10 days and average daily timing of sleep onset from the night before the report of NSSI urge severity across the 10 days. Given the well-established association between negative affect and both sleep and NSSI [11, 31], a time-varying fixed effect daily average of negative affect also was included. Group (NSSI+ vs. NSSI−) was included as a time-invariant fixed effect. Participant level random intercepts were included for all models. To aid in interpretation, sleep duration and timing were scaled to 15-minute intervals and SRI was z-scored. Parameters then were reverse transformed to the metric of rate ratios. For our exploratory analyses to examine whether the relationship between SRI and daily maximum severity NSSI urges differed across participants with and without a history of NSSI, we ran an additional model that included the interaction between SRI and lifetime history of NSSI as a fixed effect.

Results

Among the NSSI+ group, participants reported engaging in 2–720 lifetime acts of NSSI ($M = 53.13$; $SD = 125.61$), employing an average of 1.93 methods ($SD = 1.08$). Approximately 41.94% ($n = 26$) of the NSSI+ sample endorsed engaging in NSSI over the prior year and 19.35% ($n = 12$) over the prior month.

There was excellent participant compliance with actigraphy and sleep diary procedures. Participants wore their Actiwatch an average of 9.49 out of 10 days and completed an average of 9.3 out of 10 sleep diaries. The NSSI+ and NSSI− groups did not differ significantly in their compliance with wearing the Actiwatch ($t(117) = -1.29$, $p > .05$) or with completing the sleep diaries ($t(117) = 0.66$, $p > .05$). See Table 1 for study variable correlations.

There were no differences in sleep duration between the NSSI+ and NSSI− group (NSSI+: 391.71 [*SD* = 52.03]; NSSI−: 387.66 min [*SD* = 52.34]; $t[117] = -0.42$, $p = .67$). There also were no differences in sleep timing between the NSSI+ and NSSI− group (NSSI+: 1:10 am [*SD* = 2.49]; NSSI−: 12:48 am [*SD* = 1.69]; $t[112] = -0.91$, $p = .10$). There was a significant difference between the groups in sleep regularity, such that NSSI+ participants evidenced significantly greater variation in their sleep duration across the 10 days of study (NSSI+: 0.73 [*SD* = 0.95]; NSSI−: 0.78 [*SD* = 0.97]; $t[117] = 2.73$, $p < .01$).

Generalized linear mixed effect models

Findings indicated that greater sleep irregularity across the 10 days predicted greater daily NSSI urge severity, even after controlling for sleep duration, sleep timing, and negative affect (Table 2). Sleep duration and timing were not significantly predictive of greater daily NSSI urge severity; however, group status (history of NSSI) and daily mean negative affect significantly predicted greater daily NSSI urge severity. Moderation analyses indicated that history of NSSI behavior did not moderate the association between SRI and daily NSSI urges (Est = 0.38, $p = .502$).

Discussion

The current study examined the relationship between sleep regularity and NSSI lifetime history and daily urges among young adults. Results indicated that individuals with a repetitive NSSI history were more likely to experience sleep irregularity, as derived by actigraphy, and that sleep irregularity also predicted more intense urges to engage in NSSI on a daily basis over a 10-day period. Lifetime NSSI history did not moderate the association between sleep irregularity and severity of daily NSSI urges, suggesting that sleep regularity may be a relevant risk factor for future NSSI urges, and, in turn, NSSI behavior, regardless of prior engagement.

Importantly, sleep regularity predicted daily NSSI urge severity controlling for average sleep duration, average timing of sleep onset, and daily mean negative affect, which suggests that sleep irregularity may offer both salient and unique information about individual differences in NSSI risk. Further, average sleep duration *was not* related to NSSI history or daily NSSI urge severity in the current study, indicating that it may be the *irregularity* of one's sleep/wake cycle that may put individuals at greater risk for NSSI thoughts and behaviors and, in turn, potentially even future suicidal thoughts and behaviors [9]. Indeed, recent research points to sleep irregularity as a key dimension of sleep that is associated with circadian rhythm disturbance and poor health outcomes [17, 18, 22], including NSSI [9].

Our results are consistent with prior research using self-reported and cross-sectional methods documenting the association between sleep/wake cycle irregularity and self-injurious behaviors [32]. However, our study extends prior research by examining irregularity using actigraphy, evaluating NSSI urges in a more fine-grained way using EMA throughout a 10-day period, and examining individuals with and without a lifetime history of repetitive NSSI. The wrist Actiwatches employed in this study to capture sleep/wake cycle are considered to be the gold standard for wearable devices and have been validated by polysomnography [29]. Participant compliance with completing sleep diaries and wearing the Actiwatches over the 10-day assessment period was notably high. Further, our measure of sleep regularity, the SRI, is highly granular, assessing sleep/wake regularity epoch by epoch,

Table 2. Association between the Sleep Regularity Index and daily NSSI urges

	Estimate	SE	Rate ratio	95% CI
(Intercept)	−5.85***	0.86	0.00	0.00 to 0.02
Sleep duration	0.05	0.08	1.05	0.90 to 1.24
Sleep timing	−0.08	0.05	0.92	0.84 to 1.01
Group	2.98***	0.71	19.69	4.89 to 79.27
Mean daily NA	0.12***	0.01	1.13	1.10 to 1.16
SRI	−0.54*	0.27	0.58	0.34 to 0.99
Random intercept	3.97 (1.99)			
Observations	1132			
Log-likelihood	−434.22			

Sleep duration and sleep timing were scaled to facilitate interpretation by 15 min periods and SRI was z-scored. NA, negative affect; SRI, Sleep Regularity Index; CI, confidence interval.
*$p < .05$; **$p < .01$; *** $p < .001$.

and summarizing multiple sources of regularity including sleep timing, duration, night awakenings, napping, and social jet lag.

Future prospective research is needed to confirm the present findings and also should explore potential mechanisms underlying the association between sleep irregularity and NSSI. Several theories of the etiology of NSSI, including the Benefits and Barriers Model, the Cognitive and Emotion Regulation Model, and the Four Function Model of NSSI, converge in suggesting that NSSI is often reinforced through its ability to alleviate aversive emotional states [33–35]. Thus, although candidate mechanisms are numerous (e.g. cognitive, affective, biological), one particularly compelling candidate is emotion dysregulation. It is possible that sleep irregularity may tax emotion regulation abilities, which in turn, may increase risk for the aversive emotional states that prompt NSSI [36, 37]. Reduced emotion regulation also may generate or exacerbate interpersonal stress, another well-established proximal predictor of NSSI risk [38, 39]. Research suggests that the relationship between sleep disturbance and emotion dysregulation, and between NSSI and emotion dysregulation may be bidirectional [40–42] suggesting the potential for a pernicious cycle that serves to maintain NSSI.

Although the current study had many strengths, there are notable limitations. Specifically, the SRI incorporates data from sleep/wake behaviors over the full 10-day period, which is used to predict daily urges over this same period. Thus, our findings are unable to shed light on the temporal relations between sleep irregularity and NSSI urges. Future studies that use longer assessment periods and intensive longitudinal designs may be well-suited to better tease apart the predictive relationship between sleep regularity and future NSSI urges and behaviors. In addition, there was considerable heterogeneity of past NSSI engagement among individuals with a lifetime history of NSSI, including frequency, severity, and recency. It is possible that the heterogeneity in NSSI among our NSSI+ subsample may have influenced our null moderation findings. Thus, it will be critical to evaluate sleep regularity and additional sleep-wake dimensions as predictors of future NSSI urges and behaviors among a sample with active and more frequent/severe NSSI engagement to ascertain whether findings replicate in this population. Furthermore, the majority of our sample identified as female, limiting the generalizability of our findings and necessitating replication. Indeed, prior research has found that sleep disturbance is predictive of NSSI only among females, and not among males [43]; whether our findings would replicate in a more gender diverse sample is currently unclear. Finally, although our study evaluated lifetime NSSI behaviors, there was a limited occurrence of NSSI behaviors in the 10-day period, which precluded the evaluation of sleep irregularity as a predictor of NSSI behaviors beyond lifetime history. However, given that NSSI urges prospectively predict future NSSI behaviors [5, 44–47], our finding that sleep irregularity is associated with more severe NSSI urges may indicate a critical point of intervention and prevention of NSSI behaviors.

Clinical implications

If replicated in a prospective design, the current findings suggest a significant relationship between sleep irregularity and NSSI that highlights the potential utility of integrating sleep irregularity in clinical assessments of risk factors for self-injury. For example, a core component of dialectical behavioral therapy, a primary treatment modality for reducing self-injury, includes the daily tracking of interpersonal stressors and problem behaviors [48]. Our work indicates that including daily sleep patterns in such logs may be helpful in assessing an individual's risk profile. Additionally, if sleep irregularity is found to be a prospective predictor of NSSI urges and/or behavior, there may be important implications for novel and low-burden interventions. Sleep hygiene protocols with psychoeducation highlighting the importance of sleep regularity paired with light interventions to correct delayed circadian rhythm [19] may aid individuals at risk for NSSI. Clinicians also may consider a course of cognitive-behavioral therapy for insomnia as a tool for increasing sleep regularity and potentially protecting against self-injury risk [49].

The present study supports the growing evidence linking sleep disturbance with the risk for self-injury. It expands upon prior studies by confirming this relationship with an objective measure of sleep (i.e. actigraphy) and real-time assessments of NSSI urge severity. This study is an important step toward identifying the nuances in sleep irregularity that are proximally associated with NSSI risk. Continuing to identify modifiable risk factors for NSSI is necessary for increasing the efficacy of treatments and reducing the personal and societal burden of self-injury.

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Disclosure Statement

None declared.

Data Availability

The data underlying this article will be shared on reasonable request to the corresponding author.

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