The impact of homeostatic and circadian sleep processes on non-suicidal self-injury and suicide urges in borderline personality disorder

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Ethical statement: This work received approval from all relevant institutional research boards. All participants provided informed consent prior to participation.

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Abstract

Objective: Borderline Personality Disorder (BPD) involves high rates of non-suicidal self-injury (NSSI) and suicidal behaviours, which are often preceded by urges. Disrupted sleep processes have been linked to NSSI and suicidal behaviours. However, it is unclear which specific sleep processes influence NSSI and suicide urges at rest (i.e., baseline) or in response to distress (i.e., reactivity) in BPD, and thus require targeting in BPD-specific interventions. This study examined whether two distinct homeostatic sleep processes (i.e., total sleep time [TST] and time in bed [TIB]), and one circadian sleep process (i.e., chronotype, or tendencies towards early versus late bed and risetimes) predict baseline NSSI and suicide urges and urge reactivity in BPD.

Methods: Forty adults with BPD completed a seven-day sleep diary to measure average TST and TIB. They then completed a questionnaire to measure chronotype and underwent an experiment wherein they rated NSSI and suicide urges at baseline and following an emotion induction.

Results: Generalized estimating equations revealed that higher TST was associated with lower baseline NSSI urges, and lower suicide urge reactivity. Additionally, higher TIB predicted higher NSSI urge reactivity.

Conclusions: Sleep deprivation and extended time in bed may increase proclivity towards NSSI and/or suicide. Targeting these variables in BPD interventions may ultimately facilitate the reduction of NSSI and suicidal acts.

Keywords: Borderline personality disorder; suicide; non-suicidal self-injury; sleep; circadian
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Highlights:
- Higher total sleep time predicts lower baseline NSSI urges, suicide urge reactivity
- Higher time in bed predicts higher NSSI urge reactivity
- Reducing sleep deprivation in BPD may facilitate reductions in suicide, NSSI urges

Biographical Note:

Skye Fitzpatrick: Dr. Skye Fitzpatrick is an Assistant Professor in the Department of Psychology at York University. Her current research focuses on identifying ways to optimize, expedite, and broaden access to borderline personality disorder (BPD) and posttraumatic stress disorder (PTSD) treatments on their own and as they co-occur, including the identification of clinical targets that influence core components of these problems. In the interest of optimizing and expediting BPD and PTSD treatments, Dr. Fitzpatrick has become particularly focused on harnessing the power of relationships through the development and study of conjoint or dyadic interventions. In the interest of broadening access to BPD and PTSD interventions, she has become interested in developing and studying online, remote-delivered, and brief interventions.

Sonya Varma: Ms. Sonya Varma is a graduate student in the clinical psychology program at York University, under the supervision of Dr. Skye Fitzpatrick. She has significant experience in clinical trial research study design, coordination, and implementation for those with Borderline Personality Disorder (BPD), and recently with Posttraumatic Stress Disorder (PTSD). Ms. Varma’s research is focused on better understanding BPD pathology and identifying various ways to optimize BPD interventions. She is interested in studying the therapeutic alliance and rupture repair processes in Dialectical Behaviour Therapy, as well as more broadly elucidating the various ways trauma-related experiences (e.g., Posttraumatic Stress Disorder, childhood trauma), emotion dysregulation, and interpersonal problems impact BPD pathology and treatment outcomes.

Jennifer Ip: Ms. Jennifer Ip is a graduate student in the clinical psychology program at Ryerson University, supervised by Dr. Candice Monson. Her research is focused on understanding borderline personality disorder (BPD), posttraumatic stress disorder (PTSD), and associated clinical behaviours (e.g., non-suicidal self-injury; suicidal ideation, urges, and behaviours; interpersonal detachment and conflict). She is particularly interested in using quantitative and qualitative methods to elucidate mechanisms of treatment for BPD and PTSD and identify ways to enhance existing interventions.
The impact of homeostatic and circadian sleep processes on non-suicidal self-injury and suicide urges in borderline personality disorder

Approximately 50-84% of individuals with borderline personality disorder (BPD) engage in non-suicidal self-injury (NSSI) or suicidal behavior (Chapman et al., 2005; Soloff et al., 1994), which are often precipitated by urges to engage in them (Ammerman et al., 2017). Accordingly, BPD involves heightened NSSI and suicide urges at baseline (e.g., Stanley et al., 2007), and increases in them in response to distress (i.e., NSSI and suicide urge reactivity; e.g., Sauer et al., 2014; Abdul-Hamid et al., 2014). Reducing NSSI and suicide in BPD requires identifying and targeting modifiable variables that influence urges to engage in them. Thus, this study examined whether sleep processes predict NSSI and suicide baseline urges and urge reactivity (collectively referred to as “urges”) in BPD.

Sleep, NSSI, and Suicide in BPD

A primary function of NSSI and suicidal behavior is reducing negative emotion (e.g., Chapman et al., 2006; Klonsky, 2007; Nock & Prinstein, 2004). This may be particularly relevant in BPD, which is characterized by elevated baseline negative emotion (e.g., Kuo et al., 2016; Gratz et al., 2010), and heightened emotional reactivity (i.e., larger increases in emotion; Linehan, 1993) in response to specific stressors (e.g., Chapman et al., 2015; Gratz et al., 2019; Rosenthal et al., 2016). Given the emotion regulatory functions of NSSI and suicidal behavior, their urges may both occur at baseline (i.e., in the absence of emotionally-evocative stimuli) and rise following emotional provocations in BPD. Such elevations may be exacerbated by disrupted sleep, which diminishes emotion regulation and urge inhibition (e.g., Klumpp et al., 2018; Dahl & Lewin, 2008). Although work examining links between sleep and urges is limited, general sleep problems (e.g., insomnia severity) are associated with NSSI and suicidal thoughts and
behaviors across healthy and clinical groups (e.g., Chu et al., 2018; Fekih-Romdhane et al., 2018; Mirsu-Paun et al., 2017). It remains unclear which specific sleep problems are associated with urges in BPD.

**Homeostatic Sleep Processes**

Sleep involves two opposing processes. Homeostatic processes involve accumulating sleep drive during wakefulness, leading to restorative sleep, and circadian processes regulate the timing of wakefulness and sleep (Borbély, 1982; Webb, 1988). Homeostatic processes can be disrupted through (a) total sleep time (TST); or (b) unnecessarily extending time spent in bed (TIB), resulting in less efficient sleep, decreased signals that promote restorative sleep, and conditioned associations between alertness and sleep stimuli (e.g., the bed; Edinger & Carney, 2008). TST and TIB thus both influence homeostatic sleep drive processes.

Although the relationship between TIB and urges is unclear, shorter TST is associated with greater suicidal thoughts and behavior (e.g., Ferentinos et al., 2016; Goodwin & Marusic, 2008; Littlewood et al., 2019; Mars et al., 2019; Mirsu-Paun et al., 2017; Walker et al., 2019). However, some research suggests that TST is not related to suicidal ideation (Swinkels et al., 2013), or longer TST is associated with increased NSSI or suicidal thoughts and behaviors (Agarun et al., 1997; Dahl et al., 1999). Other studies indicate that both shorter and longer TSTs predict suicidal behavior (Michaels et al., 2017; Shin et al., 2017), and meta-analysis suggests that suicidal ideation is lowest for individuals with 8-9 hours of nightly sleep (i.e., neither short nor long; Chiu et al., 2018). Thus, although short TST may be particularly predictive of elevated urges, the relationship between these variables may be curvilinear, wherein long and short TST are both problematic.
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Studies suggest that BPD involves shorter TST than healthy (e.g., Fleischer et al., 2012; Winsper et al., 2017; Oltmanns & Oltmanns, 2015), but not necessarily clinical (e.g., depression; Winsper et al., 2017), controls. As well, while adolescents with BPD may exhibit higher TIB compared to those with healthy and clinical controls (Huynh et al., 2016), adults with BPD may not (Fitzpatrick et al., 2020). TIB may be prolonged in adolescents with BPD compared to adults because adolescents may have less social and occupational demands that naturally truncate it (e.g., rising early for work or childcare). Taken together, research suggests that BPD in adulthood may therefore be characterized by lower TST and possibly higher TIB. However, the relationship between these processes and urges in BPD is unknown.

Circadian Sleep Processes

Sleep is also governed by a circadian system that regulates the timing of wakefulness and sleep (Borbély, 1982; Webb, 1988). A key component of the circadian system is sleep chronotype, wherein some individuals naturally rise earlier (morning-type chronotype) or later (evening-type chronotype; McEnany & Lee, 2000). Evening-type chronotypes are associated with more severe and frequent suicidal behaviour (Selvi et al., 2011), and increased depressive symptoms, which subsequently predict higher suicidal thoughts and behaviors (Park et al., 2018). Furthermore, individuals with bipolar I disorder with later chronotypes are more likely than those with the morning-type chronotype to exhibit current suicidal ideation and behaviour, but not number of attempts (Feki-Romdhane et al., 2019). These findings suggest that later chronotypes may predict higher urges, although extreme chronotypes in either direction may be problematic.

Though limited, some research suggests that BPD, healthy, and clinical groups do not differ in chronotypes (Bromundt et al., 2013; Fitzpatrick et al., 2020). However, other literature suggests that individuals with BPD sleep more during the day and stay up later in the evening,
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perhaps indicating evening-type chronotypes compared to other groups (Fleischer et al., 2012). Regardless, the impact of chronotype on urges in BPD is unclear.

The Present Study

In sum, the link between sleep disruptions, and NSSI and suicidal thoughts and behaviors is clear. However, it remains unclear which specific homeostatic (i.e., TST, TIB) or circadian (i.e., chronotype) processes influence urges in BPD. Furthermore, several studies examining the relationship between homeostatic and circadian processes and NSSI/suicidal thoughts and behaviors only examined linear relationships (e.g., Blasco-Fontecilla et al., 2011; Ferentinos et al., 2016; Mars et al., 2019; Mirsu-Paun et al., 2017), despite research indicating that such relationships may be curvilinear (e.g., Czyz et al., 2019, Michaels et al., 2017; Shin et al., 2017; Chiu et al., 2018; Selvi et al., 2011). Additionally, up to 83% of individuals with BPD also have depression (e.g., Shah & Zanarini, 2018; Zanarini et al., 1998). Given this high rate of comorbidity, and that sleep problems are a defining feature of depression (APA, 2013), depressive symptoms may obfuscate whether and which sleep processes are predictive of urges in BPD. Identifying which specific sleep processes influence these variables could illuminate key sleep targets for NSSI and suicide interventions in BPD.

The present study therefore utilized a combination of daily diary and experimental methods to examine whether homeostatic (TST, TIB) and circadian (chronotype) sleep processes predict NSSI and suicide urges at baseline and in response to an emotional stressor (i.e., urge reactivity) in BPD in both linear and curvilinear ways, covarying for depressive symptoms. We hypothesized that those with higher TST, lower TIB, and earlier chronotypes, would exhibit lower NSSI and suicide baseline urges and urge reactivity.

Materials and Methods
Data for the present work were collected in a parent study that involved the administration of a consensus sleep diary (CSD; Carney et al., 2012) for seven days prior to an in-person experiment (Fitzpatrick et al., 2020). The experiment involved examining changes in emotion processes and urges across varying experimental trials detailed below (Fitzpatrick et al., in press). Full details regarding study methodology are in the parent study, and are briefly described below.

**Participants**

Forty individuals with BPD between 18 to 60 years old were recruited via online and flier advertisements (see Table 1 for main demographic information). As the parent study involved psychophysiology (e.g., Fitzpatrick et al., in press), prospective participants were excluded if they took scheduled medications that interfered with psychophysiology such as any psychiatric medications other than selective serotonin reuptake inhibitors and beta-blockers. They were also excluded if they had comorbid medical conditions likely to interfere with psychophysiological recording or task participation including epilepsy, cardiac conditions, or current diagnoses of Bipolar I disorder, a severe psychotic disorder, or substance/alcohol dependence.

**Measures**

**Psychodiagnostic interviews**

The *International Personality Disorders Examination-BPD Module* (IPDE-BPD; Loranger et al., 1994) was administered to assess for study eligibility and the presence of BPD. The *Structured Clinical Interview for Diagnostic and Statistical Manual of Mental Disorders-IV-TR* (SCID-IV-TR; First et al., 1995) was used to assess for the presence of other psychiatric diagnoses. Assessors were trained to reliably administer these interviews with a gold standard
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assessor (average prevalence-adjusted bias-adjusted kappas (Byrt et al., 1993) were .95 for the IPDE-BPD and .97 for the SCID-IV-TR (.67 to 1 across modules)).

Sleep Predictors

TST and TIB were measured via the CSD (Carney et al., 2012): a daily log that participants are asked to complete upon waking about their past night of sleep. It asks about several sleep parameters (e.g., time got into bed, time tried to fall asleep, length of time to fall asleep). TST is computed as the length of time between falling asleep and waking up, minus the duration of awakenings. TIB is computed as the time participants got out of bed minus the time they got into bed. In the parent study (Fitzpatrick et al., 2020), the CSD was administered for the seven days immediately prior to the experiment, and seven days after it. However, only data from the week before the experiment was used for the present study, and a week of recording sleep parameters via sleep diaries is usually sufficient for stable and reliable estimates (Wohlgemuth et al., 1999). TST and TIB from the first and second week were also not significantly different (ps range from .17 to .86).

Chronotype was assessed via the Morningness-Eveningness Questionnaire (Horne & Östberg, 1976), which is a 19-item questionnaire that assesses the extent to which participant’s experiences indicate a proclivity towards “morningness” (higher scores) or “eveningness” (lower scores) (Horne & Östberg, 1976). Its Cronbach alpha was .85.

Depression

Depression symptoms were measured as a covariate via the Depression subscale of the Depression, Anxiety, and Stress Scales (Lovibond & Lovibond, 1995). Its Cronbach alpha was .96.

NSSI and Suicide Urges
NSSI and suicide urges were measured via two items on a visual analogue scale administered repeatedly throughout the experiment (i.e., after completion of the CSD). Participants were presented with the prompt “How do you feel right now, at the present moment?” and independently asked to rate their current urges to attempt suicide and NSSI on a scale ranging from 0 (“No urges”) to 100 (“Very strong urges”). Visual analogue scales are a reliable and valid way of measuring internal experiences (McCormack et al., 1988).

**Procedures**

Full study procedures are described elsewhere (Fitzpatrick et al., in press) and were approved by relevant institutional review boards. Prospective participants completed phone or online screening and, if potentially eligible, were invited for in-person psychodiagnostic interviews. Eligible participants were scheduled for the experiment at least one week later and instructed in the use of the CSD, which was to be completed daily for the seven days prior to their experiment. On the experiment day, participants completed aforementioned questionnaires followed by a 10-minute baseline (not examined here). They then began the experiment, which was a within-subjects design with three trials. Each trial had four phases, two of which are relevant to the present study. In the baseline phase, participants sat quietly in front of a computer without any stimuli being presented on it for five minutes. After this phase, in the induction phase, participants listed to an auditory story designed to elicit negative emotion for ~two minutes and were asked to imagine themselves as the story protagonist. These stories were developed for the parent study and pilot data with a sample of undergraduates indicated that they elicited comparable general negative emotion (See [https://osf.io/cqaj2/](https://osf.io/cqaj2/) for additional information). Manipulation check analyses suggested that they elicited increases in self-reported negative emotion from baseline in those with BPD (Fitzpatrick et al., in press). Participants were
asked to rate their urges after each baseline and emotion induction phase. After the emotion induction, participants were instructed to either react as they usually would, or to attempt to change their emotions using mindfulness or distraction (data from this phase not included here, see Fitzpatrick et al., in press, for details). Participants then repeated the trials with different inductions and instructions that follow them. Order of induction presentation was counterbalanced across participants.

Data Analytic Strategy

Generalized estimating equations (GEE) analyses were run in SPSS using version 25. GEE was selected because it is a semi-parametric method that is robust to covariance structure misspecification, can examine nested data, and can retain participants with missing data using the all-available-pairs method. Four separate sets of analyses were run for baseline suicide urges, baseline NSSI urges, suicide urge reactivity, and NSSI urge reactivity outcomes. The suicide and NSSI variables across the induction and baseline were positively skewed (skew statistics = 1.95 and 1.64 respectively) and were therefore log-transformed with a base of 10 and one unit added to yield more normal distributions (skew statistics = .94 to .65), respectively.

Suicide or NSSI urges after each trial baseline were entered as outcomes for analyses examining baseline urges. Suicide or NSSI urges after each trial induction were entered as outcomes for analyses examining urge reactivity, with suicide or NSSI urges, respectively, from the trial baselines entered as covariates. In all analyses, linear TST, TIB, and chronotype variables were entered into analyses along with squared versions of each of these variables (i.e., quadratic terms) to test curvilinear effects. TST and TIB values were averaged across the week of data collection. Depression was entered as a covariate in all analyses. Three covariance structures were run for each of these analyses—exchangeable, autoregressive, and unstructured—
and the structure with the lowest Quasiliklihood under the Independence model Criterion (QIC) value was retained. We then removed the non-significant quadratic predictors within each model one at a time and retained the reduced models if their corrected Quasiliklihood under the Independence model Criterion (QICC) value was smaller than the previous model. In all except for one model, this resulted in the removal of all quadratic effects.

**Results**

Age was not significantly correlated with urges across any experimental phase (ps range from .34 to 1.00). Repeated measures ANOVAs indicated that race/ethnicity and sex did not significantly predict urges (ps range from .05 to .27). Therefore, these variables were not included as covariates.

**Baseline Urges**

Means and standard deviations for study variables are in Table 2. Tables 3 and 4 present final, reduced analyses for baseline suicide and NSSI urges. Sleep processes did not significantly predict baseline suicide urges. There was a significant quadratic, but not linear, effect of TST predicting baseline NSSI urges. To interpret this effect, we calculated the anticipated change in baseline NSSI urges when TST was set to its mean and one and two standard deviations above and below the mean (all of which were real values in the data which ranged from 2.18 hours to 11.4). Predicted values of baseline NSSI urges at varying levels of TST are depicted in Figure 1. Results indicated that the magnitude of the inverse relationship between TST and baseline NSSI urges was larger at high levels of TST than at lower levels, with the most negative slope (-.23) at least.

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1 To improve interpretability of analyses and avoid entering a categorical variable with small cell sizes into analyses, the race/ethnicity variable was collapsed into three categories: Caucasian (40%), Asian (40%), and other (20%).
2 These estimates were calculated based on this formula: \( y' = B_1 + 2 \times B_2 \times x \) wherein \( B_1 \) and \( B_2 \) reflect parameter estimates of the linear and quadratic TST effects, respectively, and \( x \) reflects the varying values of TST (UCLA Statistical Consulting Group, 2020).
the highest value of TST (10.31, 2 SDs above mean), and an increasingly less negative slope as TST decreased, culminating to a slightly positive slope (.02) when TST was 2 SDs below the mean (4.03).

**Urge Reactivity**

Tables 5 and 6 present final, reduced analyses for suicide and NSSI urge reactivity. There was a significant linear main effect of TST wherein higher TST predicted lower suicide urge reactivity. Linear and quadratic TIB and chronotype variables did not predict suicide urge reactivity. There was also a significant linear main effect of TIB predicting NSSI urge reactivity, wherein higher TIB was associated with higher NSSI urge reactivity. Linear and quadratic TST and chronotype variables, and the quadratic TIB variable, did not predict NSSI urge reactivity.

**Discussion**

This study aimed to specify the homeostatic (TST, TIB), and circadian (chronotype) sleep processes associated with suicide and NSSI urges in BPD. We hypothesized that individuals with BPD who reported higher TST, lower TIB, and the evening-type chronotype would exhibit elevated urges.

**Homeostatic Sleep Processes**

Consistent with past research (e.g., Littlewood et al., 2019; Liu et al., 2017), higher TST predicted lower baseline NSSI urges and suicide urge reactivity. The deleterious effects of low TST on negative emotion (e.g., Deliens et al., 2014; Dinges et al., 1997; Klumpp et al., 2017; Yoo et al., 2007) and its regulation (Zhang et al., 2018) are well-documented. NSSI and suicidal behavior often function to regulate negative emotion (e.g., Chapman et al., 2006; Klonsky, 2007; Nock & Prinstein, 2004; Nock & Mendes, 2008), and individuals with BPD may experience the urge to use NSSI or suicidal behavior for this purpose when sleep deprived (Talbot et al., 2010;
Vanderkerckhove et al., 2011). Our NSSI findings suggest that increasing TST in people with already moderate to high TST may be beneficial in reducing NSSI urges, but targeting TST may yield less relative benefit to this end when people are sleep deprived. For such individuals, increasing sleep for longer time periods may be necessary before changes in NSSI outcomes are observable. Alternatively, as not all individuals in the study engaged in NSSI, perhaps some individuals with high TST had lower NSSI urges because they exhibited less severe psychopathology, including a lack of NSSI urges/behaviour and sleep deprivation. Further, individuals with BPD may have lower emotional thresholds for NSSI urges than suicidal urges, such that the elevated negative emotion that low TST may be associated with at baseline may predict higher NSSI urges but may not yet be sufficiently intense to elicit suicide urges. Once emotion is provoked, low TST may increase emotional reactivity and suicide urges may rise (i.e., urge reactivity) to facilitate emotion regulation.

Low TST may also impact risk factors for suicide urge reactivity beyond negative emotion. Resisting urges requires cognitive resources which may be a limited resource (Muraven & Baumeister, 2000) that is depleted by low TST (Meldrum et al., 2013), resulting in increases in urges. Other theories suggest that thwarted belongingness (i.e., the unmet need to belong/feel connected to others) and perceived burdensomeness (i.e., one’s perception that they are a burden) are core to suicidal thoughts and behaviors (Joiner, 2005; Van Orden et al., 2010). Those with low TST may experience impairments in social functioning due to fatigue, irritability, or diminished cognition, and loneliness when awake while others sleep, increasing thwarted belongingness (Hom et al., 2017). Similarly, perceived burdensomeness may mediate the relationship between other sleep problems (i.e., nightmare distress) and suicidal ideation, such that those with nightmare distress (and potentially, subsequent sleep loss) may feel powerless or
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out of control during sleep, which may lead to greater perceived burdensomeness (Suh et al., 2016).

It is unclear why low TST predicted suicide urge reactivity but not baseline suicide urges. In our study, mean suicide urges were low at baseline (M=6.38) but were higher post-induction (M=16.60). Baseline suicide urges may have been too low to capture its relationship with sleep processes. There is also a difference between urges measured within our study and suicidal ideation (i.e., thinking about, considering, or planning suicide; Klonsky, 2016), which has been previously associated with low TST (e.g., Goodwin & Marusic, 2008; Littlewood et al., 2019). Suicidal ideation may capture a broader range of suicide-related thoughts, whereas urges may reflect a higher severity of suicidal ideation than has traditionally been studied. Sleep processes may be more important to lower-intensity suicidal ideation than higher-severity ideation such as urges, unless they are actively provoked by a stressor.

It is further unclear why TST predicted lower NSSI urges at baseline and not NSSI urge reactivity. Indeed, our findings suggested that high TIB, rather than low TST, predicts NSSI urge reactivity. Akin to emotion regulation models of NSSI (e.g., Chapman et al., 2006; Klonsky, 2007), individuals who spend more TIB may be enacting an effort to escape from negative internal or external experiences and thus, both TIB and NSSI may act as a proxy for experiential avoidance. Although low TST (i.e., sleep deprivation) may generally predict increased NSSI urges at baseline, the extent to which individuals experience rises in these urges in response to provocation may be less related to sleep deprivation and more related to the extent to which they attempt to escape aversive emotional experiences that may have been elicited.

Despite their presence in study analyses, findings did not reveal significant curvilinear effects of the sleep variables on suicide or NSSI urge reactivity. Mean values of TST and TIB
were between ~7 and 9 hours, which may not have been a wide enough range to observe curvilinear effects. Further, individuals with BPD may be so sleep deprived (low in TST), that higher TST by contrast is generally beneficial for them as an opportunity for compensatory sleep.

**Circadian Sleep Processes**

Unlike the homeostatic processes, and contrary to hypotheses, results did not suggest that circadian sleep processes predicted any NSSI or suicide urge variables. Research is equivocal regarding whether chronotype is abnormal in BPD (Bromundt et al. 2013; Fleischer et al., 2012), and mean chronotype in our sample was between evening-types and normal (Horne & Ostberg, 1976). Individuals with BPD may not have particularly atypical chronotypes, obfuscating understanding of the impact of atypical chronotypes on urges. It is also possible that, converse to homeostatic processes, circadian sleep processes may be linked to psychopathology through alternative non-emotional mechanisms and are therefore less likely to influence NSSI and suicide.

**Future Directions and Limitations**

This study is limited by its somewhat small sample size, which may have resulted in limited statistical power to detect curvilinear effects. Furthermore, although common in suicide research (e.g., Bernert et al., 2015), single-item measurement of urges is a limitation and prevents a comprehensive assessment of suicide and NSSI processes. Indeed, there are several suicide and NSSI processes not examined in this study that may be impacted by sleep (e.g., general ideation, behaviours, intent, preparation) and several unstudied sleep processes may impact them (e.g., insomnia severity, fatigue, sleep-related beliefs). Future researchers should attempt to replicate the present findings with a larger sample size and more comprehensive
measurement of sleep, suicide, and NSSI processes. Finally, the exclusion criteria of the present study prohibited inclusion of individuals who were taking scheduled medications such as benzodiazepines, which may have inadvertently eliminated individuals with severe sleep problems and obstructed the ability to detect curvilinear effects by restricting the range of sleep variables. Broader inclusion criteria in future research are advised.

**Conclusion**

Despite these limitations, this study offers several clinical implications. Working to reduce sleep deprivation may be important to decreasing baseline NSSI urges and the extent to which suicide urges rise following provocation. Insomnia treatment models suggest that decreasing TIB in those with insomnia may be important to improving TST to extinguish conditioned associations between the bed and wakefulness and build up a homeostatic sleep drive (Edinger & Carney, 2008). Reducing excessive TIB may improve TST and reduce NSSI urge reactivity as well. However, such decisions must be guided by a careful assessment of individual sleep processes and whether TIB is, in fact, excessive (Edinger & Carney, 2008). Further, no studies to our knowledge have evaluated treatments that target TIB and TST in individuals with BPD, although one pilot study suggested that light therapy can advance biological sleep rhythms and reduce TST in BPD (Bromundt et al., 2013). Research testing the efficacy of sleep-based interventions in BPD specifically is thus needed. Ultimately, findings highlight that sleep processes, particularly low TST, may be critical to assess and target in the pursuit of reducing life-threatening behavior in BPD.
References


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Journal of Adolescent Health, 31(6), 175-184.

https://doi.org/10.1016/s1054-139x(02)00506-2


https://doi.org/10.1007/s00221-014-3832-1


https://doi.org/10.1016/j.psychres.2012.07.020


https://doi.org/10.1002/jclp.22793


https://doi.org/10.1016/j.sleep.2015.10.021
SLEEP PROCESSES AND SELF-INJURY URGES


Huỳnh, C., Guilé, J. M., Breton, J. J., & Godbout, R. (2016). Sleep-wake patterns of adolescents
SLEEP PROCESSES AND SELF-INJURY URGES


SLEEP PROCESSES AND SELF-INJURY URGES


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[https://doi.org/10.1016/j.psychres.2018.08.046](https://doi.org/10.1016/j.psychres.2018.08.046)

[https://doi.org/10.1007/s10608-015-9736-y](https://doi.org/10.1007/s10608-015-9736-y)

[https://doi.org/10.3389/fpsyt.2018.00320](https://doi.org/10.3389/fpsyt.2018.00320)

[https://doi.org/10.1016/j.sleep.2013.11.780](https://doi.org/10.1016/j.sleep.2013.11.780)

[https://doi.org/10.1016/j.psychres.2014.06.041](https://doi.org/10.1016/j.psychres.2014.06.041)
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https://doi.org/10.3109/07420528.2010.535938

https://doi.org/10.1016/j.psc.2018.07.009

https://doi.org/10.1007/s41105-016-0083-5

https://doi.org/10.1016/S0193-953X(18)30532-X


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Table 1

*Main demographic information*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean or %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Mean = 23.35 (SD = 6.77)</td>
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<tr>
<td>Most common racial/ethnic categories</td>
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<td>Chinese/Chinese-Canadian</td>
<td>22.5%</td>
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<tr>
<td>Other Asian/Asian-Canadian</td>
<td>12.5%</td>
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<td>Other</td>
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<td>Most common comorbid diagnoses</td>
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<td>Generalized anxiety disorder</td>
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<tr>
<td>Obsessive compulsive disorder</td>
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</tr>
<tr>
<td>Major depressive disorder</td>
<td>30%</td>
</tr>
</tbody>
</table>

Note. See Fitzpatrick et al. (in press) for full demographic information
Table 2

*Means (standard deviations) for study variables*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depression</td>
<td>19.85 (10.30)</td>
</tr>
<tr>
<td>Total sleep time</td>
<td>7.17 (1.57)</td>
</tr>
<tr>
<td>Time in bed</td>
<td>9.48 (1.86)</td>
</tr>
<tr>
<td>Chronotype</td>
<td>41.40 (10.47)</td>
</tr>
<tr>
<td>Baseline suicide urges</td>
<td>6.38 (13.72)</td>
</tr>
<tr>
<td>Post-induction suicide urges</td>
<td>16.60 (25.97)</td>
</tr>
<tr>
<td>Baseline NSSI urges</td>
<td>8.21 (17.61)</td>
</tr>
<tr>
<td>Post-induction NSSI urges</td>
<td>22.27 (29.29)</td>
</tr>
</tbody>
</table>

Note. NSSI = Non-suicidal self-injury.
SLEEP PROCESSES AND SELF-INJURY URGES

Table 3

*Final generalized estimating equations model predicting baseline suicide urges*

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>SE</th>
<th>$\chi^2$</th>
<th>df</th>
<th>p-value</th>
<th>Wald 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-.13</td>
<td>.40</td>
<td>.10</td>
<td>1</td>
<td>.75</td>
<td>-.90, .65</td>
</tr>
<tr>
<td><strong>Depression</strong></td>
<td>.02</td>
<td>.01</td>
<td>9.30</td>
<td>1</td>
<td>.002</td>
<td>.01, .04</td>
</tr>
<tr>
<td>Past week total sleep time</td>
<td>-.07</td>
<td>.04</td>
<td>2.45</td>
<td>1</td>
<td>.12</td>
<td>-.15, .02</td>
</tr>
<tr>
<td>Past week time in bed</td>
<td>.05</td>
<td>.03</td>
<td>1.88</td>
<td>1</td>
<td>.17</td>
<td>-.02, .11</td>
</tr>
<tr>
<td>Chronotype</td>
<td>.002</td>
<td>.01</td>
<td>.09</td>
<td>1</td>
<td>.77</td>
<td>-.01, .02</td>
</tr>
</tbody>
</table>

*Note.* Suicide urges had one unit added to them and were then log transformed (base 10). CI = confidence interval.
SLEEP PROCESSES AND SELF-INJURY URGES

Table 4

*Final generalized estimating equations model predicting baseline NSSI urges*

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>SE</th>
<th>( \chi^2 )</th>
<th>df</th>
<th>p-value</th>
<th>Wald 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-1.01</td>
<td>.56</td>
<td>3.27</td>
<td>1</td>
<td>.07</td>
<td>-2.10, .08</td>
</tr>
<tr>
<td>Depression</td>
<td>.02</td>
<td>.01</td>
<td>2.49</td>
<td>1</td>
<td>.11</td>
<td>-.004, .03</td>
</tr>
<tr>
<td>Past week total sleep time</td>
<td>.18</td>
<td>.13</td>
<td>1.79</td>
<td>1</td>
<td>.18</td>
<td>-.08, .44</td>
</tr>
<tr>
<td><strong>Past week total sleep time (squared)</strong></td>
<td><strong>-.02</strong></td>
<td><strong>.01</strong></td>
<td><strong>4.61</strong></td>
<td>1</td>
<td><strong>.03</strong></td>
<td><strong>-.04, -.002</strong></td>
</tr>
<tr>
<td>Past week time in bed</td>
<td>.07</td>
<td>.04</td>
<td>3.01</td>
<td>1</td>
<td>.08</td>
<td>-.01, .14</td>
</tr>
<tr>
<td>Chronotype</td>
<td>.01</td>
<td>.01</td>
<td>.52</td>
<td>1</td>
<td>.47</td>
<td>-.01, .03</td>
</tr>
</tbody>
</table>

Note. NSSI = Non-suicidal self-injury. CI = confidence interval.
## Table 5

*Final generalized estimating equations model predicting suicide urge reactivity*

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>SE</th>
<th>$\chi^2$</th>
<th>df</th>
<th>p-value</th>
<th>Wald 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>.33</td>
<td>.45</td>
<td>.54</td>
<td>1</td>
<td>.46</td>
<td>-.55, 1.21</td>
</tr>
<tr>
<td>Depression</td>
<td>.02</td>
<td>.01</td>
<td>9.11</td>
<td>1</td>
<td>.003</td>
<td>.01, .03</td>
</tr>
<tr>
<td>Baseline suicide urges</td>
<td>.58</td>
<td>.13</td>
<td>19.51</td>
<td>1</td>
<td>&lt;.001</td>
<td>.33, .84</td>
</tr>
<tr>
<td>Total sleep time</td>
<td>-.11</td>
<td>.04</td>
<td>5.98</td>
<td>1</td>
<td>.02</td>
<td>-.19, -.02</td>
</tr>
<tr>
<td>Time in bed</td>
<td>.03</td>
<td>.03</td>
<td>.67</td>
<td>1</td>
<td>.41</td>
<td>-.04, .10</td>
</tr>
<tr>
<td>Chronotype</td>
<td>.01</td>
<td>.01</td>
<td>.91</td>
<td>1</td>
<td>.34</td>
<td>-.01, .02</td>
</tr>
</tbody>
</table>

*Note.* Suicide urge outcomes had one unit added to them and were then log transformed (base 10). CI = confidence interval.
## Table 6

*Final generalized estimating equations model predicting NSSI urge reactivity*

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>SE</th>
<th>$\chi^2$</th>
<th>df</th>
<th>p-value</th>
<th>95% Wald CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-.49</td>
<td>.53</td>
<td>.89</td>
<td>1</td>
<td>.35</td>
<td>-1.52, .54</td>
</tr>
<tr>
<td>Depression</td>
<td>.02</td>
<td>.01</td>
<td>3.37</td>
<td>1</td>
<td>.07</td>
<td>-.001, .03</td>
</tr>
<tr>
<td><strong>Baseline NSSI urges</strong></td>
<td>.59</td>
<td>.09</td>
<td><strong>46.29</strong></td>
<td>1</td>
<td><strong>&lt;.001</strong></td>
<td><strong>.42, .76</strong></td>
</tr>
<tr>
<td>Total sleep time</td>
<td>-.05</td>
<td>.04</td>
<td>1.29</td>
<td>1</td>
<td>.26</td>
<td>-.13, .04</td>
</tr>
<tr>
<td><strong>Time in bed</strong></td>
<td>.08</td>
<td>.03</td>
<td><strong>5.80</strong></td>
<td>1</td>
<td><strong>.02</strong></td>
<td><strong>.02, .15</strong></td>
</tr>
<tr>
<td>Chronotype</td>
<td>.01</td>
<td>.01</td>
<td>1.47</td>
<td>1</td>
<td>.23</td>
<td>-.01, .02</td>
</tr>
</tbody>
</table>

*Note. NSSI urge outcomes had one unit added to them and were then log transformed (base 10). NSSI = Non-suicidal self-injury. CI = confidence interval.*
Figure 1

Graphical depiction of the predicted values of baseline NSSI urges (log transformed) at varying levels of total sleep time

Note. Y-axis begins at 0. Depression, time in bed, and chronotype values were set to their mean. Predicted values of baseline NSSI urges were calculated based on the following formula: $y = B_0 + B_1x + B_2x^2$. In this formula, $y$ refers to predicted values of baseline NSSI urges (log transformed), $B_0$ refers to the parameter estimate of the intercept and all other predictors, set to their mean value. $B_1$ refers to the parameter estimate of the linear TST effect, $B_2$ refers to the parameter estimate of the quadratic TST effect, and $x$ refers to the values of TST.