ACCEPTED MANUSCRIPT

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

Skye Fitzpatrick[1], Sonya Varma[1], and Jennifer Ip[2]

[1]Department of Psychology, York University

[2]Department of Psychology, Ryerson University

This is an Accepted Manuscript of an article published by Taylor & Francis in *Archives of Suicide Research* on May 14, 2021, available online: https://doi.org/10.1080/13811118.2021.1932647.

Ethical statement: This work received approval from all relevant institutional research boards. All participants provided informed consent prior to participation.
ORCID IDs:
Skye Fitzpatrick: https://orcid.org/0000-0002-1347-1827
Sonya Varma: https://orcid.org/0000-0003-3574-8783
Jennifer Ip: https://orcid.org/0000-0002-3056-3790
Funding: Canadian Institutes of Health Research (grant numbers: 201210GSD-304038-229817 and 201711MFE-395820-229817), the American Psychological Association Dissertation Research Award, and the Ontario Mental Health Foundation Studentship Award funded this work.
Conflict of interest: The authors have no conflicts of interest to disclose.
Word count: 3998
Correspondence: Skye Fitzpatrick, Department of Psychology, York University, 4700 Keele Street, Toronto, Ontario, M3J 1P3, Canada. E-mail: skyefitz@yorku.ca

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

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.

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 (Fekih-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,

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

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 (*p*s 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/ 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 (*p*s range from .34 to 1.00). Repeated measures ANOVAs indicated that race/ethnicity and sex did not significantly predict urges (*p*s range from .05 to .27).[1] 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).[2] 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

[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 a., 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

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

Abdul-Hamid, S., Denman, C., & Dudas, R. B. (2014). Self-relevant disgust and self-harm urges in patients with borderline personality disorder and depression: a pilot study with a newly designed psychological challenge. PloS ONE, 9(6), e99696. https://doi.org/10.1371/journal.pone.0099696

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). https://doi.org/10.1176/appi.books.9780890425596

Ammerman, B.A., Olino, T.M., Coccaro, E.F., McCloskey, M.S., 2017. Predicting nonsuicidal self-injury in borderline personality disorder using ecological momentary assessment. *Journal of Personality Disorders, 31*(6), 844–855. https://doi.org/10.1521/pedi_2017_31_278

Baumeister, R. F. (1990). Suicide as escape from self. *Psychological Review, 97*(1), 90–113. https://doi.org/10.1037/0033-295X.97.1.90

Bell, J., Lycaki, H., Jones, D., Kelwala, S., & Sitaram, N. (1983). Effect of preexisting borderline personality disorder on clinical and EEG sleep correlates of depression. *Psychiatry Research, 9*(2), 115-123. https://doi.org/10.1016/0165-1781(83)90033-1

Bernert, R. A., Kim, J. S., Iwata, N. G., & Perlis, M. L. (2015). Sleep disturbances as an evidence-based suicide risk factor. Current Psychiatry Reports, 17(3), 554. https://doi.org/10.1007/s11920-015-0554-4

Borbély, A. A. (1982). A two process model of sleep regulation. *Human Neurobiology, 1*(3), 195-204.

Brain, K. L., Haines, J., & Williams, C. L. (1998). The psychophysiology of self-mutilation:

Evidence of tension reduction. *Archives of Suicide Research, 4*(3), 227–242. https://doi.org/10.1023/A:1009692507987

Brandalize, M., Pereira, E. F., Leite, N., Filho, G. L., & Louzada, F. M. (2011). Effect of morning school schedule on sleep and anthropometric variables in adolescents: A follow-up study. *Chronobiology International, 28*(9), 779-785. https://doi.org/10.3109/07420528.2011.603452

Bromundt, V., Wirz-Justice, A., Kyburz, S., Opwis, K., Dammann, G., & Cajochen, C. (2013). Circadian sleep-wake cycles, well-being, and light therapy in borderline personality disorder. *Journal of Personality Disorders, 27*(5), 680-696. https://doi.org/10.1521/pedi_2012_26_057

Burnham, K. P., & Anderson, D. R. (2004). Multimodel inference: Understanding AIC and BIC in Model Selection. *Sociological Methods and Research, 33*(2), 261-304. https://doi.org/10.1177/0049124104268644

Byrt, T., Bishop, J., & Carlin, J. B. (1993). Bias, prevalence and kappa. *Journal of Clinical Epidemiology, 46*(5), 423–429. http://dx.doi.org/10.1016/0895-4356(93)90018-V

Caci, H., Deschaux, O., Adan, A., & Natale, V. (2009). Comparing three morningness scales: Age and gender effects, structure and cut-off criteria. *Sleep Medicine, 10*(2), 240–245. http://dx.doi.org/10.1016/j.sleep.2008.01.007

Carney, C. E., Buysse, D. J., Ancoli-Israel, S., Edinger, J. D., Krystal, A. D., Lichstein, K. L., & Morin, C. M. (2012). The consensus sleep diary: Standardizing prospective sleep self-monitoring. *Sleep, 35*(2), 287–302. http://dx.doi.org/10.5665/sleep.1642

Chapman, A. L., Specht, M. W., & Cellucci, T. (2005). Borderline personality disorder and

deliberate selfharm: Does experiential avoidance play a role? *Suicide and Life-Threatening Behavior, 35*(4), 388–399. https://doi.org/10.1521/suli.2005.35.4.388

Chapman, A. L., Gratz, K. L., & Brown, M. Z. (2006). Solving the puzzle of deliberate self-harm: The experiential avoidance model. *Behaviour Research and Therapy, 44*(3), 371-394. https://doi.org/10.1016/j.brat.2005.03.005

Chapman, A. L., Dixon-Gordon, K., Butler, S. M., & Walters, K. N. (2015). Emotional reactivity to social rejection versus a frustration induction among persons with borderline personality features. *Personality Disorders: Theory, Research, and Treatment, 6*(1), 88-96. https://doi.org/10.1037/per0000101

Chiu, H. Y., Lee, H. C., Chen, P. Y., Lai, Y. F., & Tu, Y. K. (2018). Associations between sleep duration and suicidality in adolescents: A systematic review and dose-response meta-analysis. *Sleep Medicine*, 42, 119-126. https://doi.org/10.1016/j.smrv.2018.07.003

Chu, C., Nota, J. A., Silverman, A. L., Beard, C., & Björgvinsson, T. (2019). Pathways among sleep onset latency, relationship functioning, and negative affect differentiate patients with suicide attempt history from patients with suicidal ideation. *Psychiatry Research, 273*, 788-797. https://doi.org/10.1016/j.psychres.2018.11.014

Czyz, E. K., Horwitz, A. G., Arango, A., & King, C. A. (2019). Short-term change and prediction of suicidal ideation among adolescents: A daily diary study following psychiatric hospitalization. *The Journal of Child Psychology and Psychiatry, 60*(7), 732-741. https://doi.org/10.1111/jcpp.12974

Dahl, R. (1999). The Consequences of Insufficient Sleep for Adolescents: Links Between Sleep and Emotional Regulation. *Phi Delta Kappan, 80*, 354.

Dahl, R. E., & Lewin, D. S. (2002). Pathways to adolescent health sleep regulation and behavior.

Journal of Adolescent Health, 31(6), 175-184. https://doi.org/10.1016/s1054-139x(02)00506-2

Deliens, G., Gilson, M., & Peigneux, P. (2014). Sleep and the processing of emotions. Experimental Brain Research, 232(5), 1403-1414. https://doi.org/10.1007/s00221-014-3832-1

Dinges, D. F., Pack, F., Williams, K., Gillen, K. A., Powell, J. W., Ott, G. E., Aptowicz, C., & Pack, A. I. (1997). Cumulative sleepiness, mood disturbance, and psychomotor vigilance performance decrements during a week of sleep restricted to 4-5 hours per night. *Sleep*, *20*(4), 267–277.

Edinger, J. D., & Carney, C. E. (2008). *Overcoming insomnia: A cognitive-behavioral therapy approach, workbook.* Oxford University Press.

Elices, M., Soler, J., Fernández, C., Martín-Blanco, A., Jesús Portella, M., Pérez, V., Alvarez, E., & Pascual, J. C. (2012). Physiological and self-assessed emotional responses to emotion-eliciting films in borderline personality disorder. *Psychiatry Research, 200,* 437-443. https://doi.org/10.1016/j.psychres.2012.07.020

Fekih-Romdhane, F., Jendoubi, J., Saguem, B. N., Ridha, R., & Cheour, M. (2019). The link between sleep disturbances and suicidal thoughts and behaviors in remitted bipolar I patients. *Journal of Clinical Psychology, 75*(9), 1643-1657. https://doi.org/10.1002/jclp.22793

Ferentinos, P., Porichi, E., Christodoulou, C., Dikeos, D., Papageorgiou, C., & Douzenis, A. (2016). Sleep disturbance as a proximal predictor of suicidal intent in recently hospitalized attempters. *Sleep Medicine, 19,* 1-7. https://doi.org/10.1016/j.sleep.2015.10.021

Fiorentino, L., & Martin, J. L. (2010). Awake at 4 AM: Treatment of insomnia with early morning awakenings among older adults. *Journal of Clinical Psychology, 66*(11), 1161–1174. https://doi.org/10.1002/jclp.20734

First, M., Spitzer, R., Gibbon, M., & Williams, J. (1995). Structured Clinical Interview for Axis I DSM–IV Disorders—Patient Edition (SCIDI/P). New York, NY: Biometrics Research Department, New York State Psychiatric Institute.

Fitzpatrick, S., Maich, K. H. G., Carney, C. E., & Kuo, J. R. (2020). Identifying specific insomnia components in borderline personality disorder and their influence on emotion dysregulation. *Personality Disorders: Theory, Research, and Treatment, 11*(6), 440-450. http://dx.doi.org/10.1037/per0000395

Fitzpatrick, S., Varma, S., Kuo, J. K. (in press). Is borderline personality disorder really an emotion dysregulation disorder and, if so, how?: A comprehensive experimental paradigm. *Psychological Medicine.*

Fleischer, M., Schäfer, M., Coogan, A., Häßler, F., & Thome, J. (2012). Sleep disturbances and circadian CLOCK genes in borderline personality disorder. *Journal of Neural Transmission, 119*(10), 1105-1110. https://doi.org/10.1007/s00702-012-0860-5

Goodwin, R. D., & Marusic, A. (2008). Association between short sleep and suicidal ideation and suicide attempt among adults in the general population. *Sleep, 31*(8), 1097–1101. https://doi.org/10.5665/sleep/31.8.1097

Gratz, K. L., Rosenthal, M. Z., Tull, M. T., Lejuez, C. W., & Gunderson, J. G. (2010). An experimental investigation of emotional reactivity and delayed emotional recovery in borderline personality disorder: The role of shame. *Comprehensive Psychiatry, 51*(3), 275-285. https://doi.org/10.1016/j.comppsych.2009.08.005

Gratz, K. L., Richmond, J. R., Dixon-Gordon, K. L., Chapman, A. L., & Tull, M. T. (2019). Multimodal assessment of emotional reactivity and regulation in response to social rejection among self-harming adults with and without borderline personality disorder. *Personality Disorders: Theory, Research, and Treatment, 10*(5), 395–405. https://doi.org/10.1037/per0000334

Holden, G. W., Stein, J. D., Ritchie, K. L., Harris, S. D., & Jouriles, E. N. (1998). Parenting behaviors and beliefs of battered women. In G. W. Holden, Geffner, R., & Jouriles, E. N. (Eds.), *Children exposed to marital violence: theory, research, and applied issues* (pp. 289–334). Washington, DC: American Psychological Association. https://doi.org/10.1037/10257-009

Hom, M. A., Chu, C., Schneider, M. E., Lim, I. C., Hirsch, J. K., Gutierrez, P. M., & Joiner, T. E. (2017). Thwarted belongingness as an explanatory link between insomnia symptoms and suicidal ideation: Findings from three samples of military service members and veterans. *Journal of Affective Disorders, 209,* 114-123. https://doi.org/10.1016/j.jad.2016.11.032

Horne, J. A., & Östberg, O. (1976). A self-assessment questionnaire to determine morningness eveningness in human circadian rhythms. *International Journal of Chronobiology, 4*(2), 97–110.

Hughes, C. D., King, A. M., Kranzler, A., Fehling, K., Miller, A., Lindqvist, J., & Selby, E. A. (2019). Anxious and overwhelming affects and repetitive negative thinking as ecological predictors of self-injurious thoughts and behaviors. *Cognitive Therapy and Research, 43,* 88–101. https://doi.org/10.1007/s10608-019-09996-9

Huỳnh, C., Guilé, J. M., Breton, J. J., & Godbout, R. (2016). Sleep-wake patterns of adolescents

with borderline personality disorder and bipolar disorder. *Child Psychiatry & Human Development, 47*(2), 202-14. https://doi.org/10.1007/s10578-015-0557-8

Joiner, T. (2005). *Why people die by suicide.* Cambridge: Harvard University Press.

Kleindienst, N., Bohus, M., Ludäscher, P., Limberger, M. F., Kuenkele, K., Ebner-Priemer, U. W., Chapman, A. L., Reicherzer, M., Stieglitz, R. D., & Schmahl, C. (2008). Motives for nonsuicidal self-injury among women with borderline personality disorder. *Journal of Nervous and Mental Disease, 196*(3), 230-236. https://doi.org/10.1097/NMD.0b013e3181663026

Klumpp, H., Roberts, J., Kapella, M. C., Kennedy, A. E., Kumar, A., & Phan, K. L. (2017). Subjective and objective sleep quality modulate emotion regulatory brain function in anxiety and depression. *Depression and Anxiety, 34*(7), 651-660. https://doi.org/10.1002/da.22622

Klonsky, E. D. (2007). The functions of deliberate self-injury: A review of the evidence. *Clinical Psychology Review, 27*(2), 226-239. https://doi.org/10.1016/j.cpr.2006.08.002

Klonsky, E. D., May, A. M., & Saffer, B. Y. (2016). Suicide, suicide attempts, and suicidal ideation. *Annual Review of Clinical Psychology, 12*(1), 307-330. https://doi.org/10.1146/annurev-clinpsy-021815-093204

Kröger, C., Harbeck, S., Armbrust, M., & Kliem, S. (2013). Effectiveness, response, and dropout of dialectical behavior therapy for borderline personality disorder in an inpatient setting. *Behaviour Research and Therapy, 51*, 411-416. doi:10.1016/j.brat.2013.04.008

Kuo, J. R., Fitzpatrick, S., Metcalfe, R. K., & McMain, S. (2016). A multi-method laboratory investigation of emotional reactivity and emotion regulation abilities in borderline

personality disorder. *Journal of Behavior Therapy and Experimental Psychiatry, 50*, 52-60. https://doi.org/10.1016/j.jbtep.2015.05.002

Kuo, J. R., & Linehan, M. M. (2009). Disentangling emotion processes in borderline personality disorder: Physiological and self-reported assessment of biological vulnerability, baseline intensity, and reactivity to emotionally evocative stimuli. *Journal of Abnormal Psychology, 118*(3), 531–544. doi:10.1037/a0016392

Licht, C. M. M., de Geus, E. J., van Dyck, R., & Penninx, B. W. (2010). Longitudinal evidence for unfavorable effects of antidepressants on heart rate variability. *Biological Psychiatry, 68*(9), 861–868. https://doi.org/10.1016/j.biopsych.2010.06.032

Linehan, M. M. (1993). *Cognitive-behavioral treatment of borderline personality disorder.* The Guilford Press.

Linehan, M. M. (2015). *DBT® skills training manual* (2nd ed.). Guilford Press.

Littlewood, D. L., Kyle, S. D., Carter, L.-A., Peters, S., Pratt, D., & Gooding, P. (2019). Short sleep duration and poor sleep quality predict next-day suicidal ideation: An ecological momentary assessment study. *Psychological Medicine, 49*(3), 403-411. https://doi.org/10.1017/S0033291718001009

Liu, X., Chen, H., Bo, Q., Fan, F., & Jia, C. (2017). Poor sleep quality and nightmares are associated with non-suicidal self-injury in adolescents. European Child and Adolescent Psychiatry, 26(3), 271-279. doi:10.1007/s00787-016-0885-7

Loranger, A. W., Sartorius, N., Andreoli, A., Berger, P., Buchheim, P., Channabasavanna, S. M., Coid, B., Dahl, A., Diekstra, R. F. W., Ferguson, B., Jacobsberg, L. B., Mombour, W., Pull, C., Ono, Y., & Regier, D. A. (1994). The International Personality Disorder Examination: The World Health Organization/Alcohol, Drug Abuse, and Mental Health

Administration international pilot study of personality disorders. *Archives of General Psychiatry, 51*(3), 215–224. https://doi.org/10.1001/archpsyc.1994.03950030051005

Lovibond, S. H., & Lovibond, P. F. (1995). *Manual for the Depression Anxiety Stress Scales* (2nd ed.). Sydney, Australia: Psychology Foundation.

Mars, B., Heron, J., Klonsky, E. D., Moran, P., O'Connor, R. C., Tilling, K., Wilkinson, P., & Gunnell, D. (2019). Predictors of future suicide attempt among adolescents with suicidal thoughts or non-suicidal self-harm: A population-based birth cohort study. *The Lancet Psychiatry, 6*(4), 327–337. https://doi.org/10.1016/S2215-0366(19)30030-6

McCormack, H. M., Horne, D. J., & Sheather, S. (1988). Clinical applications of visual analogue scales: A critical review. *Psychological Medicine, 18*(4), 1007–1019. https://doi.org/10.1017/S0033291700009934

McEnany, G., & Lee, K. A. (2000). Owls, larks and the significance of morningness/eveningness rhythm propensity in psychiatric-mental health nursing. *Issues in Mental Health Nursing, 21*(2), 203–216. https://doi.org/10.1080/016128400248194

McGlinchey, E. L., Reyes-Portillo, J. A., Turner, J. B., & Mufson, L. (2017). Innovations in practice: The relationship between sleep disturbances, depression, and interpersonal functioning in treatment for adolescent depression. *Child and Adolescent Mental Health, 22*(2), 96-99. http://dx.DOI:10.1111/camh.12176

Meldrum, R. C., Barnes, J. C., & Hay, C. (2013). Sleep deprivation, low self-control, and delinquency: A test of the strength model of self-control. *Journal of Youth and Adolescence, 44*(2), 465-477. https://doi.org/10.1007/s10964-013-0024-4

Michaels, M. S., Balthrop, T., Nadorff, M. R., & Joiner, T. E. (2017). Total sleep time as a predictor of suicidal behaviour. *Journal of Sleep Research, 26*(6), 732-738.

https://doi.org/10.1111/jsr.12563

Mirsu-Paun, A., Jaussent, I., Komar, G., Courtet, P. & Lopez-Castroman, J. (2017). Sleep complaints associated with wish to die after a suicide crisis—an exploratory study. *Journal of Sleep Research, 26*(6), 726-731. https://doi.org/10.1111/jsr.12537

Muraven, M., & Baumeister, R. F. (2000). Self-regulation and depletion of limited resources: Does self-control resemble a muscle? *Psychological Bulletin, 126*(2), 247–259. https://doi.org/10.1037/0033-2909.126.2.247

Nock, M. K., & Favazza, A. (2009). Non-suicidal self-injury: Definition and classification. In M. K. Nock (Ed.), *Understanding non- suicidal self-injury: Origins, assessment, and treatment* (pp. 9–18). Washington, DC: American Psychological Association.

Nock, M. K., & Mendes, W. B. (2008). Physiological arousal, distress tolerance, and social problem-solving deficits among adolescent self-injurers. *Journal of Consulting and Clinical Psychology, 76*(1), 28–38. https://doi.org/10.1037/0022-006X.76.1.28

Nock, M. K., & Prinstein, M. J. (2004). A functional approach to the assessment of self-mutilative behavior. *Journal of Consulting and Clinical Psychology, 72*(5), 885-890. https://doi.org/10.1037/0022-006X.72.5.885

Oltmanns, J.R., & Oltmanns, T.F. (2015). Borderline personality pathology, polysomnography, and self-reported sleep problems: A review. *Current Sleep Medicine Reports, 1*, 141–149. https://doi.org/10.1007/s40675-015-0011-2

Pagura, J., Stein, M. B., Bolton, J. M., Cox, B. J., Grant, B., & Sareen, J. (2010). Comorbidity of borderline personality disorder and posttraumatic stress disorder in the US population. *Journal of Psychiatric Research*, *44*(16), 1190–1198. https://doi.org/10.1016/j.jpsychires.2010.04.016

Pan, W. (2001). Model selection in estimating equations. *Biometrics, 57*(2), 529-534. https://doi.org/10.1111/j.0006-341X.2001.00529.x

Park, H., Lee, H., & Lee, K. (2018). Chronotype and suicide: The mediating effect of depressive symptoms. *Psychiatry Research, 269*, 316-320. https://doi.org/10.1016/j.psychres.2018.08.046

Rosenthal, M. Z., Neacsiu, A. D., Geiger, P. J., Fang, C., Ahn, R., & Larrauri, J. (2016). Emotional reactivity to personally-relevant and standardized sounds in borderline personality disorder. *Cognitive Therapy and Research, 40*(3), 314-327. https://doi.org/10.1007/s10608-015-9736-y

Rössler, W., Angst, J., Ajdacic-Gross, V., Haker, H., Berrouiguet, S., Ujeyl, M., Glozier, N., & Hengartner, M. P. (2018). Sleep disturbances and suicidality—A longitudinal analysis from a representative community study over 30 years. *Frontiers in Psychiatry, 9*, 320. https://doi.org/10.3389/fpsyt.2018.00320

Sarchiapone, M., Mandelli, L., Carli, V., Iosue, M., Wasserman, C., Hadlaczky, G., Hoven, C. W., Apter, A., Balazs, J., Bobes, J., Brunner, R., Corcoran, P., Cosman, D., Haring, C., Kaess. M., Keeley, H., Keresztény, A., Kahn, J. P., Postuvan, V., … & Wasserman, D. (2014). Hours of sleep in adolescents and its association with anxiety, emotional concerns, and suicidal ideation. *Sleep Medicine, 15*(2), 248-254. https://doi.org/10.1016/j.sleep.2013.11.780

Sauer, C., Arens, E. A., Stopsack, M., Spitzer, C., & Barnow, S. (2014). Emotional hyper-reactivity in borderline personality disorder is related to trauma and interpersonal themes. *Psychiatry Research, 220*(1-2), 468-476. https://doi.org/10.1016/j.psychres.2014.06.041

Selvi, Y., Aydin, A., Atli, A., Boysan, M., Selvi, F., & Besiroglu, L. (2011). Chronotype differences in suicidal behavior and impulsivity among suicide attempters. *Chronobiology International, 28*(2), 170-175. https://doi.org/10.3109/07420528.2010.535938

Shah, R., & Zanarini, M. C. (2018). Comorbidity of borderline personality disorder: Current status and future directions. *Psychiatric Clinics of North America, 41*(4), 583-593. https://doi.org/10.1016/j.psc.2018.07.009

Shin, Y. C., Kim, J. W., Seol, J.M., Oh, K. S., Shin, D. W., Kim, E. J., & Lim, S. W. (2017). Long and short sleep duration are both associated with suicidal ideation in Korean employees. *Sleep and Biological Rhythms, 15,* 81–86. https://doi.org/10.1007/s41105-016-0083-5

Spielman, A. J., Caruso, L. S., & Glovinsky, P. B. (1987). A behavioral perspective on insomnia treatment. *Psychiatric Clinics of North America, 10*(4), 541–553. https://doi.org/10.1016/S0193-953X(18)30532-X

Soloff, P., Lis, J., Kelly, T., Cornelius, J., & Ulrich, R. (1994). Self-mutilation and suicidal behavior in borderline personality disorder. *Journal of Personality Disorders, 8*(4), 257–267. https://doi.org/10.1521/pedi.1994.8.4.257

Stanley, B., Brodsky, B., Nelson, J. D., & Dulit, R. (2007). Brief dialectical behavior therapy (DBT-B) for suicidal behavior and non-suicidal self injury. *Archives of Suicide Research, 11*(4), 337-341. https://doi.org/10.1080/13811110701542069

Suh, S., Schneider, M., Lee, R., & Joiner, T. (2016). Perceived interpersonal burdensomeness as a mediator between nightmare distress and suicidal ideation in nightmare sufferers. *Frontiers in Psychology, 7,* 1805. https://doi.org/10.3389/fpsyg.2016.01805

Swinkels, C. M., Ulmer, C. S., Beckham, J. C., Buse, N., & Calhoun, P. S. (2013). The association of sleep duration, mental health, and health risk behaviors among U.S. Afghanistan/Iraq era veterans. *Sleep*, *36*(7), 1019-1025. https://doi.org10.5665/sleep.2800

Talbot, L. S., McGlinchey, E. L., Kaplan, K. A., Dahl, R. E., & Harvey, A. G. (2010). Sleep deprivation in adolescents and adults: Changes in affect. *Emotion, 10*, 831-841. https://doi.org/10.1037/a0020138

UCLA Statistical consulting group (2020). FAQ How do I interpret the sign of the quadratic term in a polynomial regression? Retrieved from https://stats.idre.ucla.edu/other/mult-pkg/faq/general/faqhow-do-i-interpret-the-sign-of-the-quadratic-term-in-a-polynomial-regression/

Vandekerckhove, M., Weiss, R., Schotte, C., Exadaktylos, V., Haex, B., Verbraecken, J., & Cluydts, R. (2011). The role of presleep negative emotion in sleep physiology. *Psychophysiology, 48*, 1738-1744. https://doi.org/10.1111/j.1469-8986.2011.01281.x

Van Orden, K. A., Witte, T. K., Cukrowicz, K. C., Braithwaite, S. R., Selby, E. A., & Joiner, T. E., Jr (2010). The interpersonal theory of suicide. *Psychological review*, *117*(2), 575–600. https://doi.org/10.1037/a0018697

Walker, R. L., Talavera, D. C., Nomamiukor, F., Madubata, I. J., Alfano, C., & Vujanovic, A. A. (2019). Sleep-related problems and suicide behavior and ideation among Black and White trauma-exposed psychiatric inpatients. *Comprehensive Psychiatry, 91,* 22–28. https://doi.org/10.1016/j.comppsych.2019.03.001

Webb, W. B. (1988). An objective behavioral model of sleep. *Sleep, 11*(5), 488–496. https://doi.org/10.1093/sleep/11.5.488

Winsper, C., Tang, N. K. Y., Marwaha, S., Lereya, S. T., Gibbs, M., Thompson, A. D., & Singh, S. P. (2017) The sleep phenotype of borderline personality disorder: A systematic review and meta-analysis. Neuroscience and Biobehavioral Reviews, 73, 48-67, https://doi.org/10.1016/j.neubiorev.2016.12.008

Wohlgemuth, W. K., Edinger, J. D., Fins, A. I., & Sullivan, R. J., Jr. (1999). How many nights are enough? The short-term stability of sleep parameters in elderly insomniacs and normal sleepers. *Psychophysiology, 36*(2), 233–244. https://doi.org/10.1111/1469-8986.3620233

Yoo, S. S., Gujar, N., Hu, P., Jolesz, F. A., & Walker, M. P. (2007). The human emotional brain without sleep—a prefrontal amygdala disconnect. *Current Biology, 17*(20), 877-878. https://doi.org/10.1016/j.cub.2007.08.007

Zanarini, M. C., Frankenburg, F. R., Dubo, E. D., Sickel, A. E., Trikha, A., Levin, A., & Reynolds, V. (1998). Axis I comorbidity of borderline personality disorder. *American Journal of Psychiatry, 155*(12), 1733–1739. https://doi.org/10.1176/ajp.155.12.1733

Zhang, J., Lau, E. Y. Y., & Hsiao, J. H. (2018). Using emotion regulation strategies after sleep deprivation: ERP and behavioral findings. *Cognitive, Affective, and Behavioral Neuroscience, 19*(2), 283-295. https://doi.org/10.3758/s13415-018-00667-y

Table 1

Main demographic information

Variable		Mean or %
Age		Mean = 23.35 (SD = 6.77)
Most common racial/ethnic categories		
	White/Caucasian/European Origin	40%
	Chinese/Chinese-Canadian	22.5%
	Other Asian/Asian-Canadian	12.5%
	Other	10%
Most common comorbid diagnoses		
	Social anxiety disorder	45%
	Generalized anxiety disorder	40%
	Obsessive compulsive disorder	32.5%
	Major depressive disorder	30%

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

Table 2

Means (standard deviations) for study variables

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

Note. NSSI = Non-suicidal self-injury.

Table 3

Final generalized estimating equations model predicting baseline suicide urges

	B	SE	χ^2	df	*p*-value	Wald 95% CI
Intercept	-.13	.40	.10	1	.75	-.90, .65
Depression	**.02**	**.01**	**9.30**	**1**	**.002**	**.01, .04**
Past week total sleep time	-.07	.04	2.45	1	.12	-.15, .02
Past week time in bed	.05	.03	1.88	1	.17	-.02, .11
Chronotype	.002	.01	.09	1	.77	-.01, .02

Note. Suicide urges had one unit added to them and were then log transformed (base 10). CI = confidence interval.

Table 4

Final generalized estimating equations model predicting baseline NSSI urges

	B	SE	χ^2	df	*p*-value	Wald 95% CI
Intercept	-1.01	.56	3.27	1	.07	-2.10, .08
Depression	.02	.01	2.49	1	.11	-.004, .03
Past week total sleep time	.18	.13	1.79	1	.18	-.08, .44
Past week total sleep time (squared)	**-.02**	**.01**	**4.61**	**1**	**.03**	**-.04, -.002**
Past week time in bed	.07	.04	3.01	1	.08	-.01, .14
Chronotype	.01	.01	.52	1	.47	-.01, .03

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

Table 5

Final generalized estimating equations model predicting suicide urge reactivity

	B	SE	χ^2	df	*p*-value	Wald 95% CI
Intercept	.33	.45	.54	1	.46	-.55, 1.21
Depression	**.02**	**.01**	**9.11**	**1**	**.003**	**.01, .03**
Baseline suicide urges	**.58**	**.13**	**19.51**	**1**	**<.001**	**.33, .84**
Total sleep time	**-.11**	**.04**	**5.98**	**1**	**.02**	**-.19, -.02**
Time in bed	.03	.03	.67	1	.41	-.04, .10
Chronotype	.01	.01	.91	1	.34	-.01, .02

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

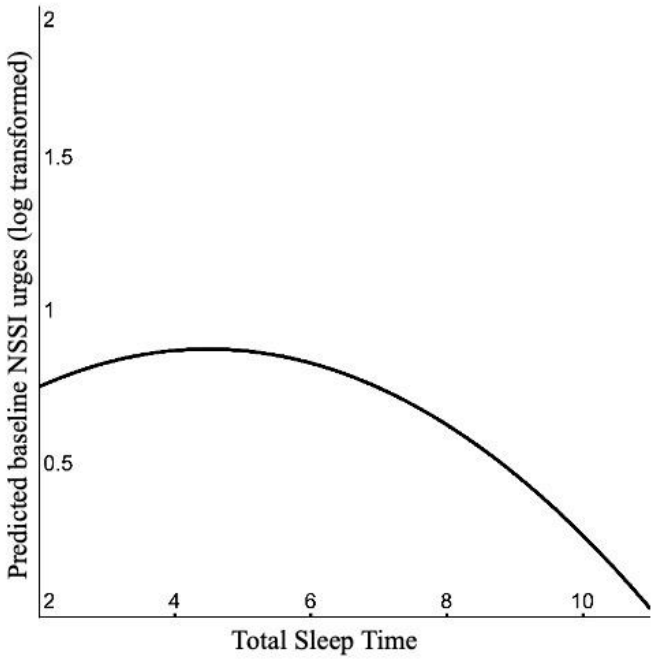
	B	SE	χ^2	df	*p*-value	95% Wald CI
Intercept	-.49	.53	.89	1	.35	-1.52, .54
Depression	.02	.01	3.37	1	.07	-.001, .03
Baseline NSSI urges	**.59**	**.09**	**46.29**	**1**	**<.001**	**.42, .76**
Total sleep time	-.05	.04	1.29	1	.26	-.13, .04
Time in bed	**.08**	**.03**	**5.80**	**1**	**.02**	**.02, .15**
Chronotype	.01	.01	1.47	1	.23	**-.01, .02**

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.