

**Daily associations between sleep and urgency, and variation
by risk for developing bipolar disorder**

Katherine K. Seldin

A dissertation

submitted in partial fulfillment of the
requirements for the degree of:

Doctor of Philosophy

University of Washington

2024

Reading Committee:

Kevin M. King, Chair

Katherine T. Foster

Teresa M. Ward

Program Authorized to Offer Degree:

Department of Psychology

©Copyright 2024

Katherine K. Seldin

University of Washington

Abstract

Daily associations between sleep and urgency, and variation
by risk for developing bipolar disorder

Katherine K. Seldin

Chair of the Supervisory Committee:

Kevin M. King

Department of Psychology

Sleep has been widely associated with negative mental health outcomes and has been considered a key feature of mood disorders, bipolar disorder in particular. Previous work has found that aspects of sleep health, such as perceived sleep quality and sleep-wake rhythms, may predict and be predicted by emotional impulsivity (i.e., urgency) to varying degrees, though few studies have explored this association on a daily level. What is yet to be explored is the bidirectional nature of these associations on a daily level, and the extent to which these associations may differ for those at higher risk for developing bipolar disorder. The present study examined the associations between urgency, sleep quality, and sleep-wake rhythms as they unfold in daily life and extended past work by exploring differential associations based on risk for bipolar disorder. It was hypothesized that worse sleep quality and greater sleep-wake rhythm irregularity would exhibit bidirectional associations with higher urgency on within-person and between-person levels, and that these associations would be stronger in participants at greater risk for developing bipolar disorder. The present study used data collected from a larger ecological momentary assessment (EMA) protocol in a community sample of young adults ($n = 495$). Participant self-reports on an initial baseline survey and 8 weekends of surveys collected 5 times per day were used to test hypotheses. Multilevel models were used for confirmatory analyses and for additional exploratory analyses aiming to distinguish among aspects of sleep quality and whether these associations held specifically for groups that are disproportionately impacted

by sleep disturbances. Within- and between-person associations between sleep quality and urgency were supported in both directions, though only between-person associations were detected for the sleep-wake rhythm variables. The two variables measuring sleep-wake rhythm irregularity yielded inverse results, with higher sleep duration irregularity predicting higher urgency and higher sleep midpoint irregularity predicting *lower* urgency, contrary to hypotheses. These associations were not moderated by risk for bipolar disorder. Exploratory analyses revealed that specific types of sleep quality disturbance showed associations with urgency that mirrored urgency's association with general sleep quality disturbance. There were some differences in sleep-urgency associations based on race, gender identity, and sexual orientation. Urgency may be more tightly tied to sleep quality than to sleep-wake rhythms on the daily level, and the inconsistent between-person associations with sleep-wake rhythms may warrant further investigation. Thus, improving sleep quality may be a more effective clinical target than regulating sleep-wake rhythms for some individuals. Finally, the comparatively stronger associations between sleep health and urgency that are seen in bipolar disorder may not emerge until after disorder onset, which has important implications for early intervention strategies as well as theories of the etiology of bipolar disorder.

Table of Contents

Introduction	7
Sleep and urgency	7
Urgency, sleep, and bipolar disorder	9
The current study	11
Aims and Hypotheses	12
Confirmatory analyses	12
Exploratory analyses	14
Method	14
Participants	14
Retention and missing data	15
Procedure	16
Measures	17
Urgency	17
Sleep quality	18
Sleep-wake rhythm regularity	19
Bipolar risk	20
Timing covariates	20
Substance use	21
Demographic variables for exploratory analyses	21
Analyses	22
Model building process	23
Sensitivity analyses	23
Exploratory analyses	24
Results	24
Confirmatory analyses	24
Sleep quality predicting urgency	25
Urgency predicting sleep quality	25
Sleep midpoint irregularity predicting urgency	25
Urgency predicting sleep midpoint irregularity	26
Sleep duration irregularity predicting urgency	26
Urgency predicting sleep duration irregularity	26
Exploratory Analyses	26
Sleep onset latency predicting urgency	26
Urgency predicting sleep onset latency	26
Waking after sleep onset predicting urgency	27
Urgency predicting waking after sleep onset	27
Race and ethnicity	27
Gender identity	28
Sexual orientation	28
Parental education	28
Discussion	28
Sleep quality and urgency	29
Sleep-wake rhythm irregularity and urgency	30
Bipolar risk	32
Exploratory analyses	33

Limitations.....	35
Clinical implications	36
Conclusion	37
References.....	38
Tables and Figures	52
Table 1. Demographic information.	52
Table 2a. Results of confirmatory analyses for urgency and sleep quality.....	53
Table 2b. Results of confirmatory analyses for urgency and sleep midpoint irregularity.....	54
Table 2c. Results of confirmatory analyses for urgency and sleep duration irregularity.	55
Figure 1. Bivariate correlations between variables of interest.	56
Figure 2. Standardized coefficients for confirmatory analyses.	57

Introduction

The dynamic interplay between sleep and mental health outcomes, particularly among adolescents and young adults, has been an increasing topic of interest, as poor sleep health has been connected to outcomes such as substance use (Hasler & Pedersen, 2020; Hertenstein et al., 2019; Kwon et al., 2019; Yurasek et al., 2020), suicidality (Porrás-Segovia et al., 2019), internalizing disorders such as depression and anxiety (Ben Simon et al., 2020; Hertenstein et al., 2019), emotion and broad emotion regulation processes (Goldstein & Walker, 2014; Gruber & Cassoff, 2014; Konjarski et al., 2018), risk taking behaviors (Meldrum & Restivo, 2014; Womack et al., 2013), and problematic internet and phone use (Onat et al., 2019; Zhu et al., 2021). Indeed, disruptions to sleep and sleep-wake and circadian rhythms have been proposed to be a critical component in the development and maintenance of mood disorders (Harvey, 2011; Palagini, Bastien, et al., 2019). Furthermore, sleep seems to be particularly important for health outcomes in adolescence and young adulthood (Bruce et al., 2017).

Sleep and urgency

An emerging area of study is how sleep health may relate to the similarly transdiagnostic risk factor of urgency, which is a facet of impulsivity defined as rash action in response to emotion (Whiteside & Lynam, 2001). The importance of differentiating between types of impulsivity when exploring associations with negative mental health outcomes has been well-established (Berg et al., 2015; Strickland & Johnson, 2021), and this list of outcomes may also include sleep. For instance, while sleep *duration* has been a primary focus in previous literature exploring sleep and broad impulsivity (Anderson & Platten, 2011; Curtis et al., 2018; Demos et al., 2016; Drummond et al., 2006), among studies examining urgency specifically, there has been more robust support for associations with sleep *quality* (Galbiati et al., 2020; Grove et al., 2017; Nicholson et al., 2021; Pickett et al., 2016; Schmidt et al., 2008, 2010; Tashjian et al., 2017) and general sleep disturbance (Bauducco et al., 2019; Hom et al., 2016; Palagini, Cipollone, Masci, et al., 2019; Pickett et al., 2016; Șandru & Voinescu, 2014; Schmidt et al., 2008, 2010; Schmidt & Van der Linden, 2009) compared to sleep duration (Barker et al., 2016; Freitag et al., 2017; Grove et al., 2017; Hasler et al., 2022; A. A. Miller & Rucas, 2012; M. B. Miller et al., 2017; Titone et al., 2022).

The majority of the existing literature exploring the association between sleep and urgency is cross-sectional. While there are some mixed findings regarding how urgency relates to sleep quality and general sleep disturbance, results are largely in support of a moderate to large effect size, with worse sleep quality

and greater general sleep disturbance being associated with higher urgency. Measurements of sleep health can be quite variable, and those that don't fit clearly into categories of sleep duration, sleep quality, daytime impairment, and sleep-wake rhythms can be lumped together into a broad category of general sleep disturbance. This includes measures of insomnia symptoms, such as a combination of sleep quality, duration, and daytime impairment issues (Bauducco et al., 2019; Hom et al., 2016; Palagini, Cipollone, Masci, et al., 2019; Schmidt et al., 2008, 2010; Schmidt & Van der Linden, 2009); a count of sleep disorder diagnoses (A. A. Miller & Rucas, 2012); and other various items such as “How often does thinking too much keep you awake?” (Schmidt et al., 2010). Measurements of sleep quality have also varied across studies, though to a lesser extent, with measures ranging from well-known sleep measures such as the Pittsburgh Sleep Quality Index (PSQI; (Buysse et al., 1998)) (Barker et al., 2016; Freitag et al., 2017; Galbiati et al., 2020; Grove et al., 2017; Nicholson et al., 2021; Pickett et al., 2016), which includes items such as “During the past month, how would you rate your sleep quality overall?” and “How long (in minutes) has it taken you to fall asleep each night?”, to polysomnography (PSG) (Galbiati et al., 2020), which involves overnight monitoring of physiological measures such as heart rate and breathing in a lab. A small number of studies (Galbiati et al., 2020; Schmidt et al., 2008; Titone et al., 2022) have more explicitly divided sleep quality into specific types of sleep maintenance issues, such as sleep onset latency (SOL), waking after sleep onset (WASO), and early awakening (EA). Of these three types of sleep maintenance issues, it appears that SOL may be the most strongly related to urgency, with a moderate to large effect size (Galbiati et al., 2020; Schmidt et al., 2008), though there has also been support for associations with WASO and, to a lesser extent, EA (Schmidt et al., 2008). Timescales of measurement have also varied, with some studies asking participants to estimate sleep quality over the past month (Freitag et al., 2017; Galbiati et al., 2020; Grove et al., 2017; M. B. Miller et al., 2017; Nicholson et al., 2021; Pickett et al., 2016), for instance, and others measuring daily sleep quality through actigraphy for as long as two weeks (Tashjian et al., 2017). Despite this variation, results appear to be largely consistent regardless of measurement or other variation in study methodology (e.g., analytic strategy, sample characteristics).

Associations between sleep and urgency may be a result of the negative impact that poor sleep health is thought to have on emotions, such as increased negative affect (Kahn et al., 2013; Konjarski et al., 2018; Narmandakh et al., 2021) and decreased positive affect (Finan et al., 2015, 2017; Kahn et al., 2013; Konjarski et al., 2018; Pilcher et al., 2015), altered salience and reward networks (Ben Simon et al., 2020;

Kahn et al., 2013; Mullin et al., 2013), and disrupted connectivity between the amygdala and the medial prefrontal cortex (Ben Simon et al., 2020; Kahn et al., 2013), in addition to the negative impact on *responses* to emotions via cognitive control and emotion regulation disruptions (Gruber & Cassoff, 2014; Kahn et al., 2013; Lowe et al., 2017; Palmer & Alfano, 2017), as both emotion and response to emotion are fundamental components of urgency. The sleep-urgency association could also run in the other direction, with urgency adversely impacting sleep. For instance, arousal resulting from intense emotion is thought to disrupt sleep quality (Kahn et al., 2013; Konjarski et al., 2018) as well as the transition to sleep (Saper et al., 2005), and people with worse self-regulation may have less effective sleep health behaviors such as delaying bedtimes (Kroese et al., 2016). While most of the sleep-urgency literature is cross-sectional, one recent review found that there is stronger support for bidirectionality than unidirectionality between sleep disturbances and various externalizing behaviors (Liu et al., 2022), and one longitudinal study found support for a bidirectional association between general sleep disturbance and urgency (Bauducco et al., 2019). In the longitudinal study, which took place over a two-year period, cross-sectional associations were stronger than longitudinal ones, suggesting that this association occurs on a more granular timescale.

A small number of studies have provided opportunity for greater temporal granularity between sleep and urgency by using ecological momentary assessment (EMA). Both within- and between-person sleep quality were related to next-day urgency when sleep duration was not included as a covariate (A. L. McGowan et al., 2021). Other EMA studies have explored urgency's association with measures that share construct overlap with sleep-wake rhythm regularity: within-person deviations in sleep duration and sleep midpoint. These studies did not support daily associations with urgency (Hasler et al., 2022; A. L. McGowan et al., 2021), though there were tentative between-person associations. The strong theoretical basis behind associations between sleep quality, sleep-wake rhythms, and urgency, robust support for between-person associations, and limited number of studies examining daily dynamics make these associations worth further investigation on a daily level.

Urgency, sleep, and bipolar disorder

Both sleep health and emotional impulsivity are key features of bipolar disorder. While poor sleep health is common among psychiatric disorders (Dolsen et al., 2014), it is especially prominent in bipolar disorder, with one recent study finding that during euthymic periods, lower sleep efficiency and worse general sleep disturbance in particular differentiated people with bipolar disorder from those with unipolar

depression (Vieira et al., 2021). Sleep disturbances are a cardinal symptom of both mania and depression and are even a proposed underlying mechanism of the disorder as a whole (Caruso et al., 2021; Harvey, 2011; Palagini, Bastien, et al., 2019). Compared to controls, individuals with bipolar disorder have demonstrated worse sleep quality, higher SOL and WASO, and greater irregularity in sleep-wake and social rhythms, which are disturbances that can also already been seen in individuals at high risk for developing bipolar disorder even prior to onset (Dondé et al., 2021; Geoffroy et al., 2015; Hensch et al., 2019; Melo et al., 2016; Ng et al., 2015; Scott et al., 2022).

Just as poor sleep health is a core feature of bipolar disorder, high impulsivity is a key diagnostic criterion of mania, and urgency in particular has been shown to be related to risk for developing bipolar disorder (Giovannelli et al., 2013; Johnson, Carver, Mulé, et al., 2013). Moreover, previous work suggests associations between broad impulsivity and sleep features in individuals at risk for or with a diagnosis of bipolar disorder. In a sample of adults with a diagnosis of bipolar disorder, daily sleep quality was associated with broad impulsivity, with higher impulsivity predicting worse and more irregular sleep quality that night, though this effect was not found in the other direction (Patapoff et al., 2022). Daily associations between broad impulsivity and constructs overlapping with sleep-wake rhythms were more inconsistent in adults with diagnoses of or at risk for bipolar disorder (Kaufmann et al., 2016; Patapoff et al., 2022; Sperry & Kwapil, 2022), but this association has have been more robustly supported on a between-person level in both populations (Gershon et al., 2019; Kaufmann et al., 2016; Patapoff et al., 2022; Sperry & Kwapil, 2022). Between-person associations between impulsivity and sleep quality and general sleep disturbance have also been found in individuals with bipolar disorder (Azzam et al., 2019; Patapoff et al., 2022; Russo et al., 2015). Thus, in the context of bipolar disorder, there is support for both within- and between-person associations between *sleep quality* and general impulsivity, but limited support for within-person associations with *sleep-wake rhythms* in these populations despite support for between-person associations. However, there are few EMA studies examining these associations, and sample sizes have been small (under 60 participants) for the majority of these studies, so further exploration is needed.

There is reason to suspect that associations between sleep and urgency may be stronger for those at higher risk for developing bipolar disorder in comparison to those who are at lower risk. For example, one study looked specifically at how degree of risk for developing bipolar disorder might relate to daily sleep-impulsivity associations in a sample of high-risk young adults and found that sleep duration and broad

impulsivity were more strongly associated in those with higher risk, with higher within-person impulsivity predicting shorter sleep duration that night (Sperry & Kwapil, 2022). While a stronger sleep-impulsivity association for higher-risk individuals was found specifically for sleep duration (and not deviations in sleep duration) in this study, greater sleep-wake rhythm irregularity and general sleep disturbance have been shown to relate more strongly to increased impulsivity (Azzam et al., 2019; Gershon et al., 2019) and emotion regulation difficulties (Palagini, Cipollone, Moretto, et al., 2019) in adolescents (Gershon et al., 2019) and adults (Palagini, Cipollone, Moretto, et al., 2019) with a diagnosis of bipolar disorder than in their control group counterparts. Greater disturbances in sleep quality and sleep-wake rhythms that are typical in bipolar disorder are already seen in those who are high-risk (Melo et al., 2016; Ng et al., 2015; Scott et al., 2022; Sperry & Kwapil, 2022), so it is also possible that the stronger association between these disturbances and impulsivity is also already present. Furthermore, turning to urgency more specifically, Tashjian and colleagues (2017) found cross-sectional associations between actigraphy-measured sleep quality and negative urgency that were moderated by PFC-DMN connectivity, such that worse sleep quality was associated with higher negative urgency *only* in those with disrupted connectivity. Distinct disruptions to those networks have been seen in those with bipolar disorder (see Maletic & Raison, 2014 for review), and there is also evidence that some of the neurobiological differences characteristic of bipolar disorder can be seen in those who are at high risk (Özerdem et al., 2016). In light of Tashjian and colleagues' findings, this further suggests that the association between poor sleep quality and urgency may be stronger in those with disrupted PFC connectivity, which may include those with diagnoses of or at risk for bipolar disorder.

The current study

While there has been support for daily associations between sleep and broad impulsivity, as well as cross-sectional studies supporting associations between sleep and urgency specifically, very few studies have explored the *daily* associations between sleep and *urgency*. To my knowledge, no studies have explored the possible *bidirectionality* of daily urgency-sleep associations. Given that disrupted sleep and emotional impulsivity are both transdiagnostic risk factors and associated with a broad array of negative mental health outcomes (Carver & Johnson, 2018; Dolsen et al., 2014; Johnson, Carver, & Joormann, 2013), further clarification of how they relate to one another and how this association unfolds on a daily level may ultimately provide insight into underlying mechanisms of these associated negative outcomes as well as inform intervention strategies. Effective intervention on sleep in adolescents and young adults is of the

utmost importance, as they may be especially vulnerable to negative impacts of sleep disturbances (Bruce et al., 2017) and prone to engaging in impulsive and risk-taking behaviors (Kelley et al., 2004; Somerville et al., 2010; Steinberg, 2007).

Likewise, while daily associations between sleep and broad impulsivity have been established in at-risk samples, no studies have looked at daily associations between sleep and *urgency* in this population. There is copious research supporting the need to differentiate among the facets of impulsivity (Berg et al., 2015; Strickland & Johnson, 2021). Urgency in particular is strongly implicated in bipolar disorder and risk for bipolar disorder (Giovanelli et al., 2013; Johnson, Carver, Mulé, et al., 2013; Muhtadie et al., 2014), and therefore may be especially related to sleep in a way that varies by bipolar risk. Furthermore, while one study found that the daily association between sleep duration and broad impulsivity was moderated by degree of risk within an already higher-risk sample (Sperry & Kwapil, 2022), no one has explored whether associations between *urgency* and *sleep quality* and *sleep-wake rhythms* differ in those who are at higher versus lower risk for developing bipolar disorder. Sleep disturbances are associated with an increased risk of bipolar disorder onset in youth at higher risk (Scott et al., 2022); differential associations between sleep and urgency in those who are at higher risk may provide some insight into how bipolar disorder develops as well as inform interventions on sleep and emotionally rash behavior in this population.

Aims and Hypotheses

The proposed study will add to the literature and extend previous work by exploring the person-level and bidirectional daily associations between urgency and sleep quality and two different measures of sleep-wake rhythm regularity. The moderating effect of bipolar risk on these associations will also be tested.

Confirmatory analyses

Aim 1: Explore bidirectional daily associations between urgency and sleep quality and sleep-wake rhythm regularity.

Hypothesis 1a: Worse *sleep quality* (within-person) will predict higher next-day urgency, and higher urgency (within-person) will predict worse sleep quality that same night.

Hypothesis 1b: Greater deviation from typical *sleep midpoint* on a given day (using square of within-person value) will predict higher next-day urgency, and higher urgency (within-person) will predict greater deviation from typical sleep midpoint (using square of within person value) that same night.

Hypothesis 1c: Greater deviation from typical *sleep duration* on a given day (using square of within-person value) will predict higher next-day urgency, and higher urgency (within-person) will predict greater deviation from typical sleep duration (using square of within person value) that same night.

Aim 2: Examine person-level associations between urgency and sleep quality and sleep-wake rhythm regularity.

Hypothesis 2a: Worse person-level *sleep quality* (between-person) will be associated with higher urgency.

Hypothesis 2b: Greater person-level deviation from typical *sleep midpoint* (using within-person standard deviation) will be associated with higher urgency.

Hypothesis 2c: Greater person-level deviation from typical *sleep duration* (using within-person standard deviation) will be associated with higher urgency.

Aim 3: Test whether these associations are moderated by risk for developing bipolar disorder.

Hypothesis 3a: Worse *sleep quality* (within-person) will predict higher next-day urgency, and higher urgency (within-person) will predict worse sleep quality that same night, both to a greater degree in those who are at higher risk for bipolar disorder.

Hypothesis 3b: Greater deviation from typical *sleep midpoint* on a given day (using square of within-person value) will predict higher next-day urgency, and higher urgency (within-person) will predict greater deviation from typical sleep midpoint (using square of within person value) that same night, both to a greater degree in those who are at higher risk for bipolar disorder.

Hypothesis 3c: Greater deviation from typical *sleep duration* on a given day (using square of within-person value) will predict higher next-day urgency, and higher urgency (within-person) will predict greater deviation from typical sleep duration (using square of within person value) that same night, both to a greater degree in those who are at higher risk for bipolar disorder.

Hypothesis 3d: Worse person-level *sleep quality* (between-person) will be associated with higher urgency to a greater degree in those who are at higher risk for bipolar disorder.

Hypothesis 3e: Greater person-level deviation from typical *sleep midpoint* (using within-person standard deviation) will be associated with higher urgency to a greater degree in those who are at higher risk for bipolar disorder.

Hypothesis 3f: Greater person-level deviation from typical *sleep duration* (using within-person standard deviation) will be associated with higher urgency to a greater degree in those who are at higher risk for bipolar disorder.

Exploratory analyses

Exploratory analyses will be conducted with SOL and WASO to explore the degree to which types of sleep quality disturbance relate to urgency. Furthermore, given the well-documented sleep disparities among traditionally socially and economically marginalized groups (Billings et al., 2021; Butler et al., 2020; Grandner et al., 2016; Titone et al., 2020; Yip et al., 2021; Yip & Cheon, 2020), additional exploratory analyses will test moderation by parental education (as a proxy for socioeconomic status), race and ethnicity, gender identity, and sexual orientation. This will be to examine whether the hypothesized associations differ for those who may be disproportionately impacted by specific contextual factors that affect sleep, such as neighborhood safety concerns, noise and light pollution, discrimination, beliefs about sleep and health, and experience of discrimination and other stressors (Billings et al., 2021; Cohen et al., 2022; Fuller-Rowell et al., 2017; Grandner et al., 2016).

Method

Participants

The current study utilized data collected as part of a larger project examining emotion and emotion regulation, substance use, impulsivity, and a variety of other mental health related variables in a community sample of young adults ($n = 495$; $M_{age} = 20.3$, $SD = 1.3$). Participants were predominantly non-Hispanic White (54%), with the next highest racial and ethnic identities being biracial/multiracial (20%), East Asian (7.5%), Hispanic (6.3%), Southeast Asian (4.2%), and African American (3.6%). Of the biracial/multiracial participants, 65.9% included White as one of their identities, 30.9% included East Asian, and 23.7% included Southeast Asian, with other endorsed identities including Middle Eastern (15.5%), African American (11.3%), Hispanic (11.3%), South Asian (8.2%), Native American (8.2%), Pacific Islander (6.2%), and African (3.1%). Forty-five percent of participants identified as cisgender female and 42% identified as cisgender male, with the remaining participants identifying as nonbinary/gender queer/gender nonconforming (8.5%), transgender male (3.0%), transgender female (1.0%), or nongendered (0.2%). Most participants identified as

heterosexual (52%), with the remaining participants either identifying as LGBTQ+ (47.6%) or declining to respond ($n = 2$). If participants indicated more than one value for parental education (e.g., different values for different parents), the highest value was used. Most participants had at least one parent with a college degree or graduate degree (72%). Full demographic information can be found in Table 1.

Inclusion criteria for enrollment in the larger study were that participants were between the ages of 18 to 22 at the time of enrollment, used marijuana or alcohol at least weekly over the past 3 months, were fluent in English, moved to the United States before age 12 (in order to exclude participants who may not be acculturated to United States norms of substance use), lived in the study area, and had access to an Internet-enabled smartphone in order to complete the daily EMA surveys. Participants were excluded from enrollment only if they did not meet these inclusion criteria or were unable/unwilling to verify their identity.

Retention and missing data

Most participants responded to at least 80% of the surveys ($n = 338$), for a mean response rate of 94.1% among high responders ($SD = 5.6$, range: 80-115%) and 42.6% among low responders ($SD = 25.4$, range: 2.5-77.5%). Participants contributed an average of 31.1 days of data each ($SD = 11.3$, range: 1-45 days)¹, for a total of 15,391 days with data for at least one variable of interest (i.e., urgency, sleep quality, or sleep duration). Sleep data were only collected at certain timepoints throughout the day, making it possible for participants to have provided urgency data (asked at all timepoints) without providing sleep quality (asked on morning surveys only) or sleep duration data (bedtime asked on morning surveys and rise time asked on night surveys, with both values needed for a calculation). Therefore, the number of days included in a given model were less than total available days ($M_{days} = 7,820.7$, range: 4,707-13,823) and varied across models based on directionality and sleep variable used. For instance, there were more days with sleep quality data ($n = 13,871$) than sleep duration data ($n = 6,646$), as the former required a response to only one survey while the latter required a response to two separate surveys at different times. The total number of days used in a given model are listed in the results in Table 2.

Participants who had higher response rates were lower in urgency ($r = -0.19$, $p < 0.001$), bipolar risk ($r = -0.15$, $p < 0.001$), and disrupted sleep quality ($r = -0.12$, $p < 0.001$), and had lower sleep duration

¹ Two participants contributed data on more days than total possible days (40 days) due to extended EMA periods. This was a result of a participant's phone being stolen in one case, and a combination of technical issues with the survey distribution platform and getting a new phone number in the case of the other participant.

irregularity ($r = -0.10$, $p = 0.03$). Additionally, surveys were more commonly responded to ($M = 12.3$, $SD = 7.3$) versus not responded to ($M = 16.0$, $SD = 7.7$) in earlier months of the overall study period, $t(226.67) = 7.0$, $p < 0.001$, which could be attributed to a variety of factors, such as busier lifestyles due to decreased COVID restrictions. Surveys were also more commonly responded to ($M = 25.9$, $SD = 16.1$) versus not responded to ($M = 43.9$, $SD = 20.1$) earlier in a given participant's 2-month study window, $t(35114) = 93.0$, $p < 0.001$.

Procedure

Participants were recruited through posts on a variety of social media and other local websites with the intention of targeting a diverse group of 18–22-year-olds in the Puget Sound region that was representative of the racial and ethnic composition of the study area, balancing across five age bins (18, 19, 20, 21, and 22 years old) and binary gender categories of male and female. Recruitment strategies were adjusted across the study period in order to achieve the target demographic composition (e.g., temporarily restricting enrollment and targeting recruitment efforts towards younger and male-identifying participants only). The study enrollment period was from August 2020 through January 2023.

Participants for this study completed a virtual orientation session, at which time participant identity and age was verified with photo ID, and participants were provided with instructions and given a practice EMA survey. Participants then completed baseline self-report measures and provided eight weeks of EMA data, with five assessments per day on Thursday through Sunday each week, and one additional survey on Monday morning. Assessments were randomly sent by text message within five separate three-hour blocks between 9am and 11pm, with at least one hour between surveys. Participants were sent a reminder text if they had not completed the survey within 30 minutes, and the survey link expired one hour after being sent. Participants received \$50 for completing the baseline survey, and an additional \$1 per completed EMA survey with a \$5 bonus granted per weekend for a completion rate of 80% or higher. A total of four follow-up surveys were collected, with one survey collected every six months over a two-year period. Participants received \$40 for each of the first two follow-up surveys and \$50 for each of the final two follow-up surveys. All study procedures were approved by the University of Washington IRB.

Measures

To reduce participant burden, for all scales that had multiple items, participants were presented with a randomly selected subset of items (70-85% of items from each subscale) at each assessment. Because items are by definition MCAR, mean scores may be computed without bias (Schafer & Graham, 2002).

When urgency and all sleep variables were the outcome variables, they were standardized across all possible observations. When urgency and sleep quality were within-person predictors, they were standardized and centered within each participant's own daily values; when they were between-person predictors, they were standardized and centered across person-level values. When sleep midpoint irregularity and sleep duration irregularity were the predictors, they were standardized, but not centered, within- and between-person. Furthermore, given that previous night's sleep was measured on the same day as urgency, these values were lagged in models in which sleep prospectively predicted next-day urgency. For instance, the sleep responses provided on Friday morning refer to sleep on Thursday night, so modeling Friday's sleep values as predicting Friday's urgency values reflected *Thursday night's sleep* prospectively predicting Friday's (i.e., next-day) urgency. When urgency predicted sleep that same night, urgency was lagged by one day, such that Thursday's urgency value prospectively predicted Friday morning's sleep responses, which refer to sleep on Thursday night (i.e., same-day).

Urgency

Urgency was measured with six items adapted from the urgency subscale of the UPPS (Whiteside & Lynam, 2001), with item stems changed to reflect impulsive behaviors in the past hour, and urgency items free from emotional content. For example, the original urgency item "when I am upset, I often act without thinking" became "I acted without thinking." In each EMA survey, four of the six urgency items were randomly presented. Participants were prompted to rate how strongly they agreed with the impulsivity related statements on a slider bar that ranged from "Strongly Disagree" to "Strongly Agree." These slider bars were scored continuously from 0-100 based on the slider position. Subscale means were used to create urgency values at each observation, and then observation-level values were averaged to create day-level values². Higher scores indicate more emotional impulsivity. Reliability was high in current data ($R_kF = 0.99$), and

² Participants were only given one survey on Mondays, so no more than one urgency value could be provided on Mondays. These single Monday morning urgency values were considered daily urgency values for those days; there were not differences in inferences when Monday morning values of urgency were excluded, so they were retained for the final models.

there was also strong evidence of validity in pilot data, which was replicated in an independent sample of adults (Halvorson et al., 2021).

Sleep quality

The original PROMIS-Sleep Disturbance measure was one of two PROMIS sleep measures (with the other being Sleep-Related Impairment) developed through a rigorous process of reviewing previous literature, item response theory (IRT) analyses, classical test theory (CTT) methods, consulting experts, and qualitative research methods (Buysse et al., 2010). The final items selected following this process showed a four-factor structure. These factors were conceptually merged to create the two PROMIS sleep measures: Sleep Disturbance and Sleep-Related Impairment. The PROMIS-Sleep Disturbance measure comprises the “sleep-onset problems” and “sleep quality” factors and is a total of 27 items. In its original form, it reflects subjective impressions of sleep quality and disruption over the past seven days. Responses are on a five-point Likert scale with response options differing by question prompt. The eight-item short form of the PROMIS-Sleep Disturbance was developed through computerized adaptive testing (Yu et al., 2012). The short-form measure also asks about perceptions of sleep over the past seven days.

For the present study, however, these questions were adapted for EMA and prompted participants to rate their perceptions of the previous night's sleep. Two of these eight items (“I had difficulty falling asleep” and “I had trouble staying asleep”) were asked each morning along with two randomly selected items of the remaining six, for a total of four items administered per morning survey, which were displayed evenly across observations. Participants responded on a sliding scale from 1-5, with 1 being “Not at all” and 5 being “Very much.” Subscale means were used to create daily sleep quality values. The two items that were asked each morning reflect SOL and WASO and were each examined independently in exploratory analyses. Higher scores indicate more disrupted sleep quality. Within-person reliability was good in the present study ($R_kF = 0.98$).

This measure has shown good reliability and validity. Under the IRT framework, reliability is allowed to vary as a function of θ . The PROMIS-Sleep Disturbance short-form demonstrated a high reliability of 0.90 or above for those with θ scores between -1.5 to 2.5 (Yu et al., 2012). Scores on the PROMIS-Sleep Disturbance were higher in those with sleep disorders than in those without. Also, scores on this measure were more highly correlated with the Pittsburgh Sleep Quality Index (PSQI; $r = 0.83$) than with the Epworth Sleepiness Scale (ESS; $r = 0.30$), the former of which is a well-established measure that is intended to

measure sleep quality, whereas the latter is intended to measure a slightly different construct, daytime sleepiness. Of note, the PROMIS-Sleep Disturbance demonstrated greater measurement precision than the PSQI (Yu et al., 2012). Furthermore, PROMIS-Sleep Disturbance scores were significantly correlated with actigraphy-measured sleep times (Hanish et al., 2017).

Sleep-wake rhythm regularity

Irregularity of sleep duration and sleep midpoint were both calculated from daily questions about bedtime and rise time adapted from the Social Rhythm Metric 5-item (SRM-5) (Monk et al., 2002), with bedtime being asked in each morning survey and rise time being asked in each night survey. First, sleep duration was calculated as the difference between bedtime and rise time in minutes, and sleep midpoint was calculated as the midpoint between bedtime and rise time. These variables were then centered within-person and squared to create regularity scores for each variable for each day (e.g., Kaufmann et al., 2016). The person-level values for both variables were generated by calculating the within-person standard deviations for each variable (Kaufmann et al., 2016).

When calculating sleep duration, several instances of impossible or improbable sleep duration values were discovered, which may have been due to participants incorrectly indicating whether the time was “AM” or “PM.” Of the 6,646 total days, 44 days had sleep durations that were below 0 minutes, 329 days were over 12 hours, and 216 days were over 15 hours. Additionally, in the process of calculating blood alcohol concentration (BAC) values (a covariate discussed below), days with negative BAC values were also detected, which were caused by participants indicating a bedtime that was earlier than they began drinking.

Days with negative sleep duration or negative BAC values were extracted for further investigation. For these days, educated guesses about potential response error were made based on that participant’s typical sleep pattern. For instance, participant X consistently went to bed between the hours of 11:00pm and 1:00am and consistently woke up between the hours of 7:00am and 10:00am. If on one survey they indicated that they went to bed at 12:00pm the previous day, started drinking after 8:00pm that day, and then woke up at 8:00am the next day, then their 12:00 bedtime was changed from “PM” to “AM.” After these select manual adjustments to sleep timing were made ($n = 91$), both sleep duration and sleep midpoint values were Winsorized at 3 standard deviations, which impacted 176 sleep duration values (0.03% of adjusted values) and 14 sleep midpoint values (0.002% of adjusted values).

Bipolar risk

The Hypomanic Personality Scale (HPS) is a self-report questionnaire developed in an undergraduate population to assess hypomanic personality traits as well as to determine risk for developing bipolar disorder (Eckblad & Chapman, 1986). All 48 items originally selected for this measure refer to either stable characteristics or recurring experiences. Items include prompts such as “I am frequently in such high spirits that I can’t concentrate on any one thing for too long,” “I seem to be a person whose mood goes up and down easily,” and “I do most of my work during brief periods of intense inspiration.” A short form of the HPS was developed (HPS-20) that includes 20 items of the original 48 items. The short form was developed through Rasch analysis and retains similar psychometric properties to the original. The short form of the HPS is unidimensional (Meads & Bentall, 2008). Some questions have been raised regarding whether the short form of the HPS taps into more maladaptive components of hypomanic personality traits but has overall been found to be acceptable (Sperry et al., 2015). In the present study, 15 items were randomly presented from the 20 available items in the baseline survey, with response options on a Likert scale ranging from 1-5 (1 = “Strongly agree”, 5 = “Strongly disagree”). Items were averaged to create a total HPS score and centered between-person, with higher scores reflecting greater risk for developing bipolar disorder.

The HPS demonstrated good internal reliability (Cronbach’s $\alpha = 0.87$) and test-retest reliability ($r = 0.81$) in the original study (Eckblad & Chapman, 1986) and has consistently demonstrated good psychometric properties in other study samples since. In the current sample, the internal reliability was similarly strong ($\alpha = 0.86$, $\omega = 0.88$). The HPS-20 was correlated with long form at 0.92 and, although it was slightly less internally reliable, it still demonstrated a Cronbach’s α of 0.78 (Meads & Bentall, 2008). Both the long and short forms have shown good convergent and discriminant validity, relating more strongly overall with other bipolar-relevant measures, such as risk-taking and hyperactivity, than those of different psychopathologies, such as psychopathy and unipolar depression (Sperry et al., 2015; Stanton et al., 2019). The HPS also demonstrated good predictive validity with respect to later development of bipolar disorder (Kwapil et al., 2000; Walsh et al., 2015).

Timing covariates

Covariates related to timing of survey response were EMA day to account for study reactivity and weekday vs weekend (coded 0 = weekday, 1 = weekend) to account for possible shared variation in sleep features and urgency on weekends. As a sensitivity analyses, overall month of the study was added to

account for the evolution and fluctuations in various factors related to COVID-19 (e.g., restrictions, lifestyle adjustments).

Substance use

Substance use, particularly alcohol and marijuana use, has been consistently associated with both sleep (Hasler & Pedersen, 2020; Kwon et al., 2019; Yurasek et al., 2020) and urgency (King et al., 2011; Stautz & Cooper, 2013; VanderVeen et al., 2016). Given that this sample was intentionally recruited for their substance use behaviors, variables reflecting alcohol and marijuana use were included as covariates in sensitivity analyses. In line with study preregistration, daily BAC at bedtime was calculated first but, because of the large number of zeroes ($n = 9,552$), subjective intoxication was selected to reflect alcohol use instead. Each morning, participants reported how drunk or intoxicated they felt the previous night using a visual analogue scale ranging from 0 = “Not at all/I didn’t drink” to 100 = “Very drunk.” Participants used this same scale each morning to report subjective high from marijuana use the previous day, responding to the prompt “How ‘stoned’ or ‘high’ did you get?” on a slider scale from 0 = “Not at all/ I didn’t use marijuana” to 100 = “Very high.” If participants did not answer these intoxication items *and* they also indicated through other substance use questions that they did not consume alcohol or marijuana on a given day (e.g., they indicated that they had 0 drinks when asked about drink quantity), then zeroes were populated for the blank intoxication items.

Demographic variables for exploratory analyses

At the baseline assessment, participants selected their *race and/or ethnicity* from a list of 13 options, including “other” (with a text entry option). Participants selected their *gender identities* from a list of 11 options, including “other” (with a text entry option), and indicated their *sexual orientation* from a list of 14 options, including “other” (with a text entry option). Participants were able to select all race and ethnicity, gender, and sexual orientation identity options that applied. Finally, *parental education* was used a proxy for socioeconomic status, which participants were able to indicate separately for two parents, selecting from a list of options ranging from “8th grade or less” to “Graduate/Professional school.” The higher value of the two possible answers was used for analyses.

Racial and ethnic sleep disparities may be due to a variety of factors, such as racial discrimination (Billings et al., 2021; Cohen et al., 2022; Fuller-Rowell et al., 2017; Grandner et al., 2016; Wang & B  r  ,

2021) and culturally-bound beliefs about and practices around sleep (Billings et al., 2021; Grandner et al., 2016). As the greatest disparities have been documented among Black individuals (Yip et al., 2021), with additionally disrupted sleep in Asian-American and Latinx groups (Billings et al., 2021; Yip & Cheon, 2020), contrast coding focused on these groups (non-Hispanic White, Black, Asian and Pacific Islander [API], and Hispanic) in addition to a multiracial group, which included a substantial portion of participants. An additional exploratory analysis included only two groups, participants of color and non-Hispanic White participants, as this would allow for comparison between larger sample sizes (thus resulting in higher power) and also to explore whether there were differences based on simply being a member of a marginalized racial or ethnic.

Sleep disparities for gender identity and sexual orientation are presumed to stem from experiences of discrimination; as such, these variables were coded based on majority and minority status, with three groups for gender (cisgender male, cisgender female, and transgender or gender expansive) and two groups for sexual orientation (heterosexual and LGBTQ+). Like with the race and ethnicity variable, each group was separately positioned as the reference group for gender.

Finally, regarding socioeconomic status, sleep disparities are theorized to arise from factors such as neighborhood safety concerns, noise and light pollution, and less control over work schedules, including shift work, holding multiple jobs, and manual labor (Billings et al., 2021; Grandner et al., 2016). Prior research has identified differences in sleep based on having completed college or not (Grandner et al., 2016), so parental education was coded along this distinction (has not completed college and has completed college).

Analyses

Multilevel modeling (MLM) was used to account for the nested structure of the EMA data. All analyses were conducted in RStudio (RStudio Team, 2020), and hypotheses were tested by fitting multilevel models using the statistical package 'nlme' (Pinheiro et al., 2022). MLM can accept missing data at Level 1 provided participants have some available Level 1 data. Thus, all available data was included for analyses.

Relative fit indices (AIC, BIC, and -2 log likelihood) were used for nested model comparisons, one of which was testing for random slopes. To account for similarities between temporally adjacent observations, models were also built both with and without auto-correlated residuals and these nested models were also compared. Alpha was set at 0.05 and 95% confidence intervals were used when determining significance of coefficients for hypothesis testing. However, the Benjamini-Hochberg procedure (Benjamini & Hochberg, 1995) was applied to control for false discovery rate, which was set at 5%. "Families" were defined as

follows: 1. All predictors of interest in models testing associations between urgency and sleep quality in both directions (4 coefficients total), 2. All predictors of interest in models testing associations between urgency and sleep-wake rhythms in both directions (8 coefficients total), 3. All bipolar risk interaction coefficients (12 coefficients total).

Model building process

First, each model was fitted without a random slope for the daily-level predictor of interest, which was then compared to a second model that *did* include a random slope for the daily-level predictor. A random slope was included in subsequent model building if relative fit indices indicated improved fit. This same model comparison process was then conducted with and without accounting for autocorrelated residuals. Next, the HPS was added as a moderator, and covariates related to the timing of the surveys (i.e., EMA day and weekend vs. weekday) were added to the model. If the addition of timing-related covariates did not change inferences, these covariates were not retained as part of the final model. An example model of between-person sleep quality (SQbtwn) and within-person sleep quality (SQwi) predicting next-day urgency, moderated by HPS score, and with the timing-related covariates is included below. A random slope for sleep quality is included here for illustrative purposes but would not be included in the model if it did not improve model fit.

$$urgency_{ij} = \beta_0 + u_{0j} + \beta_1 SQwi_{ij} + u_{1j} SQwi_{ij} + \beta_2 (SQwi_{ij} * HPS_j) + \beta_3 SQbtwn_j + \beta_4 (SQbtwn_j * HPS_j) + covariates + \varepsilon_{ij}$$

Sensitivity analyses

Sensitivity analyses included the addition of substance use variables as covariates, as well as testing for and removing influential outliers. To test for influential outliers, Cook's distance (Cook's D, or D_i) was used, which is appropriate for multilevel model structures (Van der Meer et al., 2010), with the "predictmeans" R package (Luo et al., 2021). To determine whether to further investigate a given observation, a cutoff point of $4/n$ was used for D_i , where n is the number of observations (Altman & Krzywinski, 2016). Whether effects were robust when the final models were run again with these observations excluded is reported in the results section. Furthermore, impulsivity tends to not be normally distributed. In this study, the residuals had a non-normal distribution and violated assumptions of homoskedasticity; therefore, a third sensitivity analysis tested whether a log-transformation of urgency as the

outcome variable improved the residual distribution or changed inferences. Fourth, in order to avoid misestimation of main effects, checks were run for independence of predictor effects by testing all possible predictor interactions. Effects that were significant at $p < 0.001$ were planned to be included as covariates in a given model without interpreting any incidentally detected interactions, but no such interactions were detected. For the fifth and final sensitivity analysis, overall study month, which served as a proxy for fluctuations in COVID-related variables such as lifestyle restrictions, was included as an interaction term with predictors of interest to ensure that main effects were not impacted by this variable.

Exploratory analyses

This same model building process was conducted with WASO and SOL as the sleep variables of interest. Additional exploratory analyses were conducted separately for each demographic variable of interest. Within these demographic variables, separate models were fitted such that each identity category could be compared with all other identity categories within that demographic variable. For gender identity, for example, cisgender male and cisgender female were each set as the reference group for each hypothesis, thus enabling all 3 of the groups (cisgender male, cisgender female, and transgender or gender expansive) to be compared to one another. Given the large number of exploratory analyses run with demographic variables, alpha was set at 0.001 to determine coefficient significance.

Results

Correlations between all variables are displayed in Figure 1. The ICCs of urgency and sleep quality were 0.68 and 0.34, respectively, suggesting that 68% of the variance in urgency and 34% of the variance in sleep quality was attributable to between-person differences.

Confirmatory analyses

Accounting for autocorrelated residuals improved model fit for all tested models, though a random slope only significantly improved model fit when sleep quality the predictor or outcome variable. Furthermore, the inclusion of timing-related covariates did not meaningfully impact inferences for any of the models; these covariates were therefore excluded from the final models for parsimony. Since residuals were not normally distributed and heteroskedasticity was detected, outcomes for each model were log-transformed as a sensitivity analysis. Results of confirmatory analyses can be found in Table 2 and were largely robust to

sensitivity analyses, with any exceptions described below. See Figure 2 for a graphical depiction of effect sizes.

Sleep quality predicting urgency

There were significant effects such that worse within-person sleep quality predicted elevated next-day urgency ($b = 0.03$, $SE = 0.005$, $p < 0.001$, 95% CI = [0.02, 0.04]), though this varied across individuals ($Var = 0.003$, $SD = 0.05$). The main effect of between-person sleep quality on urgency was also significant, such that a 1 SD increase in disrupted sleep quality was associated with a 0.28 SD increase in urgency at any given time ($SE = 0.03$, $p < 0.001$, 95% CI = [0.22, 0.34]). There were not significant interaction terms between bipolar risk and either within- or between-person sleep quality. All significant effects survived correction for multiple comparisons.³

Urgency predicting sleep quality

Higher within-person urgency significantly predicted worse sleep quality that night ($b = 0.008$, $SE = 0.003$, $p = 0.01$, 95% CI = [0.002, 0.01]), with significant variance across individuals ($Var = 0.0003$, $SD = 0.02$). Between-person urgency also significantly predicted sleep quality, such that a 1 SD increase in between-person urgency related to a 0.10 SD increase in sleep quality disturbances ($SE = 0.01$, $p < 0.001$, 95% CI = [0.09, 0.12]). These effects were robust to correction for multiple comparisons. There were not interaction effects for bipolar risk.

While the within-person effect of urgency was robust to correction for multiple comparisons, it was no longer present when daily marijuana use was added as a covariate ($b = 0.009$, $SE = 0.005$, $p = 0.07$, 95% CI = [-0.0007, 0.02]), nor when potentially influential outliers ($n = 222$; 2.1% of the 10,445 observations included in the full model) were removed ($b = 0.005$, $SE = 0.003$, $p = 0.11$, 95% CI = [-0.001, 0.01]).

Sleep midpoint irregularity predicting urgency

Higher person-level sleep midpoint irregularity was significantly associated with *lower* urgency ($b = -0.19$, $SE = 0.07$, $p = 0.01$, 95% CI = [-0.33, -0.04]) and was robust to correction for multiple comparisons.

³ A random slope for within-person sleep quality was not included when checking for changes to inferences when influential outliers ($n = 237$; 1.7% of the 13,823 observations included in the full model) were removed, as there was a convergence error when a random slope was included. Results of the outlier-free model without a random slope were consistent with results from models including all data both with and without a random slope.

There was no significant association between urgency and previous night's midpoint irregularity, nor were there any interaction effects.

Urgency predicting sleep midpoint irregularity

There were no significant effects of daily or person-level urgency on sleep midpoint irregularity, nor were there a significant moderation effects of bipolar risk.

Sleep duration irregularity predicting urgency

Higher person-level irregularity in sleep duration predicted higher urgency ($b = 0.31$, $SE = 0.07$, $p < 0.001$, 95% CI = [0.17, 0.44]), which survived correction for multiple comparisons. There was no daily effect of sleep duration irregularity on next-day urgency or any significant interactions with bipolar risk.

Urgency predicting sleep duration irregularity

After correction for multiple comparisons, there were no significant daily or person-level effects of urgency on sleep duration irregularity, nor was there significant moderation by bipolar risk.

Exploratory Analyses

Sleep onset latency predicting urgency

There were significant associations between higher urgency and higher between-person SOL ($b = 0.29$, $SE = 0.03$, $p < 0.001$, 95% CI = [0.23, 0.35]), as well as between higher urgency and higher within-person SOL the previous night ($b = 0.02$, $SE = 0.004$, $p < 0.001$, 95% CI = [0.02, 0.03]), which varied across individuals ($Var = 0.002$, $SD = 0.04$). These associations were robust to correction for multiple comparisons. There was no evidence of bipolar risk moderating these associations.

Urgency predicting sleep onset latency

A 1 SD increase in within-person urgency was associated with a 0.01 SD increase in SOL that night ($SE = 0.005$, $p = 0.009$, 95% CI = [0.003, 0.02]), with variation across individuals ($Var = 0.001$, $SD = 0.04$), and a 1 SD increase in between-person urgency was associated with a 0.14 SD increase in SOL ($SE = 0.01$, $p < 0.001$, 95% CI = [0.12, 0.17]). All effects survived correction for multiple comparisons, and there were no interactions with bipolar risk.

Waking after sleep onset predicting urgency

Though it varied across individuals ($Var = 0.003$, $SD = 0.06$), there was a significant association between higher within-person WASO and higher next-day urgency ($b = 0.02$, $SE = 0.005$, $p < 0.001$, 95% CI = [0.01, 0.03]). There was also an association between higher between-person WASO and higher urgency ($b = 0.30$, $SE = 0.03$, $p < 0.001$, 95% CI = [0.24, 0.36]). The interaction between bipolar risk and within-person WASO did not survive correction for multiple comparisons.

Urgency predicting waking after sleep onset

Both higher within-person urgency ($b = 0.02$, $SE = 0.005$, $p < 0.001$, 95% CI = [0.008, 0.03]) and higher between-person urgency ($b = 0.15$, $SE = 0.01$, $p < 0.001$, 95% CI = [0.12, 0.18]) were significantly associated with higher WASO that night, with no variation across individuals, and were robust to correction. There was no evidence of moderation by bipolar risk.

Race and ethnicity

Race and ethnicity significantly moderated the association between between-person sleep quality and urgency with Black participants having a stronger association between average poor sleep and urgency than API participants ($b = -0.66$, $SE = 0.17$, $p < 0.001$, 95% CI = [-1.01, -0.31]) and multiracial participants ($b = -0.58$, $SE = 0.17$, $p < 0.001$, 95% CI = [-0.91, -0.24]). There was also moderation such that the interaction between bipolar risk and person-level sleep midpoint irregularity was stronger for Black compared to both non-Hispanic White ($b = -0.005$, $SE = 0.001$, $p < 0.001$, 95% CI = [-0.008, -0.002]) and multiracial participants ($b = -0.005$, $SE = 0.001$, $p < 0.001$, 95% CI = [-0.008, -0.002]). This interaction effect was significant for Black participants, such that those with higher risk for developing bipolar disorder had a stronger association between person-level sleep midpoint irregularity and urgency ($b = 0.005$, $SE = 0.001$, $p < 0.001$, 95% CI = [0.002, 0.007]). Finally, the association between person-level sleep duration irregularity and urgency was stronger for Hispanic participants than for Black participants ($b = -1.19$, $SE = 0.35$, $p < 0.001$, 95% CI = [-1.89, -0.50]) and API participants ($b = -0.96$, $SE = 0.29$, $p < 0.001$, 95% CI = [-1.52, -0.40]), and greater person-level sleep duration irregularity predicted higher urgency in Hispanic participants ($b = 0.96$, $SE = 0.23$, $p < 0.001$, 95% CI = [0.52, 1.40]) but not in Black participants ($b = -0.23$, $SE = 0.27$, $p = 0.39$, 95% CI = [-0.77, 0.30]) or API participants ($b = 0.001$, $SE = 0.18$, $p = 0.99$, 95% CI = [-0.34, 0.34]).

Gender identity

The only difference for gender identity was the association between between-person sleep quality and urgency, with worse between-person sleep quality being more strongly related to increased urgency in cisgender males than cisgender females ($b = -0.25$, $SE = 0.06$, $p < 0.001$, 95% CI = [-0.37, -0.12]).

Sexual orientation

There was moderation by sexual orientation for the effect of between-person sleep quality on urgency ($b = -0.19$, $SE = 0.06$, $p < 0.001$, 95% CI = [-0.31, -0.08]) such that the association was stronger for heterosexual participants. The interaction between within-person sleep quality and bipolar risk was also significant ($b = 0.02$, $SE = 0.006$, $p < 0.001$, 95% CI = [0.01, 0.04]) and stronger in heterosexual participants than LGBTQ+ participants ($b = -0.03$, $SE = 0.009$, $p < 0.001$, 95% CI = [-0.05, -0.01]), such that the association between worse within-person sleep quality and higher next-day urgency was stronger for heterosexual participants with higher bipolar risk.

Parental education

Parental education did not moderate effects.

Discussion

Disrupted sleep health has been implicated in a wide range of negative mental health outcomes (Ben Simon et al., 2020; Dolsen et al., 2014; Hertenstein et al., 2019; Porras-Segovia et al., 2019; Zhu et al., 2021), especially bipolar disorder (Caruso et al., 2021; Harvey, 2011; Palagini, Bastien, et al., 2019). Poor sleep health has also been robustly associated with increased urgency (Galbiati et al., 2020; Grove et al., 2017; M. B. Miller et al., 2017; Nicholson et al., 2021; Pickett et al., 2016; Schmidt et al., 2008, 2010; Tashjian et al., 2017), which is an extensively supported transdiagnostic risk factor for negative mental health outcomes (Carver & Johnson, 2018; Johnson, Carver, & Joormann, 2013). The present study expanded on prior work by examining bidirectional daily associations between urgency and two specific aspects of sleep health, which were sleep quality and sleep-wake rhythm irregularity, as well as whether these associations varied in those who were at higher risk for developing bipolar disorder. Hypothesized effects were robust for both person-level and daily bidirectional associations between urgency and sleep quality, with mixed

evidence for associations between sleep-wake rhythm irregularity and urgency, and limited evidence for any moderation by bipolar risk.

Sleep quality and urgency

While there was evidence of bidirectionality, the effect sizes when poor sleep quality predicted higher urgency were three times as large as the effects in the opposite direction and also more robust to sensitivity analyses, suggesting that sleep quality is a stronger predictor of urgency than urgency is of sleep quality, on both the daily level (i.e., within-person) and the overall person level (i.e., between-person). This association is consistent with previous findings that poor sleep quality, measured in a variety of ways, is related to increased urgency (Galbiati et al., 2020; Grove et al., 2017; M. B. Miller et al., 2017; Nicholson et al., 2021; Pickett et al., 2016; Schmidt et al., 2008, 2010; Tashjian et al., 2017), with generally similar effect sizes to what was found in the present study. Most of the previous work has been cross-sectional, limiting inferences about temporal dynamics or directionality, but the stronger effects of sleep quality predicting urgency than the opposite indicate that an effect of sleep quality on urgency may be primarily responsible for these previously detected cross-sectional associations.

There is some evidence to support bidirectionality between general sleep health and urgency (Bauducco et al., 2019) as well as between sleep quality and various externalizing behaviors (Liu et al., 2022); however, this is the first study to explicitly examine bidirectionality between sleep quality and urgency on a daily scale. One study that investigated this association on a daily level found mixed evidence for worse daily sleep quality predicting higher next-day urgency (A. L. McGowan et al., 2021), while another study looking at sleep quality and broad impulsivity in individuals with bipolar disorder found a daily association in the opposite direction only (Patapoff et al., 2022). Bidirectional daily associations between sleep quality and urgency are aligned with neurocognitive theories that poor sleep health results in emotional reactivity (Gruber & Cassoff, 2014), increased negative affect (Kahn et al., 2013; Konjarski et al., 2018; Narmandakh et al., 2021) and decreased positive affect (Finan et al., 2015, 2017; Kahn et al., 2013; Konjarski et al., 2018; Pilcher et al., 2015), and disrupted reward and salience networks (Ben Simon et al., 2020; Kahn et al., 2013; Mullin et al., 2013), as well as disrupted ability to effectively regulate and respond to emotions (Gruber & Cassoff, 2014; Kahn et al., 2013; Lowe et al., 2017; Palmer & Alfano, 2017). In the opposite direction, heightened arousal is thought to disrupt or delay sleep (Kahn et al., 2013; Konjarski et al., 2018; Saper et al., 2005). Impulsive responding to emotion differentiates urgency from broad impulsivity, and the centrality of

emotion to these theories may account for why daily sleep quality did not predict broad impulsivity in a sample of individuals with bipolar disorder, but daily broad impulsivity did predict sleep quality (Patapoff et al., 2022). This suggests that processes underlying daily associations between sleep quality and urgency may be distinct from those underlying its association with broad impulsivity, perhaps due to the role of emotion in urgency.

In the present study, the daily associations between sleep quality and urgency varied across participants, which signals that there are additional moderators underlying these individual differences. One such moderator could be differences in trait emotion regulation. As noted above, poor sleep quality has been shown to disrupt emotional networks, with effects including increased negative emotion and emotional reactivity. People who generally struggle to regulate their emotions or have not developed adaptive ways of responding to their emotions may be less likely to have other strategies to turn to when they haven't slept well and are feeling heightened negative emotion. In the absence of other strategies to effectively regulate emotion, impulsive action may be more challenging to avoid or may serve as its own form of maladaptive emotion regulation. Additionally, previous work has found that urgency was only related to worse sleep quality in participants with worse PFC-DMN connectivity (Tashjian et al., 2017), which further supports the possibility that pre-existing challenges with regulation may moderate relations between sleep quality and urgency.

Sleep-wake rhythm irregularity and urgency

Hypotheses regarding associations between urgency and sleep-wake rhythm irregularity were not supported on a daily level, which is consistent with the two previous studies exploring how daily urgency related to measures with construct overlap with sleep-wake rhythm irregularity (Hasler et al., 2022; A. L. McGowan et al., 2021). However, results of the present study regarding person-level associations were not as consistent with previous literature supporting person-level associations between sleep-wake rhythm irregularity and broad impulsivity (Gershon et al., 2019; Gillett et al., 2021; Kaufmann et al., 2016; Patapoff et al., 2022; Sperry & Kwapil, 2022). More specifically, results of the present study do not support evidence that overall urgency predicted sleep-wake rhythm irregularity at any given time, and there was mixed evidence for how overall irregularity relates to urgency at any given time, with *lower* overall sleep midpoint irregularity and *higher* sleep duration irregularity predicting higher urgency.

Although sleep midpoint irregularity and sleep duration irregularity have been used to measure the same construct, they were uncorrelated with one another in the present study. Furthermore, sleep duration irregularity was correlated with urgency, sleep quality, and bipolar risk in the expected directions, but sleep midpoint irregularity was either negatively correlated or uncorrelated with these constructs. This suggests that these measures may have tapped different constructs in this study. Sleep midpoint irregularity is a measure of consistency of sleeping earlier versus later at night. Several studies have found an overall trend of delayed sleep timing following the onset of the COVID-19 pandemic (Becker et al., 2021; Cellini et al., 2020; Gupta et al., 2020; Romero et al., 2020), which is when data for the current study were collected. One study in particular demonstrated that, following the onset of COVID-19, young adults reported going to bed later and that this difference was more pronounced in weekday bedtimes, closing the timing gap between weekend and weekday bedtimes in this age group (Ramos Socarras et al., 2021). Thus, in the present study, greater consistency in sleep midpoint might have been fueled by later *weekday* bedtimes, which would then have also resulted in later *average* sleep timing. Previous work has found that people with later sleep timing, which also indicates later circadian phases, are more impulsive (Caci et al., 2005; Gamble et al., 2013; Kang et al., 2015; N. M. McGowan & Coogan, 2018). If participants with later sleep timing were also more consistent in their sleep midpoint, then it could be the case that *shared variance with later sleep timing and circadian phase* was driving the association between higher sleep midpoint consistency and higher urgency. Despite the possibility that there was less of a discrepancy in weekend-weekday sleep timing during this period, thus resulting in later sleep timing, this could not be tested directly, as these analyses were conducted on data that were intentionally collected over weekends.

Sleep duration irregularity, on the other hand, reflects how inconsistent people are in how long they are sleeping; this measure is more independent of late sleep timing and is, therefore, potentially less contaminated by this other construct. The results for the person-level association with sleep duration irregularity were consistent with previous literature supporting associations with broad impulsivity, though there was no daily relation. Thus, perhaps greater sleep-wake rhythm irregularity predicts increased urgency on the person level only, and greater irregularity over time is a stronger predictor of urgency than just one temporally-adjacent night. While a single night of disrupted sleep quality predicts increased urgency, sleep-wake rhythm irregularity may need to accumulate over time to have adverse impacts.

Bipolar risk

In the present study, there was not evidence to support the hypothesis that the association between sleep quality and sleep-wake rhythms and urgency differs for people at higher risk for bipolar disorder. No prior work has explicitly tested this particular moderation effect, but associations between sleep features (sleep duration and sleep-wake rhythm irregularity) and constructs that overlap with urgency (broad impulsivity and emotion regulation) have been stronger in people who were higher risk or diagnosed with bipolar disorder versus controls (Azzam et al., 2019; Gershon et al., 2019; Palagini, Cipollone, Moretto, et al., 2019).

The unexpected results of the present study have several possible explanations. The first possibility is that, despite the large the sample size for the present study, a small number of participants ($n = 32$) had risk scores that are considered elevated (1.5 SDs above the mean, e.g, (Sperry & Kwapil, 2022; Walsh et al., 2015)), and participants with higher risk tended to provide fewer survey responses. While there was enough variation in bipolar risk scores to capture a main effect of bipolar risk on sleep quality and urgency, which is consistent with prior literature demonstrating robust associations between bipolar risk and sleep quality (Melo et al., 2016) and urgency (Giovanelli et al., 2013; Johnson, Carver, Mulé, et al., 2013), the previously found association between bipolar risk and sleep-wake rhythms was not present in this sample (Melo et al., 2016; Ng et al., 2015; Scott et al., 2022; Sperry & Kwapil, 2022). As such, it might have been the case that there was not enough power to detect moderation and that these associations are only stronger at more extreme ends of the risk spectrum. The one study that explored bipolar risk moderating daily associations between sleep and broad impulsivity did find evidence of moderation of urgency's daily association with sleep duration (not deviations in sleep duration); these authors may have found moderation due to oversampling for participants with elevated risk (Sperry & Kwapil, 2022). Future studies should explore whether these results replicate with more power along the risk spectrum.

Another possibility is that the stronger association between sleep health and broad impulsivity and emotion regulation in diagnosed samples versus control samples (Azzam et al., 2019; Gershon et al., 2019; Palagini, Cipollone, Moretto, et al., 2019) doesn't develop until after disorder onset; the study that found moderation by risk and oversampled for higher bipolar risk (Sperry & Kwapil, 2022) might have unintentionally captured people would qualify for a diagnosis. It has been proposed that disrupted circadian and social rhythms in particular are a core element of the etiology of bipolar disorder through theories such

as the social zeitgeber theory, which posits that that a less entrained 24-hour cycle is a key component of what gives rise to bipolar symptoms and is present even before disorder onset (Caruso et al., 2021; Harvey, 2011; Palagini, Bastien, et al., 2019; Scott et al., 2022). Given that emotional impulsivity, or urgency, is a core feature of bipolar symptom expression and has been connected with these sleep-wake rhythm disruptions, it is a promising mechanism for how rhythm irregularity may give rise to bipolar symptoms. Should rhythm irregularity not be more strongly tied to urgency until *after* disorder onset, however, it would indicate that this process triggers or is triggered by disorder onset. The point at which this association arises would provide insight into the etiology of bipolar disorder, as well as elucidate intervention targets for higher risk populations, as it may indicate whether improving sleep health *prior* to onset may be an important target. This line of inquiry would not only benefit from testing moderation with a larger number of participants at higher and lower levels of the risk spectrum, but also with participants who have actually received a diagnosis to determine whether the theorized stronger link only occurs after disorder onset.

Exploratory analyses

Measurement of sleep health, including sleep quality, has been broad and variable, so the present study also included exploration of two specific types of sleep quality disturbance, sleep onset latency (SOL) and waking after sleep onset (WASO). Results demonstrated that SOL and WASO had associations with urgency that were comparable to how broader sleep quality related to urgency, suggesting that type of sleep quality disturbance may not be as important to distinguish in how sleep quality relates to urgency. The limited number of previous studies examining how urgency relates to these specific types of sleep quality disturbance measured via self-report were cross-sectional in support of associations (Galbiati et al., 2020; Schmidt et al., 2008). Interestingly, when actigraphy was used to measure SOL, a person-level association with urgency was not supported (Titone et al., 2022). This suggests that the *perception* of how long it takes to fall asleep may be related to urgency as opposed to the actual amount of time it takes to fall asleep. However, previous work has demonstrated associations between urgency and other physiological measures of sleep quality (Galbiati et al., 2020; Tashjian et al., 2017), so further investigation of how urgency may differentially relate to different aspects of sleep quality should be conducted with physiological measures and compared with self-report findings.

Exploratory analyses also revealed some moderation of effects of person-level sleep quality and urgency by race, gender identity, and sexual orientation, though only moderation by race was as might be

expected. No explicit hypotheses were proposed for these analyses, but given that experiences of typically socially and economically disadvantaged groups, such as increased discrimination, stress, and safety concerns, are thought to negatively impact the aspects of sleep that relate to urgency (Billings et al., 2021; Fuller-Rowell et al., 2017; Grandner et al., 2016), it seemed more likely that members of these groups would experience stronger associations between sleep and urgency. This can be seen in previous work that found stronger effects between sleep disturbance and urgency in females than in males (Bauducco et al., 2019), which makes the pattern of stronger effects for cisgender male participants in the present study especially puzzling. Of note, effect sizes in the present study were substantially stronger for the race interaction effects than for the gender and sexual orientation interaction effects, suggesting that the latter two are more likely to be spurious than the former.

Surprisingly, there were no moderation effects at all for parental education, which was a proxy for socioeconomic status. Several of the possible explanations for sleep disparities are directly related to factors impacted by socioeconomic status such as noise and light pollution, neighborhood safety concerns, shift work, and increased stress (Billings et al., 2021). These factors are also thought to impact REM and slow wave sleep (Halperin, 2014; Lo Martire et al., 2020); these sleep architecture disturbances have been implicated in urgency (Galbiati et al., 2020), emotion and emotion regulation (Finan et al., 2017; Simor & Horváth, 2013; Walker & van der Helm, 2009), and broad impulsivity (Simor & Horváth, 2013). However, results of the current study suggest that perhaps experiences that are more specific to race and ethnicity, such as discrimination, may be more relevant to how sleep relates to urgency. If discrimination were the responsible underlying mechanism, then one would expect associations to also be stronger in LGBTQ+ and gender expansive participants than heterosexual and cisgender participants given the discrimination experienced by these groups (Medina & Mahowald, 2023); this was contrary to current results. One explanation may be region-specific, as a recent report indicated that the area in which this study was conducted has one of the largest LGBTQ+ populations (Balk, 2020) and some of the highest protections for this population in the country (*Washington's Equality Profile*, 2023), which may mitigate impacts of discrimination related to gender and sexual orientation to some degree. Additionally, these data were collected following the murder of George Floyd and resulting increased public awareness of violence against Black individuals in particular, which may have exacerbated feelings of stress (Eichstaedt et al., 2021) and discrimination more in this group than non-Black members of other marginalized identities. Further work that

more explicitly examines these possible underlying processes, such as discrimination, noise pollution, and the role of sleep architecture, is needed.

Another interesting finding of the present study is that moderation was not detected when participants were divided into binary categories of non-Hispanic White and BIPOC identities, and that the effects of sleep duration irregularity on urgency were stronger in Hispanic participants compared to Black and API participants. This highlights the need for specificity and granularity when examining differences in these associations across racial and ethnic identities. Results of the present study also revealed that higher bipolar risk predicted a stronger association for between-person sleep midpoint irregularity and urgency in Black participants, and higher bipolar risk also predicted a stronger association between within-person sleep quality and next-day urgency in heterosexual participants. However, these three-way interactions were not explicitly identified as confirmatory or exploratory analyses, which limits the utility of further interpretation.

Limitations

While there were many strengths of the current study, such as a large sample size, EMA data spanning a 2-month period, and specificity in measurement of variables of interest, some key factors limit interpretation of results. One limitation is that participants who had overall higher urgency, higher bipolar risk, and worse sleep health also tended to have lower response rates to daily surveys. As more data were available from participants who reported lower severity on these variables, inferences about these associations in higher severity groups are more limited. Individuals with higher urgency, worse sleep health, and greater risk for developing bipolar disorder are the most clinically important to study, as they are at the most risk for negative mental health outcomes.

Next, while this study employed greater temporal granularity than the bulk of the existing work around this line of inquiry, greater clarity on timing of these associations is needed. For instance, associations between sleep health and urgency were stronger on the person level than the daily level, which may suggest that chronic sleep issues are more relevant to urgency than acute sleep issues. Chronic, cumulative, and acute sleep loss have been shown to negatively impact cognitive and emotional processes (Baum et al., 2014; Krause et al., 2017; Lowe et al., 2017; Shen et al., 2021), and one study in particular found that broad impulsivity was lower 2 days after increased sleep duration but not immediately after (Kaufmann et al., 2016). As such, questions still remain about whether multiple days of poor sleep quality in

a row are more strongly predictive of urgency, for instance, or how many days of improved sleep it may take for urgency to decrease again.

Finally, exploratory analyses used categorical definitions of identity without consideration of intersectionality of these identities. Past research has demonstrated that associations among sex, gender, socioeconomic status, and sleep behavior varied across ethnicities (Grandner et al., 2010; Marczyk Organek et al., 2015), such as sleep duration differences between Hispanic, White, and Asian males but, in females, sleep duration was only different between African American and White participants (Marczyk Organek et al., 2015). This is also aligned with research demonstrating that intersectionality informs experiences such as discrimination or stressors encountered, with LGBTQ+ people of color reporting more discrimination than their White counterparts, for instance (Medina & Mahowald, 2023).

Clinical implications

As this study is correlational, further experimental work is needed to determine causality. That being said, these findings may still inform clinical intervention in a number of ways. First, inferences may assist in narrowing down of the most effective point of intervention. Urgency's daily associations with sleep quality but not with sleep-wake rhythms suggest that monitoring and addressing sleep quality may benefit emotional impulsivity both short-term and long-term, but that regulating sleep-wake rhythms may be more impactful long-term than short-term. This study also suggests that while both sleep quality and urgency predicted one another on a daily scale, sleep quality may be the stronger point of intervention than emotional impulsivity in curtailing negative downstream effects of these transdiagnostic risk factors. In other words, prioritizing sleep hygiene may be an effective way to improve emotional impulsivity *as well as* subsequent additional impairments resulting from both sleep (e.g., concentration issues) *and* urgency (e.g., interpersonal conflict). Furthermore, regulating sleep is a core component of several recommended evidence-based treatments for bipolar disorder (Harvey et al., 2015; Malhi et al., 2020), such as interpersonal and social rhythm therapy (IPSRT) (Frank et al., 2000). Findings of the present study suggest that this type of intervention may be most relevant for individuals who have been diagnosed with bipolar disorder as opposed to subclinical high-risk populations.

Conclusion

This line of research is of particular importance given the wealth of literature implicating both sleep health and urgency in negative mental health outcomes, especially bipolar disorder; sleep health is especially critical to health outcomes in adolescents and young adults. Overall, results of the present study suggest that urgency has robust short-term and long-term associations with sleep quality, but associations with sleep-wake rhythms may only be long-term and require further clarification. Important future directions include investigation of these associations in samples that include both greater variability in risk for bipolar disorder and participants with bipolar disorder, exploration of additional moderators of individual differences in these associations, and further examination of temporal dynamics.

References

- Altman, N., & Krzywinski, M. (2016). Analyzing outliers: Influential or nuisance? *Nature Methods*, 13(4), 281–282. <https://doi.org/10.1038/nmeth.3812>
- Anderson, C., & Platten, C. R. (2011). Sleep deprivation lowers inhibition and enhances impulsivity to negative stimuli. *Behavioural Brain Research*, 217(2), 463–466. <https://doi.org/10.1016/j.bbr.2010.09.020>
- Azzam, P., Obeid, S., Haddad, C., Kazour, F., Nabbout, R., Hallit, S., & Azar, J. (2019). Relationship between impulsivity and clinical and sociodemographic variables among Lebanese patients with bipolar disorder: results of a cross-sectional study. *Journal of Nervous and Mental Disease*, 207(7), 596–603. <https://doi.org/10.1097/NMD.0000000000001012>
- Balk, G. (2020, October 10). More than 10% of Seattle residents identify as LGBTQ+ — on par with San Francisco. *The Seattle Times*.
- Barker, L. F., Ireland, J. L., Chu, S., & Ireland, C. A. (2016). Sleep and its association with aggression among prisoners: Quantity or quality? *International Journal of Law and Psychiatry*, 47, 115–121. <https://doi.org/10.1016/j.ijlp.2016.02.014>
- Bauducco, S. V., Salihovic, S., & Boersma, K. (2019). Bidirectional associations between adolescents' sleep problems and impulsive behavior over time. *Sleep Medicine: X*, 1, 100009. <https://doi.org/10.1016/j.sleepx.2019.100009>
- Baum, K. T., Desai, A., Field, J., Miller, L. E., Rausch, J., & Beebe, D. W. (2014). Sleep restriction worsens mood and emotion regulation in adolescents. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, 55(2), 180–190. <https://doi.org/10.1111/jcpp.12125>
- Becker, S. P., Dvorsky, M. R., Breaux, R., Cusick, C. N., Taylor, K. P., & Langberg, J. M. (2021). Prospective examination of adolescent sleep patterns and behaviors before and during COVID-19. *Sleep*, 44(8), 1–11. <https://doi.org/10.1093/sleep/zsab054>
- Ben Simon, E., Vallat, R., Barnes, C. M., & Walker, M. P. (2020). Sleep loss and the socio-emotional brain. *Trends in Cognitive Sciences*, 24(6), 435–450. <https://doi.org/10.1016/j.tics.2020.02.003>
- Benjamini, Y., & Hochberg, Y. (1995). Controlling the false discovery rate : A practical and powerful approach to multiple testing. *Journal of the Royal Statistical Society: Series B (Methodological)*, 57(1), 289–300.
- Berg, J. M., Latzman, R. D., Bliwise, N. G., & Lilienfeld, S. O. (2015). Parsing the heterogeneity of

- impulsivity: A meta-analytic review of the behavioral implications of the UPPS for psychopathology. *Psychological Assessment*, 27(4), 1129. <https://doi.org/10.1037/pas0000111>
- Billings, M. E., Cohen, R. T., Baldwin, C. M., Johnson, D. A., Palen, B. N., Parthasarathy, S., Patel, S. R., Russell, M., Tapia, I. E., Williamson, A. A., & Sharma, S. (2021). Disparities in sleep health and potential intervention models: A focused review. *Chest*, 159(3), 1232–1240. <https://doi.org/10.1016/j.chest.2020.09.249>
- Bruce, E. S., Lunt, L., & McDonagh, J. E. (2017). Sleep in adolescents and young adults. *Clinical Medicine, Journal of the Royal College of Physicians of London*, 17(5), 424–4228. <https://doi.org/10.7861/clinmedicine.17-5-424>
- Butler, E. S., McGlinchey, E. L., & Juster, R. P. (2020). Sexual and gender minority sleep: A narrative review and suggestions for future research. *Journal of Sleep Research*, 29(1). <https://doi.org/10.1111/jsr.12928>
- Buyse, D. J., Reynolds, C. F., Monk, T. H., Berman, S. R., & Kupfer, D. J. (1998). The Pittsburgh Sleep Quality Index: A new instrument for psychiatric practice and research. *Psychiatry Research*, 28(2), 193–213. [https://doi.org/10.1016/0165-1781\(89\)90047-4](https://doi.org/10.1016/0165-1781(89)90047-4)
- Buyse, D. J., Yu, L., Moul, D. E., Germain, A., Stover, A., Dodds, N. E., Johnston, K. L., Shablesky-Cade, M. A., & Pilkonis, P. A. (2010). Development and validation of patient-reported outcome measures for sleep disturbance and sleep-related impairments. *Sleep*, 33(6), 781–792. <https://doi.org/10.1093/sleep/33.6.781>
- Caci, H., Mattei, V., Baylé, F. J., Nadalet, L., Dossios, C., Robert, P., & Boyer, P. (2005). Impulsivity but not venturesomeness is related to morningness. *Psychiatry Research*, 134(3), 259–265. <https://doi.org/10.1016/j.psychres.2004.02.019>
- Caruso, D., Palagini, L., Miniati, M., Massa, L., Marazziti, D., Geoffroy, P. A., & Etain, B. (2021). Early life stress and chronobiological rhythms desynchronization: Possible impact on mood symptoms and suicidal ideation in bipolar disorder. *Journal of Nervous and Mental Disease*, 209(7), 518–524. <https://doi.org/10.1097/NMD.0000000000001333>
- Carver, C. S., & Johnson, S. L. (2018). Impulsive reactivity to emotion and vulnerability to psychopathology. *American Psychologist*, 73(9), 1067–1078. <https://doi.org/10.1016/j.gde.2016.03.011>
- Cellini, N., Canale, N., Mioni, G., & Costa, S. (2020). Changes in sleep pattern, sense of time and digital

- media use during COVID-19 lockdown in Italy. *Journal of Sleep Research*, 29(4), 1–5.
<https://doi.org/10.1111/jsr.13074>
- Cohen, M. F., Corwin, E. J., Johnson, D. A., Amore, A. D., Brown, A. L., Barbee, N. R., Brennan, P. A., & Dunlop, A. L. (2022). Discrimination is associated with poor sleep quality in pregnant Black American women. *Sleep Medicine*. <https://doi.org/10.1016/j.sleep.2022.07.015>
- Curtis, B. J., Williams, P. G., & Anderson, J. S. (2018). Objective cognitive functioning in self-reported habitual short sleepers not reporting daytime dysfunction: Examination of impulsivity via delay discounting. *Sleep*, 41(9), 1–9. <https://doi.org/10.1093/sleep/zsy115>
- Demos, K. E., Hart, C. N., Sweet, L. H., Mailloux, K. A., Trautvetter, J., Williams, S. E., Wing, R. R., & McCaffery, J. M. (2016). Partial sleep deprivation impacts impulsive action but not impulsive decision-making. *Physiology and Behavior*, 164, 214–219. <https://doi.org/10.1016/j.physbeh.2016.06.003>
- Dolsen, E. A., Asarnow, L. D., & Harvey, A. G. (2014). Insomnia as a transdiagnostic process in psychiatric disorders. *Current Psychiatry Reports*, 16, 471. <https://doi.org/10.1007/s11920-014-0471-y>
- Dondé, C., Jaffiol, A., Khouri, C., Pouchon, A., Tamisier, R., Lejoyeux, M., d'Ortho, M.-P., Polosan, M., & Geoffroy, P. A. (2021). Sleep disturbances in early clinical stages of psychotic and bipolar disorders: A meta-analysis. *Australian & New Zealand Journal of Psychiatry*, 00(0), 000486742110683.
<https://doi.org/10.1177/00048674211068395>
- Drummond, S. P. A., Paulus, M. P., & Tapert, S. F. (2006). Effects of two nights sleep deprivation and two nights recovery sleep on response inhibition. *Journal of Sleep Research*, 15(3), 261–265.
<https://doi.org/10.1111/j.1365-2869.2006.00535.x>
- Eckblad, M., & Chapman, L. J. (1986). Development and validation of a scale for hypomanic personality. *Journal of Abnormal Psychology*, 95(3), 214–222. <https://doi.org/10.1037/0021-843X.95.3.214>
- Eichstaedt, J. C., Sherman, G. T., Giorgi, S., Roberts, S. O., Reynolds, M. E., Ungar, L. H., & Guntuku, S. C. (2021). The emotional and mental health impact of the murder of George Floyd on the US population. *Proceedings of the National Academy of Sciences of the United States of America*, 118(39), 1–5.
<https://doi.org/10.1073/pnas.2109139118>
- Finan, P. H., Quartana, P. J., Remeniuk, B., Garland, E. L., Rhudy, J. L., Hand, M., Irwin, M. R., & Smith, M. T. (2017). Partial sleep deprivation attenuates the positive affective system: Effects across multiple measurement modalities. *Sleep*, 40(1). <https://doi.org/10.1093/sleep/zsw017>

- Finan, P. H., Quartana, P. J., & Smith, M. T. (2015). The effects of sleep continuity disruption on positive mood and sleep architecture in healthy adults. *Sleep*, 38(11), 1735–1742. <https://doi.org/10.5665/sleep.5154>
- Frank, E., Swartz, H. A., & Kupfer, D. J. (2000). Interpersonal and social rhythm therapy: Managing the chaos of bipolar disorder. *Biological Psychiatry*, 48(6), 593–604. [https://doi.org/10.1016/S0006-3223\(00\)00969-0](https://doi.org/10.1016/S0006-3223(00)00969-0)
- Freitag, L., Ireland, J. L., & Niesten, I. J. M. (2017). Exploring the relationship between sleep quality, emotional well-being and aggression levels in a European sample. *Journal of Aggression, Conflict and Peace Research*, 9(3), 167–177. <https://doi.org/10.1108/JACPR-08-2016-0239>
- Fuller-Rowell, T. E., Curtis, D. S., El-Sheikh, M., Duke, A. M., Ryff, C. D., & Zgierska, A. E. (2017). Racial discrimination mediates race differences in sleep problems: A longitudinal analysis. *Cultural Diversity and Ethnic Minority Psychology*, 23(2), 165–173. <https://doi.org/10.1037/cdp0000104>
- Galbiati, A., Sforza, M., Fasiello, E., Casoni, F., Marrella, N., Leitner, C., Zucconi, M., & Ferini-Strambi, L. (2020). The association between emotional dysregulation and REM sleep features in insomnia disorder. *Brain and Cognition*, 146, 105642. <https://doi.org/10.1016/j.bandc.2020.105642>
- Gamble, K. L., May, R. S., Besing, R. C., Tankersly, A. P., & Fargason, R. E. (2013). Delayed sleep timing and symptoms in adults with attention-deficit/ hyperactivity disorder: A controlled actigraphy study. *Chronobiology International*, 30(4), 598–606. <https://doi.org/10.3109/07420528.2012.754454>
- Geoffroy, P. A., Scott, J., Boudebesse, C., Lajnef, M., Henry, C., Leboyer, M., Bellivier, F., & Etain, B. (2015). Sleep in patients with remitted bipolar disorders: A meta-analysis of actigraphy studies. *Acta Psychiatrica Scandinavica*, 131(2), 89–99. <https://doi.org/10.1111/acps.12367>
- Gershon, A., Johnson, S. L., Thomas, L., & Singh, M. K. (2019). Double trouble: Weekend sleep changes are associated with increased impulsivity among adolescents with bipolar I disorder. *Bipolar Disorders*, 21(2), 132–141. <https://doi.org/10.1111/bdi.12658>
- Gillett, G., Watson, G., Saunders, K. E. A., & McGowan, N. M. (2021). Sleep and circadian rhythm actigraphy measures, mood instability and impulsivity: A systematic review. *Journal of Psychiatric Research*, 144(March), 66–79. <https://doi.org/10.1016/j.jpsychires.2021.09.043>
- Giovanelli, A., Hoerger, M., Johnson, S. L., & Gruber, J. (2013). Impulsive responses to positive mood and reward are related to mania risk. *Cognition and Emotion*, 27(6), 1091–1104.

<https://doi.org/10.1080/02699931.2013.772048>

Goldstein, A. N., & Walker, M. P. (2014). The role of sleep in emotional brain function. *Annual Review of Clinical Psychology*, 10, 679–708. <https://doi.org/10.1146/annurev-clinpsy-032813-153716>

Grandner, M. A., Patel, N. P., Gehrman, P. R., Xie, D., Sha, D., Weaver, T., & Gooneratne, N. (2010). Who gets the best sleep? Ethnic and socioeconomic factors related to sleep complaints. *Sleep Medicine*, 11(5), 470–478. <https://doi.org/10.1016/j.sleep.2009.10.006>

Grandner, M. A., Williams, N. J., Knutson, K. L., Roberts, D., & Jean-Louis, G. (2016). Sleep disparity, race/ethnicity, and socioeconomic position. *Sleep Medicine*, 18(2016), 7–18. <https://doi.org/10.1016/j.sleep.2015.01.020>

Grove, J. L., Smith, T. W., Crowell, S. E., & Ellis, J. H. (2017). Preliminary evidence for emotion dysregulation as a mechanism underlying poor sleep quality in borderline personality disorder. *Journal of Personality Disorders*, 31(4), 542–552. https://doi.org/10.1521/pedi_2016_30_261

Gruber, R., & Cassoff, J. (2014). The interplay between sleep and emotion regulation: Conceptual framework empirical evidence and future directions. *Current Psychiatry Reports*, 16(11). <https://doi.org/10.1007/s11920-014-0500-x>

Gupta, R., Grover, S., Basu, A., Krishnan, V., Tripathi, A., Subramanyam, A., Nischal, A., Hussain, A., Mehra, A., Ambekar, A., Saha, G., Mishra, K. K., Bathla, M., Jagiwala, M., Manjunatha, N., Nebhinani, N., Gaur, N., Kumar, N., Dalal, P. K., ... Avasthi, A. (2020). Changes in sleep pattern and sleep quality during COVID-19 lockdown. *Indian Journal of Psychiatry*, 62, 370–378. <https://doi.org/10.4103/psychiatry.IndianJPsychiatry>

Halperin, D. (2014). Environmental noise and sleep disturbances: A threat to health? *Sleep Science*, 7(4), 209–212. <https://doi.org/10.1016/j.slsci.2014.11.003>

Halvorson, M. A., Pedersen, S. L., Feil, M. C., Lengua, L. J., Molina, B. S. G., & King, K. M. (2021). Impulsive states and impulsive traits: A study of the multilevel structure and validity of a multifaceted measure of impulsive states. *Assessment*, 28(3), 796–812. <https://doi.org/10.1177/1073191120939161>

Hanish, A. E., Lin-Dyken, D. C., & Han, J. C. (2017). PROMIS sleep disturbance and sleep-related impairment in adolescents: Examining psychometrics using self-report and actigraphy. *Nursing Research*, 66(3), 246–251. <https://doi.org/10.1097/nnr.0000000000000217>

Harvey, A. G. (2011). Sleep and circadian functioning: Critical mechanisms in the mood disorders? *Annual*

- Review of Clinical Psychology*, 7, 297–319. <https://doi.org/10.1146/annurev-clinpsy-032210-104550>
- Harvey, A. G., Kaplan, K. A., & Soehner, A. M. (2015). Interventions for sleep disturbance in bipolar disorder. *Sleep Medicine Clinics*, 10(1), 101–105. <https://doi.org/10.1016/j.jsmc.2014.11.005>
- Harvey, A. G., Talbot, L. S., & Gershon, A. (2009). Sleep disturbance in bipolar disorder across the lifespan. *Clinical Psychology: Science and Practice*, 16(2), 256–277. <https://doi.org/10.1111/j.1468-2850.2009.01164.x>
- Hasler, B. P., & Pedersen, S. L. (2020). Sleep and circadian risk factors for alcohol problems: a brief overview and proposed mechanisms. *Current Opinion in Psychology*, 34, 57–62. <https://doi.org/10.1016/j.copsyc.2019.09.005>
- Hasler, B. P., Wallace, M. L., Graves, J. L., Molina, B. S. G., & Pedersen, S. L. (2022). Circadian preference is associated with multiple domains of trait and state level impulsivity. *Chronobiology International*, 00(00), 1–13. <https://doi.org/10.1080/07420528.2022.2035392>
- Hensch, T., Wozniak, D., Spada, J., Sander, C., Ulke, C., Wittekind, D. A., Thiery, J., Löffler, M., Jawinski, P., & Hegerl, U. (2019). Vulnerability to bipolar disorder is linked to sleep and sleepiness. *Translational Psychiatry*, 9(1), 1–10. <https://doi.org/10.1038/s41398-019-0632-1>
- Hertenstein, E., Feige, B., Gmeiner, T., Kienzler, C., Spiegelhalder, K., Johann, A., Jansson-Fröjmark, M., Palagini, L., Rücker, G., Riemann, D., & Baglioni, C. (2019). Insomnia as a predictor of mental disorders: A systematic review and meta-analysis. *Sleep Medicine Reviews*, 43, 96–105. <https://doi.org/10.1016/j.smr.2018.10.006>
- Hom, M. A., Stanley, I. H., Rogers, M. L., Tzoneva, M., Bernert, R. A., & Joiner, T. E. (2016). The association between sleep disturbances and depression among firefighters: Emotion dysregulation as an explanatory factor. *Journal of Clinical Sleep Medicine*, 12(2), 235–245. <https://doi.org/10.5664/jcsm.5492>
- Johnson, S. L., Carver, C. S., & Joormann, J. (2013). Impulsive responses to emotion as a transdiagnostic vulnerability to internalizing and externalizing symptoms. *Journal of Affective Disorders*, 150(3), 872–878. <https://doi.org/10.1016/j.jad.2013.05.004>
- Johnson, S. L., Carver, C. S., Mulé, S., & Joormann, J. (2013). Impulsivity and risk for mania: Towards greater specificity. *Psychology and Psychotherapy: Theory, Research and Practice*, 86(4), 401–412. <https://doi.org/10.1111/j.2044-8341.2012.02078.x>

- Kahn, M., Sheppes, G., & Sadeh, A. (2013). Sleep and emotions: Bidirectional links and underlying mechanisms. *International Journal of Psychophysiology*, 89(2), 218–228.
<https://doi.org/10.1016/j.ijpsycho.2013.05.010>
- Kang, J. I., Park, C. II, Sohn, S. Y., Kim, H. W., Namkoong, K., & Kim, S. J. (2015). Circadian preference and trait impulsivity, sensation-seeking and response inhibition in healthy young adults. *Chronobiology International*, 32(2), 235–241. <https://doi.org/10.3109/07420528.2014.965313>
- Kaufmann, C. N., Gershon, A., Eyler, L. T., & Depp, C. A. (2016). Clinical significance of mobile health assessed sleep duration and variability in bipolar disorder. *Journal of Psychiatric Research*, 81, 152–159. <https://doi.org/10.1016/j.jpsychires.2016.07.008>
- Kelley, A. E., Schochet, T., & Landry, C. F. (2004). Risk taking and novelty seeking in adolescence: Introduction to part I. *Annals of the New York Academy of Sciences*, 1021, 27–32.
<https://doi.org/10.1196/annals.1308.003>
- King, K. M., Karyadi, K. A., Luk, J. W., & Patock-Peckham, J. A. (2011). Dispositions to rash action moderate the associations between concurrent drinking, depressive symptoms, and alcohol problems during emerging adulthood. *Psychology of Addictive Behaviors*, 25(3), 446–454.
<https://doi.org/10.1037/a0023777>
- Konjarski, M., Murray, G., Lee, V. V., & Jackson, M. L. (2018). Reciprocal relationships between daily sleep and mood: A systematic review of naturalistic prospective studies. *Sleep Medicine Reviews*, 42, 47–58.
<https://doi.org/10.1016/j.smr.2018.05.005>
- Krause, A. J., Ben Simon, E., Mander, B. A., Greer, S. M., Saletin, J. M., Goldstein-Piekarski, A. N., & Walker, M. P. (2017). The sleep-deprived human brain. *Nat Rev Neurosci*, 18(7), 404–418.
<https://doi.org/10.1038/nrn.2017.55>
- Kroese, F. M., Evers, C., Adriaanse, M. A., & De Ridder, D. T. D. (2016). Bedtime procrastination: A self-regulation perspective on sleep insufficiency in the general population. *Journal of Health Psychology*, 21(5), 853–862. <https://doi.org/10.1177/1359105314540014>
- Kwapil, T. R., Miller, M. B., Zinser, M. C., Chapman, L. J., Chapman, J., & Eckblad, M. (2000). A longitudinal study of high scorers on the hypomanic personality scale. *Journal of Abnormal Psychology*, 109(2), 222–226. <https://doi.org/10.1037/0021-843X.109.2.222>
- Kwon, M., Park, E., & Dickerson, S. S. (2019). Adolescent substance use and its association to sleep

- disturbances: A systematic review. *Sleep Health*, 5(4), 382–394.
<https://doi.org/10.1016/j.sleh.2019.06.001>
- Liu, J., Magielski, J., Glenn, A., & Raine, A. (2022). The bidirectional relationship between sleep and externalizing behavior: A systematic review. *Sleep Epidemiology*, 100039.
<https://doi.org/10.1016/j.sleep.2022.100039>
- Lo Martire, V., Caruso, D., Palagini, L., Zoccoli, G., & Bastianini, S. (2020). Stress & sleep: A relationship lasting a lifetime. *Neuroscience and Biobehavioral Reviews*, 117(July 2019), 65–77.
<https://doi.org/10.1016/j.neubiorev.2019.08.024>
- Lowe, C. J., Safati, A., & Hall, P. A. (2017). The neurocognitive consequences of sleep restriction: A meta-analytic review. *Neuroscience and Biobehavioral Reviews*, 80(July), 586–604.
<https://doi.org/10.1016/j.neubiorev.2017.07.010>
- Luo, D., Ganesh, S., & Koolgaard, J. (2021). *predictmeans: Calculate predicted means for linear models*.
<https://cran.r-project.org/package=predictmeans>
- Maletic, V., & Raison, C. (2014). Integrated neurobiology of bipolar disorder. *Frontiers in Psychiatry*, 5, 98.
<https://doi.org/10.3389/fpsy.2014.00098>
- Malhi, G. S., Bell, E., Boyce, P., Bassett, D., Berk, M., Bryant, R., Gitlin, M., Hamilton, A., Hazell, P., Hopwood, M., Lyndon, B., McIntyre, R. S., Morris, G., Mulder, R., Porter, R., Singh, A., Yatham, L. N., Young, A., & Murray, G. (2020). The 2020 Royal Australian and New Zealand College of Psychiatrists Clinical Practice Guidelines for Mood Disorders: Bipolar Disorder. *Bipolar Disorders*, 22(8), 805–821.
<https://doi.org/10.1111/bdi.13036>
- Marczyk Organek, K. D., Taylor, D. J., Petrie, T., Martin, S., Greenleaf, C., Dietch, J. R., & Ruiz, J. M. (2015). Adolescent sleep disparities: Sex and racial/ethnic differences. *Sleep Health*, 1(1), 36–39.
<https://doi.org/10.1016/j.sleh.2014.12.003>
- McGowan, A. L., Falk, E. B., Zurn, P., Bassett, D., & Lyndon-Staley, D. M. (2021). Daily and momentary sensation-seeking and urgency in young adults: Associations with risk-taking and sleep. *PsyArxiv Preprint*. <https://doi.org/10.31234/osf.io/b9dez>
- McGowan, N. M., & Coogan, A. N. (2018). Sleep and circadian rhythm function and trait impulsivity: An actigraphy study. *Psychiatry Research*, 268, 251–256. <https://doi.org/10.1016/j.psychres.2018.07.030>
- Meads, D. M., & Bentall, R. P. (2008). Rasch analysis and item reduction of the hypomanic personality scale.

- Personality and Individual Differences*, 44(8), 1772–1783. <https://doi.org/10.1016/j.paid.2008.02.009>
- Medina, C., & Mahowald, L. (2023). *Discrimination and Barriers to Well-Being: The State of the LGBTQI+ Community in 2022*.
- Meldrum, R. C., & Restivo, E. (2014). The behavioral and health consequences of sleep deprivation among U.S. high school students: Relative deprivation matters. *Preventive Medicine*, 63, 24–28. <https://doi.org/10.1016/j.ypmed.2014.03.006>
- Melo, M. C. A., Garcia, R. F., Linhares Neto, V. B., Sá, M. B., de Mesquita, L. M. F., de Araújo, C. F. C., & de Bruin, V. M. S. (2016). Sleep and circadian alterations in people at risk for bipolar disorder: A systematic review. *Journal of Psychiatric Research*, 83, 211–219. <https://doi.org/10.1016/j.jpsychires.2016.09.005>
- Miller, A. A., & Rucas, S. L. (2012). Sleep-wake state tradeoffs, impulsivity and life history theory. *Evolutionary Psychology*, 10(2), 173–186. <https://doi.org/10.1177/147470491201000201>
- Miller, M. B., Dibello, A. M., Lust, S. A., Meisel, M. K., & Carey, K. B. (2017). Impulsive personality traits and alcohol use: Does sleeping help with thinking? *Psychology of Addictive Behaviors*, 31(1), 46–53. <https://doi.org/10.1037/adb0000241>
- Monk, T. H., Frank, E., Potts, J. M., & Kupfer, D. J. (2002). A simple way to measure daily lifestyle regularity. *Journal of Sleep Research*, 11(3), 183–190. <https://doi.org/10.1046/j.1365-2869.2002.00300.x>
- Muhtadie, L., Johnson, S. L., Carver, C. S., Gotlib, I. H., & Ketter, T. A. (2014). A profile approach to impulsivity in bipolar disorder: The key role of strong emotions. *Acta Psychiatrica Scandinavica*, 129(2), 100–108. <https://doi.org/10.1111/acps.12136>
- Mullin, B. C., Phillips, M. L., Siegle, G. J., Buysse, D. J., Forbes, E. E., & Franzen, P. L. (2013). Sleep deprivation amplifies striatal activation to monetary reward. *Psychological Medicine*, 43(10), 2215–2225. <https://doi.org/10.1017/S0033291712002875>
- Narmandakh, A., Oldehinkel, A. J., Masselink, M., Jonge, P. De, & Roest, A. M. (2021). Affect, worry, and sleep: Between- and within-subject associations in a diary study. *Journal of Affective Disorders Reports*, 4, 100134. <https://doi.org/10.1016/j.jadr.2021.100134>
- Ng, T. H., Chung, K. F., Ho, F. Y. Y., Yeung, W. F., Yung, K. P., & Lam, T. H. (2015). Sleep-wake disturbance in interepisode bipolar disorder and high-risk individuals: A systematic review and meta-analysis. *Sleep Medicine Reviews*, 20, 46–58. <https://doi.org/10.1016/j.smr.2014.06.006>

- Nicholson, L. R., Lewis, R., Thomas, K. G., & Lipinska, G. (2021). Influence of poor emotion regulation on disrupted sleep and subsequent psychiatric symptoms in university students. *South African Journal of Psychology*, 51(1), 6–20. <https://doi.org/10.1177/0081246320978527>
- Onat, M., Özyurt, G., Öztürk, Y., & Pekcanlar Akay, A. (2019). The relationship between problematic internet use, sleep quality and impulsivity in adolescents with major depressive disorder. *Anadolu Psikiyatri Dergisi*, 20(5), 491–498. <https://doi.org/10.5455/apd.17978>
- Özerdem, A., Ceylan, D., & Can, G. (2016). Neurobiology of Risk for Bipolar Disorder. *Current Treatment Options in Psychiatry*, 3(4), 315–329. <https://doi.org/10.1007/s40501-016-0093-6>
- Palagini, L., Bastien, C. H., Marazziti, D., Ellis, J. G., & Riemann, D. (2019). The key role of insomnia and sleep loss in the dysregulation of multiple systems involved in mood disorders: A proposed model. *Journal of Sleep Research*, 28(6), 1–16. <https://doi.org/10.1111/jsr.12841>
- Palagini, L., Cipollone, G., Masci, I., Caruso, D., Paolilli, F., Perugi, G., & Riemann, D. (2019). Insomnia symptoms predict emotional dysregulation, impulsivity and suicidality in depressive bipolar II patients with mixed features. *Comprehensive Psychiatry*, 89, 46–51. <https://doi.org/10.1016/j.comppsy.2018.12.009>
- Palagini, L., Cipollone, G., Moretto, U., Masci, I., Tripodi, B., Caruso, D., & Perugi, G. (2019). Chronobiological dis-rhythmicity is related to emotion dysregulation and suicidality in depressive bipolar II disorder with mixed features. *Psychiatry Research*, 271(October 2018), 272–278. <https://doi.org/10.1016/j.psychres.2018.11.056>
- Palmer, C. A., & Alfano, C. A. (2017). Sleep and emotion regulation: An organizing, integrative review. *Sleep Medicine Reviews*, 31, 6–16. <https://doi.org/10.1016/j.smr.2015.12.006>
- Patapoff, M., Ramsey, M., Titone, M. K., Kaufmann, C. N., Malhotra, A., Ancoli-Israel, S., Wing, D., Lee, E., & Eyler, L. T. (2022). Temporal relationships of ecological momentary mood and actigraphy-based sleep measures in bipolar disorder. *Journal of Psychiatric Research*, 150, 257–263. <https://doi.org/10.1016/j.jpsychires.2022.03.055>
- Pickett, S. M., Barbaro, N., & Mello, D. (2016). The relationship between subjective sleep disturbance, sleep quality, and emotion regulation difficulties in a sample of college students reporting trauma exposure. *Psychological Trauma: Theory, Research, Practice, and Policy*, 8(1), 25–33. <https://doi.org/10.1037/tra0000064>

- Pilcher, J. J., Callan, C., & Posey, J. L. (2015). Sleep deprivation affects reactivity to positive but not negative stimuli. *Journal of Psychosomatic Research*, 79(6), 657–662.
<https://doi.org/10.1016/j.jpsychores.2015.05.003>
- Pinheiro, J., Bates, D., DebRoy, S., Sarkar, D., & R Core Team. (2022). *nlme: Linear and nonlinear mixed effects models*. <https://cran.r-project.org/package=nlme>
- Porras-Segovia, A., Pérez-Rodríguez, M. M., López-Esteban, P., Courtet, P., Barrigón M, M. L., López-Castromán, J., Cervilla, J. A., & Baca-García, E. (2019). Contribution of sleep deprivation to suicidal behaviour: A systematic review. *Sleep Medicine Reviews*, 44, 37–47.
<https://doi.org/10.1016/j.smr.2018.12.005>
- Ramos Socarras, L., Potvin, J., & Forest, G. (2021). COVID-19 and sleep patterns in adolescents and young adults. *Sleep Medicine*, 83, 26–33. <https://doi.org/10.1016/j.sleep.2021.04.010>
- Romero, C., Rodríguez, J., Onieva, M., Parra, M., Prado, M., & Hernández, A. (2020). Sleep Pattern Changes in Nursing Students during the COVID-19 Lockdown. *International Journal of Environmental Research and Public Health*, 17(14), 1–11.
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7400502/pdf/ijerph-17-05222.pdf>
- RStudio Team. (2020). *RStudio: Integrated Development for R*. RStudio, PBC.
- Russo, M., Mahon, K., Shanahan, M., Ramjas, E., Solon, C., Purcell, S. M., & Burdick, K. E. (2015). The relationship between sleep quality and neurocognition in bipolar disorder. *Journal of Affective Disorders*, 187, 156–162. <https://doi.org/10.1016/j.jad.2015.08.009>
- Șandru, C., & Voinescu, B. I. (2014). The relationship between emotion regulation, dysfunctional beliefs about sleep and sleep quality – An exploratory study. *Journal of Evidence-Based Psychotherapies*, 14(2), 249–257.
- Saper, C. B., Cano, G., & Scammell, T. E. (2005). Homeostatic, circadian, and emotional regulation of sleep. *Journal of Comparative Neurology*, 493(1), 92–98. <https://doi.org/10.1002/cne.20770>
- Schafer, J. L., & Graham, J. W. (2002). Missing data: Our view of the state of the art. *Psychological Methods*, 7(2), 147–177. <https://doi.org/10.1037/1082-989X.7.2.147>
- Schmidt, R. E., Gay, P., Ghisletta, P., & Van Der Linden, M. (2010). Linking impulsivity to dysfunctional thought control and insomnia: A structural equation model. *Journal of Sleep Research*, 19, 3–11.
<https://doi.org/10.1111/j.1365-2869.2009.00741.x>

- Schmidt, R. E., Gay, P., & Van der Linden, M. (2008). Facets of impulsivity are differentially linked to insomnia: evidence from an exploratory study. *Behavioral Sleep Medicine*, 6(3), 178–192.
<https://doi.org/10.1080/15402000802162570>
- Schmidt, R. E., & Van der Linden, M. (2009). The aftermath of rash action: Sleep-interfering counterfactual thoughts and emotions. *Emotion*, 9(4), 549–553. <https://doi.org/10.1037/a0015856>
- Scott, J., Etain, B., Miklowitz, D. J., Crouse, J. J., Carpenter, J., Marwaha, S., Smith, D. J., Merikangas, K. R., & Hickie, I. (2022). A systematic review and meta-analysis of sleep and circadian rhythms disturbances in individuals at high-risk of developing or with early onset of bipolar disorders. *Neuroscience & Biobehavioral Reviews*, 104585. <https://doi.org/10.1016/j.neubiorev.2022.104585>
- Shen, L., Wiley, J. F., & Bei, B. (2021). Perceived daily sleep need and sleep debt in adolescents: associations with daily affect over school and vacation periods. *Sleep*.
- Simor, P., & Horváth, K. (2013). Altered sleep in borderline personality disorder in relation to the core dimensions of psychopathology. *Scandinavian Journal of Psychology*, 54(4), 300–312.
<https://doi.org/10.1111/sjop.12048>
- Somerville, L. H., Jones, R. M., & Casey, B. J. (2010). A time of change: Behavioral and neural correlates of adolescent sensitivity to appetitive and aversive environmental cues. *Brain and Cognition*, 72(1), 124–133. <https://doi.org/10.1016/j.bandc.2009.07.003>
- Sperry, S. H., & Kwapil, T. R. (2022). Variability in sleep is associated with trait-based and daily measures of bipolar spectrum psychopathology. *Behavioral Sleep Medicine*, 20(1), 90–99.
<https://doi.org/10.1080/15402002.2021.1890076>
- Sperry, S. H., Walsh, M. A., & Kwapil, T. R. (2015). Measuring the validity and psychometric properties of a short form of the Hypomanic Personality Scale. *Personality and Individual Differences*, 82, 52–57.
<https://doi.org/10.1016/j.paid.2015.03.004>
- Stanton, K., McArtor, D. B., & Watson, D. (2019). Parsing the hypomanic personality: Explicating the nature of specific dimensions defining mania risk. *Assessment*, 26(3), 492–507.
<https://doi.org/10.1177/1073191117725170>
- Stautz, K., & Cooper, A. (2013). Impulsivity-related personality traits and adolescent alcohol use: A meta-analytic review. *Clinical Psychology Review*, 33(4), 574–592. <https://doi.org/10.1016/j.cpr.2013.03.003>
- Steinberg, L. (2007). Risk taking in adolescence: New perspectives from brain and behavioral science.

Current Directions in Psychological Science, 16(2), 55–59. <https://doi.org/10.1111/j.1467-8721.2007.00475.x>

Strickland, J. C., & Johnson, M. W. (2021). Rejecting impulsivity as a psychological construct: A theoretical, empirical, and sociocultural argument. *Psychological Review*, 128(2), 336–361.

<https://doi.org/10.1037/rev0000263>

Tashjian, S. M., Goldenberg, D., & Galván, A. (2017). Neural connectivity moderates the association between sleep and impulsivity in adolescents. *Developmental Cognitive Neuroscience*, 27, 35–44.

<https://doi.org/10.1016/j.dcn.2017.07.006>

Titone, M. K., Goel, N., Ng, T. H., MacMullen, L. E., & Alloy, L. B. (2022). Impulsivity and sleep and circadian rhythm disturbance predict next-day mood symptoms in a sample at high risk for or with recent-onset bipolar spectrum disorder: An ecological momentary assessment study. *Journal of Affective Disorders*, 298, 17–25.

<https://doi.org/10.1016/j.jad.2021.08.155>

Titone, M. K., McArthur, B. A., Ng, T. H., Burke, T. A., McLaughlin, L. E., MacMullen, L. E., Goel, N., & Alloy, L. B. (2020). Sex and race influence objective and self-report sleep and circadian measures in emerging adults independently of risk for bipolar spectrum disorder. *Scientific Reports*, 10(1), 1–7.

<https://doi.org/10.1093/sleep/zsaa056.361>

Van der Meer, T., Te Grotenhuis, M., & Pelzer, B. (2010). Influential cases in multilevel modeling: A methodological comment. *American Sociological Review*, 75(1), 173–178.

<https://doi.org/10.1177/0003122409359166>

VanderVeen, J. D., Hershberger, A. R., & Cyders, M. A. (2016). UPPS-P model impulsivity and marijuana use behaviors in adolescents: A meta-analysis. *Drug and Alcohol Dependence*, 168, 181–190.

<https://doi.org/10.1016/j.drugalcdep.2016.09.016>

Vieira, I. S., Barreto, N. T., Moreira, F. P., Mondin, T. C., Jansen, K., Dias, L., & Souza, D. M. (2021). Sleep alterations in individuals recently diagnosed with bipolar disorder across different mood stages.

Psychiatry Research, 299, 113824. <https://doi.org/10.1016/j.psychres.2021.113824>

Walker, M. P., & van der Helm, E. (2009). Overnight therapy? The role of sleep in emotional brain processing. *Psychological Bulletin*, 135(5), 731–748. <https://doi.org/10.1037/a0016570>

Walsh, M. A., DeGeorge, D. P., Barrantes-Vidal, N., & Kwapil, T. R. (2015). A 3-year longitudinal study of risk for bipolar spectrum psychopathology. *Journal of Abnormal Psychology*, 124(3), 486–497.

<https://doi.org/10.1037/abn0000045>

Wang, F., & Bíró, É. (2021). Determinants of sleep quality in college students: A literature review. *Explore*, 17(2), 170–177. <https://doi.org/10.1016/j.explore.2020.11.003>

Washington's Equality Profile. (2023). Movement Advancement Project. https://www.lgbtmap.org/equality-maps/profile_state/WA

Whiteside, S. P., & Lynam, D. R. (2001). The five factor model and impulsivity: Using a structural model of personality to understand impulsivity. *Personality and Individual Differences*, 30(4), 669–689. [https://doi.org/10.1016/S0191-8869\(00\)00064-7](https://doi.org/10.1016/S0191-8869(00)00064-7)

Womack, S. D., Hook, J. N., Reyna, S. H., & Ramos, M. (2013). Sleep loss and risk-taking behavior: A review of the literature. *Behavioral Sleep Medicine*, 11(5), 343–359. <https://doi.org/10.1080/15402002.2012.703628>

Yip, T., & Cheon, Y. M. (2020). Sleep, psychopathology and cultural diversity. *Current Opinion in Psychology*, 34, 123–127. <https://doi.org/10.1016/j.copsyc.2020.02.006>

Yip, T., Feng, Y., Fowle, J., & Fisher, C. B. (2021). Sleep disparities during the COVID-19 pandemic: An investigation of AIAN, Asian, Black, Latinx, and White young adults. *Sleep Health*, 7(4), 459–467. <https://doi.org/10.1016/j.sleh.2021.05.008>

Yu, L., Buysse, D. J., Germain, A., Moul, D. E., Stover, A., Dodds, N. E., Johnston, K. L., & Pilkonis, P. A. (2012). Development of short forms from the PROMIS™ sleep disturbance and sleep-related impairment item banks. *Behavioral Sleep Medicine*, 10(1), 6–24. <https://doi.org/10.1080/15402002.2012.636266>

Yurasek, A. M., Miller, M. B., Pritschmann, R. K., Curtis, A. F., & McCrae, C. S. (2020). Negative mood as a mediator of the association between insomnia severity and marijuana problems in college students. *Journal of Sleep Research*, 29(4), e12985. <https://doi.org/10.1111/jsr.12985>

Zhu, J., Jiang, Y., Chen, Y., Huang, L., Bao, Z., & Zhang, W. (2021). High impulsivity, low self-control and problematic mobile phone use: The effect of poor sleep quality. *Current Psychology*, 40(7), 3265–3271. <https://doi.org/10.1007/s12144-019-00259-0>

Tables and Figures

Table 1. Demographic information.

Variable	N = 495	Variable	N = 495
Race and Ethnicity		Parental Education	
White	265 (54%)	Graduate/Professional school	205 (41%)
Biracial or multiracial	113 (23%)	BA or BS (4-year college degree)	152 (31%)
East Asian	37 (7.5%)	High school graduate	27 (5.5%)
Southeast Asian	21 (4.2%)	Some graduate or professional school	27 (5.5%)
African American	18 (3.6%)	AA degree (2-year college)	19 (3.8%)
Hispanic	15 (3.0%)	Some college	19 (3.8%)
South Asian	11 (2.2%)	No response	14 (2.8%)
Middle Eastern	7 (1.4%)	Some vocational/technical school	13 (2.6%)
No response	3 (0.6%)	GED (high school equivalency diploma)	7 (1.4%)
Pacific Islander	2 (0.4%)	Some high school	7 (1.4%)
African	1 (0.2%)	8th grade or less	4 (0.8%)
Native American	1 (0.2%)	Age	
Another race and/or ethnicity	1 (0.2%)	Mean (SD)	20.26 (1.33)
Gender		Range	18, 23
Cisgender female	224 (45%)	Urgency	
Cisgender male	207 (42%)	Mean (SD)	13 (15)
Nonbinary, gender queer, or gender nonconforming	42 (8.5%)	Range	0, 64
Transgender male	15 (3.0%)	Sleep Quality	
Transgender female	5 (1.0%)	Mean (SD)	2.24 (0.57)
Nongendered	1 (0.2%)	Range	1.00, 4.52
Sexual Orientation		Sleep Duration (hours)	
Heterosexual	254 (52%)	Mean (SD)	8.65 (0.02)
Bisexual	88 (18%)	Range	3.5, 17.0
Multiple sexual identities	58 (12%)	Hypomanic Personality Scale (HPS)	
Lesbian/gay	42 (8.6%)	Mean (SD)	2.87 (0.64)
Queer	19 (3.9%)	Range	1.07, 4.80
Pansexual	12 (2.4%)		
Questioning	9 (1.8%)		
Asexual	4 (0.8%)		
Demisexual	2 (0.4%)		
No response	2 (0.4%)		

Note. Counts and percentages are shown for categorical variables (race, gender, sexual orientation, parental education), and means and standard deviations are shown for continuous variables (age, urgency, sleep quality, sleep duration, HPS). Ranges are included below continuous variables.

Table 2a. Results of confirmatory analyses for urgency and sleep quality.

Sleep quality predicting next-day urgency

$n_{\text{obs}} = 13,823$	<i>b</i>	<i>S.E.</i>	<i>p</i>	<i>LCL</i>	<i>UCL</i>	<i>Variance</i>	<i>S.D.</i>
Fixed effects							
Intercept	0.59	0.03	< 0.001	0.53	0.64		
Within-person sleep quality	0.03	0.005	< 0.001	0.02	0.04		
Between-person sleep quality	0.28	0.03	< 0.001	0.22	0.34		
Between-person bipolar risk	0.13	0.03	< 0.001	0.07	0.18		
Within-person sleep quality X Bipolar risk	0.01	0.005	0.05	0.009	0.02		
Between-person sleep quality X Bipolar risk	0.05	0.03	0.11	-0.01	0.10		
Random effects							
Intercept						0.33	0.57
Within-person sleep quality						0.003	0.05
Residual						0.20	0.45

Urgency predicting sleep quality that night

$n_{\text{obs}} = 10,445$	<i>b</i>	<i>S.E.</i>	<i>p</i>	<i>LCL</i>	<i>UCL</i>	<i>Variance</i>	<i>S.D.</i>
Fixed effects							
Intercept	0.94	0.01	< 0.001	0.92	0.96		
Within-person urgency (previous day)	0.008	0.003	0.01	0.002	0.01		
Between-person urgency	0.10	0.01	< 0.001	0.09	0.12		
Between-person bipolar risk	0.02	0.01	0.05	-0.0001	0.04		
Within-person urgency X Bipolar risk	0.004	0.003	0.29	-0.003	0.01		
Between-person urgency X Bipolar risk	-0.004	0.01	0.68	-0.02	0.02		
Random effects							
Intercept						0.03	0.18
Within-person urgency						0.0003	0.02
Residual						0.09	0.30

Table 2b. Results of confirmatory analyses for urgency and sleep midpoint irregularity.

Sleep midpoint irregularity predicting next-day urgency

$n_{\text{obs}} = 6,621$	b	$S.E.$	p	LCL	UCL	$Variance$	$S.D.$
Fixed effects							
Intercept	0.75	0.07	< 0.001	0.61	0.89		
Within-person midpoint irregularity	0.005	0.006	0.37	-0.01	0.02		
Between-person midpoint irregularity	-0.19	0.07	0.01	-0.33	-0.04		
Between-person bipolar risk	0.26	0.07	< 0.001	0.12	0.41		
Within-person midpoint irregularity X Bipolar risk	0.01	0.01	0.20	-0.004	0.02		
Between-person midpoint irregularity X Bipolar risk	-0.11	0.07	0.13	-0.26	0.03		
Random effects							
Intercept						0.40	0.63
Residual						0.13	0.36

Urgency predicting sleep midpoint irregularity that night

$n_{\text{obs}} = 4,707$	b	$S.E.$	p	LCL	UCL	$Variance$	$S.D.$
Fixed effects							
Intercept	0.49	0.01	< 0.001	0.46	0.51		
Within-person urgency	-0.0007	0.01	0.96	-0.03	0.03		
Between-person urgency	0.005	0.01	0.70	-0.02	0.03		
Between-person bipolar risk	-0.004	0.01	0.77	-0.03	0.02		
Within-person urgency X Bipolar risk	0.006	0.01	0.68	-0.02	0.03		
Between-person urgency X Bipolar risk	-0.002	0.01	0.91	-0.03	0.03		
Random effects							
Intercept						< 0.001	< 0.001
Residual						0.79	0.89

Table 2c. Results of confirmatory analyses for urgency and sleep duration irregularity.

Sleep duration irregularity predicting next-day urgency

<i>n_{obs}</i> = 6,621	<i>b</i>	<i>S.E.</i>	<i>p</i>	<i>LCL</i>	<i>UCL</i>	<i>Variance</i>	<i>S.D.</i>
Fixed effects							
Intercept	0.30	0.07	< 0.001	0.17	0.44		
Within-person duration irregularity	0.005	0.005	0.32	-0.005	0.02		
Between-person duration irregularity	0.31	0.07	< 0.001	0.17	0.44		
Between-person bipolar risk	0.11	0.07	0.11	-0.02	0.24		
Within-person duration irregularity X Bipolar risk	0.007	0.005	0.19	-0.003	0.02		
Between-person duration irregularity X Bipolar risk	0.05	0.06	0.46	-0.08	0.17		
Random effects							
Intercept						0.39	0.62
Residual						0.13	0.36

Urgency predicting sleep duration irregularity that night

<i>n_{obs}</i> = 4,707	<i>b</i>	<i>S.E.</i>	<i>p</i>	<i>LCL</i>	<i>UCL</i>	<i>Variance</i>	<i>S.D.</i>
Fixed effects							
Intercept	0.51	0.01	< 0.001	0.49	0.54		
Within-person urgency	-0.01	0.01	0.39	-0.04	0.01		
Between-person urgency	-0.002	0.01	0.90	-0.03	0.02		
Between-person bipolar risk	0.008	0.01	0.54	-0.02	0.04		
Within-person urgency X Bipolar risk	-0.03	0.01	0.02	-0.06	-0.004		
Between-person urgency X Bipolar risk	-0.01	0.01	0.44	-0.04	0.02		
Random effects							
Intercept						< 0.001	< 0.001
Residual						0.81	0.9

Note. All coefficients are standardized. LCL = lower confidence limit; UCL = upper confidence limit.

Figure 1. Bivariate correlations between variables of interest.

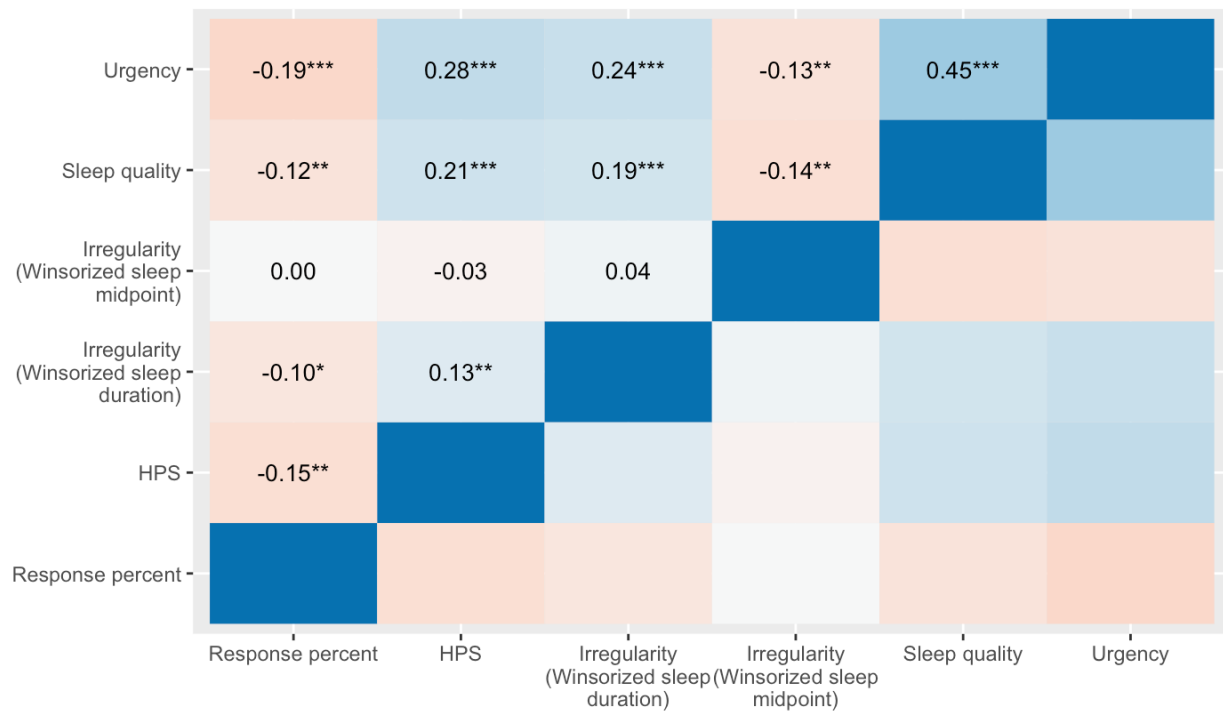
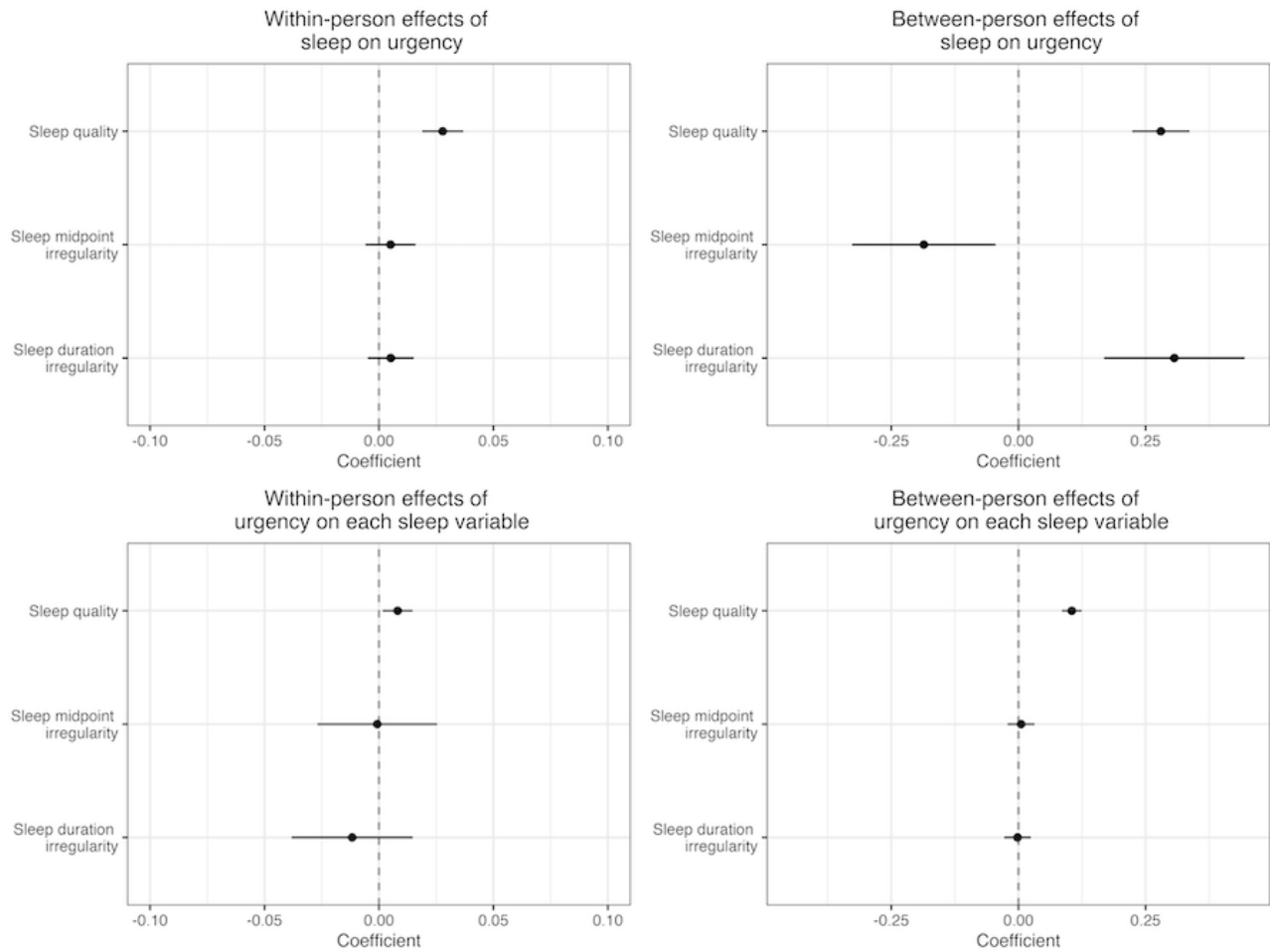


Figure 2. Standardized coefficients for confirmatory analyses.



Note. Standardized coefficients for results of confirmatory analyses. Figures on the top depict the within- and between-person effects of each sleep variable predicting urgency. Figures on the bottom depict the within- and between-person effects of urgency predicting each sleep variable. Error bars capture 95% confidence intervals.