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Daily Associations Between Sleep and Affect in Youth at Risk for Psychopathology: The Moderating Role of Externalizing Symptoms

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Abstract

Problems with sleep, emotion regulation, and externalizing psychopathology are interrelated, but little is known about their day-to-day associations in youth. We examined self-reported daily sleep quality as a bidirectional predictor of next-day positive and negative affect (PA/NA), with externalizing symptoms as a moderator. Data were drawn from an ecological momentary assessment (EMA) study involving 82 youths (ages 9–13; 50% female; 44% White, 37% Black/African American) at high ($n = 41$) or low ($n = 41$) familial risk for psychopathology. Parents rated youths' externalizing symptoms at baseline. Youths then completed a 9-day EMA protocol, reporting sleep quality 1x/day and affect 4-8x/day. Daily means, peaks, and variability in PA and NA were computed. Multilevel models examined bidirectional associations between sleep and affect (between- and within-person), testing externalizing symptoms as a moderator and controlling for age and sex. *In models of sleep predicting affect:* Within-person, poorer-than-usual sleep quality predicted greater variability and higher peaks in next-day NA, but only for youth with higher levels of externalizing symptoms. Between-person, poor sleep quality and higher levels of externalizing symptoms predicted lower mean and peak PA. *In models of affect predicting sleep:* Within-person, lower-than-usual mean PA predicted poorer subsequent sleep quality, but only for youth with higher levels of externalizing symptoms. Between-person, youths with higher mean and peak PA had better sleep quality. These findings suggest that affective functioning is bidirectionally linked to daily self-reported sleep quality among high- and low-risk youth. Specific disturbances in daily sleep-affect cycles may be distinctly associated with externalizing psychopathology.

Keywords Externalizing · Sleep · Affect · Ecological momentary assessment · Developmental psychopathology · Disruptive behavior disorders

Introduction

Sleep disturbance and emotion dysregulation undergo key developmental changes during early adolescence and covary across development (Palmer & Alfano, 2017; Williams et al., 2017), with each being associated with risk for and maintenance of psychopathology–including externalizing problems (Williamson et al., 2021). For example, youth with symptoms of Oppositional Defiant Disorder (ODD) (Aronen et al., 2014) and Attention-Deficit/Hyperactivity Disorder (ADHD) (Lycett et al., 2014) experience significantly greater sleep problems than their peers, which may exacerbate the emotional and behavioral challenges they encounter. Given that emotion dysregulation is central to these forms of psychopathology (Cole et al., 2017; Evans et al., 2017; Kircanski et al., 2017; Shaw et al., 2014), gaining a clearer understanding of the daily associations between affect and sleep in relation to externalizing problems could have important implications for developing interventions and identifying mechanisms of change during a critical developmental period. However, little is known about this topic, underscoring the need for intensive-longitudinal research among youth at risk for

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psychopathology. The present study aims to address this gap by investigating the day-to-day associations between perceived sleep quality and affective functioning and their relation to externalizing psychopathology in youth.

Emotion Dysregulation and Externalizing Psychopathology in Youth

Emotion regulation has been defined as changes that occur in the valence, intensity, or duration of an activated emotion (Cole et al., 2004; Thompson, 1994). In this way, emotion regulation is distinct from emotions themselves, and has come to be understood as a central vulnerability, process, or trait relevant to the development and maintenance of psychopathology (Cole et al., 2004, 2017). Adolescence is a critical period for emotion regulation, given the unique developmental changes that alter the intensity and frequency of emotional experiences and cognitive abilities to regulate such emotions (Ahmed et al., 2015). When considering emotion regulation via intensive-longitudinal designs, two further points warrant attention (Reitsema et al., 2022; Schatten et al., 2020; Shiffman et al., 2008). First, it is common to model superordinate domains of *positive affect* (PA; e.g., joyful, satisfied, relaxed) and *negative affect* (NA; e.g., worried, sad, irritated). Second, consistent with the view of emotion regulation as *process*, it is ideal to capture the temporal dynamics of these variables, such as a person's mean level, variability, and peaks in PA and NA over a day. As discussed below, these variables carry particular importance in relation to externalizing and sleep problems.

Although emotion dysregulation has more often been examined in internalizing conditions like depression (Bylsma et al., 2008; Hyde et al., 2008) and anxiety (Newman & Llera, 2011; Young et al., 2019) in adults, a growing body of research has identified emotion regulation as a transdiagnostic factor that contributes to externalizing problems across the lifespan (Compas et al., 2017; Lahey et al., 2017). For instance, emotion dysregulation is implicated in the social, behavioral, and clinical impairments experienced by youth with ADHD (Bunford et al., 2015; Shaw et al., 2014). Emotion dysregulation is not only correlated with externalizing problems, it is central to them. Research on ODD symptoms robustly identifies a core dimension of irritability or negative affect (Burke et al., 2014; Herzhoff & Tackett, 2016). The World Health Organization now recognizes in ICD-11 a subtype of ODD characterized by prevailing chronic irritability/anger (Evans et al., 2017). Others have argued that ODD should be redefined in its entirety as "a disorder of emotion dysregulation" (Cavanagh et al., 2017).

Although most research has focused on the dysregulation of negatively valenced emotions, evidence also points to the role of *positive affect* in contributing to externalizing problems (Toro et al., 2020). Both PA and NA are implicated in disruptive behavior problems in childhood (Nigg et al., 2020). Later in early adolescence, greater intensity of and variability in PA and NA may emerge as part of typical or atypical trajectories. For example, a subdimension of emotion dysregulation, emotional lability—defined as "frequent, excessively rapid, and intense changes in emotions," including positive and negative emotional responses (p. 1319) (Leaberry et al., 2020b)—is distinctly associated with externalizing symptoms (Cole et al., 2017) including ADHD and ODD (Sobanski et al., 2010).

Youth with elevated externalizing symptoms experience more pronounced difficulties with PA and NA in several ways. Global or mean levels of NA, and to some extent PA, are related to symptoms of inattention, hyperactivity-impulsivity, and oppositionality (Frick & Brocki, 2019; Karalunas et al., 2019; Martel, 2009). For instance, childhood irritability predicts neuroticism, personality disorders, anxiety, depression, ODD, suicidal behaviors, and other problems into adolescence and adulthood (Burke, 2012; Burke & Stepp, 2012; Vidal-Ribas et al., 2016). One study of clinically referred youth found that those with ADHD *alone* tended to report higher overall positive affect and lower negative affect, relative to those with ADHD and a comorbid diagnosis, most often ODD or Conduct Disorder (CD) (Okado et al., 2016). Thus, greater overall severity on the externalizing spectrum may be linked to more NA and less PA.

Due to limitations in the designs of previous studies, fluctuations in youths' daily affect remain poorly understood. To our knowledge, only a few studies using ecological momentary assessment (EMA) have probed such questions along the externalizing spectrum. Using parent-report EMA, Rosen and colleagues reported that youth with ADHD and externalizing problems showed greater overall emotional variability (Rosen & Factor, 2015; Rosen et al., 2015), including variability in both PA and NA (Factor et al., 2014; Leaberry et al., 2020a) as well as poorer emotional awareness (Factor et al., 2016), relative to various comparison groups. Further, emotional variability was linked to greater levels of and variability in functional impairment among youth with ADHD but not healthy controls (Walerius et al., 2018). These studies point to the promise of daily EMA for uncovering daily variations and predictors of affect among youth with varying degrees of externalizing symptoms.

Such findings suggest that externalizing symptoms might function as a predictor or moderator of youths' daily affect patterns. That is, youth with higher levels of externalizing symptoms have greater daily affective problems and variability in PA and NA. In particular, externalizing symptoms may play a role in *amplifying* their experience of affect-related difficulties on a day-to-day basis. For example, consider the association with sleep quality. Although many

youths experience an uptick in in NA and affective variability after a night of poor sleep, these associations between sleep quality and affective patterns may be especially pronounced among youth with externalizing problems. As reviewed below, sleep quality appears to be one significant and modifiable variable linked to affective functioning in youth with externalizing psychopathology, with potentially important clinical implications.

The Role of Daily Sleep Quality

Sleep is a dynamic phenomenon that also undergoes dramatic changes during the early adolescent years and across development (Carskadon, 2011). Indeed, sleep timing shifts later and homeostatic sleep drive builds more slowly during adolescence (Hagenauer et al., 2009), which along with increasing social and scholastic demands and early school start times results in the majority of adolescents not receiving sufficient sleep (Carskadon, 2011). Other sleep problems, such as difficulty falling and staying sleep (insomnia), also increase following the onset of puberty (Hysing et al., 2013). Poor perceived sleep quality has been consistently linked to greater emotion dysregulation over time (Palmer & Alfano, 2017), with even more immediate effects observed the next day (Konjarski et al., 2018). Experimental studies demonstrate the impact of poor sleep on next-day affect among adolescents (Baum et al., 2014; McMakin et al., 2016), with sleep restriction leading to next-day increases in NA and decreases in PA.

Given that both sleep quality and emotions fluctuate considerably on a day-to-day basis (Hamilton et al., 2022; Reitsema et al., 2022), intensive monitoring designs are needed to better understand their temporal dynamics and daily associations. Studies using daily diaries have shown links between various sleep domains and next-day PA and NA in childhood and adolescence (Cousins et al., 2011; Fuligni et al., 2019; Kouros & El-Sheikh, 2015). Fuligni et al. (2019) found that younger adolescents showed more pronounced effects of sleep loss on daily distress, highlighting the importance of developmental considerations. However, most prior studies only assessed affect once per day, with an exception by van Zundert et al. (2015). In this study, EMA methods and morning sleep diaries were used to assess sleep and affect (9x/day for 6 days) among youth ages 13–16, with affect aggregated for a daily mean. Results indicated that poorer sleep quality was associated with higher NA and lower PA the next day (van Zundert et al., 2015). Extending such findings, EMA provides the opportunity to study more dynamic aspects of daily sleep and affect, such as variability and upticks (peaks) in PA and NA over the course of a day, which may be more common after a night of poor sleep.

It may be particularly important to understand daily sleep-affect associations among youth with externalizing symptoms. Sleep problems are common among youth with behavior problems (Gregory & Sadeh, 2012) such as aggression, delinquency, and hyperactivity-impulsivity (Chervin et al., 2003; Gruber et al., 2012; Rubens et al., 2017). Relative to their peers, youths with ADHD and ODD or CD symptoms have less healthy sleep patterns per subjective and objective measures (Aronen et al., 2014). Longitudinal associations have also been established; sleep difficulties in early and middle childhood predict greater ADHD, ODD, and CD symptoms as in adolescence, and vice-versa (Quach et al., 2018; Shanahan et al., 2014; Tomasiello et al., 2021). Thus, youth with externalizing symptoms may be particularly impacted by poor sleep, given pre-existing difficulties with emotion regulation (Modecki et al., 2017). Sleep disturbances may also exacerbate these emotion regulation difficulties. For instance, one study indicates that higher next-day NA may be one mechanism linking daily poor sleep to subsequent externalizing symptoms (Kouros & El-Sheikh, 2015), further highlighting the importance of intensive longitudinal designs in this area.

The Present Study

In sum, sleep quality and affective functioning are associated with one another, and both are associated with externalizing psychopathology in youth. A deeper understanding of daily sleep-affect processes could provide important insights into the causes, correlates, and course of externalizing problems, with possible implications for intervention. But such research questions require intensive longitudinal designs, which have received little use in externalizing research to date. Accordingly, this study examines youth-reported EMA data on perceived sleep quality and PA/NA in relation to externalizing psychopathology. To better understand sleep-affect dynamics, we evaluated these associations both *between-person* (Do youth who report worse sleep quality, relative to their peers, experience greater daily affect dysregulation?) and *within-person* (Do youth who experience a night of worse-than-usual sleep quality, compared to their own baseline, experience upticks in affect dysregulation the following day?). Affect was examined in terms of daily means, peaks, and variability in PA and NA. Considering the research reviewed above, we investigated these questions testing *externalizing symptoms as a moderator* (Are daily sleep-affect associations exacerbated by higher levels of externalizing symptoms?) and *bidirectionality* (Does sleep quality predict next-day affect, and vice versa?).

More specifically, this study had two aims: First, we investigated daily perceived sleep quality as a predictor of next-day affect variables, testing externalizing symptoms

as a moderator. Second, given evidence for bidirectional sleep-affect associations (van Zundert et al., 2015), we estimated bidirectional versions of these models to investigate whether daily affect variables predicted next-day sleep quality, again testing externalizing symptomsas a moderator. We hypothesized that youth with poorer sleep quality would have higher daily mean NA, lower mean PA, as well as greater peaks and variability in both PA and NA. We also expected that the *daily time-varying associations of interest* in each model–broadly, between changes in one's usual patterns of daily sleep quality (or affect) one day, and poorer outcomes in affect (or sleep quality) the next day–would be moderated by externalizing symptoms. In other words, we expected that youth with higher levels of externalizing symptoms would experience stronger associations between their perceived sleep quality and their affective functioning on a day-to-day basis, as compared to youth with lower levels of externalizing symptoms.

The present sample was well-suited for these research questions in terms of both developmental considerations and psychopathology risk. Early adolescence (specifically, ages 9–13 here) is a period of dynamic changes in emotional reactivity with the onset of puberty (Guyer et al., 2016) and heightened risk for initial emergence of externalizing and internalizing disorders (Lawrence et al., 2021). There is also evidence for feasibility, validity, and reliability of self-report EMA among youth in this age range (Russell & Gajos, 2020). In addition, half our sample had familial history of depression, an important risk factor for youth psychopathology, including externalizing and internalizing conditions, through myriad genetic, environmental, and G×E pathways (Gruhn et al., 2016; Moffitt, 2005; Reising et al., 2013; Swales et al., 2022). By considering risk for psychopathology as part of the study design and analytic plan, results may have implications for the emergence, maintenance, and mitigation of emotion dysregulation and sleep problems in early adolescence.

Method

Participants

Data were collected from 82 youths (ages 9–13, M = 11.12, SD = 1.46) and their caregivers participating in a study on neurobehavioral indices of emotional functioning in depression risk (K01MH104325; see also Hamilton et al., 2020a, b). The sample was evenly distributed by sex (50% male, 50% female) and relatively diverse in terms of race and ethnicity (37% Black or African American, 44% White, 16%; see Table 1 for more sample characteristics). As part of the study design, participants were categorized into two groups: *high risk* (50%), based on having at least one biological parent with a history of two or more episodes of major depression; or *low risk* (50%), based on no lifetime history of psychopathology in biological parents. As summarized in Table 1, the high-risk group showed higher levels of externalizing symptoms, lower mean and *SD* in PA; otherwise, the two groups were comparable in terms of sex, race, ethnicity, age, pubertal development, sleep, and other affect variables. Exclusion criteria included parental lifetime history of bipolar disorder, mania, or psychosis; and youth lifetime history of depressive disorder, pervasive developmental disorder, intellectual disability, substance abuse/dependence, or serious head injury or neurological condition. The sample was recruited using local advertising methods online and in print (e.g., research registries, websites, clinics, listservs). Informed consent for parents and assent for youth were obtained prior to participation. Parents and youth received compensation for their time and participation. All procedures were approved by the institutional review board affiliated with the University of Pittsburgh.

Procedure

Parents first participated in a screening by phone and answered questions about both parental and child mental health history. Eligible parent-child dyads were then scheduled for their first laboratory visit, including diagnostic assessments with trained interviewers using the Kiddie Schedule for Affective Disorders and Schizophrenia for youths (Kaufman et al., 1997) and the Structured Clinical Interview for DSM-IV (Spitzer et al., 1992) for parents. These interviews were used only to ascertain parent and youth diagnoses for inclusion and exclusion criteria and group assignment, and were not applicable to the present analyses (e.g., no ADHD or ODD diagnoses). After the diagnostic interview, participants completed surveys rating their child's level of ODD and ADHD symptoms, among other measures. Each youth participant was provided with a study smartphone with a custom EMA application and instructed on how to use it.

EMA Protocol The youth EMA component was administered over a 9-day period standardized to the weekly calendar. It always began on a Saturday and ended on the Sunday of the following weekend; thus, study participation included 5 weekdays and 4 weekend days for all participants. The protocol included affect and sleep items on different schedules as described below, with differences only for weekday vs. weekend schedules. On Saturdays and Sundays, youths were asked to complete a total of 8 PA/NA prompts, distributed at quasi-random intervals between 10:00 AM and 10:00 PM. On Monday through Friday, youths were asked to complete 4 PA/NA prompts per day, including one distributed in the morning and 3 distributed at quasi-random

Table 1 Participant characteristics

Variable	Full Sample ($N = 82$)	Familial Risk for Psychopathology		
		Low Risk ($N = 41$)	High Risk ($N = 41$)	Group Comparison and Effect Size
Categorical Variables, *N* (%)				χ^2, *V*
Sex	–	–	–	*ns*
Male	41 (50.0)	19 (46.3)	22 (53.7)	–
Female	41 (50.0)	22 (53.7)	19 (46.3)	–
Race	–	–	–	*ns*
Black or African American	30 (36.6)	16 (39.0)	14 (34.1)	–
White	36 (43.9)	21 (51.2)	15 (36.6)	–
Multi-Racial	13 (15.9)	3 (7.3)	10 (24.4)	–
Other	3 (3.7)	1 (2.4)	2 (4.9)	–
Ethnicity	–	–	–	*ns*
Hispanic	5 (6.1)	1 (2.4)	4 (9.8)	–
Not Hispanic	77 (93.9)	40 (97.6)	37 (90.2)	–
Continuous Variables, *M* (*SD*)				*t*, *d*
Age in Years	11.12 (1.46)	11.27 (1.40)	10.98 (1.52)	*ns*
PDS Pubertal Development (Scale: 1–5)	2.84 (1.09)	2.76 (1.09)	2.92 (1.10)	*ns*
SNAP Externalizing Symptoms (Scale: 0–78)	12.75 (13.44)	7.85 (7.54)	17.64 (16.12)	$d = 0.78$, $t(80) = 3.52^{***}$
ODD Symptom Subscale (Scale: 0–24)	4.07 (4.79)	2.12 (2.86)	6.02 (5.52)	$d = 0.89$, $t(80) = 4.02^{***}$
ADHD Symptom Subscale (Scale: 0–54)	8.68 (9.75)	5.73 (5.82)	11.62 (11.87)	$d = 0.63$, $t(80) = 2.85^{**}$
Person-Mean Sleep	–	–	–	–
Sleep Quality (Scale: 0–100)	72.08 (17.93)	73.73 (16.07)	70.34 (19.77)	*ns*
Sleep In-Bed Time (Clock Hours, 0–24)	23.13 (1.48)	22.98 (1.37)	23.28 (1.58)	*ns*
Sleep Wake Time (Clock Hours, 0–24)	8.13 (1.22)	7.96 (1.10)	8.31 (1.32)	*ns*
Sleep Duration in Hours	9.02 (0.93)	9.01 (0.96)	9.03 (0.92)	*ns*
Person-Mean Affect (Scale: 0–100)	–	–	–	–
PA Mean	46.04 (20.91)	51.25 (20.58)	40.82 (20.17)	$d = 0.51$, $t(80) = 2.32^{*}$
PA *SD*	11.68 (6.36)	11.94 (7.10)	11.42 (5.61)	*ns*
PA Peak	57.95 (21.32)	63.35 (20.83)	52.54 (20.65)	$d = 0.52$, $t(80) = 2.36^{*}$
NA Mean	8.66 (7.35)	8.15 (6.37)	9.18 (8.27)	*ns*
NA *SD*	5.81 (3.53)	5.97 (3.79)	5.65 (3.28)	*ns*
NA Peak	16.06 (10.48)	16.10 (10.38)	16.02 (10.72)	*ns*

PDS Pubertal Development Scale (Petersen et al., 1988), *SNAP* Swanson, Nolen, and Pelham scale (Swanson et al., 2001), *ODD* oppositional defiant disorder symptoms, *ADHD* attention-deficit/hyperactivity disorder symptoms, *PA* positive affect, *NA* negative affect

$^{*}p < 0.05$, $^{**}p < 0.\ 01$, $^{***}p < 0.001$

intervals between 4:00 PM and 9:30 PM. The software was programmed to send no more than 1 EMA prompt within the same 1.5-h bin. There was no difference in self-reported sleep quality for weekends vs. weekdays $t(149) = 1.30$, $p = 0.20$. The standard EMA protocol did not change to account for holidays, school breaks, vacations, sick days, etc. About 30% of the sample participated during their summer break, but they showed no difference in sleep quality as compared to those who participated during the school year, $t(81) = 0.19$, $p = 0.85$.

The EMA protocol also included a daily sleep diary. Rather than being sent as an interval prompt, the sleep diary was a user-initiated data collection tool that youths were instructed to complete within 1 h of waking, same for weekdays and weekend (with observed *M* waketimes of 7:39 AM and 8:49 AM, respectively). The sleep diary included questions about sleep quality, sleep times, and waketimes. Table 1 summarizes all sleep statistics for descriptive purposes; however, primary analyses focus solely on sleep quality, as described below (Measures). We focus on sleep

quality as it provides a single global index of how well individuals perceive they slept without adding undue complexity and multiplying the number of models even further (e.g., given 6 affect variables).

Participating youths completed 582 (78.9%) of 738 total possible sleep diaries, or sleep diaries for a mean of 7.10 days out of the 9-day protocol. For the affect data, youths completed 3,112 (73.0%) of 4,264 total possible PA/NA ratings, or a mean of 37.95 ratings per person, or 4.22 per day (averaging about 5.52 on weekends and 2.95 on weekdays). When aggregated at the day level (described below), the six PA/NA variables were available on 651–682 (88.2–92.4%) of the 738 total study days. This translates to participant day-level PA/NA data being available for 7.94–8.32 out of 9 days, on average. These compliance rates are similar to most other youth EMA studies per recent reviews and meta-analyses (averaging 76–78%, with individual studies ranging from 51 to 96%; Heron et al., 2017; Wen et al., 2017).

Measures

Positive and Negative Affect (PA/NA) At each EMA prompt, participants rated their momentary emotional state on 8 NA items (mad, sad, guilty, embarrassed, scared, worried, bored, irritated) and 8 PA items (happy, joyful, proud, interested, energetic, satisfied, relaxed, excited) on a sliding scale from 0 (*Not at all*) to 100 (*A great deal*). Higher scores reflect higher levels of that emotion subjectively experienced in the moment. For each person at each prompt, momentary NA and PA values were computed as the average of their 8 item ratings. We further operationalized PA/NA via daily means, peaks, and variability, as described below (Analytic Overview). These 8 PA and 8 NA items have shown evidence of reliability, validity, and feasibility in prior youth EMA research (Silk et al., 2011).

Perceived Sleep Quality As part of the EMA protocol, youths received a daily sleep diary within 1 h of waking each morning. Items asked participants to rate their perception of their prior night's sleep. Sleep quality was assessed as follows: "How well would you say you slept last night?" rated on a sliding scale from 0 (*Not well at all*) to 100 (*Extremely well*).

Externalizing Symptoms Externalizing symptoms were measured dimensionally using the SNAP-IV, which was completed by parents at the baseline visit. The SNAP-IV is a revised version of the Swanson, Nolen, and Pelham (SNAP) scale (Swanson et al., 2001) that includes 90 items (26 of which were used here) to assess children's disruptive behavior symptoms. Parents are asked to respond on a four-point scale from 0 (*Not at all*) to 3 (*Very much*). A total score was computed as the sum of 26 externalizing symptom severity items: 8 ODD items plus 18 ADHD items, corresponding to the ODD/ADHD diagnostic criteria over the last 3 decades (*DSM-IV* through *DSM-5-TR*). The SNAP-IV has shown evidence of test-retest reliability and convergent and discriminant validity (Swanson, 1992). Internal consistency was excellent, overall (externalizing $\alpha = 0.96$) and by subscale (ADHD $\alpha = 0.95$; ODD $\alpha = 0.92$).

Although we are unable to report ADHD and ODD diagnoses from the K-SADS, parent-report SNAP scores allow for estimates of clinically significant symptom rates. Based on the mean scale score cutoff of > 1.0 adopted by the measure's developer (Swanson et al., 2001), $n = 14$ (17.1%) had clinical symptoms of inattention, $n = 7$ (8.5%) had hyperactivity/impulsivity, and $n = 13$ (15.9%) had ODD symptoms; and $n = 18$ (22.0%) had at least one of the above. In other words, more than 1 in 5 participants had clinically meaningful SNAP scores (Externalizing Symptoms $M = 31.75$, $SD = 15.43$), as compared to the other 4 in 5 participants who showed little to no symptoms ($M = 5.99$, $SD = 15.43$). Importantly, these estimates do not consider impairment, teacher/self-report, or other key considerations for diagnosing ODD and ADHD.

Puberty The Pubertal Development Scale (PDS; (Petersen et al., 1988) is a well-validated measure of self-reported pubertal timing and course. Scores parallel the Tanner Stages and convert to a 5-point scale (Shirtcliff et al., 2009) with higher scores indicating more pubertal maturation. Pubertal development is linked to sleep (Colrain & Baker, 2011) but was only correlated with age in the present data. Analyses already controlled for age, so PDS scores are reported in Table 1 only for descriptive purposes.

Analytic Overview

Data Preparation For analysis, each person's available EMA **affect ratings**–originally collected as mean PA and NA scores at up to 8 occasions per day (as described above)–were aggregated to create day-level variables that summarize the person's affective experiences over the course of an entire day. Specifically, we computed three variables for both PA and NA, or six variables total: each person's daily *mean* (*M*) level of PA; their daily variability or *standard deviation (SD)* in PA; and their daily *peak* or maximum level of observed PA; as well as their daily *M*, *SD*, and peak of NA. This day-level aggregation brought our PA/NA data structure to mirror that of **sleep quality ratings**, which were collected once per day.

Daily sleep and affect variables retained their original 0–100 scales when used as dependent variables; but when used as predictor variables, centering was used to parse within- vs. between-person variance. **Sleep quality ratings** were centered in two ways: *person-mean centered* (within-person, level-1), such that 0 = each person's usual level of sleep quality, and higher or lower values reflect deviations from their usual (i.e.,

better-than-usual sleep quality or worse-than-usual sleep quality, respectively); and *grand-mean centered* (between-person, level-2), such that 0 = the grand mean sleep quality rating of about 72 on a 0–100 scale, with higher or lower values reflecting between-person variations relative to the sample. **Affect ratings** were similarly centered in two ways: *person-mean centered* (within-person, level-1), such that 0 = each person's usual level of affect (PA or NA; *M*, *SD*, or peak), and deviations from their usual; and *person-mean* ratings (between-person, level-2), which retained their original 0–100 scale properties but functioned in models as between-person variations relative to the sample. When testing bidirectional associations, sleep quality values were shifted forward in the dataset to evaluate the effect of one day's affective variables in predicting the next day's sleep quality.[1]

Statistical Analysis Descriptive statistics, correlations, and group comparisons were examined with attention to distributional characteristics, associations of interest, and covariates. Primary analyses were conducted as multilevel models (MLMs) with daily observations of outcome variables (level 1) nested within person (level 2). In interpreting MLMs, intra-class correlation coefficients (ICCs) were estimated to indicate the percentage of variance in outcomes accounted for at a between-person level; and total model r-squares were computed to indicate the total amount of variance that was accounted for by all model terms (Hoffman, 2020).

The planned sequence of MLMs was carried out in two phases: sleep quality predicting affect, then affect predicting sleep quality. Base MLMs were estimated first to examine sleep quality (between- and within-person) as a predictor of the next-day affect variables; then, cross-level interactions were added to test externalizing symptoms as a moderator of the effects of sleep quality at both levels (i.e., six models [PA and NA; x *M*, *SD*, and peak], where each model has two steps, base and externalizing). Next, the converse models were estimated to examine longitudinal bidirectionality in these paths. That is, all 6 PA/NA variables were respecified this time as *predictors* (between- and within-person, with externalizing moderator terms) of next-day sleep quality. Given the redundancy of the two-step MLM approach, we focus here on main results concerning externalizing problems; results of base models are reported in the Supplement.

Considering our analytic plan, sample size, and results, we estimated power *post hoc* through the EMATools R package and based on summary-statistics from mixed-effects model results (Murayama et al., 2022). Based on these analyses, we obtained adequate power (1-β ≥ 0.80) to detect any large effects; and nearly adequate power (1-β ≥ 0.75) to detect medium effects for models with adequate variance (ICCs > 0.4), but underpowered (1-β ≥ 0.60) to detect medium effects (when ICCs < 0.4) or smaller effects.

All MLMs control for child sex and age based on the relevance of these variables to externalizing psychopathology, sleep, and affect. We also estimated all models with and without controlling for familial risk for psychopathology as a between-person predictor. This inclusion of risk as a covariate did not lead to any changes in results. For parsimony, we therefore report results from models without controlling for risk group status. MLMs were estimated using maximum likelihood estimators via the PROC MIXED command in SPSS. At level 1, MLMs included random intercepts and random effects for the time-varying predictor of interest. At level 2, models included fixed effects for the time-varying predictor between-person as well as age, sex, and externalizing symptoms, with interaction terms for externalizing symptoms with the time-varying predictor at levels 1 and 2. In some cases (including all models of affect predicting sleep), it was necessary for convergence to specify time-varying predictors as fixed effects.

Significant interactions, when found, were probed in a manner intended to be clinically, normatively, and idiographically meaningful, as follows (see footnotes and figures for elaboration). For externalizing symptoms, we probed interactions at scores of 0 (no symptoms, scale floor, and -1*SD*), 13 (low symptoms, *M),* 26 (moderate symptoms, sample +1*SD*), and 39 (high symptoms, sample +2*SD*).[2] For perceived sleep quality and affect variables, we probed interactions at each person's "usual" level or their within-person mean; and we used increments of ±1 within-person *SD*s to represent days on which each time-varying variable was higher or lower than "usual" at a within-person level.[3]

[1] The centering and coding of other variables in our models is as follows: SNAP externalizing symptoms were left such that 0 = no symptoms and higher scores reflecting higher externalizing symptoms. Age was centered such that 0 = 9 years, the youngest age in the sample. Sex is coded as 0 = male, 1 = female.

[2] SNAP Externalizing Symptom scores had a possible range from 0 to 78, with our sample's *M* and *SD* both falling at 13 (rounded), making this a useful increment for probing different symptom levels from "none" to "high." For reference, participants with any "elevated" ADHD or ODD scales (based on Swanson et al.'s, 2001 cutoffs) showed a total Externalizing Symptoms Score of *M* = 31.75 (*SD* = 15.43), as compared to those with all their SNAP scale scores below the cutoffs (*M* = 5.99, *SD* = 15.43).

[3] Time-varying variables (sleep quality and PA/NA variables) were grand- and person-mean-centered such that a value of 0 represents a "usual" day for the average participant in our sample. Relative to that mean/usual value, interactions were probed at within-person high and low values. Specifically, time-varying sleep-quality was probed at 0 ± 17, representing days on which each person's sleep quality was better or worse than their usual by about 1 within-person *SD*. Similarly, person-mean PA variables were probed at 0 ± 11, representing days on which each person's mean PA levels were higher or lower than their usual by about 1 within-person *SD*. These values for within-person *SD*s (17, 11) represent the mean of the within-person *SD*s, averaged across all participants.

Results

Perceived Sleep Quality Predicting Affect

Table 2 presents the results of models of daily sleep quality predicting daily PA and NA variables. The ICC estimates revealed that between-person variance accounted for as little as 27.9% (NA variability) to as much as 74.6% (PA mean) of the variance in daily affective variables, possibly being related to person mean differences or other between-persons variables such as externalizing symptoms. In other words, this left 72.1–25.4% of the remaining variance that could potentially accounted for by within-person variables.

In the models predicting individual daily variability (*SD*) and peaks in NA, externalizing symptoms significantly moderated the effects of within-person sleep quality on these NA outcomes. These effects are plotted in Fig. 1. As shown, youth with higher levels of externalizing symptoms showed higher levels of peak NA (Fig. 1a) and greater variability in NA (Fig. 1b) on days after they received worse-than-usual quality sleep. In contrast, for youth without externalizing symptoms, worse-than-usual sleep quality did not predict changes in next-day NA. There were no significant effects on daily mean NA.

In models predicting PA (right side of Table 2), there were no significant within-person effects or cross-level interactions; only between-person effects emerged, consistent with the high ICCs. At a between-person level, higher levels of average sleep quality and lower levels of externalizing symptoms each predicted higher mean and peak PA.

Overall, daily sleep quality, externalizing symptoms, and covariates accounted for 1.4% (NA peak outcome) to 37.1% (PA peak outcome) of the total variance in daily affect (Table 2).

Affect Predicting Perceived Sleep Quality

The ICC for sleep quality (lagged forward to next day) was 0.395, suggesting that 39.5% of the observed variance in

Table 2 Multilevel models examining sleep quality, externalizing symptoms, and covariates as predictors of daily PA and NA variables

Model Effects	Dependent Variables					
	Daily NA (NA)			Daily Positive Affect (PA)		
	NA Mean	NA *SD*	NA Peak	PA Mean	PA *SD*	PA Peak
Model for the Means						
Intercept	9.395 (1.804)***	6.649 (0.951)***	18.101 (2.866)***	55.796 (4.403)***	13.528 (1.702)***	69.936 (4.274)***
Age	-0.086 (0.498)	-0.373 (0.269)	-0.442 (0.807)	-0.327 (1.260)	-1.234 (0.480)*	-1.490 (1.215)
Female	-3.116 (1.428)*	-0.012 (0.771)	-2.552 (2.314)	-2.441 (3.604)	0.391 (1.373)	-2.623 (3.478)
BP Sleep Quality	-0.015 (0.061)	0.026 (0.032)	0.027 (0.097)	0.902 (0.149)***	0.025 (0.058)	0.879 (0.145)***
WP Sleep Quality	-0.009 (0.028)	0.019 (0.017)	0.011 (0.047)	0.085 (0.050)	-0.035 (0.026)	0.051 (0.056)
ExtSx	0.072 (0.071)	-0.006 (0.036)	0.025 (0.109)	-0.603 (0.163)***	0.041 (0.064)	-0.549 (0.160)***
ExtSx*BPSlpQual	0.001 (0.003)	-0.002 (0.002)	-0.001 (0.005)	-0.014 (0.007)	0.003 (0.003)	-0.009 (0.007)
ExtSx*WPSlpQual	-0.002 (0.002)	-0.003 (0.001)**	-0.006 (0.003)*	0.001 (0.003)	0.002 (0.001)	0.002 (0.003)
Model for the Variance						
Random Intercept	42.656 (7.816)***	8.415 (1.886)***	93.196 (18.021)***	231.124 (39.996)***	30.973 (6.151)***	216.932 (38.571)***
WP Sleep Quality	0.010 (0.003)**	0.000 (0.001)	0.019 (0.009)*	0.021 (0.011)*	0.003 (0.003)	0.027 (0.014)
Covariance	-0.491 (0.147)***	-0.057 (0.046)	-0.819 (0.384)*	-0.398 (0.534)	-0.243 (0.140)	-1.007 (0.626)
Residual	33.416 (2.168)***	21.436 (1.404)***	117.531 (7.648)***	121.266 (7.987)***	47.596 (3.141)***	152.855 (10.096)***
ML Model Fit						
N Parameters	12	12	12	12	12	12
-2LL	3887.0	3462.7	4582.3	4668.1	3949.4	4779.2
AIC	3911.0	3486.7	4606.3	4692.1	3973.4	4803.2
BIC	3963.3	3538.8	4658.6	4744.5	4025.6	4855.6
Empty Means ICC	0.478	0.279	0.391	0.746	0.416	0.704
Total R-Square	0.025	0.029	0.014	0.360	0.064	0.371

Coefficient and variance terms are reported as estimate (standard error). Models were estimated first without externalizing problem terms included; for clarity those results are not included here, but see Supplement (Table S1) for results of those base models

BP between-person (level 2) effects, *WP* within-person (level 1) effects, *ExtSx* = externalizing symptoms, *ICC* Intra-class correlation

$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

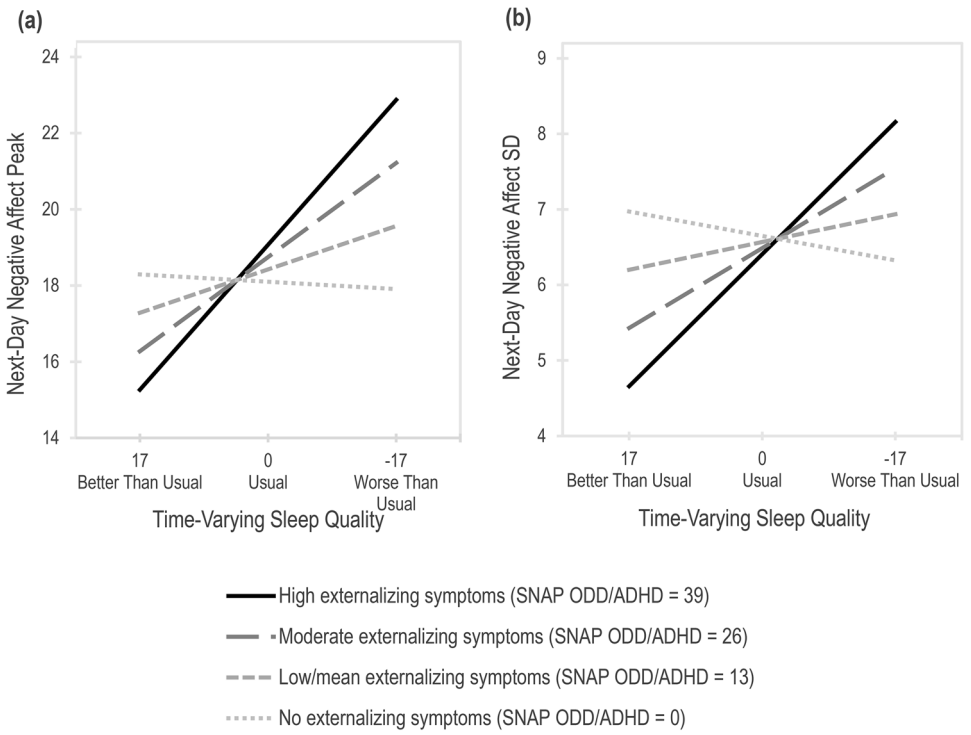

Fig. 1 Worse-than-usual perceived sleep quality predicts increases in daily NA peaks (**a**) and variability (**b**), but only among youth with higher levels of externalizing symptoms. *Note*. Time-varying sleep quality is person-mean-centered, and the mean within-person standard deviation was about 17. Thus, a score of 0 represents each person's mean sleep quality from day-to-day, and scores of ± 17 represent days on which each person's sleep quality was better or worse than their usual sleep quality by about 1 standard deviation. Externalizing symptoms are a between-person variable assessed at baseline, plotted as specified in the figure. Dependent variables are time-varying on their original scales as computed for peak NA (range: 0 to 99.13), and *SD* of NA (range: 0 to 53.48). See Table 1 for descriptive statistics on all variables

sleep quality was attributable to person mean differences or other between-persons variables such as externalizing symptoms. This left the remaining 60.5% of the variance to be potentially accounted for by within-person variables.

Tables 3 and 4 report results of models with NA and PA, respectively, as predictors of sleep quality. The NA models did not show any significant predictors (Table 3). That is, virtually none of the variance (0.4% to 0.9%) in daily sleep quality was accounted for by these models' covariates, NA variables (mean, *SD*, or peak), or externalizing problem variables.

In contrast, PA models (Table 4) showed significant between-person effects of mean and peak levels of PA on sleep quality. That is, youth who experienced higher *average levels* of PA, and those who experienced more highly positive *moments*, also tended to have better quality sleep throughout the study. One significant cross-level interaction emerged: externalizing symptoms moderated the link between within-person mean PA and sleep quality. As shown in Fig. 2, youth with higher levels of externalizing symptoms showed significantly worse sleep quality after they experienced lower-than-usual PA; however, this effect was not observed among youth without externalizing symptoms (similar to the interactions shown in Fig. 1). Overall, these models accounted for 5.9% to 23.9% of the variance in daily PA variables.

Lastly, supplemental sensitivity analyses were conducted by re-estimating all these MLMs, controlling for familial risk for psychopathology. Results did not change, supporting the robustness of findings reported above.[4]

[4] Specifically, when adding risk group as a covariate, the significance status (i.e., $p < 0.05$ vs. $p \geq 0.05$) of the 84 fixed effects reported in Tables 2–4 and Tables S1–S3 remained the same. Risk emerged only as a significant covariate in two base models, predicting next-day PA mean (B = -7.837, SE = 3.825, p = 0.044) and the model predicting next-day PA peak (B = -8.528, SE = 3.610, p = 0.021); however, it was not associated with dependent variables in any of the Step 2 models (all risk coefficient ps > 0.152), suggesting that any effect of risk was overshadowed by externalizing symptoms. See also Table 1 for a breakdown of primary study variables by risk group: few group differences emerged, with risk being correlated as expected with externalizing symptoms (r = 0.37, p = 0.001), and with both variables being modestly associated with PA means and peaks (rs = -0.22 to -0.26, ps = 0.021 to 0.047).

Table 3 Multilevel models examining NA (NA), externalizing symptoms, and covariates as predictors of daily perceived sleep quality

Model Effects	Model for NA Mean as Predictor		Model for NA *SD* as Predictor		Model for NA Peak as Predictor	
Model for the Means						
Intercept		75.301 (6.364)***		68.606 (7.144)***		72.290 (6.852)***
Age		-0.146 (1.409)		-0.176 (1.445)		-0.121 (1.411)
Female		0.683 (4.124)		0.295 (4.216)		0.851 (4.174)
BP Term:	NA Mean	-0.396 (0.550)	NA *SD*	0.737 (0.921)	NA Peak	-0.011 (0.337)
WP Term:	NA Mean	0.128 (0.223)	NA *SD*	0.067 (0.255)	NA Peak	0.033 (0.110)
ExtSx		-0.314 (0.300)		0.251 (0.438)		-0.204 (0.360)
ExtSx*BPTerm		0.026 (0.031)		-0.065 (0.071)		0.007 (0.022)
ExtSx*WPTerm		-0.015 (0.014)		-0.010 (0.014)		-0.004 (0.007)
Model for the Variance						
Random Intercept		253.941 (51.414)***		254.536 (52.227)***		253.954 (51.485)***
Residual		391.860 (26.439)***		394.204 (26.976)***		392.961 (26.517)***
ML Model Fit						
N Parameters		10		10		10
-2LL		4671.9		4557.6		4673.2
AIC		4691.9		4577.6		4693.2
BIC		4734.3		4619.8		4735.6
Total R-square		0.005		0.009		0.004

Coefficient and variance terms are reported as estimate (standard error). The dependent variable in all models is sleep quality as rated the following day, with an intra-class correlation of 0.395 in the empty means models. The only difference between models is the affective variable specified as predictor BP Term and WP Term. Models were estimated first without any externalizing problem terms included; for clarity those results are not included here, but see Supplement (Table S2) for results of those base models

BP between-person (level 2) effects, *WP* within-person (level 1) effects

$^{*}p < 0.05$, $^{**}p < 0.\ 01$, $^{***}p < 0.001$

Table 4 Multilevel models examining positive affect (PA), externalizing symptoms, and covariates as predictors of daily perceived sleep quality

Model Effects	Model for PA Mean as Predictor		Model for PA *SD* as Predictor		Model for PA Peak as Predictor	
Model for the Means						
Intercept		44.356 (6.542)***		69.404 (7.201)***		36.281 (7.125)***
Age		0.167 (1.086)		0.334 (1.394)		0.659 (1.043)
Female		2.922 (3.146)		1.272 (3.985)		3.196 (3.022)
BP Term:	PA Mean	0.456 (0.107)***	PA *SD*	0.069 (0.480)	PA Peak	0.484 (0.098)***
WP Term:	PA Mean	-0.013 (0.120)	PA *SD*	-0.062 (0.198)	PA Peak	0.040 (0.115)
ExtSx		-0.081 (0.266)		-0.596 (0.319)		-0.141 (0.278)
ExtSx*BPTerm		0.010 (0.007)		0.047 (0.028)		0.008 (0.006)
ExtSx*WPTerm		0.017 (0.007)*		0.012 (0.012)		0.010 (0.005)
Model for the Variance						
Random Intercept		124.536 (30.172)***		226.053 (47.984)***		110.162 (27.813)***
Residual		381.106 (25.717)***		393.984 (27.001)***		381.022 (25.709)***
ML Model Fit						
N Parameters		10		10		10
-2LL		4618.7		4550.3		4612.4
AIC		4638.7		4570.3		4632.4
BIC		4681.1		4612.5		4674.8
Total R-square		0.218		0.059		0.239

Coefficient and variance terms are reported as estimate (standard error). The dependent variable in all models is sleep quality as rated the following day, with an intra-class correlation of 0.395 in the empty means models. The only difference between models is the affective variable specified as predictor BP Term and WP Term. Models were estimated first without any externalizing problem terms included; for clarity those results are not included here, but see Supplement (Table S3) for results of those base models

BP between-person (level 2) effects, *WP* within-person (level 1) effects

$^{*}p < 0.05$, $^{**}p < 0.\ 01$, $^{***}p < 0.001$

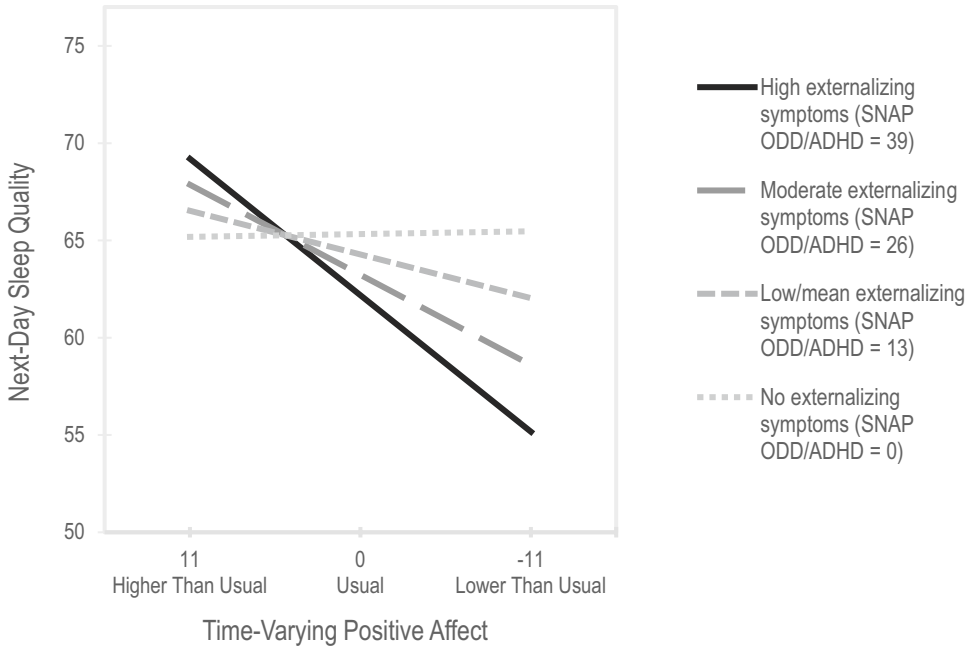

Fig. 2 Lower-than-usual positive affect predicts decrements in next-day's reported sleep quality, but only among youth with higher levels of externalizing symptoms *Note*. Time-varying positive affect is a person-mean-centered and the mean within-person standard deviation of positive affect was about 11. Thus, a score of 0 represents each person's mean positive affect from day-to-day, and scores of ±11 represent days on which each person's overall positive affect was higher or lower than usual by about 1 standard deviation. Externalizing symptoms are a between-person variable assessed at baseline, plotted as specified in the figure. The sleep quality dependent variable is based on its original scale ranging from 0–100. See Table 1 for descriptive statistics on all variables

Discussion

This study examined how youths' affective functioning and perceived sleep quality are related to one another on a day-to-day basis and across varying levels of externalizing symptoms. Several interesting findings emerged. At a within-person level, we found that worse-than-usual sleep quality predicted higher levels of, and greater variability in, next-day NA—but only for youth with elevated externalizing symptoms. Conversely, lower-than-usual mean PA predicted poorer sleep quality that night—but again, this was evident only for youth with elevated externalizing symptoms. At a between-person-level, youths with lower average sleep quality and higher externalizing symptoms had lower means and peaks in their PA. Similarly, youths with lower means and peaks in their PA tended to have poorer overall sleep quality.

Consistent with our general hypotheses, the observed time-varying effects (i.e., daily affective dynamics predicting daily sleep quality decrements; and vice versa) were *evident only among youth with higher levels of externalizing symptoms*–where "higher" refers both to relative differences in externalizing scores in this sample and to thresholds for clinical elevations. This is important because it presents an externalizing-specific view of daily cycles between sleep and emotion regulation, rather than a view that is common to youths in typically developing or internalizing samples that have traditionally been studied (Baum et al., 2014; Cousins et al., 2011; Fuligni et al., 2019; Kouros & El-Sheikh, 2015; McMakin et al., 2016).

The present findings also reveal *important patterns of bidirectionality* in the associations between daily sleep quality and affect. Similar bidirectional findings have been documented before, particularly in studies focusing on internalizing problems (Cousins et al., 2011; van Zundert et al., 2015). The present study extends this body of evidence into the externalizing domain. Consistent with this prior literature, our findings suggest that associations between sleep and affect are not uniform across different degrees and forms of psychopathology. It is important to note that perfectly bidirectional conclusions are not warranted given the asymmetries in the results for predictors and outcomes. That is, among youth with externalizing problems, we documented three day-to-day effects: (a) decreases in sleep quality predict increases in peak NA; (b) decreases in sleep quality predict increases in variability of NA; and (c) decreases in PA predict decreases in sleep quality. Regarding the former two, a poor night's sleep predicts greater NA dysregulation the next day, possibly including behavioral outbursts (e.g., Hirsch et al., 2022) that are directly negatively valenced (i.e., interwoven with angry, irritable, or distressed affect). Poor sleep quality could also predict forms

of disruptive behavior that may elicit NA in a more indirect manner (e.g., "acting out" in class leading to school discipline and negative emotion).

Regarding the third finding, it is interesting that these same NA problems–identified above as outcomes of poor sleep quality–are *not* also functioning as predictors. Instead, it is *decreased PA* that seems to be deleterious to sleep quality for youth with externalizing problems. When a youth with externalizing problems has a day where they experience less overall positive emotion (not necessarily more negative emotions) than usual, this may lead to poorer sleep because (a) they are in a low mood (even if not especially *distressed*, in line with Clark and Watson's Tripartite Model), or (b) they were in a relatively lower-than-expected reward context (e.g., they were grounded for misbehaving, their fun plans were interrupted; in line with frustrative nonreward models), or (c) they did not engage in "third-variable" activities (e.g., sports, social activities) that may bring higher PA and better sleep. These possibilities provide testable hypotheses for future research. There is much work to be done to clarify how different patterns of sleep quality may be bidirectionally tied to various PA/NA parameters in context.

This study is the first to evaluate the daily temporal and bidirectional associations between sleep quality and PA/NA specifically in relation to youth externalizing problems. Our findings highlight the value of intensive monitoring designs for modeling the dynamics between sleep and affect, to more fully capture the heterogeneity of daily affective experiences that youth encounter. Whereas most past research aggregates PA and NA in the form of daily means, we went a step further and modeled their daily peaks and variability, yielding several interesting findings not captured by mean levels alone. Findings are consistent with the view that youths are leading daily lives characterized by rich, temporally dynamic, positive and negative emotional experiences that affect, and are affected by, their sleep–particularly for those with externalizing problems. This is especially relevant during the early adolescent period when youth are experiencing developmental changes in sleep and emotional experiences (Carskadon, 2011) and given the importance of early intervention for behavioral problems that can affect longer-term outcomes into later adolescence and adulthood. In the future, research integrating intensive- and long-term-longitudinal designs would be useful for understanding these dynamics in relation to developmental, functional, and clinical outcomes. The present study design also allowed us to probe the potential bidirectional effects using a temporal, lagged approach, with findings indicating that sleep quality and PA affect one another, where sleep quality more directly affects next-day NA. We also parsed out the extent to which sleep and affect influence one another at the between-person (compared to other youth) and within-person (daily fluctuations) levels, offering novel insights at the individual level.

Study strengths include an innovative approach to intensive longitudinal monitoring among a diverse youth sample enriched for familial risk for psychopathology. Still, limitations should be noted. First, the original study was not designed to examine externalizing symptoms, which has downstream implications for the both the sample recruited (potential range restriction, constraints on generalizability) and for how externalizing symptoms were measured (e.g., no ADHD, ODD, or CD diagnoses available). Specifically, SNAP Externalizing scores (M = 12.75, range = 0–72) showed a right skew, with fewer cases falling toward the high-severity tail. This distribution precluded us from examining more fine-grained dimensions (e.g., inattention, hyperactivity, irritability, defiance, oppositionality); instead, we focused here on externalizing symptoms more broadly. This is a common approach, to use DSM-based ODD/ADHD symptom scales to measure of total externalizing severity, but it lacks strong normative data or empirically based cutoffs specific to the SNAP and to our sample's age range. Still, results can be interpreted dimensionally as an indicator of overall externalizing severity. Further, we did observe a reasonable distribution of externalizing symptoms for results modeled here, suggesting that these problems may have been well-represented given the high-risk design.

Second, we only examined one aspect of sleep (subjective sleep quality). It is imperative to evaluate multiple dimensions of sleep (e.g., sleep duration, timing, efficiency, insomnia, nighttime awakenings, and daytime sleepiness), which may provide more information about sleep quality rather than perceived sleep quality (assessed in this study). In addition, using multiple approaches and more objective measures (e.g., actigraphy) are needed to better understand the nature of subjective compared to objective aspects of sleep linked with emotional experiences, particularly for externalizing youth. Third, although our sample size (N = 82) was similar to that of other youth EMA studies (mean N = 77) (Heron et al., 2017) and provided adequate power to detect medium-to-large effects, we were slightly underpowered to detect small-to-medium effects in models, particularly for the cross-level interaction terms.

Fourth, affective variables were derived from PA and NA ratings, not necessarily the most precise operationalization of clinically relevant constructs like emotion dysregulation, regulation, and lability. Moreover, these data were aggregated at the day-level in this analysis; future research may benefit from a more complex approach to modeling of EMA data to better understand the temporal dynamics of youth affect across and within days. Finally, sleep, affect, and externalizing problems are probably jointly related to factors such as racial/ethnic discrimination experience (Johnson et al., 2019), sexual/gender minority stress (Levenson et al., 2020), general family stress (Sperber et al., 2022), and various other factors

(e.g., social and family relationships, peer victimization, school and community) beyond the scope of the present study. Future research should adopt a more ecological approach that considers a range of contextual variables.

Regarding clinical implications, our findings point to two key targets that are malleable and ripe for intervention among youth with externalizing problems: sleep quality and affective functioning. Broadly, a thorough assessment of regulation (emotions, behaviors, and thoughts, and strengths and difficulties in regulating them) is already an important part of the clinical services for youths experiencing externalizing symptoms (Evans et al., 2021; Southam-Gerow, 2013). Yet, our study points to the importance of routinely including assessment and psychoeducation around sleep in intervention and prevention programs, particularly for youth with externalizing problems. Externalizing symptoms may exacerbate the affective state and regulatory abilities of youth with these problems, and likely contribute to worse outcomes in the short- and long-term. Further, sleep problems are also common among youth with externalizing problems (Chervin et al., 2003; Gruber et al., 2012; Rubens et al., 2017). Thus, it is possible that addressing and improving sleep among youth with externalizing problems may be a less stigmatized approach to providing youth mental health services for some families at a broader scale, with potential upstream effects on improving the range of their emotional experience.

Given that low PA predicts poor sleep, it also may be clinically beneficial to promote PA, which can be achieved through positive, parent-child "one on one" activities, in line with behavioral parent training, or through planful positive social and physical activities, in line with behavioral activation. It is also possible that addressing sleep preventatively during this key developmental period, when these problems may first onset or be exacerbated, may help keep these problems from emerging in the first place. For instance, CBT-I is effective treatment for insomnia (Zachariae et al., 2016) and the Transdiagnostic Intervention for Sleep and Circadian Dysfunction (TranS-C) is a modularized CBT-I approach for youth (Harvey, 2016). Integrating these approaches and targeting sleep in family-based or school-based prevention programs when youth show early signs of externalizing symptoms may be particularly beneficial. However, research is needed to test whether integrating sleep-focused treatment for youth with externalizing problems improves affective and behavioral problems from day to day.

In sum, the present study offers new insights into the daily associations between sleep quality and affective functioning experienced by youth with externalizing symptoms. Findings suggest that–among youth with higher levels of externalizing symptoms and irrespective of familial risk for psychopathology–poorer sleep quality on a given night predicts greater variability and peaks in negative affect the following day; and lower positive affect on a given day predicts poorer sleep quality later that night. Greater NA variability and peaks may result in greater daily behavioral disturbances or problems with both potential short- and long-term consequences for youth during a critical developmental period for adjustment and emergence of mental health problems. Of note, sleep and affect are dynamic variables that likely reflect a larger system explaining their time-varying systems among individuals with and without externalizing problems. Further research is needed to better understand these systems and to fully translate and disseminate findings into more effective clinical approaches for youth and families.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s10802-023-01087-4.

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Compliance with Ethical Standards

Research Involving Human Participants and/or Animals The study was approved by the appropriate institutional and/or national research ethics committee and was performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. This study was approved by the institutional review board at the University of Pittsburgh.

Informed Consent Informed consent was obtained from the legal guardians of all minors who participated in the study, and youth assent was obtained from all participating minors.

Competing Interests The authors declare they have no potential conflicts of interest to disclose.

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