



Associations among adolescent sleep problems, emotion regulation, and affective disorders: Findings from a nationally representative sample



Cara A. Palmer^{a,*}, Benjamin Oosterhoff^b, Joanne L. Bower^a, Julie B. Kaplow^b, Candice A. Alfano^a

^a Department of Psychology, University of Houston, Houston, TX, United States

^b Department of Psychiatry and Behavioral Sciences, University of Texas, Health Science Center at Houston, Houston, TX, United States

ARTICLE INFO

Article history:

Received 10 July 2017

Received in revised form

12 September 2017

Accepted 14 September 2017

Keywords:

Adolescent

Insomnia

Mood disorders

Anxiety

Affective symptoms

Emotion regulation

ABSTRACT

Sleep problems in youth reliably forecast the development of anxiety and mood disorders, presumably due to increased emotional difficulties. However, precise emotional mechanisms have yet to be delineated. The current study investigated how sleep problems in adolescence are associated with different emotion regulation strategies, and how sleep and psychiatric risk may be indirectly associated via poor emotion regulation. This study utilized data from the National Comorbidity Survey-Adolescent Supplement, a nationally representative sample from the United States ($N = 10,148$; age range 13–18 years). A diagnostic interview determined if adolescents qualified for a mood or anxiety disorder within the past year. Participants provided reports of their sleep, emotion regulation, and current life stress. Adolescents who reported greater sleep problems were more likely to qualify for a mood or anxiety disorder and generally reported poorer emotion regulation strategy use, even when accounting for demographic characteristics and current stress. Specifically, adolescents with greater sleep problems reported less problem solving, and greater avoidance, suppression, rumination, and acceptance. Sleep problems were indirectly associated with anxiety disorders through greater suppression and rumination, and indirectly associated with mood disorders through greater rumination and lower problem solving. Although cross-sectional, this study extends current research by suggesting that certain emotion regulation strategies may be more difficult for youth struggling with sleep problems, and provides initial evidence that poor emotion regulation may be one factor contributing to sleep-based psychiatric risk. These findings can inform more efficacious intervention efforts.

© 2017 Elsevier Ltd. All rights reserved.

1. Associations among adolescent sleep problems, emotion regulation, and affective disorders: findings from a nationally representative sample

Chronic sleep loss is exceedingly pervasive among adolescents and is now considered a public health epidemic (Owens et al., 2014). Among the many harmful effects of problematic sleep patterns is heightened risk for psychiatric disorders, including anxiety and depression (Alvaro et al., 2013; Greene et al., 2015; Gregory

et al., 2005; Hatzinger et al., 2014; Ivanenko et al., 2004; Kelly and El-Sheikh, 2014; Ohayon and Roth, 2003; Ong et al., 2006). A mounting body of research proposes that deleterious relations between sleep and psychiatric risk may be rooted in disrupted emotional processes, such as emotion regulation (i.e., the ability to control or modulate one's emotions; Harvey et al., 2011; Palmer and Alfano, 2017). Nonetheless, the precise emotional mechanisms that may be disrupted by poor sleep are largely unknown, particularly during adolescence when sleep and psychiatric problems dramatically increase (Kessler et al., 2001; Owens et al., 2014). The literature on sleep and emotion regulation is currently limited by the use of broad, non-specific indicators of emotional processes and the reliance on healthy adult samples. This study fills a critical gap in the literature by examining how sleep problems are related to distinct emotion regulation strategies in youth with psychiatric

* Corresponding author. Health and Biomedical Sciences Building, #373, University of Houston, Houston, TX 77204, United States.

E-mail addresses: cara.palmer@times.uh.edu, capalme3@central.uh.edu (C.A. Palmer).

disorders, and how sleep problems and psychiatric risk may be indirectly associated via specific emotional processes.

1.1. Adolescent sleep and risk for psychopathology

Early sleep problems have been shown to predict the onset of anxiety and depressive disorders even decades later (Greene et al., 2015; Gregory et al., 2005). Although relations between problems sleep and psychiatric disorders are bidirectional (e.g., Johnson et al., 2006), the strongest pathways are routinely shown to extend from early sleep in youth to later affective problems (Alvaro et al., 2013; Gregory and Sadeh, 2016; Kelly and El-Sheikh, 2014; McMakin and Alfano, 2015), highlighting a potential developmental window for intervention. Insomnia-like symptoms in youth in particular are associated with the development of later depression and anxiety (Baglioni et al., 2010; Gregory and O'Connor, 2002; Gregory et al., 2005, 2009; Roberts et al., 2002). For example, bedtime problems (e.g., difficulty initiating sleep) in childhood predict internalizing problems in adolescence (Reynolds and Alfano, 2016), and youth who experience increased sleep onset latency are at increased risk for later depression (Silk et al., 2007) and depression relapse (Emslie et al., 1994). Nonetheless, while the relation between sleep problems and affective symptoms is well-established, more research is needed to investigate the specific processes and mechanisms by which sleep problems may increase psychiatric risk.

Researchers have suggested that disrupted sleep increases vulnerability for anxiety and depression via emotional processes (Harvey et al., 2011; Gregory and Sadeh, 2016). This is supported by research from correlational and experimental studies in healthy adults suggesting that a loss of sleep results in poorer emotional responses, such as heightened reactivity to negative emotional experiences (Kahn et al., 2013; Palmer and Alfano, 2017). Although research in youth samples is more limited, findings are consistent with the adult literature, suggesting that youth experience greater reactivity to negative emotional stimuli and report increased negative mood after their sleep is restricted (McMakin et al., 2016; Motomura et al., 2013; Talbot et al., 2010). Preliminary evidence also suggests that adolescents may be more susceptible to the emotional effects of sleep disruption than adults (McGlinchey et al., 2011; Talbot et al., 2010), highlighting the importance of understanding emotional functioning as a mechanism underpinning relations between sleep and mental health during this key developmental period.

1.2. Emotion regulation

Presumably, sleep-based changes in emotional reactivity are rooted in disrupted emotion regulation, which is an intrinsic part of emotional responding and encompasses attempts to influence the nature, magnitude, and duration of emotions (Gross, 1998). There are numerous ways individuals can regulate their emotions, including volitional attempts to manage stressors (i.e., analogous to coping), as well as automatic processes that may alter emotional responses (Compas et al., 2014). Research on emotion regulation suggests that the inability to down-regulate (i.e., reduce) negative emotions is a transdiagnostic feature of many disorders (Gross and Jazaieri, 2014), and several specific emotion regulation strategies have been commonly studied with regard to mood and anxiety symptoms in both adults and adolescents (for meta-analyses, see: Aldao et al., 2010; Schäfer et al., 2017).

Several emotion regulation strategies have been found to successfully reduce negative emotional experiences. *Cognitive reappraisal* (e.g., generating thoughts related to a negative event that are more benign) is effective for reducing negative emotions related to

a stressful event (Gross, 1998). Another strategy for managing stressors is *problem solving*, which refers to actions directed at changing a situation that is causing negative emotions (Frye and Goodman, 2000). *Acceptance* refers to the non-judgmental awareness of emotional experience, and can also result in lower levels of distress (Campbell-Sills et al., 2006).

In contrast, other strategies employed in response to stressors are less adaptive and tend to result in increased or prolonged negative emotions. *Suppression* commonly refers to attempts to minimize visible signs of an emotion (e.g., facial expressions); however, suppressing negative emotions often results in increased activation in emotion-generative brain regions (Goldin et al., 2008) and increased physiological responses (Gross, 1998). *Rumination*, or repetitively and passively thinking about negative emotional experiences, results in a fixation on emotions without concurrent action to problem solve, thereby maintaining negative feelings (Nolen-Hoeksema et al., 2014). *Avoidance* includes maladaptive attempts to circumvent or disengage from aversive situations or experiences (Servatius, 2016). A large body of research links habitual use of these particular strategies (i.e., suppression, rumination, and avoidance) with increased rates of depression and anxiety (Aldao et al., 2010; Schäfer et al., 2017) as well as increased risk for suicide (Kaplow et al., 2014).

1.3. Sleep and emotion regulation

Shared neurobiological processes that govern both emotion and sleep result in intimate connections between these domains. Accordingly, sleep deprivation results in altered neurological functioning in response to negative stimuli, including decreased connectivity between the medial prefrontal cortex and the ventral anterior cingulate cortex, which can weaken emotional control (Yoo et al., 2007). Studies using samples of children, adolescents, and young adults all suggest that disrupted sleep results in greater dysregulated emotion (Baum et al., 2014; Tavernier and Willoughby, 2015; Vriend et al., 2013), and research on adults with insomnia suggest greater negative mood compared to controls (Buysse et al., 2007; Smith et al., 2015). However, research investigating how sleep may be differentially associated with specific types of emotion regulation strategies is limited. Preliminary research in adults suggests that insomnia patients experience more rumination (Gruber et al., 2008). Poor sleep quality in adults also relates to increased tendencies to engage in rumination (Carney et al., 2006; Thomsen et al., 2003) and reduced ability to use cognitive reappraisal (Mauss et al., 2013). Conversely, one study in adolescents found that the ability to use cognitive reappraisal to down-regulate negative emotion was unaffected by one night of sleep restriction (Reddy et al., 2017). However, Reddy and colleagues provided participants with detailed instructions to cognitively reappraise, which may have attenuated any sleep-based emotional disruptions and may not accurately represent tendencies to regulate in real-world settings. Little is known about how sleep relates to other emotion regulation strategies commonly associated with psychopathology (e.g., suppression, avoidance, problem solving, acceptance).

1.4. The current study

In sum, despite robust links between sleep problems in youth and psychiatric risk, a notable lack of research has examined these relations in the context of emotion regulation. Research investigating the specific emotion regulation strategies that might be especially vulnerable to disrupted sleep is lacking. While preliminary evidence suggests sleep-emotion regulation relations exist, identifying the precise emotion regulation strategies that are

associated with sleep difficulties would aid in the development of more targeted interventions for youth experiencing sleep problems.

Using a large, nationally representative sample of adolescents from the United States, this study sought to advance research on sleep problems and psychiatric risk by examining links between sleep difficulties, specific emotion regulation strategies, and mood and anxiety disorders. Our first aim was to replicate prior findings linking sleep problems to affective disorders in youth (Gregory and Sadeh, 2016). We expected that youth endorsing more sleep problems would be more likely to meet criteria for an anxiety or mood disorder. Our second aim was to examine relations between sleep and discrete emotion regulation strategies thought to be linked with mood and anxiety disorders in adolescents (i.e., suppression, rumination, avoidance, cognitive reappraisal, problem-solving, and acceptance; Schäfer et al., 2017). We hypothesized that sleep problems would be positively related to emotion regulation strategies generally considered maladaptive (i.e., rumination, suppression, and avoidance) and negatively related to strategies considered to be adaptive (i.e., cognitive reappraisal, problem-solving, acceptance). Finally, we sought to examine whether sleep problems and affective disorders were indirectly associated via emotion regulation strategies. We hypothesized that sleep problems would be indirectly associated with mood and anxiety disorders through greater use of maladaptive emotion regulation strategies, and less frequent use of adaptive strategies.

2. Method

2.1. Participants

Data were drawn from the National Comorbidity Survey-Adolescent Supplement (NCS-A; Kessler et al., 2009), which is a nationally representative epidemiological survey conducted in the United States (Merikangas et al., 2009). This study utilized the total sample of youth included in the NCS-A ($N = 10,148$). Adolescents ($M_{age} = 15.18$, $SD_{age} = 1.51$, range = 13–18 years) were 51.1% female and primarily identified as White (55.7%), followed by Black (19.3%), Hispanic (18.9%), and other (6.1%). Parents of adolescents varied in their highest achieved education level: 33.1% had at least one parent earning a college degree, 19.7% had at least one parent complete some college, 30.5% had at least one parent complete high school, and 16.7% had neither parent complete high school. The median household income was \$75,500.

2.2. Measures

2.2.1. Demographics

Adolescents reported on their age, gender, and race/ethnicity. Parents reported on their household income and education level (i.e., number of school years completed). Family income was recorded as the ratio of income to the federal poverty line.

2.2.2. Mood and anxiety disorders

Mood and anxiety disorders were assessed with a modified version of the World Health Organization Composite International Diagnostic Interview using DSM-IV criterion. Our analyses focused on mood and anxiety disorders that were present within the past 12 months (Kessler et al., 2009; Merikangas et al., 2009). Mood disorders included major depression, dysthymia, bipolar I and II, mania, and/or hypomania, and anxiety disorders included social phobia, separation anxiety, panic disorders, specific phobias, generalized anxiety, or posttraumatic stress disorder. The presence/

absence of each disorder was coded and used to create two indices representing the presence of a mood disorder (coded as 1) versus no mood disorder (coded as 0) and the presence of an anxiety disorder (coded as 1) versus no anxiety disorder (coded as 0).

2.2.3. Sleep problems

Sleep problems were assessed with 3 items ($\alpha = 0.67$) taken from the sleep module of the NCS-A. Participants provided separate yes/no ratings on whether they had a period lasting 2 weeks or longer in the past 12 months in which they had experienced: (1) difficulty initiating sleep (“... problems getting to sleep, when nearly every night it took you a long time to fall asleep?”), (2) difficulty maintaining sleep (“... problems staying asleep, when you woke up nearly every night and took a long time to get back to sleep?”), or (3) early morning awakenings (“... problems waking too early, when you woke up nearly every morning much earlier than you wanted to?”). Summed scores were calculated with higher values indicating greater overall sleep problems.

2.2.4. Emotion regulation

Emotion regulation was assessed using items that represented distinct forms of emotion regulation commonly linked to mood and anxiety symptoms (Aldao et al., 2010; Schäfer et al., 2017). These items were a part of a larger battery included in the NCS-A to assess emotion regulation/coping. Participants were asked to imagine that they have experienced a social stressor (e.g., a breakup, fighting with a friend) and rate the frequency at which they would engage in each of the following behaviors: *suppression* (i.e., “keep your feelings to yourself to avoid embarrassment”), *rumination* (i.e., “go over the situation again and again in your mind?”), *avoidance* (i.e., “try not to think about it at all”), *reappraisal* (i.e., “look at the situation in a different way so it doesn't seem so bad?”), *problem solving* (i.e., “make a plan of action and follow it”), and *acceptance* (i.e., “accept that nothing can be done and try to move on”). Responses were given on a 4-point scale from 1 (not at all) to 4 (a lot).

2.2.5. Current life stress

Current life stress was measured using a 16-item checklist which dichotomously (yes = 1, and no = 0) assessed whether adolescents experienced specific negative events in the past year (e.g., parental divorce, experiencing the death of a loved one). A summed score was calculated so that higher values indicated greater life stress.

2.3. Analytic technique

All analyses were performed in Mplus version 6.0. Two logistic regressions tested whether sleep problems were associated with an increased likelihood of qualifying for a psychiatric disorder. To test whether sleep problems were associated with emotion regulation strategies, a structural model was estimated with observed scores for sleep problems specified as an exogenous variable and observed scores for each emotion regulation strategy specified as separate endogenous variables. An additional structural model was used to test whether sleep problems were indirectly associated with anxiety or mood disorders through emotion regulation. Sleep problems was specified as an observed exogenous variable, presence/absence of mood and anxiety disorders were specified as separate endogenous variables, and the emotion regulation strategies were specified as separate mediators. All analyses accounted for the complex survey design by incorporating sampling weights, clustering, and stratification. All analyses also included demographic characteristics (adolescent age, gender, race/ethnicity, parent education, and

household income) and current life stress as covariates. Some participants were missing data on current life stress (<1%) or emotion regulation (<1%). Thus, full-information maximum likelihood (FIML) estimation was used. The pattern of findings did not change with and without estimates calculated based on FIML.

3. Results

3.1. Preliminary descriptive and bivariate statistics

A total of 1204 (11.9%) youth met criteria for a mood disorder and 2688 (26.5%) met criteria for an anxiety disorder. Classification for specific diagnoses were as follows: major depression ($n = 772$; 7.6%), dysthymia ($n = 240$; 2.4%), bipolar I ($n = 114$; 1.1%), bipolar II ($n = 87$; 0.9%), hypomania ($n = 294$; 2.9%), mania ($n = 109$; 1.1%), specific phobia ($n = 1634$; 16.1%), social phobia ($n = 1285$; 12.7%), posttraumatic stress ($n = 293$; 2.9%), panic ($n = 194$; 1.9%), generalized anxiety ($n = 177$; 1.7%), and separation anxiety ($n = 163$; 1.6%). Some participants met criteria for multiple mood disorders ($n = 395$; 3.9%), multiple anxiety disorders ($n = 820$; 8.1%), or comorbid mood and anxiety disorders ($n = 722$; 7.1%). The most commonly endorsed sleep problem was difficulty initiating sleep ($n = 2317$; 22.8%), followed by waking up too early ($n = 1760$; 17.3%), and difficulty maintaining sleep ($n = 1407$; 13.9%). Descriptive statistics for all variables of interest are presented in Table 1. Table 2 displays bivariate correlations among all study variables.

3.2. Sleep problems and mood and anxiety disorders

As hypothesized, logistic regressions indicated that sleep problems were associated with an increased likelihood of qualifying for a disorder, even after accounting for demographic characteristics and current life stress (see Table 3). Each additional sleep problem endorsed resulted in a 77% greater likelihood of qualifying for a mood disorder and an 82% greater likelihood of qualifying for an anxiety disorder.

3.3. Sleep problems and emotion regulation

A structural model was estimated to test whether greater sleep problems were associated with emotion regulation strategies accounting for demographic characteristics and current life stress (see Table 4). The model provided an excellent fit to the data, $\chi^2(20) = 149.42$, CFI = 0.930, RMSEA = 0.025 [90% CI: 0.022, 0.029]. Consistent with hypotheses, sleep problems were related to greater suppression, rumination, and avoidance, and lower problem solving. Contrary to hypotheses, sleep problems were also related to greater acceptance. Sleep problems were not significantly related to reappraisal.

Table 1
Descriptive statistics for key study variables.

	Range	M	SD
Parents' Education	0–20	13.81	2.89
Household Income ^a	0–142	6.00	7.60
Current Life Stress	0–12	1.44	1.44
Sleep Problems	0–3	0.54	0.89
Avoidance	1–4	2.58	0.91
Suppression	1–4	2.62	1.01
Rumination	1–4	2.57	1.01
Reappraisal	1–4	3.11	0.82
Problem Solving	1–4	2.94	0.81
Acceptance	1–4	2.56	0.96

^a Ratio of income to poverty line used.

3.4. Indirect associations between sleep, emotion regulation, and psychopathology

A model with multiple indirect pathways was estimated to test whether greater sleep problems were associated with mood or anxiety disorders through specific emotion regulation strategies (see Table 5). The model provided an excellent fit to the data, $\chi^2(23) = 95.42$, CFI = 0.958, RMSEA = 0.019 [90% CI: 0.014, 0.021]. Fig. 1 displays the significant indirect effects. As hypothesized, the relation between sleep problems and psychopathology was partially mediated by emotion regulation. Specifically, greater sleep problems were indirectly associated with a greater likelihood of qualifying for an anxiety disorder through greater suppression and rumination. Greater sleep problems were also indirectly associated with a greater likelihood of qualifying for a mood disorder through greater rumination and lower problem solving.¹

4. Discussion

Using a large, nationally representative sample of adolescents from the United States, this study sought to better elucidate the precise emotion regulation strategies associated with sleep problems and psychiatric disorders in adolescents. As hypothesized and aligning with prior work (Gregory and Sadeh, 2016), adolescents reporting greater sleep problems were significantly more likely to be diagnosed with a psychiatric disorder, independent of reported life stress or other demographic risk factors. Additionally, our findings suggested that sleep problems and affective disorders were indirectly associated through emotion regulation strategy use. Building on research suggesting that poor sleep results in disrupted regulatory ability more broadly (Yoo et al., 2007; Vriend et al., 2013), this is one of the first studies to investigate the specific emotion regulation strategies that are associated with sleep problems. Adolescents experiencing greater sleep difficulties generally reported poorer emotion regulation. Importantly, however, these findings suggest that sleep is differentially related to specific emotion regulation strategies. These relations may be particularly important during adolescence when insufficient sleep is common and emotion regulation skills are still developing (Owens et al., 2014; Steinberg, 2005).

As expected, sleep problems were associated with greater use of problematic emotion regulation strategies. The association between rumination and sleep problems is in line with previous research in adults (Carney et al., 2006; Thomsen et al., 2003) and replicates this link in an adolescent population. To our knowledge however, our study is the first to examine relations between sleep and suppression or avoidance strategies, regardless of age. The current findings suggest that sleep was related to greater avoidance, in line with research suggesting that insomnia patients are more likely to engage in safety behaviors (e.g., avoiding an uncomfortable situation that might produce anxiety; Harvey, 2002a, 2002b; Hood et al., 2011). The higher rates of suppression among poorer sleepers in the current study may be due in part to altered social communication more broadly (Palmer and Alfano, 2017). Sleep loss results in a diminished willingness to alleviate conflict

¹ Based on research suggesting differing neural activity during emotion regulation in bipolar and unipolar mood disorders (e.g., Rive et al., 2015), we also ran sensitivity analyses examining a model including only participants diagnosed with major depressive disorder and a model only including participants diagnosed with bipolar disorder. Results indicated that the model predicting major depressive disorder was consistent with our overall model that included all mood disorders. The model predicting only bipolar disorder was also largely consistent with the overall model, with the exception of the indirect effect of problem solving, which was no longer significant ($p = 0.78$).

Table 2
Bivariate correlations for all study variables.

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1.Age	0.00	-0.06**	0.00	-0.01	0.00	0.05**	0.00	0.03**	-0.03*	-0.04**	0.09**	0.00	0.02	-0.02	0.09**	0.03*
2.Gender		0.01	-0.02	0.01	0.00	0.02	-0.02	0.08**	-0.02	-0.10**	0.09**	0.00	0.03*	-0.06**	0.11**	0.13**
3.Race Black			-0.24**	-0.13**	-0.10**	-0.12**	0.00	0.08**	0.10**	0.07**	-0.01	0.04**	0.03*	0.11**	0.00	0.05**
4.Race Hispanic				-0.12**	-0.27**	-0.07**	-0.01	0.03**	0.05**	0.04**	-0.01	0.00	-0.02	0.07**	0.04*	0.03*
5.Race Other					0.01	0.00	0.02	0.01	-0.01	0.01	0.01	-0.02	-0.02	-0.01	0.02	0.01
6.Parents' Education						0.22**	0.00	-0.07**	-0.12**	-0.08**	0.02*	-0.01	0.02	-0.12**	-0.02	-0.07**
7.Income							0.02	-0.05**	-0.07**	-0.05**	0.00	-0.02	0.01	-0.06**	-0.02	-0.03*
8.Current Life Stress								0.23**	0.03**	0.06**	0.19**	0.02	0.00	0.03*	0.23**	0.19**
9.Sleep Problems									0.05**	0.09**	0.14**	0.00	-0.01	0.03*	0.28**	0.28**
10.Avoidance										-0.25**	-0.01	-0.13**	0.00	-0.26**	0.03*	0.05**
11.Suppression											-0.11**	-0.10**	0.01	-0.18**	0.05**	0.10**
12.Rumination												-0.07**	-0.11**	0.05**	0.16**	0.15**
13.Reappraisal													-0.20**	-0.21**	0.01	-0.02
14.Problem Solving														-0.02*	-0.03**	-0.02*
15.Acceptance															0.03*	0.01
16.Mood Disorder																0.28**
17.Anxiety Disorder																

Notes: ** $p < 0.01$, * $p < 0.05$. Gender is coded as 1 = Male and 2 = Female. Race/ethnicity is coded as 1 = Black/Hispanic/Other and 0 = Not Black/Hispanic/Other.

Table 3
Logistic regressions predicting mood and anxiety disorders.

	Mood disorders				Anxiety disorders			
	b	SE	OR	95% CI	b	SE	OR	95% CI
Age	0.13**	0.04	1.14	1.05, 1.23	-0.02	0.02	0.98	0.94, 1.02
Gender	0.77**	0.13	2.16	1.68, 2.78	0.45**	0.08	1.57	1.34, 1.84
Race Black	0.00	0.09	1.00	0.83, 1.20	0.08	0.11	1.08	0.87, 1.34
Race Hispanic	0.32	0.17	1.38	0.98, 1.22	-0.03	0.16	0.97	0.71, 1.32
Race Other	0.37	0.20	1.44	0.97, 2.14	0.09	0.13	1.09	0.85, 1.40
Parents' Education	0.03	0.03	1.03	0.98, 1.08	-0.04*	0.01	0.96	0.94, 0.99
Income	0.00	0.01	1.00	0.99, 1.01	0.00	0.01	1.00	0.99, 1.01
Current Life Stress	0.27**	0.03	1.30	1.22, 1.39	0.20**	0.02	1.22	1.17, 1.28
Sleep Problems	0.57**	0.04	1.77	1.63, 1.91	0.60**	0.03	1.82	1.70, 1.94
R ²	0.19				0.14			

Notes: ** $p < 0.01$, * $p < 0.05$. Unstandardized estimates are displayed. OR = Odds Ratio. 95% CI = 95% confidence interval for the odds ratio. Gender is coded as 1 = Male and 2 = Female. Race/ethnicity is coded as 1 = Black/Hispanic/Other and 0 = Not Black/Hispanic/Other.

Table 4
Unstandardized estimates and standard errors for associations among sleep problems and emotion regulation strategies.

	Avoidance		Suppression		Rumination		Reappraisal		Problem solve		Acceptance	
	b	SE	b	SE	b	SE	b	SE	b	SE	b	SE
Age	-0.03**	0.01	-0.04**	0.01	0.04**	0.01	0.00	0.01	0.01	0.01	-0.01	0.01
Gender	-0.03	0.03	-0.23***	0.03	0.16***	0.03	-0.03	0.02	0.01	0.03	-0.14***	0.02
Race Black	0.15***	0.03	0.15***	0.04	-0.06	0.05	0.06*	0.03	0.06*	0.03	0.23***	0.04
Race Hispanic	0.04	0.04	0.12***	0.03	-0.03	0.04	-0.02	0.03	-0.01	0.04	0.16***	0.03
Race Other	0.00	0.06	0.13**	0.05	0.00	0.06	-0.09	0.07	-0.07	0.04	0.03	0.07
Parents' Education	-0.04***	0.00	-0.02	0.01	0.01*	0.01	-0.01	0.00	0.00	0.01	-0.02***	0.01
Income	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Current Life Stress	0.01	0.01	0.03**	0.01	0.11***	0.01	0.02*	0.01	0.00	0.01	0.02	0.01
Sleep Problems	0.03*	0.02	0.09***	0.02	0.13***	0.02	0.00	0.01	-0.02*	0.01	0.02*	0.01
R ²	0.02		0.03		0.06		0.01		0.01		0.02	

Notes: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$. Gender is coded as 1 = Male and 2 = Female. Race/ethnicity is coded as 1 = Black/Hispanic/Other and 0 = Not Black/Hispanic/Other.

(Kahn-Greene et al., 2006), and poorer ability to appropriately interact with others (Christian and Ellis, 2011) and pick-up on others' nonverbal cues (Cote et al., 2014). Thus, suppressing negative emotional expressions may be implemented more often to avoid social confrontation in light of these sleep-based impairments. Overall, these findings are in line with preliminary findings in adults suggesting that insomnia symptoms are associated with greater dysregulation of emotion (Cerolini et al., 2015).

Relations between sleep problems and emotion regulation strategies that are generally considered adaptive were less clear cut. As expected, greater sleep problems were associated with less

problem solving in response to a stressful situation. These findings are not surprising considering a large body of research showing sleep loss to impair problem solving more broadly (Harrison and Horne, 2000; Killgore et al., 2006) and extend this research to suggest a similar relation between sleep and problem solving in emotionally-laden situations specifically. Contrary to predictions, sleep was related to greater acceptance in the current study. However, acceptance was also positively related to experiencing a mood disorder, whereas a recent meta-analysis suggests that acceptance is generally negatively related to psychiatric risk in adolescents (Schäfer et al., 2017). These inconsistent findings are

Table 5
Unstandardized estimates and standard errors for associations among sleep problems and emotion regulation strategies through emotion regulation.

	Avoidance		Suppression		Rumination		Reappraisal		Problem solving		Acceptance		Mood		Anxiety	
	b	SE	b	SE	b	SE	b	SE	b	SE	b	SE	b	SE	b	SE
Age	-0.03*	0.01	-0.04*	0.01	0.04*	0.01	0.00	0.01	0.01	0.01	-0.01	0.01	0.06*	0.02	-0.01	0.01
Gender	-0.03	0.03	-0.23*	0.03	0.16*	0.03	-0.03	0.02	0.01	0.03	-0.14*	0.03	0.37*	0.06	0.26*	0.05
Black	0.18*	0.03	0.15*	0.03	-0.06	0.04	0.07*	0.03	0.07*	0.03	0.22*	0.04	-0.05	0.05	0.06	0.06
Hispanic	0.04	0.04	0.13*	0.03	-0.03	0.04	-0.02	0.03	-0.01	0.04	0.16*	0.04	0.15	0.09	-0.04	0.09
Other	-0.01	0.06	0.11*	0.05	0.01	0.06	-0.09	0.06	-0.06	0.05	0.00	0.07	0.14	0.09	0.04	0.07
Parents' Education	-0.04*	0.01	-0.02	0.01	0.01*	0.01	-0.01	0.00	0.00	0.01	-0.02*	0.01	0.02	0.01	-0.02*	0.01
Household Income	-0.01*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Current Life Stress	0.01	0.01	0.03*	0.01	0.11*	0.01	0.02*	0.01	0.00	0.01	0.02	0.01	0.13*	0.02	0.10*	0.01
Sleep Problems	0.04*	0.02	0.10*	0.01	0.13*	0.02	0.00	0.01	-0.02*	0.01	0.03*	0.02	0.28*	0.03	0.33*	0.02
Avoidance	–	–	–	–	–	–	–	–	–	–	–	–	-0.03	0.03	0.06*	0.03
Suppression	–	–	–	–	–	–	–	–	–	–	–	–	0.05	0.03	0.12*	0.02
Rumination	–	–	–	–	–	–	–	–	–	–	–	–	0.14*	0.03	0.13*	0.02
Reappraise	–	–	–	–	–	–	–	–	–	–	–	–	-0.01	0.04	-0.05	0.03
Problem Solving	–	–	–	–	–	–	–	–	–	–	–	–	-0.16*	0.03	-0.07*	0.03
Acceptance	–	–	–	–	–	–	–	–	–	–	–	–	0.06	0.04	-0.02	0.02
R ²	0.02		0.03		0.06		0.01		0.01		0.02		0.20		0.19	

Notes: * $p < 0.05$. Unstandardized estimates are displayed. Gender is coded as 1 = Male and 2 = Female. Race/ethnicity is coded as 1 = Black/Hispanic/Other and 0 = Not Black/Hispanic/Other.

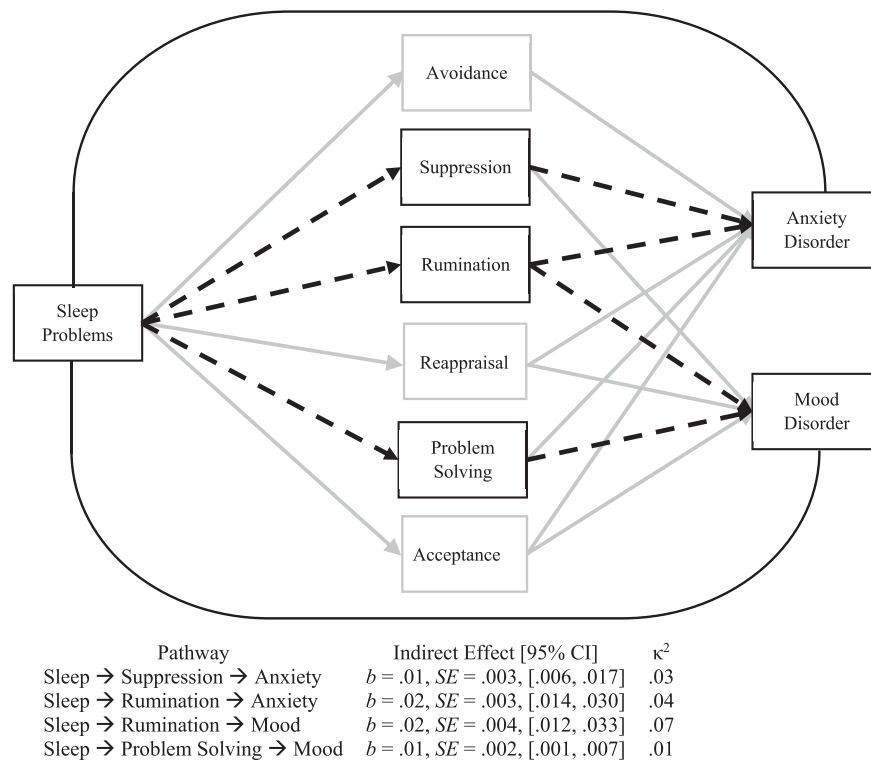


Fig. 1. Significant indirect effects of sleep problems on mood and anxiety disorders through emotion regulation.

Notes: Solid lines indicated tested but non-significant indirect effects. Dashed lines indicate significant indirect effects. Model controlled for demographic characteristics and life stress. Unstandardized estimates and Kappa-squared statistics are displayed for indirect effects.

possibly due to the wording of our acceptance measure (i.e., “accept that nothing can be done and try to move on”), which may have inadvertently captured other facets of emotional responding (i.e., hopelessness) that could increase risk for depression (Hankin et al., 2001).

Sleep problems were unrelated to cognitive reappraisal in the current study. The only other study to our knowledge investigating sleep and cognitive reappraisal in adolescents also found that partial sleep restriction did not affect cognitive reappraisal ability (Reddy et al., 2017). One study with adults also found that

individuals with higher trait cognitive reappraisal are less susceptible to the negative emotional effects of sleep deprivation, suggesting that this regulatory ability may be at least somewhat resistant to the negative effects of sleep loss (Cote et al., 2015). Conversely, these findings are in direct contrast to correlational work with adults suggesting poorer sleep quality is related to a reduced ability to cognitively reappraise negative information (Mauss et al., 2013). It is possible that the inconsistency in these findings are a function of age, as adolescents use cognitive reappraisal less frequently when compared to adults (Garnefski and

Kraaij, 2002), and recruit different neural regions when engaging in this strategy (McRae et al., 2012).

Finally, these findings suggest that sleep problems are indirectly associated with heightened risk for affectively-based psychiatric disorders in adolescents via a tendency to respond to negative emotions in maladaptive ways. Adverse changes in emotion regulation may be one pathway by which sleep loss increases the negative emotional experiences commonly present in mood and anxiety disorders (Pilcher and Huffcutt, 1996). Specific findings suggested that sleep problems were indirectly related to a greater likelihood of qualifying for a mood disorder through decreased problem solving. Rumination also mediated the relation between sleep problems and both anxiety and mood disorders. These findings are not surprising, as a recent meta-analysis suggests that poorer problem solving may be particularly deleterious for depressive symptoms in adolescence, and that rumination is linked to both anxiety and depressive symptoms (Schäfer et al., 2017). Suppression also mediated the sleep-anxiety link. Suppression is generally related to anxious psychopathology in adolescents (Schäfer et al., 2017), likely due to increasing sympathetic activity and neural activation in emotion generative brain regions (Goldin et al., 2008; Gross, 1998). Although cross-sectional, these findings provide initial empirical support for hypotheses in the literature suggesting that disrupted sleep increases vulnerability for psychiatric disorders due to disrupted emotional processes (Gregory and Sadeh, 2016; Harvey et al., 2011).

4.1. Limitations and future directions

Although these findings address an important gap in the literature on sleep, emotion, and adolescent psychiatric risk using a large, representative sample, these findings should nonetheless be interpreted in light of several limitations. Although our hypothesized relationships were based on prior research and theory, the results from the current study are cross-sectional, and thus conclusions regarding the temporal relations between these variables are tentative. While existing developmental research suggests that sleep problems often precede the onset of psychopathology, more longitudinal research is needed to disentangle trajectories of sleep-emotion interactions. Another limitation is that the assessment of some anxiety and mood disorders included questions about sleep difficulties, which may have resulted in inflated associations. However, this overlap only occurred in some of the disorders assessed (i.e., major depression, posttraumatic stress, generalized anxiety, and separation anxiety) and only consisted of one or two questions for each disorder throughout the entire diagnostic interview. We also relied on self-reports of sleep problems (i.e., difficulty initiating or maintaining sleep, and early morning awakenings) and emotion regulation strategies, which may have been prone to recall biases. Further, research should be conducted to explain why emotion regulation strategies are differentially impacted by sleep (e.g., diverse neurobiological correlates, impact on motivational or emotional goals).

5. Conclusions

Insufficient sleep is one of the most common yet modifiable public health problems facing youth, with chronic sleep difficulties affecting the majority of middle and high schoolers (Owens et al., 2014). Thus, identifying the precise emotional effects of poor sleep is critical, especially given increased rates of psychiatric risk in adolescence (Kessler et al., 2001; Spear, 2013). Taken together, these findings suggest that one way disrupted sleep might increase risk in adolescence might be through poorer emotion regulation. Further, these findings suggest differential relations between sleep

problems and certain regulation strategies. Interventions for affective disorders can selectively target sleep problems, which can help improve emotion regulation strategies and reduce overall psychiatric risk. Alternatively, selectively targeting particular emotion regulation strategies most at risk for youth experiencing sleep problems (e.g., rumination), or promoting strategies that are not affected by sleep difficulties (e.g., cognitive reappraisal) can result in more efficacious intervention efforts. Although future longitudinal studies are needed to build on these initial cross-sectional findings, the current study highlights the importance of investigating sleep-emotion regulation links and may aid prevention and intervention efforts for adolescents experiencing sleep problems.

Conflicts of interest

None.

Funding Source

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Acknowledgements

The National Comorbidity Survey-Adolescent Supplement (NCSA) and the larger program of related National Comorbidity Survey projects are supported by the National Institute of Mental Health (U01-MH60220) and the National Institute of Drug Abuse (R01 DA016558) with supplemental support from Substance Abuse and Mental Health Services Administration (SAMHSA), the Robert Wood Johnson Foundation (Grant 044708), and the John W. Alden Trust. The NCS-A was carried out in conjunction with the World Health Organization World Mental Health Survey Initiative.

References

- Aldao, A., Nolen-Hoeksema, S., Schweizer, S., 2010. Emotion-regulation strategies across psychopathology: a meta-analytic review. *Clin. Psychol. Rev.* 30, 217–237.
- Alvaro, P.K., Roberts, R.M., Harris, J.K., 2013. A systematic review assessing bidirectionality between sleep disturbances, anxiety, and depression. *Sleep* 36, 1059–1068.
- Baglioni, C., Spiegelhalder, K., Lombardo, C., Riemann, D., 2010. Sleep and emotions: a focus on insomnia. *Sleep. Med. Rev.* 14, 227–238.
- 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. *J. Child. Psychol. Psychiatry* 55, 180–190.
- Buyssse, D.J., Thompson, W., Scott, J., Franzen, P.L., Germain, A., et al., 2007. Daytime symptoms in primary insomnia: a prospective analysis using ecological momentary assessment. *Sleep. Med.* 8, 198–208.
- Campbell-Sills, L., Barlow, D.H., Brown, T.A., Hofmann, S.G., 2006. Effects of suppression and acceptance on emotional responses of individuals with anxiety and mood disorders. *Behav. Res. Ther.* 44, 1251–1263.
- Carney, C.E., Edinger, J.D., Meyer, B., Lindman, L., Istre, T., 2006. Symptom-focused rumination and sleep disturbance. *Behav. Sleep. Med.* 4, 228–241.
- Cerolini, S., Balleis, A., Lombardo, C., 2015. Insomnia and emotion regulation: recent findings for treatment. *J. Sleep. Dis. Manage* 1, 1–5.
- Christian, M.S., Ellis, A.P.J., 2011. Examining the effects of sleep deprivation on workplace deviance: a self-regulatory approach. *Acad. Manag. J.* 54, 913–934.
- Compas, B.E., Jaser, S.E., Dunbar, J.P., Watson, K.H., Bettis, A.H., Gruhn, M.A., Williams, E.K., 2014. Coping and emotion regulation from childhood to early adulthood: points of convergence and divergence. *Aust. J. Psychol.* 66, 71–81.
- Cote, K.A., Jancsar, C., Hunt, B., 2015. Event-related neural response to emotional picture stimuli following sleep deprivation. *Psychol. Neurosci.* 8, 102–113.
- Cote, K.A., Mondloch, C.J., Sergeeva, V., Taylor, M., Semplonius, T., 2014. Impact of total sleep deprivation on behavioural neural processing of emotionally expressive faces. *Exp. Brain Res.* 232, 1429–1442.
- Emslie, G.J., Rush, A.J., Weinberg, W.A., Rintelmann, J.W., Roffwarg, H.P., 1994. Sleep EEG features of adolescents with major depression. *Biol. Psychiatry* 36, 573–581.
- Frye, A.A., Goodman, S.H., 2000. Which social problem-solving components buffer depression in adolescent girls? *Cogn. Ther. Res.* 24, 637–650.

- Garnefski, N., Kraaij, V., 2002. Relationships between cognitive emotion regulation strategies and depressive symptoms: a comparative study of five specific samples. *Pers. Individ. Dif.* 40, 1659–1669.
- Goldin, P.R., McRae, K., Ramel, W., Gross, J.J., 2008. The neural bases of emotion regulation: reappraisal and suppression of negative emotion. *Biol. Psychiatry* 63, 577–586.
- Greene, G., Gregory, A.M., Fone, D., White, J., 2015. Childhood sleeping difficulties and depression in adulthood: the 1970 British Cohort Study. *J. Sleep. Res.* 24, 19–23.
- Gregory, A.M., Sadeh, A., 2016. Annual research review: sleep problems in childhood psychiatric disorders—a review of the latest science. *J. Child. Psychol. Psychiatry* 57, 296–317.
- Gregory, A.M., Rijsdijk, F.V., Lau, J.Y.F., Dahl, R.E., Eley, T.C., 2009. The direction of longitudinal associations between sleep problems and depression symptoms: a study of twins aged 8 and 10 years. *Sleep* 32, 189–199.
- Gregory, A.M., Caspi, A., Eley, T.C., Moffitt, T.E., O'Connor, T.G., Poulton, R., 2005. Prospective longitudinal associations between persistent sleep problems in childhood and anxiety and depression disorders in adulthood. *J. Abnorm. Child. Psychol.* 33, 157–163.
- Gregory, A.M., O'Connor, T.G., 2002. Sleep problems in childhood: a longitudinal study of developmental change and association with behavioral problems. *J. Am. Acad. Child. Adolesc. Psychiatry* 41, 964–971.
- Gross, J.J., 1998. Antecedent-and response-focused emotion regulation: divergent consequences for experience, expression, and physiology. *J. Pers. Soc. Psychol.* 74, 224–237.
- Gross, J.J., Jazaieri, H., 2014. Emotion, emotion regulation, and psychopathology an affective science perspective. *Clin. Psychol. Sci.* 2, 387–401.
- Gruber, J., Eidelman, P., Harvey, A.G., 2008. Transdiagnostic emotion regulation process in bipolar disorder and insomnia. *Behav. Res. Ther.* 46, 1096–1100.
- Hankin, B.L., Abramson, L.Y., Siler, M.A., 2001. Prospective test of the hopelessness theory of depression in adolescence. *Cogn. Ther.* 25, 607–632.
- Harrison, Y., Horne, J.A., 2000. The impact of sleep deprivation on decision making: a review. *J. Exp. Psychol. Appl.* 6, 236–249.
- Harvey, A.G., 2002a. A cognitive model of insomnia. *Behav. Res. Ther.* 40, 869–893.
- Harvey, A.G., 2002b. Identifying safety behaviors in insomnia. *J. Nerv. Ment. Dis.* 190, 16–21.
- Harvey, A.G., Murray, G., Chandler, R.A., Soehner, A., 2011. Sleep disturbance as transdiagnostic: consideration of neurobiological mechanisms. *Clin. Psychol. Rev.* 31, 225–235.
- Hatzinger, M., Brand, S., Perren, S., Von Wyl, A., Stadelmann, S., von Klitzing, K., Holsboer-Trachsler, E., 2014. In pre-school children, sleep objectively assessed via actigraphy remains stable over 12 months and is related to psychological functioning, but not to cortisol secretion. *J. Psychiatr. Res.* 55, 22–28.
- Hood, H.K., Carney, C.E., Harris, A.L., 2011. Rethinking safety behaviors in insomnia: examining the perceived utility of sleep-related safety behaviors. *Behav. Ther.* 42, 644–654.
- Ivanenko, A., Barnes, M.E., Crabtree, V.M., Gozal, D., 2004. Psychiatric symptoms in children with insomnia referred to a pediatric sleep medicine center. *Sleep. Med.* 5, 253–259.
- Johnson, E.O., Roth, T., Breslau, N., 2006. The association of insomnia with anxiety disorders and depression: exploration of the direction of risk. *J. Psychiatr. Res.* 40, 700–708.
- Kahn, M., Sheppes, G., Sadeh, A., 2013. Sleep and emotions: bidirectional links and underlying mechanisms. *Int. J. Psychophysiol.* 89, 218–228.
- Kahn-Greene, E.T., Lipizzi, E.L., Conrad, A.K., Kamimori, G.H., Killgore, W.D.S., 2006. Sleep deprivation adversely affects interpersonal responses to frustration. *Pers. Individ. Dif.* 41, 1433–1443.
- Kaplow, J.B., Gipson, P., Horwitz, A., Burch, B., King, C., 2014. Emotional suppression mediates the relation between adverse life events and adolescent suicide: implications for prevention. *Prev. Sci.* 15, 177–185.
- Kelly, R.K., El-Sheikh, M., 2014. Reciprocal relations between children's sleep and their adjustment over time. *Dev. Psychol.* 50, 1137–1147.
- Kessler, R.C., Avenevoli, S., Costello, E.J., Green, J.G., Gruber, M.J., Heeringa, S., et al., 2009. Design and field procedures in the US national comorbidity survey replication adolescent supplement (NCS-A). *Int. J. Methods Psychiatr. Res.* 18, 69–83.
- Kessler, R.C., Avenevoli, S., Merikangas, K.R., 2001. Mood disorders in children and adolescents: an epidemiologic perspective. *Biol. Psychiatry* 49, 1002–1014.
- Killgore, W.D., Blakin, T.J., Wesensten, N.J., 2006. Impaired decision making following 49 h of sleep deprivation. *J. Sleep. Res.* 15 (15), 7–13.
- Mauss, I.B., Troy, A.S., LeBourgeois, M.K., 2013. Poorer sleep quality is associated with lower emotion-regulation ability in a laboratory paradigm. *Cogn. Emot.* 27, 567–576.
- McGlinchey, E.L., Talbot, L.S., Chang, K., Kaplan, K.A., Dahl, R.E., Harvey, A.G., 2011. The effect of sleep deprivation on vocal expression of emotion in adolescents and adults. *Sleep* 34, 1233–1241.
- McMakin, D.L., Alfano, C.A., 2015. Sleep and anxiety in late childhood and early adolescence. *Curr. Opin. Psychiatry* 28, 483–489.
- McMakin, D.L., Dahl, R.E., Buysse, D.J., Cousins, J.C., Forbes, E.E., Silk, J.S., et al., 2016. The impact of experimental sleep restriction on affective functioning in social and nonsocial contexts among adolescents. *J. Child. Psychol. Psychiatry* 57, 1027–1037.
- McRae, K., Gross, J.J., Weber, J., Robertson, E.R., Sokol-Hessner, P., Ray, R.D., et al., 2012. The development of emotion regulation: an fMRI study of cognitive reappraisal in children, adolescents and young adults. *Soc. Cogn. Affect. Neurosci.* 7, 11–22.
- Merikangas, K.R., Avenevoli, S., Costello, E.J., Koretz, D., Kessler, R.C., 2009. National comorbidity survey replication adolescent supplement (NCS-A): I. Background and measures. *J. Am. Acad. Child. Adolesc. Psychiatry* 48, 367–379.
- Motomura, Y., Kitamura, S., Oba, K., Terasawa, Y., Enomoto, M., Katayose, Y., et al., 2013. Sleep debt elicits negative emotional reaction through diminished amygdala-anterior cingulate functional connectivity. *PLoS One* 8, e56578.
- Nolen-Hoeksema, S., Wisco, B.E., Lyubomirsky, S., 2014. Rethinking rumination. *Perspect. Psychol. Sci.* 3, 400–424.
- Ohayon, M.M., Roth, T., 2003. Place of chronic insomnia in the course of depressive and anxiety disorders. *J. Psychiatr. Res.* 37, 9–15.
- Ong, S.H., Wickramaratne, P., Tang, M., Weissman, M.M., 2006. Early childhood sleep and eating problems as predictors of adolescent and adult mood and anxiety disorders. *J. Affect. Disord.* 96, 1–8.
- Owens, J.A., Adolescent Sleep Working Group, Committee on Adolescence, 2014. Insufficient sleep in adolescents and young adults: an update on causes and consequences. *Pediatr.* 134, e921–e932.
- Palmer, C.A., Alfano, C.A., 2017. Sleep and emotion regulation: an organizing integrative review. *Sleep. Med. Rev.* 31, 6–16.
- Pilcher, J.J., Huffcutt, A.L., 1996. Effects of sleep deprivation on performance: a meta-analysis. *Sleep* 19, 318–326.
- Reddy, R.M., Palmer, C.A., Jackson, C., Farris, S.G., Alfano, C.A., 2017. The effect of sleep restriction versus idealized sleep on emotional experience, reactivity, and regulation in healthy adolescents. *J. Sleep. Res.* 26, 516–525.
- Reynolds, K.C., Alfano, C.A., 2016. Childhood bedtime problems predict adolescent internalizing symptoms through emotional reactivity. *J. Pediatr. Psychol.* 41, 971–982.
- Rive, M.M., Mocking, R.J.T., Koeter, M.W.J., van Wingen, G., de Wit, S.J., van den Heuvel, O.A., et al., 2015. State-dependent differences in emotion regulation between unmedicated bipolar disorder and major depressive disorder. *JAMA Psychiatry* 72, 687–696.
- Roberts, R.E., Robert, C.R., Chen, I.G., 2002. Impact of insomnia on future functioning of adolescents. *J. Psychosom. Res.* 53, 561–569.
- Schäfer, J.Ö., Naumann, E., Holmes, E.A., Tuschen-Caffier, B., Samson, A.C., 2017. Emotion regulation strategies in depressive and anxiety symptoms in youth: a meta-analytic review. *J. Youth Adolesc.* 46, 261–276.
- Servatius, R.J., 2016. Avoidance: from basic science to psychopathology. *Front. Behav. Neurosci.* 10, 15.
- Silk, J.S., Vanderbilt-Adriance, E., Shaw, D.S., Forbes, E.E., Whalen, D.J., Ryan, N.D., Dahl, R.E., 2007. Resilience among children and adolescents at risk for depression: mediation and moderation across social and neurobiological contexts. *Dev. Psychopathol.* 19, 841–865.
- Smith, R.A., Lack, L.C., Lovato, N., Wright, H., 2015. The relationship between a night's sleep and subsequent daytime functioning in older poor and good sleepers. *J. Sleep. Res.* 24, 40–46.
- Spear, L.P., 2013. Adolescent neurodevelopment. *J. Adolesc. Health* 52, S7–S13.
- Steinberg, L., 2005. Cognitive and affective development in adolescence. *Trends Cogn. Sci.* 9, 69–74.
- Talbot, L.S., McGlinchey, E.L., Kaplan, K.A., Dahl, R.E., Harvey, A.G., 2010. Sleep deprivation in adolescents and adults: changes in affect. *Emot.* 10, 831–841.
- Tavernier, R., Willoughby, T.A., 2015. Longitudinal examination of the bidirectional association between sleep problems and social ties at university: the mediating role of emotion regulation. *J. Youth Adolesc.* 44, 317–330.
- Thomsen, D.K., Mehlsen, M.Y., Christensen, S., Zachariae, R., 2003. Rumination relationship with negative mood and sleep quality. *Pers. Individ. Dif.* 34, 1293–1301.
- Vriend, J.L., Davidson, F.D., Corkum, P.V., Rusak, B., Chambers, C.T., McLaughlin, E.N., 2013. Manipulating sleep duration alters emotional functioning and cognitive performance in children. *J. Pediatr. Psychol.* 38, 1058–1069.
- Yoo, S.S., Gujar, N., Hu, P., Jolesz, F.A., Walker, M.P., 2007. The human emotional brain without sleep—a prefrontal amygdala disconnect. *Curr. Biol.* 17, R877–R878.