Sleep, Emotion Dysregulation, and Nonsuicidal Self-Injury in Adolescents

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A Thesis in the Field of Clinical Psychology

for the Degree of Master of Liberal Arts in Extension Studies

Harvard University

March 2018

Abstract

Introduction: Numerous biological and psychosocial changes typical of adolescence combine such that adolescents get significantly less sleep than they need. Sleep deprivation is associated with emotion regulation deficits and most adolescents who engage in NSSI report doing so for emotion regulation reasons. Accordingly, adolescents may be especially likely to turn to NSSI under conditions of chronic sleep deprivation, where more adaptive emotion regulation strategies seem inaccessible. **Method:** Forty adolescents (12-19 years) completed self-report questionnaires and an in-person interview during a one-time lab visit. Correlational analyses assessed the associations between sleep deprivation (measured in self-reported sleep duration and perceived insufficient sleep), emotion dysregulation and NSSI engagement (ever or never). **Results:** Perceived insufficient sleep, but not sleep duration, was associated with both emotion dysregulation and NSSI engagement. Mediation analyses revealed that emotion dysregulation fully accounted for the relationship between perceived insufficient sleep and NSSI. **Conclusions:** Results suggest that sleep deprivation may confer risk for NSSI via emotion dysregulation, though further research is needed to confirm directionality. Insights gained from this study may inform the development of prevention and treatment interventions for NSSI in adolescents.

Acknowledgments

I would like to express my sincere gratitude to my thesis director, Professor Richard McNally, and my research advisor Dr. Dante Spetter for their expert guidance and unwavering enthusiasm throughout this journey. Also, to Kathryn Fox, whose continued support and immense knowledge of the NSSI research helped to shape this project.

In addition, I would like to thank Dr. Christine Cha and Katherine DiVasto of Columbia University for allowing me to be a part of their incredible research, and for all the additional time and effort they took to incorporate my study into theirs. Many thanks also to Dr. Edward Pace-Schott for his excellent Sleep and Mental Health class, which inspired this study.

Finally, I am profoundly grateful for the love and encouragement of my husband Michael Carter, and to our soon-to-be-born baby, for growing well and staying inside long enough for me to finish this adventure before the next begins

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Chapter I

Introduction

Sleep in adolescence has been described as "The Perfect Storm" (Carskadon, 2011); a time in which a legion of biological and psychosocial factors conspire such that adolescents get significantly less sleep than they need. The most recent US poll of sleep patterns reported that adolescents get progressively less sleep per night as they move from childhood to adolescence, with averages moving from an already too-low 8.4-hours in the 6th grade to just 6.9-hours in the 12th grade. Although adolescents report getting less sleep than they did during childhood, nightly sleep need is thought to remain at 9-10 hours as a child transitions into adolescence (Carskadon, 1990; National Sleep Foundation, 2006), with some findings suggesting that biological sleep need may even increase over this period (Carskadon, 2002). As such, approximately 80% of American adolescents get less than the recommended amount of 9 hours, 15 minutes a night (National Sleep Foundation, 2006).

Chronic sleep deprivation can have severe mental health consequences. A key mechanism by which sleep loss impairs mental health is emotion dysregulation. Although there are several ways to regulate emotion, sleep deprivation may leave adolescents particularly vulnerable to maladaptive emotion regulation strategies, including nonsuicidal self-injury (NSSI). Consistent with this possibility, NSSI is associated with emotion regulation deficits (Talbot, McGlinchey, Kaplan, Dahl & Harvey, 2010) and most commonly, people report engaging in NSSI to regulate emotion (Klonsky, 2009;

Nock, 2009; Nock & Prinstein, 2004). One way in which some adolescents regulate their emotions is through NSSI behaviors. Therefore, it is possible that NSSI may function, in part, as a compensatory behavior for a system compromised by sleep loss. In this way, NSSI may be a particularly vivid illustration of the cost of sleep debt to adolescent health.

Terminology

A clear and consistent classification system that distinguishes among behaviors and characteristics is important in all research, and certainly when discussing complex topics such as sleep and self-injury. Sleep can be described in a myriad of ways, both in terms of quality and quantity; similarly, previous research on both NSSI and emotion dysregulation have varied in their classification systems. This section defines terms used in this report.

There is much debate in the field of sleep research on what it means to have 'optimal' sleep and, conversely, how to define sleep patterns that fall outside this presumed optimal range. Studies have endeavored to define optimal sleep in terms of both duration and quality. These definitions typically take into account cultural, individual, and societal factors (for a review, see Blunden & Galland, 2014). A variety of variables have been used to validate these measures, including cognitive performance outcomes, lapses in performance, metabolic processes and mood outcomes (e.g. Edie & Showalter, 2012; Engle-Friedman, Palencar & Riela, 2010; Ferra & De Gennaro, 2001; Dahl, 1996). Defining optimal sleep in adolescents is further complicated by the necessarily restrictive research limitations to protect adolescent participants. It is difficult, for example, to ethically justify use of the strict laboratory conditions and sleep deprivation protocols necessary for precise experimental research. Arguably the best

information we have on optimal sleep in adolescence was derived from a series of 47 3-day sleep lab sessions across three summers at Stanford University (Carskadon et al., 2002). In this study, 19 participants were free to control the amount of sleep they got between 10pm and 8am (Carskadon et al., 2002). Largely informed by this research, the National Sleep Foundation recommends adolescents (6th-12th graders) get 9-10 hours of sleep each night (National Sleep Foundation, 2006).

Sleep Deprivation: Sleep deprivation describes the state that occurs when individuals get less sleep than they need. Though the distribution of sleep need across individuals appears leptokurtic, some variability does exist (Carskadon et al., 2002; Mercer, Merritt & Cowell, 1998). As such, using a strict definition of how many hours are "sufficient" and how many lead to sleep deprivation would be arbitrary and inappropriate for the current aims. As such, in the present study, the term sleep deprivation is considered in terms of both self-reported duration (hours and minutes slept), assessed as a continuous variable, and in terms of perceived insufficient sleep, (i.e., how often one reports getting 'enough' sleep).

NSSI: NSSI refers to the direct and deliberate destruction of one's own body tissue in the absence of suicidal intent (Nock & Favazza, 2009). NSSI research has also been marked by inconsistent definition and classification. Normative behaviors such as hair-pulling, lip-biting, and picking at wounds for example, are included as NSSI in some studies, but not others (Fox et al., 2015). As a result, although lifetime prevalence estimates are around 17% in the adolescent general population, this number can vary widely based on diverse factors, including the method of assessing behaviors and characteristics of the population (Swannell et al. 2014). The American Psychiatric

Association (APA) has identified NSSI disorder as a condition for further study. In their definition, APA stipulates that the nonsuicidal self-injurious behavior in question must involve direct and deliberate tissue damage, such as cutting or burning one's skin; and must not be stereotypical (e.g. behaviors commonly observed in developmental disorders), socially sanctioned (e.g. piercings or tattoos in Western cultures), or minor (e.g. lip biting; American Psychiatric Association 2013; Nock, 2009).

Emotion dysregulation: The concept of emotion regulation is marked by similar inconsistencies in the clinical psychology literature, despite its dominant appearance. In his integrative review on the topic, Gross (1998) describes emotion regulation as "the processes by which individuals influence which emotions they have, when they have them, and how they experience and express these emotions" (p. 275). Conceptualizing the term in a standard way remains a challenge for researchers; for example, in some studies emotion dysregulation is considered in terms of one or more of its various dimensions (e.g. emotional non-acceptance, lack of emotional awareness and clarity; Bagby, Taylor & Parker, 1994; Hoffman & Kashdan, 2010), whereas in others, emotion regulation strategies determined to be 'adaptive' or 'maladaptive' are assessed (e.g. emotion avoidance and expressive suppression; Gross & John, 2003; Taylor, Laposa & Alden, 2004). In this research, we are interested in emotion regulation impairment, or emotion dysregulation. We measure emotion dysregulation by using the modified Difficulties in Emotion Regulation Scale (DERS), one of the most comprehensive and widely used measures of emotion regulation difficulties (Bardeen, Fergus, Hannan, & Orcutt; 2016, modified from the original DERS; Gratz & Roemer, 2004). The modified DERS conceptualizes emotion regulation in terms of six separate (though related)

dimensions wherein difficulties may occur. Those six dimensions are: (a) lack of awareness of emotional responses, (b) lack of clarity of emotional responses, (c) non-acceptance of emotional responses, (d) limited access to emotional regulation responses perceived as effective, and (e) difficulties controlling impulses when experiencing negative emotions. According to Gratz and Roemer (2004), an individual with deficits on any of these dimensions exhibits emotion dysregulation (Gratz & Roemer, 2004).

Background

Shifts in the biological processes for the timing of sleep are arguably the most prominent sleep-related changes that occur in adolescents. Changes that favor later sleep onset occur in the two major sleep regulation processes: the circadian rhythm (process C) and the homeostasis sleep system (process S). These processes function independently of each other and interact to influence sleep timing and duration, together forming the dual-process model of sleep (Borbély, 1982). Process C is an intrinsic mechanism driven by the suprachiasmatic nucleus (SCN) in the hypothalamus and constitutes the 'biological clock'. This 'clock' mechanism oscillates on a near 24-hour cycle that is sensitive to light input for synchronization with the environment. The action of light on the circadian system is dependent on the time of day; evening light tends to cause a phase delay (i.e., delaying sleep onset), whereas early morning light tends to cause a phase advance (i.e., advancing wakening; Carskadon & Tarokh, 2014). Adolescents may have an increased sensitivity to phase-delaying evening light and a decreased sensitivity to phase-advancing morning light; as such, changes in process C may drive adolescents to fall asleep later while also making it more difficult for them to wake up early (Carskadon, 2011, Hagenauer, Perryman, Lee & Carskadon, 2009). This change in phase-dependent light

sensitivity may drive the prominent circadian phase delay observed in adolescents across many cultures, as well in several nonhuman mammalian species (Carskadon, 2008; Hagenauer et al., 2009). The circadian phase delay is reflected in changes in preferred timings of sleep/wake behaviors and in the delayed onset of sleep hormone melatonin secretion (Carskadon & Tarokh, 2014; Hagenauer et al., 2009).

Process S denotes the sleep pressure system as it represents the process by which we feel the need to sleep after long periods awake. Over the course of the day, we build up sleep 'debt' – debt that must eventually be paid off by sleeping (i.e., sleep dissipates sleep pressure; Sleep Research Society, 2009). Research suggests sleep pressure buildup slows during adolescent development, such that it becomes easier for adolescents to stay awake later (Jenni, Achermann & Carskadon, 2005). However, the ability to remain awake longer does not appear to correspond to reduced sleep need, as evinced by no corresponding change to the sleep recovery (sleep pressure dissipation) system across adolescent development. This suggests that while adolescents can stay awake longer, they need just as much sleep as children do (Tarokh, Carskadon & Achermann 2012; Taylor, Jenni, Acebo & Carskadon, 2005).

The Developmental Changes Driving Adolescent Sleep Patterns

Neurodevelopmental changes: The central nervous system (CNS) undergoes extensive reorganization during adolescence (Buchmann et al., 2011). These changes are reflected in major alterations to sleep architecture; longitudinal studies using EEG to measure adolescent sleep show that the amplitude of the slow (delta) wave in non-rapid eye movement (NREM) sleep reduces by 40-60% as children progress from their pre- to mid-teenage years (Campbell & Feinberg, 2009; Tarokh & Carskadon, 2010). These

changes may reflect major neurodevelopmental changes that occur over the same period: the diminution of cortical thickness and cortical synaptic density via "pruning", and the increase in white matter and myelinated fiber tracts. Although these changes to the adolescent CNS do not necessarily impact sleep regulation directly, they are likely to influence emotion regulatory processes, which interact with sleep in important ways, as discussed later.

Hormonal changes: The timing of this delta decline in slow-wave, NREM sleep is significantly linked to pubertal maturation ($F(1,529) = 229$, $p < .0001$; Campbell, Grimm, de Bie, & Feinberg, 2012). It is unknown whether the relationship is causal; however, the sleep regulation system does appear sensitive to changes in gonadal hormone levels, which rise steeply in adolescence. A review by Baker and Driver (2007) reported that women across a wide age range reportedly experience more sleep disturbance in the premenstrual week and first few days of menstruation, and apparently despite the absence of menstruation-associated complaints. Additionally, interference with gonadal hormones in rodents produces corresponding effects in the circadian rhythms of males and females (Karatsoreos & Silver, 2007; Manber & Armitage, 1999). Little is known about how gonadal hormones affect sleep, but some evidence suggests they act on the SCN to produce the physiological and anatomical changes that ultimately drive the circadian phase delay (Nakamura et al., 2005; Shinohara, Funabashi, Nakamura & Kimura, 2001).

Psychosocial Factors Influencing Adolescent Sleep Patterns

Adolescence is associated with several psychosocial changes that can interfere with sleep; as children move into adolescence they gain independence and responsibility

in a number of life domains, each of which can impede sleep. Many young people start to assert their autonomy in adolescence; setting their own bedtime exemplifies this. Because of the sleep phase delays, an adolescent may be inclined to go to bed later. Unfortunately, most weekday schedules do not allow adolescents to sleep the delayed phase to completion, as middle- and high school start times tend to be earlier than in elementary school. Additionally, extra-curricular activities often increase in number, intensity, or both during the transition into adolescence, further constraining available sleep time. Similarly, this is the time when additional responsibilities such as part-time jobs become relevant. Further reducing available sleep time, a number of life domains become more demanding in adolescence; school grades are more important – increasing study and homework time, and peer relationships gain greater significance – increasing socialization needs. Finally, adolescents tend to have more access to technologies such as computers, video games and smart phones; all of which make staying up late easier – due to both the engaging content available on these devices and the phase-delaying blue light they emit. In all, while the need for sleep is unchanged as a child moves into adolescence, certain psychosocial changes can mean sleep duration diminishes at both ends; adolescents go to bed later and wake earlier. Over time, these psychosocial factors interact with sleep phase changes to produce chronic sleep deprivation; which in turn is associated with emotion regulation impairment (Dahl & Lewin, 2002).

The Cost of Sleep Debt: Sleep, Emotion Regulation, and Self-Injury

Sleep has a profound effect on emotion regulation (Gau et al., 2007; Schmidt & Van der Linden, 2015; Talbot et al., 2010; Xianchen, 2004). The effect may be especially

potent for adolescents, as the adolescent pre-frontal cortex (PFC) - the brain's top-down emotion control center – is incompletely myelinated and has therefore not yet reached optimal neuronal conduction and communication (Giedd, 2004). Chronic sleep deprivation, in addition to the many hormonal changes underway, means that adolescents confront affective challenges with limited resources. Indeed, the consequences of chronic sleep deprivation in adolescents are well documented and extensive. Sleep deprivation is associated with greater emotional instability (Gau et al., 2007; Talbot et al., 2010) and psychopathology, especially symptoms of depression and anxiety (Chelminski, Ferraro, Petros, & Plaud, 1999; Gaspar-Barba et al. 2009, Vriend, Davidson, Rusak, & Corkum, 2015; Willis & Gregory, 2015).

The relationship between sleep and emotion dysregulation in adolescence appears to be dynamic and complex. Several studies provide insight into the factors involved. In a daily diary study, Fulingi and Hardway (2006) examined the dynamics of adolescent sleep time, daily activities, and psychological wellbeing across an ethnically diverse sample of 14-15 year olds (n = 750). Participants completed daily checklists of items assessing timing and duration of sleep, daily activities, and stressful demands, and daily mood over a 2-week period. The results showed adolescents spent on average 7.48 hours (SD = 0.98) per night sleeping, and nightly sleep time varied across days by almost 1-hour on average (M = 0.91, SD = 0.53). Individual differences in sleep time appeared fairly stable, with those sleeping more on school nights also sleeping more on non-school nights (r =.43, p <.001). Average sleep time and sleep deviation were related such that adolescents who showed more sleep variability tended to sleep less overall (r = -.2, p < .001), particularly on school nights (r = -.31, p < .001), but with some compensatory

sleep over the weekend (r =.18, p < .001). Not surprisingly, adolescents who spent more time studying, socializing, and playing on the computer spent less time sleeping on school nights; however, time spent helping families and watching TV was unrelated to sleep time. Adolescents who reported more stressful daily demands tended to sleep less on a typical night (r =-.13, p < .001). Daily sleep duration predicted anxiety (r = -.21), depression (r =-.17), fatigue (r =-.21), and happiness (r =.13; all p values < .001). Sleep variation was a comparable predictor of negative affect overall, and an even stronger predictor of anxiety (r =-.23, p < .001). The authors argued variation in sleep duration between weekdays and weekends might indicate a circadian phase delay, though such variation could also reflect an enduring evening, or "night owl" chronotype (as opposed to the morning-type "lark"; Gulec et al., 2012). Overall, Fulingi and Hardway's (2006) study demonstrated that numerous interrelated factors contribute to sleep deprivation in adolescents, and this deprivation has important mental health implications.

A Norwegian population-based study provides further evidence of the deleterious effects of sleep deprivation on adolescent mental health (Sivertsen, Harvey, Pallesen & Hysing, 2015). Researchers employed strict criteria recommended by Johnson, Roth & Breslau (2006) to identify adolescents with delayed sleep phase (DSP), these were: 1) minimum 1hour shift in sleep-onset and wake times from the weekdays to the weekend, (2) complaint of frequent difficulty falling asleep (≥ 3 days per week), (3) report of little or no difficulty maintaining sleep (≤ 1 day per week) and (4) frequent difficulty awakening (oversleep 'sometimes' or more often). Of the 9,338 participants, 3.3% qualified for a DSP diagnosis, though the significance of this finding could be attributed to the statistical power of the test conferred by the large sample size. The prevalence rate

was significantly higher in females than in males (3.7% versus 2.7%, respectively). Overall, DSP was associated with more mental health problems as revealed by small to moderate Cohen's *d* effect sizes from a wide range of psychological assessments. Specifically, DSP was associated with higher levels of depression (*d* =.53), anxiety (*d* =.29), and ADHD (*d* =.47) symptoms, as well as lower levels of resilience, as measured on all subscales of the Resilience Scale for Adolescents (Soest Mossige, Stefansen & Hjemdal et al., 2010; Cohen's *d* effect sizes ranged from .21 to .51). These results corroborate earlier findings that adolescents with DSP have significantly higher rates of clinically relevant anxiety (52%) and depression (35%), compared to their non-DSP peers (29% and 9%, respectively; Saxvig et al., 2012).

Though these studies provide insight into what appears to be a very serious issue for adolescents, they do not confirm a causal link between sleep deprivation and emotion dysregulation. Recognizing the need to test causality, Baum and colleagues (2014) conducted an experiment whereby chronic sleep restriction was induced in a sample of 50 adolescents aged 14 – 17 years old and the resulting changes in emotion regulation were assessed. Participants were randomized into one of two conditions: 'restricted sleep', in which participants were instructed to spend 6.5 hours in bed on week nights, or 'healthy sleep', which required 10 hours in bed on week nights. Participants chose their own bedtimes on weekends. The researchers' restricted sleep condition was comparable to the 'normal' sleep experienced of many US adolescents; 20% of healthy high school students in the US report getting around 6.5 hours of sleep on school nights (Edie & Showalter, 2012; National Sleep Foundation, 2006). A within subjects randomized crossover design was used so that all participants experienced both conditions over the course of the study.

Sleep was monitored at home via actigraphy and self-report measures. Manipulation checks showed that participants slept for 2.5 hours less, on average, in the restricted sleep condition (6.3 ±.5 hours vs. 8.8 ±.9 hours). Results provided compelling evidence for the notion that sleep deprivation causes emotion dysregulation: adolescents reported more emotion regulation difficulties and greater irritability in the restricted sleep condition than in the healthy sleep condition. Additionally, and arguably as a result of these difficulties, adolescents reported feeling more anxious, angry, confused, fatigued, and less vigorous when sleep deprived. Interestingly, there were no differences in feelings of depression across sleep conditions, though the authors point out that depression can manifest as irritability rather than sadness in adolescents (American Psychiatric Association, 2013), which did increase with restricted sleep. Overall, their results demonstrate that just a few days of sleep restricted to levels commonly experienced my millions of American adolescents can cause emotion dysregulation and negative mood changes.

The role of self-injury

Close to one fifth (17.6%) of adolescents report engaging in NSSI behaviors; a frighteningly high statistic (Swannell et al., 2014). Emotion regulation is cited as the primary function of NSSI (Klonsky, 2009; Nock, 2009; Nock & Prinstein, 2004). In fact, a seminal study into the form and function of NSSI by Nock, Prinstein and Sterba (2009) found that 64.7% of adolescents who self-injured without suicidal intent did so with the purpose of intrapersonal negative reinforcement (e.g., to decrease or distract from negative thoughts or feelings), and an additional 24.5% engaged in such behaviors for purposes of intrapersonal positive reinforcement (e.g., to generate feeling/sensation when experiencing numbness or anhedonia). The predominance of intrapersonal functions

refutes the assumption that most young people who cut themselves do so for attention, or as "a cry for help" (Nock et al., 2009). Although, by definition, acts of NSSI are "nonsuicidal", research suggests they are strongly linked to suicidality (for meta-analysis, see Ribeiro et al., 2016), further underscoring the dire need to identify factors precipitating self-injurious behaviors.

An important link between sleep and NSSI in adolescents is suggested by an emerging collection of studies on this topic, as well a relatively large body of research on sleep and suicidality more generally. Studies differ on how suicidality is conceptualized; some consider suicidal thoughts as well as acts, others just acts (e.g., suicide attempts). Some consider all acts of deliberate self-harm to be suicidal, which would include NSSI, whereas others require some non-zero intent to die (Fox et al., 2015). Research on suicidality in adults suggests sleep is a contributing factor. A large prospective cohort analysis of Taiwanese adults (n =393,983) found that participants who reported difficulty getting to sleep (11.6%) had a 2.0-fold increased risk of suicide (Gunnel, Chang, Tsai, Tsao, & Wen, 2013). During a depression clinical trial, McCall and colleagues (2010) found insomnia severity independently predicted suicidal ideation, even after accounting for core symptoms such as depressed mood and anhedonia. The idea that insufficient sleep may predict suicidality over and above comorbid psychopathology is supported by findings from large epidemiological studies and literature reviews (e.g. Bernert, Kim, Iwata & Perlis, 2015; Bernert & Joiner, 2007; Bernert & Nadorff, 2015; Goodwin, Marusic, 2008). In their review of insomnia and suicidality, Bernert and Nadorff (2015) found that many (though not all) relevant studies indicate sleep disturbances predict suicidal thoughts, attempts and deaths, even after controlling for the presence and

severity of psychopathology as confounding variables. Similarly, Bernert and Joiner (2007) reported that suicidal thoughts and behaviors are closely related to subjective sleep quality, and for some, the association exists after controlling for depressive symptoms.

In support of the notion that suicidal and nonsuicidal self-injury may be linked to sleep deprivation in adolescents, an epidemiological study of Chinese high school students (n= 1,362) showed that the prevalence rates of suicide ideation tended to increase with decreased sleep duration, increasing from 12.4% in adolescents who slept 9+ hours per night to 31.1% for those who slept for less than 7 hours (Xianchen, 2004). Suicidal ideation was assessed with questions "I think about killing myself" and "I deliberately try to hurt or kill myself", thereby also including cases of self-injury without suicidal intent (or NSSI).

In line with these strong findings, a longitudinal study by McGlinchey & Harvey (2015) linked late bedtimes to emotional difficulties and risk behaviors, including suicidality. Adolescents who went to bed later than 1 am (and consequently, slept less on school nights), were 1.76 times more likely to experience emotional distress, and 1.63 times more likely to have thought about or made a suicide attempt in the last year (p values <.001). Importantly, late bedtimes in adolescents continued to predict many risk behaviors in young adulthood, even after controlling for earlier presence of these behaviors, though the effect of adolescent bedtime on young adult suicidality was not significant. Notably, the measure of 'suicidality' in this study did not include NSSI and therefore may have understated the problem. Winsler and colleagues (2015) made a novel contribution to the research on sleep and suicidality by examining sleep duration

continuously, as opposed to in discrete "sufficient" vs. "insufficient" categories, thereby allowing estimates of the difference that one more hour of sleep can make to adolescent health outcomes. Thoughts and acts of suicide were measured by affirmative responses to single survey items: "During the past 12 months, did you ever seriously consider attempting suicide?" and "During the past 12 months did you ever actually attempt suicide?" hence, NSSI was not measured. Nevertheless, the study's finding were significant: after controlling for background variables, each hour of sleep lost was associated with a 42% increase in the odds of an adolescent seriously considering suicide, and a 58% increase in the odds of having already attempted suicide (p values <.001). This result is striking when we consider its implications: the odds accumulate multiplicatively such that an adolescent receiving 3 hours less sleep (e.g. 6 h/night compared to an adolescent receiving 9 h) is almost 4 times more likely to attempt suicide. Interestingly, most effects of ethnicity on suicidality disappeared when sleep duration was controlled for, suggesting that sleep differences across ethnicities may account for observed ethnic differences in suicidality prevalence (Winsler, Deutsch, Vorona, Payne & Szklo-Coxe, 2015).

A small number of studies have looked at sleep's relationship to NSSI specifically. As yet, there is little agreement on of which sleep variables are most important in assessing NSSI risk. In a large (n =2,090) community sample of Chinese adolescents, numerous sleep variables, including short sleep duration, insomnia symptoms, poor sleep quality, sleep insufficiency, unrefreshed sleep, sleep dissatisfaction, daytime sleepiness, fatigue, snoring, and nightmares were associated with increased risk of NSSI. Variables that remained significant after controlling for

demographic and mental health variables included sleeping fewer than 6 hours per night (OR =1.96, 95 % CI =1.12–3.41), frequent nightmares (≥1 a week, OR =2.96, 95 % CI =1.49–5.88), poor sleep quality (OR =2.17, 95 % CI =1.35–3.47), and sleep dissatisfaction (OR = 1.84, 95 % CI = 1.01–3.35). After also controlling for overlap between the sleep variables themselves, two variables remained independently associated with increased risk of NSSI engagement: poor subjective sleep quality (OR =2.18, 95 % CI = 1.37–3.47), and nightmares during the past year (several times or more, OR = 1.67, 95 % CI = 1.17–2.40; at least once a week, OR = 2.88, 95 % CI = 1.45–5.70; Liu, Chen, Bo, Fan & Jia, 2017). Due to the natural collinearity between sleep measures (e.g. the variable 'sleep duration' is likely to be affected by 'insomnia symptoms' and is likely to be reflected in 'unrefreshed sleep'), it is arguably more useful to use a single comprehensive measure of one's subjective perception of one's own sleep quality and/or sufficiency. Liu et al. (2017) proposed this as a possible explanation for the significance of the subjective sleep quality variable in their study, as it likely integrates many aspects of the sleep experience. Subjective measures of how often one 'sleeps well' or 'gets enough sleep' are also likely to account for differences in sleep need across individuals. The use of a single, subjective measure is supported by research that finds the subjective meaning of sleep quality to be broadly similar across people with and without sleep difficulties (Harvey, Stinson, Whitaker, Moskovitz & Virk, 2008).

A longitudinal study by and Lundh, Bjärehed and Wångby-Lundh (2013) used a single question to assess sleep problems: "Do you sleep well?", with a 5-point Likert response format: Always, Most often, Sometimes, Seldom, and Never. Their results showed that poor sleep in adolescent girls predicted future NSSI engagement

independently of overall psychopathology: those who reported 'seldom' or 'never' sleeping well at T1, 70% reported repeated NSSI engagement at T2 one year later. In comparison, only 20% of the girls who reported sleeping well 'always' or 'most often' at T1 reported NSSI engagement at T2. Even in the face of other severe mental health difficulties, good sleep appears to protect against NSSI: in a clinical sample of adolescents (n = 223), those who reported severe sleep difficulties endorsed more engagement in NSSI than those who did not ($\chi 2 = 6.4$, $p < .05$). No such differences were observed with regards to suicide attempts or suicide ideation (McGlinchey, Courtney-Seidler, German, & Miller, 2017).

NSSI is a severe and complex problem, one that will not simply be solved by a good night's sleep, yet it is important to investigate whether sleep deprivation leads to vulnerability. Sleep deprivation impairs emotion regulation, and emotion regulation is a major function of NSSI, but questions remain about each of these factors and how (or whether) they relate to one another. One question yet to be addressed is whether sleep deprivation is associated with NSSI engagement by way of emotion dysregulation. Sleep deprivation is plausibly implicated as either contributing to emotion dysregulation directly, or by limiting the availability of other more adaptive regulation strategies. It seems likely that for some, NSSI is the emotion regulatory mechanism selected from a repertoire limited by too-little sleep.

Study Aims and Hypotheses

Aim 1

Replicate previous findings that emotion dysregulation and NSSI are independently associated with sleep-deprivation (measured in sleep duration and perceived insufficient sleep) in adolescents.

Hypotheses: 1) Sleep deprivation will be associated with difficulties in emotion regulation; 2) sleep deprivation will be associated with NSSI engagement.

Aim 2

Investigate whether any association between sleep deprivation and NSSI in adolescents can be explained by difficulties in emotion regulation.

Hypothesis: 3) Difficulties in emotion regulation will partially mediate the relationship between sleep deprivation and NSSI engagement.

Chapter II

Method

This study was conducted as part of a larger research project at Columbia University Teachers College. The study protocol included self-report questionnaires and an in-person interview.

Participants

Participants were 40 adolescents aged 12-19 years. We focused on adolescents because this developmental period is often marked by disruptions in sleep that can lead to chronic sleep deprivation (Carskadon, 2011), and because NSSI tends to begin during this period (Calzo, Antonucci, Mays & Cochran, 2011; Nock, Joiner, Gordon, Lloyd-Richardson & Prinstein, 2006). Participants were recruited as part of a larger, parent study that looked at three specific groups of adolescents: (1) those with no history of psychopathology or NSSI, (2) those with a history of depression but no history of NSSI or other self-injurious thoughts and behaviors (SITBs), and (3) those with a history of depression and NSSI and/or other SITBs. For reasons of statistical power, I combined all participants into one group. Participants were recruited from the New York City metropolitan area via online postings on sites such as Facebook and Craigslist, and from flyers posted throughout the Morningside Heights neighborhood and greater Manhattan community, the Columbia University campus, and local treatment centers.

Measures

With the exception of NSSI, all measures were assessed using self-report questionnaires administered in-lab on iPads, via Qualtrics. NSSI was assessed with an in-person interview.

Demographics

Participants provided information about their age, race/ethnicity, gender, sexual orientation, education, and employment status.

Emotion Regulation

Modified Difficulties in Emotion Regulation Scale (DERS (Modified): Bardeen et al., 2016). The modified DERS is a 29-item self-report measure assessing different types of emotion regulation strategies. Participants are given a series of statements such as "When I'm upset, I experience my emotions as overwhelming and out of control". Responses were given in 5-point Likert format ranging from 1 (almost never) to 5 (almost always). Responses to these items are were summed to yield a total score (min 29, max 145) indexing global difficulties in emotion regulation (a higher score indicates more difficulties). The measure has good test-retest reliability, construct validity and predictive validity (Grantz & Roemer, 2004) and it performs similarly across genders and racial/ethnic groups (Ritschel, Tone, Schoemann, & Lim, 2015).

Sleep Deprivation

Sleep deprivation was assessed using select items taken from the *School Sleep Habits Survey (SSHS*; Wolfson & Carskadon, 1998) measuring sleep duration and perceived

insufficient sleep. The SSHS is a 63-item measure of sleep/wake habits and typical daytime functioning of adolescents. The measure has strong validity and reliability and is widely used in high school populations, both in the USA and internationally. Duration was assessed with the items *How long do you usually sleep on school nights (not including time spent awake in bed)?* and *How long do you usually sleep on nights when you don't have school the next day (not including time spent in bed)?* Participants responded in hours and minutes. Perceived insufficient sleep was assessed with the question *How often do you think you get enough sleep?* Responses were given on a 5-point Likert scale: (Always, Usually, Sometimes, Rarely, Never).

Depression

Quick Inventory of Depressive Symptomatology, Self-Report Version (QIDS-SR; Rush et al., 2003). The QIDS-SR is a 16 item self-report form that assesses current depressive symptoms. Symptom domains include sleep, sadness, appetite and weight change, concentration, self-view, thoughts of death or suicide, energy levels, psychomotor retardation and restlessness. Response type is multiple choice, and responses are ranked by severity and scored 1-4. Severity of depression is assessed based on total score where a total score of 1-5 = no depression, 6-10= mild depression, 11-15= moderate depression, 16-20= severe depression, 21-27= very severe depression. The scale has high internal consistency and concurrent validity (Rush et al., 2003).

NSSI

Self-Injurious Thoughts and Behaviors Interview (SITBI; Nock, Holmberg, Photos, & Michel, 2007). Participants completed a short version of the SITBI. The SITBI

constitutes five modules corresponding to the five types of SITBs: nonsuicidal self-injury, suicide plan, suicide gesture, suicide ideation, and suicide attempt; however, only questions pertaining to NSSI were used in the current study. At the beginning of the NSSI component of the SITBI, participants are given the following description to ensure as much consistency in behaviors reported as possible: *For the following questions, we will be asking about times when you have purposely hurt yourself without wanting to die, including things like cutting or burning your skin. In answering these questions, please do* ***not*** *include times where you have hurt yourself in minor ways, like picking at wounds, biting your lips or nails, or getting tattoos or piercings. Also, do not include times when you have indirectly hurt yourself, such as starving yourself or overdosing without wanting to die.* Participants are then asked directly: *Have you ever purposely hurt yourself without wanting to die?* Responses to this question (yes or no) were used to measure NSSI engagement (ever or never) in the current study. Past year NSSI engagement was assessed with the question: *How many times in the past year have you [purposely hurt yourself with identified method] without wanting to die?*

The SITBI is a gold standard measure of NSSI and other self-injurious thoughts and behaviors. Nock and colleagues (2007) determined excellent inter-rater and test-retest reliability, and construct validity.

Procedure

Data Collection

All measures were administered by members of the research team at Columbia University Teachers College responsible for the parent study of which this project is a

component. Measures were scored by the researcher or by members of their team and shared with this author in an SPSS data file.

Design

This is a cross-sectional, correlational study that aims to assess psychological factors associated with sleep deprivation in adolescents and to test whether sleep mediates the emotion regulation-NSSI relationship in this group.

Study Protocol

Those interested in participating were asked to contact the lab to complete screening questionnaire over the phone. Assent from adolescents and consent from parents was obtained prior to administration of the screening questionnaire. Qualified potential participants were then invited to complete the study by way of a one-time lab visit. During the lab visit participants completed the questionnaires on iPads before being interviewed by the researchers. Comprehensive measures were taken to ensure participant privacy and confidentiality. Participants were compensated $40 for completing the study in the form of Amazon or iTunes gift cards.

Chapter III

Results

The final sample consisted of 40 adolescents aged 12-19 years. Participants were primarily female and White (see Table 1).

Table 1

Participant Characteristics

Variable		**Study Sample**
Age: Mean (SD)		16.45 (2.14)
Gender: Total (%)	Female	33 (82.5%)
	Male	7 (17.5%)
Race: Total (%)	White	12 (30%)
	Black	8 (20%)
	Asian	10 (25%)
	Other	9 (22.5%)
	Unknown	1 (2.5%)
Sexual Orientation: Total (%)	Heterosexual	23 (57.5%)
	Bisexual	8 (20%)
	Questioning	1 (2.5%)
	Other	5 (12.5%)
	Unknown	3 (7.5%)

Note: This table presents the demographic breakdown of the sample.

Study Characteristics of Sleep, Emotion Regulation and NSSI.

Table 2 details the descriptive statistics for the sleep and emotion regulation variables of interest. Fifteen (37.5%) participants reported having ever engaged in NSSI, 11 (27.5%) reported engaging in NSSI in the past year. The NSSI characteristics of those

who reported ever engaging in NSSI are shown in Table 3. These characteristics are consistent with those seen in larger studies on NSSI in adolescents; the majority have a history of self-cutting (Nock et al., 2009).

Table 2

Sleep and Emotion Regulation Characteristics

Variables	Mean	SD	Min	Max
Sleep hours on school nights: *How long do you usually sleep on school nights (not including time spent awake in bed)?*	6.86	1.36	4.25	9.5
Sleep hours on non-school nights: *How long do you usually sleep on nights when you don't have school the next day (not including time spent in bed)?*	9.20	1.50	6	12.5
Perceived insufficient sleep: *How often do you think you get enough sleep?* (1-5 scale where 1=always, 5=never)	2.80	0.85	5	1
Emotion regulation deficits: (DERS (Modified) total; Higher scores suggest greater ER difficulties)	68.98	22.02	29	117
Depression: (QUIDS total; higher scores suggest more severe depression)	7.90	5.16	0	19

Note: This table presents the descriptive statistics for the sleep and ER variables of interest. Italicized items denote the questionnaire item used for each variable.

As expected, adolescents slept less on weeknights (mean 6.86 hours) than on weekends (mean 9.20 hours). There was no relationship between school night and weekend sleep duration. Our findings were partially aligned with those of the National Sleep Foundation's most recent (2006) poll of US adolescent sleeping habits in that sleep duration on weekends but not weeknights significantly decreased with age (r =-.332, p =.037; r weeknight sleep). Importantly, it appears our sample was more sleep deprived

than their peers; only one participant (2.5%) reported meeting the recommended 9 hours 15 minutes sleep on school nights; a percentage considerably lower than the 20% observed in the general adolescent population (National Sleep Foundation, 2006).

Table 3

NSSI Characteristics

Variable		Subs-sample with NSSI History (n=15)
Age NSSI onset: Mean (SD)		14 (2.39)
Number of NSSI episodes: Mean (SD)		14.05 (33.08)
Method: Total (%)	Ever Cut	14 (93.3%)
	Ever Hit	1 (0.06%)
	Ever Burn	0 (0%)
	Ever Insert	1 (0.06%)
	Ever Scrape	0 (0%)
	Ever Other	5 (33.3%)

Note: This table presents the NSSI characteristics of the 15 participants who reported ever engaging in NSSI.

Hypotheses 1) Sleep deprivation will be associated with difficulties in emotion regulation and 2) Sleep deprivation will be associated with NSSI engagement

Sleep duration did not correlate with emotion dysregulation or with NSSI engagement (see Table 4). However, perceived insufficient sleep was significantly correlated with both variables, as well as depression. Thus, results partially support our hypotheses such that perception of sleep deprivation, but not number of hours of sleep, were associated with difficulties in emotion regulation, NSSI, and depression.

Table 4

Correlation between sleep deprivation, emotion dysregulation and NSSI

	1	2	3	4	5
1. Sleep hours on school nights	1				
2. Sleep deprivation perception (*"How often do you think you get enough sleep? 1-5 scale: 1=always, 5=never"*)	-.557**	1			
3. Emotion regulation deficits (DERS modified)	-0.152	.541**	1		
4. Depression (QIDS)	-0.143	.444**	.642**	1	
5. NSSI history (Ever engaged: yes/no)	-0.110	.368*	.469**	.542**	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Hypothesis: 3) Difficulties in emotion regulation will partially mediate the relationship between sleep deprivation and NSSI engagement

Given that perceived insufficient sleep was significantly associated with both emotion dysregulation and NSSI, we next tested whether emotion regulation mediated the relationship between perceived insufficient sleep and NSSI. No such analyses were conducted with the sleep duration variable because there were no significant associations between sleep duration and either NSSI or emotion dysregulation. As recommended by Preacher and Hayes (2004), we first tested two logistic regression models to determine the coefficients and standard errors for (1) the association between the independent variable (i.e. perceived insufficient sleep) and the mediator (i.e. emotion dysregulation) and (2) the association of the mediator (i.e. emotion dysregulation) and the dependent

variable (i.e. history of NSSI), with the independent variable included in the model. Next, we calculated bootstrap confidence intervals, using 2 million bootstrap resamples (Purnell et al., 2012) for the sampling distribution of the indirect effect to assess statistically significant mediation.

Consistent with the correlation observed under our first hypothesis, perceived insufficient sleep was significantly associated with the odds of having an NSSI history ($p < .001$). Next, we added emotion dysregulation to the model; this variable was also significantly associated with NSSI engagement ($p = .039$). Importantly, perceived insufficient sleep was no longer significant with this updated model ($p = .32$), suggesting that there were no direct effects of perceived insufficient sleep on NSSI engagement. Instead, the relationship between perceived insufficient sleep and NSSI engagement was entirely explained by indirect effects, such that emotion dysregulation explained the association between these variables. Together, these results suggest that the association between perceived insufficient sleep and NSSI was fully mediated by emotion dysregulation. The bootstrap point estimates of the indirect effect were 0.66 (95% CI = .01-1.74). Because the confidence interval does not include zero, we concluded that there is statistically significant mediation of the relationship between perceived insufficient sleep and NSSI engagement through the effect of emotion dysregulation (Figure 1).

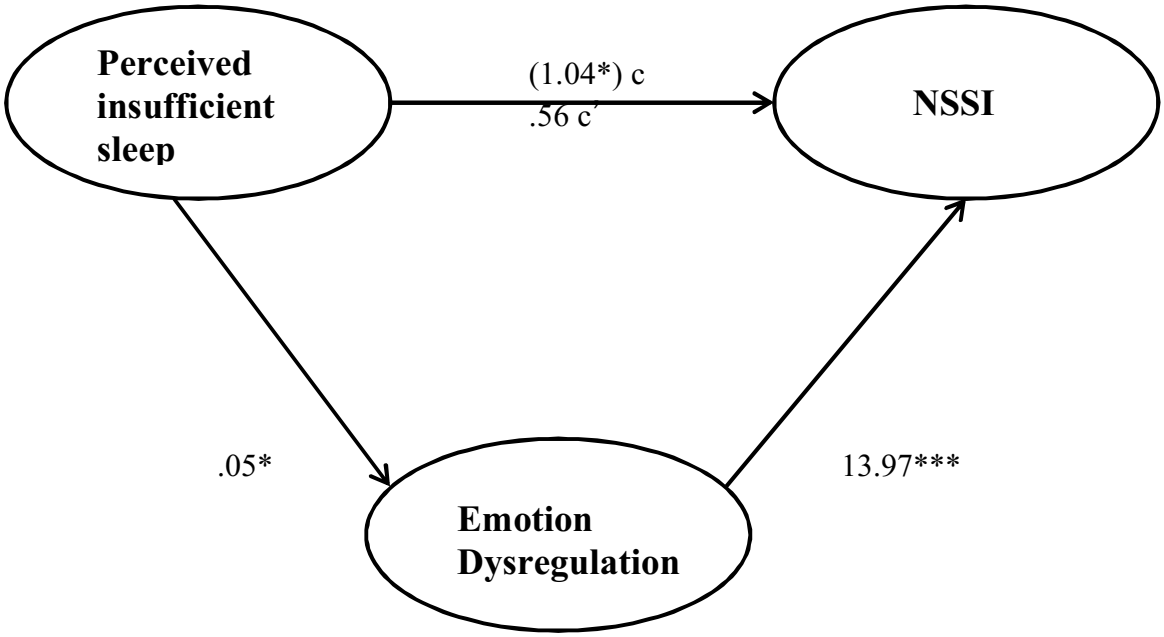

Figure 1. Emotion dysregulation fully mediates the relationship between perceived insufficient sleep and NSSI in adolescents
Note: Pathways are labeled with standardized beta coefficients
c = Path coefficient before inclusion of the mediator into the model
c'= Path coefficient after inclusion of the mediator variable into the model
* Relationship is significant at the 0.05 level (2-tailed)
*** Relationship is significant at the 0.001 level (2-tailed)

Chapter IV

Discussion

This study builds upon previous research by examining the relationships between sleep deprivation, emotion dysregulation, and NSSI in a community sample of adolescents. Specifically, this study aimed to replicate previous findings that sleep deprivation is uniquely associated with both emotion dysregulation and NSSI, and to extend these findings to test whether the association between sleep deprivation and NSSI could be explained by emotion dysregulation. We found that perceived insufficient sleep, but not sleep duration, was significantly associated with NSSI engagement and emotion dysregulation. Moreover, we found that emotion dysregulation fully mediated the relationship between perceived insufficient sleep and NSSI such that adolescents who reported not getting sufficient sleep reported more difficulties in emotion regulation and were more likely to have engaged in NSSI.

Sleep deprivation and emotion regulation

Sleep deprivation measured by sleep duration on school nights was not associated with emotion dysregulation. It is important to note that on school nights, almost all of our sample (97.5%) reported getting less than the recommended 9 hours, 15 minutes of sleep (National Sleep Foundation, 2006). As such, sleep duration in the present sample exhibited an attenuated range. In contrast, our perceived insufficient sleep variable revealed that despite the attenuated range of sleep duration, there was variance within the sample with regards to how often participants felt they got 'enough' sleep. These disparate findings observed with the two sleep deprivation variables may reflect the

superior ability of perceived insufficient sleep to capture variability in sleep need across participants. This idea is consistent with other studies that note marked variance in sleep need within adolescent populations (e.g. Mercer et al., 1998). The question "How often do you get enough sleep?" which comprised the perceived insufficient sleep variable may also have captured a more holistic image of sleep deprivation. In line with ideas presented in Liu et al. (2017), subjective sleep sufficiency as a variable may be a more valid measure of sleep deprivation than self-reported sleep duration, as one's response to the question is likely to be informed by many aspects of the subjective sleep experience, including sleep duration, unrefreshed sleep, daytime sleepiness, and perceived sleep quality.

The association between sleep deprivation (measured by perceived insufficient sleep) and emotion dysregulation found in this study is highly consistent with extant research linking sleep deprivation with poor emotion regulation in adolescents (Gau et al., 2007; Schmidt & Van der Linden, 2015; Talbot et al., 2010; Xianchen, 2004). Though we cannot assess directionality due to the cross-sectional design of the current study, our findings are in line with those of Baum and colleagues (2014) who demonstrated a causal link between restricted sleep and emotion regulation difficulties. It is important to note that many (43%) of the participants in our study reported usual weeknight sleep durations at or below the level used in the 'restricted sleep' condition of the Baum et al. (2014) study (6.5 hours). Furthermore, just two (5%) participants in the our study reported attaining at least 8.8 hours sleep on school nights; the mean duration achieved in the Baum et al. (2014) study's 'healthy sleep' condition. With so many under-slept and so few well-slept participants in the current study, it is likely that the

sleep deprivation-emotion regulation relationship was more muted than it might otherwise have been.

Sleep deprivation and NSSI

As with emotion dysregulation, perceived insufficient sleep but not sleep duration was associated with NSSI engagement. Again, it is likely that sleep duration as a variable was limited by its attenuated range, its inability to account for variability in sleep need across participants, and its relatively narrow scope. Our findings here highlight insufficient sleep as a risk factor for NSSI engagement in adolescents. They are consistent with the numerous studies linking insufficient sleep to suicidality generally (Bernert et al., 2015; Bernert & Joiner, 2007; Bernert & Nadorff, 2015; Goodwin & Marusic, 2008; Gunnel et al. 2013; McCall et al., 2010; Zuromski, Cero & Witte, 2017), and with the few to date that have investigated adolescent sleep and NSSI specifically (Liu et al., 2017; Lundh et al., 2013).

Emotion dysregulation as a mediator of the sleep-NSSI relationship

Emotion dysregulation fully mediated the relationship between perceived insufficient sleep and NSSI engagement: this was an even stronger result than the hypothesized partial mediation. These findings suggest that sleep insufficiency has no direct relationship with NSSI, but instead confers risk by way of emotion dysregulation. Longitudinal research is required to confirm directionality of the relationships in this mediation. If sleep deprivation precedes difficulties in emotion regulation and NSSI, results would support the idea that some adolescents engage in NSSI under conditions

(such as sleep deprivation) where adaptive emotion regulation strategies are less accessible to them.

In sum, this study contributes to a nascent body of research identifying sleep deprivation as an important risk factor for NSSI in adolescents. To the best of our knowledge, it is among the first to provide insight into the nature of the relationship between sleep deprivation and NSSI: sleep deprivation appears to confer risk by making emotion regulation more difficult, though further research is needed to confirm directionality. Findings are tempered by several limitations, but remain valuable in their potential to inform future research on the sleep-NSSI relationship and emotion dysregulation as a mechanism in this relationship.

Limitations

Results of the present study should be considered with the following limitations in mind. First, due to the cross-sectional study design, we were unable to assess whether changes in the emotion regulation and/or sleep duration actually predict future NSSI, hence we could not test whether the variables are causally related. Directionality should be investigated in future studies. It is possible that relationships observed are bi-directional; that is, emotion dysregulation that precipitates NSSI may also cause sleep disturbances. However, longitudinal research suggests that even short periods of mildly restricted sleep cause emotion dysregulation and mood disturbance (Baum et al., 2014), and research on internalizing disorders such as anxiety and depression suggest that sleep disturbances precede the onset of psychopathology (Breslau, Roth, Rosenthal, & Andreski, 1996; Ford & Kamerow, 1989; Johnson et al., 2006; Schmidt &Van der Linden, 2015; Willis & Gregory, 2015). Recent work on insomnia and SITBs further

supports the directionality proposed in this study: in a community sample (n =589) of adults who endorsed a lifetime history of suicidality (ideation, plan or attempt), higher levels of insomnia were found to drive increased suicide ideation over a 15-day period, but suicide ideation exerted no effects on insomnia symptoms (Zuromski et al., 2017).

A second limitation concerns the study's small sample size. We were not adequately powered to test whether these effects remained when controlling for depressive symptoms or other potential confounding variables. Because depression is related to both sleep issues and emotion regulation, and prior work shows a relationship between depression and NSSI, it is possible that our findings reflect a mechanism occurring within a larger issue relating to depression. While it is important to replicate this study with a large, representative sample that would allow depression to be controlled for, the current study's implication that promoting healthy sleep and adaptive emotion regulation may reduce NSSI in adolescents remains relevant, as these interventions are likely to also improve depressive symptoms.

A third limitation relates to the generalizability of our findings: our sample was recruited from the urban environment of metropolitan New York City, and therefore the results may not represent all adolescent populations. Indeed, our sample exhibited an attenuated range in the sleep duration variable such that our sample reported getting significantly less sleep than the general adolescent population. This may have led to more muted results than may have been attained from a larger, more representative sample.

Future Directions

This study suggests sleep deprivation is a variable risk factor for NSSI. It lays the foundation for longitudinal research to confirm directionality and, if the proposed

directionality is supported, for intervention studies to investigate whether sleep deprivation is a *causal* risk factor. This could involve manipulating (i.e. treating) sleep deprivation (e.g. though sleep-hygiene training or CBT-I) and measuring the subsequent effects on emotion dysregulation and NSSI.

In addition to confirming causality in the established relationship, future research should further investigate the specific components of emotion dysregulation. Emotion regulation is a multi-dimensional construct; it comprises both awareness and understanding of emotional responses, as well as the ability to act in desired ways and refrain from acting in undesired ways when experiencing negative emotions. It may be that specific dimensions of emotion dysregulation are more susceptible to the deleterious effects of sleep deprivation than others. Likewise, some dimensions may be more relevant to NSSI than others. For example, DERS dimensions (d) *limited access to emotional regulation responses perceived as effective*, and (e) *difficulties controlling impulses when experiencing negative emotions* may be particularly relevant to NSSI, as emotion regulation is frequently endorsed as a function of NSSI, either to reduce or distract from negative emotions, or to generate feeling or sensation when experiencing numbness or anhedonia (Nock 2009). Additionally, individuals often report experiencing intense urges to engage in NSSI that are difficult to suppress when emotionally distressed (Bresin, Carter & Gordon, 2013; Chapman, Gratz, & Brown, 2006; Nock, 2009). Perhaps by strengthening specific aspects of emotion regulation in adolescents through targeted interventions we can help to protect them against the effects of sleep deprivation. Indeed, protective factors must exist – the rate of normative sleep deprivation exceeds NSSI incidence and many sleep-deprived adolescents do not exhibit clinical levels of

psychopathology. Studying adolescents who remain resilient in the face of sleep deprivation could help us to identify these factors and develop interventions to develop them in others.

Along these lines, the findings of this study could also be used to develop interventions that bolster adaptive coping mechanisms that might compensate for the effects of sleep deprivation and protect against NSSI in situations where 'more sleep' is simply not an option. High quality social support, for example, has been shown to mediate the relationship between stress and sleep disturbance (Van Schalkwijk, Blessinga, Willemen, Van Der Werf & Schuengel, 2015). Additionally, regular aerobic exercise is associated with coping self-efficacy in the face of stressors or negative mood (Craft, 2015; Kishida & Elavsky, 2014). And recent studies show that even a single session of moderate exercise can benefit subjective emotional recovery and attenuate negative emotions for individuals experiencing emotion regulation difficulties (Bernstein & McNally, 2017a; Bernstein & McNally, 2017b).

In addition to informing future research directions, findings from this study may help improve youth vulnerability screening, as well as prevention and treatment efforts designed to help young people. A single item assessing subjective sleep sufficiency could improve existing screening tools used to identify adolescents at risk for NSSI. Interventions for at risk adolescents could occur at the level of the individual with sleep-focused therapies such as Cognitive Behavioral Therapy for Insomnia (CBT-I; Morin et al., 2006; Palermo et al., 2016), or at the community level through public health education for parents and adolescents, communicating the dangers of insufficient sleep and the importance of good sleep hygiene, and offering potential solutions to the

problems raised. For example, there is some evidence to suggest adolescents benefit from early set bedtimes. Indeed, research shows late bedtime contributes to increased risk behaviors in adolescents (McGlinchey & Harvey, 2015), and parent-enforced bedtimes of 10pm or earlier are associated with lower levels of adolescent depression and suicide ideation (Gangwisch et al., 2010). Of course, enforcing early sleep may be easier said than done; many adolescents suffer sleep phase delays, and prescribing early bedtimes may serve only to increase sleep onset latency.

Another way to communicate the importance of sufficient sleep is through sleep education programs in schools. Unfortunately, research of existing programs suggests they are limited in their effectiveness. It appears adolescents understand the messages conveyed but fail to translate those messages into actual behavioral changes such as increased sleep duration or improved sleep hygiene (Bluden, Chapman & Rigney, 2012). It seems a more systemic solution may be required. For example, one potential solution that is strongly supported by prominent researchers in the field is later school start times. This change would enable adolescents to sleep their delayed circadian phases to completion. Indeed, communities with late-starting school days enjoy more positive outcomes regarding aspects of adolescent wellbeing relative to their early-starting counterparts (e.g. Kelley, Lockley, Foster & Kelley, 2014; Vorona et al., 2011).

Conclusion

This study examined the relationships between sleep deprivation, emotion dysregulation and NSSI in a community sample of US adolescents. The data partially supports the hypothesis that sleep deprivation is related to NSSI via emotion dysregulation in that perceived insufficient sleep, but not short sleep duration, was

uniquely associated with both emotion dysregulation and NSSI, and emotion regulation fully mediated the perceived insufficient sleep-NSSI relationship. These results emphasize that insufficient sleep, or at least the perception of insufficient sleep, is an important contributor to NSSI vulnerability among youth. Given the significant association between perceived insufficient sleep and NSSI, and the mediating role of emotion dysregulation, future research should confirm directionality and investigate whether specific components of emotion regulation have more impact on the relationship. This would help those who work with adolescents to improve their sleep education efforts, vulnerability screenings, and treatment interventions to further reduce NSSI engagement. Despite constraints of the neurodevelopmental changes driving circadian phase delays in adolescents, there is potential for psychosocial and behavioral interventions to have an important impact on the relationship between sleep deprivation, emotion regulation, and NSSI.

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