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Difficult to Bed and Difficult to Rise: Complex Interplay among ADHD, Sleep, and Adolescence

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Interest in understanding the association between attention-deficit/hyperactivity disorder (ADHD) and sleep is nothing new. In fact, restless sleep was a symptom criterion for attention deficit disorder in the Third Edition of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-III) (American Psychiatric Association, 1980), and the negative impact of inadequate or insufficient sleep on attentional functioning has likewise been noted for some time (Dahl, 1996; Douglas & Peters, 1979). Despite the large body of research examining sleep and ADHD, our understanding of this association is far from being put to bed, so to speak. Recently, research has shifted away from simply documenting differences in sleep functioning between individuals with and without ADHD, which while important (Cortese, Faraone, Konofal, & Lecendreux, 2009; De Crescenzo et al., 2016), does little to inform our understanding of the causes, correlates, and consequences of these sleep difficulties (Cortese et al., 2013; Kirov & Brand, 2014; Owens et al., 2013). An emerging body of research using longitudinal methodologies (Becker, Langberg, & Evans, 2015; Gregory, Agnew-Blais, Matthews, Moffitt, & Arseneault, 2016; Langberg, Dvorsky, Becker, & Molitor, 2014; Lycett, Mensah, Hiscock, & Sciberras, 2014; Mulraney, Giallo, Lycett, Mensah, & Sciberras, 2016) is revealing that the associations between sleep and ADHD are complex, and that the clinical implications of sleep difficulties in individuals with ADHD likely varies across development.

To date, the vast majority of studies examining sleep and ADHD have focused on school-aged children, with few studies conducted in adolescents with ADHD (see Lunsford-Avery, Krystal, & Kollins, 2016, for a review). This is surprising since the combination of sleep and adolescence has been described as “the perfect storm” (Carskadon, 2011). A developmental psychopathology framework is needed to advance our understanding of the complex interplay among ADHD, sleep, and adolescence (Becker, Langberg, & Byars, 2015). Risk factors for sleep problems and the consequences of comorbid sleep problems and ADHD likely differ markedly between early childhood and adolescence, given decreases in parental involvement and influence and increases in demands associated with school academic and extracurricular responsibilities. Currently, little is known about

the impact of sleep functioning on academic, social, and emotional impairments in teens with ADHD. We likewise know little about risk factors that contribute to sleep problems in teens with ADHD, and identifying such factors is critical for informing prevention and intervention work in this area. In this article we briefly review the prevalence of sleep problems in adolescents with and without ADHD. We then describe likely risk factors that contribute to sleep difficulties during the adolescent period, as well as functional consequences of sleep difficulties combined with ADHD.

Prevalence of Sleep Problems in Adolescence

Sleep problems in adolescence are quickly becoming recognized as an international public health concern (Gradisar, Gardner, & Dohnt, 2011). In the United States, data from the National Survey of Children's Health shows that the prevalence of sleep problems has increased significantly over the past 15 years, with 10-16% of youth currently exhibiting serious sleep problems (Singh & Kenney, 2013). Frequently occurring problems include poor sleep quality (e.g., waking up multiple times during the night), inadequate sleep duration (i.e., fewer hours slept), and daytime sleepiness (i.e., feelings of tiredness during the day). Strictly defining sleep in terms of duration, approximately 60% of middle school students sleep less than the recommended 9 hours per night on school nights and this figure rises to 95% by the end of high school (National Sleep Foundation, 2006). Further, 25% of high school students report regularly falling asleep in class and 22% report regularly falling asleep while completing homework (National Sleep Foundation, 2006). Similarly, Shinkoda and colleagues (Shinkoda, Matsumoto, Park, & Nagashima, 2000) found that a significant reduction in sleep duration occurred around 7th grade, and that the percentage of students falling asleep during school significantly increased from 8th to 12th grade.

Teens with ADHD are especially susceptible to sleep problems, irrespective of medication use. Sleep problems are considerably more common in individuals with ADHD in comparison to the general population, with approximately 30% of children and 60% of adults exhibiting significant sleep problems (Yoon, Jain, & Shapiro, 2012). Reviews of the literature document that a diagnosis of ADHD is associated with a wide-range of sleep problems but is most consistently linked with inadequate sleep duration, poor sleep quality, and daytime sleepiness

(Cortese et al., 2009; Gruber, 2009). However, the few studies examining sleep difficulties in teens with ADHD specifically have reported mixed findings. For instance, one large study found that teens with ADHD had more sleep problems and sleep disorders, as well as more inadvertent daytime napping, compared to peers without ADHD (Chiang et al., 2010; Gau & Chiang, 2009). In contrast, another study that included 14 adolescents diagnosed with ADHD Combined Type did not find any differences in comparison to a sample of 21 control adolescents (Mullin, Harvey, & Hinshaw, 2011). It is important to note that the methods for assessing both ADHD (e.g., parent-report of previous diagnosis vs. careful diagnosis based on DSM criteria) and sleep problems (e.g., self-report vs. parent-report vs. actigraphy; behavioral vs. organic sleep difficulties) has varied widely across the extant studies, making it likely that the mixed findings reported in the literature to date might be, at least in part, due to sampling and measurement/diagnostic differences (Weiss et al., 2013). A recent study that included both parent and self-report ratings in a sample of 262 adolescents with ADHD found that the prevalence of sleep problems varied widely depending on the type of difficulty (Langberg, Molitor et al., in press). Daytime sleepiness was by far the most common sleep difficulty in the sample, with approximately 40% of adolescents above the clinical threshold according to both parent and adolescent report. In contrast, prevalence rates for specific nighttime sleep problems ranged from approximately 1-8% (Langberg, Molitor et al., in press). Overall, given the high rates of sleep problems in adolescence generally, it remains unclear if adolescents with ADHD experience sleep difficulties at a markedly higher degree than their peers and, if so, which domains of sleep are particularly disrupted in teens with ADHD. Specifically, sleep is a multifaceted construct including multiple distinct organic and behavioral nighttime problems (e.g., bedtime resistance, sleep onset latency, obstructive sleep apnea) and potentially associated daytime difficulties (e.g., sleepiness and fatigue). It is currently unknown which specific domains of sleep are impaired in adolescents with ADHD and whether these are the same domains as typically developing teens. This type of information is needed before intervention development can begin.

It is also important to note that while stimulant medication may exacerbate some sleep difficulties (e.g., sleep onset latency) in youth with ADHD (Kidwell, Van Dyk, Lundahl, & Nelson,

2015), the high prevalence of sleep problems in youth with ADHD cannot be wholly – or even primarily – attributed to stimulant medication use. Indeed, the Cortese et al. (2009) meta-analysis documenting more sleep problems in youth with ADHD compared to youth without ADHD excluded studies that had pharmacologically-treated participants. Further, a recent study found that a subset of children with ADHD with pre-existing sleep problems experienced improved sleep functioning after initiating medication treatment (Becker, Froehlich, & Epstein, 2016), though this possibility has yet to be examined in adolescents with ADHD specifically.

The sleep patterns of youth with ADHD may be unique. There is some indication that youth with ADHD have different sleep patterns than their peers. Although a complete review of these differences is beyond the scope of this paper, we highlight a few of the main differences here. First, there are significant differences between youth with ADHD and typically developing children in the developmental trajectory of rapid eye movement (REM) sleep. Specifically, prior to age 10, youth with ADHD display less REM sleep than their peers, but this trend reverses around the transition to middle school, and adolescents with ADHD display significantly more REM sleep than age-matched controls (Kirov & Brand, 2014). Second, children with ADHD appear to have a stronger circadian evening preference (i.e., biological bent to stay up late) in comparison to their peers (Gruber et al., 2012), though this too remains to be examined in adolescents specifically when circadian preferences markedly shift for all youth (Hagenauer, Perryman, Lee, & Carskadon, 2009). Third, youth with ADHD exhibit significantly higher intraindividual variability of sleep in comparison to their peers (Becker, Sidol, Van Dyk, Epstein, & Beebe, 2016). This greater sleep variability may be attributed to environmental factors such as parental structure and routine and conflict surrounding homework leading to increased frequency of “problematic nights” with delayed bedtime and sleep onset (Moreau, Rouleau, & Morin, 2014). In sum, although additional research is needed, it seems likely that the sleep patterns and problems of youth with ADHD are different than typically developing youth and, as such, that predictors of these problems and the association between these problems and adjustment difficulties may also differ for adolescents with and without ADHD.

Risk Factors Contributing to Sleep Problems

In order to fully understand the impact of sleep problems on the functioning of individuals with ADHD, it is critical to also examine risk factors that contribute to the presence of sleep problems. This is a particularly neglected area of research as related to adolescents with ADHD. To the best of our knowledge, our study demonstrating that school maladjustment and internalizing symptoms longitudinally predict daytime sleepiness in college students with ADHD is the only longitudinal study completed to date examining predictors of sleep functioning in adolescents with ADHD (Langberg, Dvorsky, Becker, & Molitor, 2016). This is noteworthy because it seems likely that certain predictors of sleep problems, although likely relevant for all students, are particularly salient for adolescents with ADHD and may mediate the association between ADHD and sleep. These factors include comorbid mental health concerns, family factors, and school-related factors. All of these factors are highly common in adolescents with ADHD (Spruyt & Gozal, 2011) and are discussed next as risk factors that may at least partially account for the occurrence of sleep problems.

Co-occurring mental health difficulties. Comorbid mental health problems are highly prevalent among adolescents with ADHD, with approximately one-third of adolescents with ADHD meeting criteria for a comorbid anxiety disorder and up to half meeting criteria for a comorbid disruptive behavior disorder (i.e., oppositional defiant disorder [ODD] or conduct disorder [CD]) (Smalley et al., 2007). Several recent studies (Accardo et al., 2012; Hansen, Skirbekk, Oerbeck, Richter, & Kristensen, 2011; Hansen, Skirbekk, Oerbeck, Wentzel-Larsen, & Kristensen, 2013) have found that youth with comorbid ADHD and internalizing problems (i.e., anxiety, depression) have more sleep problems than youth with ADHD alone, including greater daytime sleepiness in addition to shorter sleep duration and more frequent night wakings. For example, Moreau and colleagues (2014) found that youth with comorbid ADHD and anxiety had the longest sleep onset delay, shortest sleep duration, and greatest daytime sleepiness in comparison to typically developing youth or youth with ADHD alone. In addition, Sung et al. (Sung, Hiscock, Sciberras, & Efron, 2008) found comorbid conduct problems to be a strong predictor of sleep problems in youth with ADHD. Interestingly, one study found that children with ADHD who had co-occurring internalizing *and* externalizing problems were most likely to have moderate/severe sleep problems (Lycett, Sciberras, Mensah, & Hiscock,

2015). Finally, there has recently been interest in the extent to which sluggish cognitive tempo (SCT) symptoms – characterized by daydreaming, mental confusion, lethargy, and even sleepiness itself – relate to sleep functioning. In two studies of college students, we found SCT to be distinct from, yet strongly related to, daytime sleepiness (Becker, Luebbe, & Langberg, 2014; Langberg, Becker, Dvorsky, & Luebbe, 2014). We also found SCT to be associated with poorer sleep quality and more nighttime sleep disturbances (e.g., night wakings, having bad dreams), even after controlling for ADHD symptoms (Becker et al., 2014). Still, more research is needed to thoroughly examine the extent to which SCT is a contributor or consequence of sleep difficulties and whether this association exists above and beyond internalizing symptoms of anxiety/depression. Overall, research is largely consistent in pointing to comorbid conditions as a potential risk factor for sleep problems in adolescents with ADHD. However, it is important to acknowledge that most of these studies were cross-sectional and directionality remains unclear.

Family factors. Family factors may also contribute to the sleep problems of adolescents with ADHD. Families of youth with ADHD often exhibit high rates of conflict, and parents of adolescents with ADHD describe their family environments as being less organized and structured (Schroeder & Kelley, 2009). Importantly, parents of adolescents with ADHD are less likely to provide consistent and clear structure surrounding house-rules and routines such as bedtime (Deault, 2010), and adolescents without consistent parent-set bedtimes obtain less sleep and have greater daytime sleepiness than adolescents with parent-set bedtimes (National Sleep Foundation, 2006; Noble, O'Laughlin, & Brubaker, 2012; Short et al., 2011). Moreover, recent research has documented that adolescents without parent-set and enforced bedtimes are significantly more likely to stay-up late using technology, such as computers and phones (Cain & Gradisar, 2010; Calamaro, Mason, & Ratcliffe, 2009). Accordingly, it is likely that parental monitoring, structure, and parent-adolescent conflict are each important contributors to the night-to-night sleep variability and overall sleep problems of adolescents with ADHD.

Homework problems. A significantly higher percentage of youth with ADHD experience homework difficulties in comparison to typically developing youth (74% and 28%, respectively)

(Coghill et al., 2008). Adolescents with ADHD are more likely than their peers to fail to bring home assignments, not know what was assigned, and procrastinate in completing work (Langberg et al., 2010; Power, Werba, Watkins, Angelucci, & Eiraldi, 2006). Further, when completing homework, adolescents with ADHD often have difficulty staying on-task and rush through and make careless mistakes (Power, Karustis, & Habboushe, 2001). Importantly, parents report that most of these difficulties are concentrated during the late afternoon and evening hours leading up to bedtime (Coghill et al., 2008). Further, homework difficulties and conflict surrounding homework and studying likely contributes to the night-to-night variability in sleep functioning (e.g., bedtime, sleep onset delay) observed in youth with ADHD (Hvolby, Jorgensen, & Bilenberg, 2008; Moreau et al., 2014). Research in community samples has demonstrated that a single instance of staying-up late to study during the week can have a negative impact on functioning in school the next day (Gillen-O'Neel, Huynh, & Fuligni, 2013). Considering the frequency with which adolescents with ADHD experience significant homework problems, homework management and completion difficulties are likely significant risk factors for sleep problems in teens with ADHD.

Sleep Problems Adversely Impact Adolescent Functioning

Academic functioning. Reviews of the literature clearly document that sleep problems negatively impact academic functioning (Becker, Langberg, & Byars, 2015; Shochat, Cohen-Zion, & Tzischinsky, 2014). The impact of sleep problems and poorer academic functioning has been documented using both naturalistic and experimental studies (Astill, Van der Heijden, Van Ijzendoorn, & Van Someren, 2012), though such studies have not been conducted in teens with ADHD specifically. Another important caveat is that most of the research on sleep and academic functioning completed to date (in either ADHD or non-ADHD samples) has been cross-sectional.

To begin to address these gaps in the literature, we recently published two studies evaluating the association between sleep – and daytime sleepiness specifically – on the academic functioning of adolescents with ADHD. In the first study which used a cross-sectional design, 100 middle school students (ages 10-14 years) diagnosed with ADHD reported on the average number of hours they typically sleep each night as well as their levels of daytime sleepiness (Langberg, Dvorsky, Marshall,

& Evans, 2013). Of note, youth-reported daytime sleepiness was significantly correlated with a range of academic outcomes, including grade point average (GPA) and parent- and teacher-rated academic difficulties, whereas youth-reported hours slept was not. Furthermore, daytime sleepiness remained significantly associated with poorer parent- and teacher-rated academic functioning (but not GPA) after controlling for ADHD inattention severity (Langberg et al., 2013).

The second study built on these initial findings by examining daytime sleepiness as a longitudinal predictor of academic performance in a sample of 62 college students ($M_{\text{age}} = 19.5$) who were rigorously diagnosed with ADHD (Langberg, Dvorsky, et al., 2014). Daytime sleepiness assessed in the beginning of the academic year significantly predicted school difficulties and overall functional impairment assessed at the end of the academic year, even after accounting for sex and both parent- and self-reported ADHD symptom severity. Further, as in the study conducted with middle school students, daytime sleepiness did not significantly predict GPA, although daytime sleepiness was a significant predictor of the number of D and F grades received (Langberg, Dvorsky et al., 2014). Although more work is certainly needed examining other domains of sleep functioning, emerging research points to daytime sleepiness as an important contributor to the academic performance of teens with ADHD.

Mental health functioning. As noted above, co-occurring mental health difficulties are common in teens with ADHD (Smalley et al., 2007). Studies examining co-occurring mental health symptoms as a predictor of sleep functioning were reviewed above, and so we only briefly comment here on the only study we are aware of that has examined whether sleep problems predict later mental health adjustment in adolescents with ADHD. Specifically, we examined the one-year prospective association between sleep problems and internalizing and externalizing mental health symptoms in a sample of 81 young adolescents (ages 10-14 years at baseline) carefully diagnosed with ADHD (Becker, Langberg, & Evans, 2015). Parents reported on ODD symptoms and general externalizing behaviors at baseline and one year later, and teens provided ratings of anxiety and depression at both timepoints. We found that sleep problems predicted greater ODD and externalizing behaviors as well as depressive symptoms one year later, even after accounting for initial levels of

these externalizing and internalizing symptoms as well as demographic characteristics and ADHD symptom severity (Becker, Langberg, & Evans, 2015). This study provides preliminary evidence that the association between sleep and comorbidity is likely bi-directional and shows that longitudinal research is needed to truly determine whether comorbidity is a risk factor that leads to the development of sleep difficulties in teens with ADHD.

Social functioning. Few studies have examined the link between sleep problems and adolescents' interpersonal functioning. Indeed, despite the significant social difficulties experienced by adolescents with ADHD (Bagwell, Molina, Pelham, & Hoza, 2001; Gardner & Gerdes, 2015), we are unaware of any study that has examined whether sleep functioning contributes to or exacerbates the social difficulties of teens with ADHD. Studies conducted in non-ADHD samples indicate that youth-reported sleep problems are associated with greater peer rejection, less social acceptance, increased loneliness, and poorer friendship satisfaction (Becker, 2014; Gregory & Sadeh, 2012). Similarly, adolescents with sleep problems report experiencing more loneliness than adolescents without sleep problems (Xu et al., 2012), though there is some indication that this association may be specific to early- and mid-adolescence (Mahon, 1994). In a 12-month longitudinal study, Roberts et al. (Roberts, Roberts, & Chen, 2002) found that youth with high levels of sleep problems experienced greater problems in their family and peer relationships, as well as less social support, even after controlling for initial levels of social functioning/support. Most recently, Sarchiapone et al. (2014) reported that reduced school night sleep duration was associated with greater self-reported peer problems in a sample of 11,788 youth drawn from 11 European countries. It cannot be assumed that these findings will also emerge in studies of adolescents with ADHD who often experience interpersonal difficulties for other reasons (e.g., impulsivity, social skills deficits). However, it seems likely that sleep problems may contribute to, or compound, existing difficulties with social adjustment in adolescents with ADHD. For example, it is possible that teens with ADHD who experience peer rejection and isolation in turn experience low social support and increased loneliness which contribute to sleep difficulties. Alternatively, it is possible that some teens with ADHD develop deviant peer affiliations that contribute to alcohol and substance use or delinquent behaviors (Marshal, Molina, & Pelham, 2003), which may

in turn impact sleep stability, sleep quality, and sleep duration.

Future Directions: Toward a Developmental Psychopathology Approach

Although an interest in the association between ADHD and sleep is not new, the time has come for evaluating and understanding this association within a developmental psychopathology framework (Becker, Langberg, & Byars, 2015). This first and foremost requires evaluating any association between ADHD and sleep within the developmental context in which it arises. In addition, a variety of research designs and methods will be need to be utilized. In terms of research designs, both experimental and longitudinal studies are sorely needed. Experimental research is best-suited for drawing *causal* inferences, and experimental studies evaluating the impact of sleep restriction on neurobehavioral and emotional functioning have been conducted in children with ADHD (Gruber et al., 2011) and teens without ADHD (Baum et al., 2014; McMakin et al., 2016) but have yet to be conducted in teens with ADHD. Such studies are required if conclusions are to be drawn regarding sleep duration (or other sleep indices) being causal contributors to impairment in teens with ADHD. In contrast to experimental studies, longitudinal studies are well-suited for drawing conclusions regarding *developmental trajectories*. For example, longitudinal studies that employ multiple assessment points are highly useful for examining moderators (i.e., modifiers) and mediators (i.e., mechanisms) of associations, as well as bidirectional associations and developmental cascades. For instance, longitudinal research is needed to determine if comorbid internalizing symptoms primarily contribute to sleep problems, or are a consequence of sleep problems in teens with ADHD, or if internalizing symptoms and sleep problems are bidirectionally associated. To complicate things further, it is possible that anxiety specifically contributes to sleep difficulties, which in turn contributes to depressive symptoms (Johnson, Roth, & Breslau, 2006). In partial support of the importance of distinguishing between anxiety and depression, the one-year longitudinal study of sleep in adolescents with ADHD described above found sleep problems to predict depressive symptoms over time but not anxiety symptoms (Becker, Langberg, & Evans, 2015). The combination of experimental and longitudinal research would be highly informative in advancing our understanding the interrelations of sleep and ADHD, both causally and over time.

As noted above, although there is indication that individuals with ADHD, including teens with ADHD, experience more sleep problems than their peers, the research is far from conclusive with respect to which specific sleep problems they may exhibit. Studies are needed that carefully evaluate whether specific sleep problems are different in teens with and without ADHD, as well as whether predictors and consequences of these difficulties differ. Such differences are often assumed, but have not been empirically tested. Furthermore, it needs to be evaluated whether any associations with sleep are specific to ADHD as opposed to psychopathology more broadly. It is plausible that associations between ADHD and sleep are nonspecific and instead speak to the transdiagnostic importance of sleep functioning (Harvey, Murray, Chandler, & Soehner, 2011). There is also certainly a need to examine possible differences in sleep physiology and circadian preference between adolescents with and without ADHD (Lunsford-Avery et al., 2016), and whether differences vary over time.

Finally, we acknowledge that in this article we focused on only a few exemplars as likely predictors and consequences of sleep problems in teens with ADHD. We chose these examples based on the extant literature and key issues faced by teens with ADHD and their families. Nonetheless, sleep disturbances have been linked to a wide range of functional impairments (e.g., suicidal ideation, substance use, risk-taking behaviors) as well as biological mechanisms (e.g., default mode network) not reviewed herein. These and other domains are all worth theoretical and empirical attention. Toward this end, several studies are ongoing (primarily, to our knowledge, in the Australia, England, and the United States) using experimental and longitudinal designs to answer important questions pertaining to the interrelations of sleep and ADHD. We are hopeful that these studies will provide much-needed insight into the causes, correlates, and consequences of sleep in adolescents with ADHD, which in turn should inform prevention and intervention guidelines and strategies for youth with ADHD during this crucial developmental period.

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