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Sleep Habits in Children with Attention-Deficit/Hyperactivity Disorder Predominantly Inattentive Type and Associations with Comorbid Psychopathology Symptoms

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Abstract

Objectives—Much of what is currently known about the sleep functioning of children with attention-deficit/hyperactivity disorder (ADHD) is based on samples of children with ADHD Combined Type, and no study to date has examined the association between sluggish cognitive tempo (SCT) and sleep functioning in children diagnosed with ADHD. Accordingly, the objectives of this study were to (1) describe the sleep habits of children diagnosed with ADHD Predominantly Inattentive Type (ADHD-I), and (2) examine whether comorbid internalizing, oppositional, and/or sluggish cognitive tempo (SCT) symptoms are associated with poorer sleep functioning in children with ADHD-I. This study extends the current literature by using a large, clinical sample of children with ADHD-I to examine the association between SCT and other psychopathology symptoms with children's sleep functioning.

Methods—Participants were 147 children (ages 6–11; 59% male; 55% White) diagnosed with ADHD-I using a semi-structured diagnostic interview. Parents completed measures assessing their child's sleep habits as well as comorbid anxiety, depression, oppositionality, and SCT symptoms.

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Results—Fourteen percent of children obtain less sleep than recommended and 31% have a sleep onset latency of greater than 20 minutes. The few children taking medication for ADHD had a longer sleep onset latency than unmedicated children. Twenty-seven percent of parents indicated that it is “difficult” to get their child out of bed on school days and 41% of parents indicated that their child needs to catch-up on sleep on the weekend “at least a little”. Regression analyses found anxiety and SCT sleepy/tired symptoms to be the most consistent dimensions of psychopathology associated with sleep functioning, with little support for depression or oppositionality being associated with sleep.

Conclusions—A sizeable minority of children with ADHD-I experience impaired sleep. Comorbid anxiety, in addition to SCT sleepy/tired symptoms, were most consistently associated with poorer sleep functioning in children with ADHD-I. Importantly, SCT daydreaming and SCT working memory symptoms were unassociated with sleep functioning, and the size of the effects between SCT sleepy/tired and sleep functioning indicates that these are not overlapping constructs. Longitudinal studies are needed to evaluate the interrelations of sleep problems and comorbid psychopathology symptoms and their impact on the daytime functioning of children with ADHD-I.

Keywords

ADHD predominantly inattentive type; attention-deficit/hyperactivity disorder; comorbidity; sleep; sluggish cognitive tempo; subtypes

1. Introduction

There has been increasing interest in the sleep functioning of children with Attention-Deficit/Hyperactivity Disorder (ADHD) as an important area for research and clinical attention^{1–4}, particularly given that treated and untreated children with ADHD display more sleep problems than their typically developing peers⁵. For example, a meta-analysis found that children with ADHD experience a range of sleep difficulties to a greater extent than children without ADHD, including longer sleep onset latency, greater daytime sleepiness, less sleep efficiency, and more night wakings⁶.

1.1. Sleep Functioning in Children with ADHD Predominantly Inattentive Type

Of studies conducted to date that have examined the sleep functioning of children with ADHD, the vast majority have used samples where all^{7–9} or the majority^{10–14} of children were diagnosed with ADHD Combined Type (ADHD-C). Thus, much of what we currently know about the sleep functioning of children with ADHD is based on samples of children with ADHD-C. Although less is known about the relationship between ADHD subtype or presentation and sleep functioning^{12,15–18}, a growing body of research suggests that individuals with ADHD-I may display greater daytime sleepiness than individuals with ADHD-C^{16,19,20}. In a sample of 130 adolescents (aged 10–17 years, $M_{age} = 12.91$) with ADHD-I, Chiang et al.¹⁸ found that adolescents with ADHD-I had more sleep disturbances than adolescents without ADHD. However, this study with adolescents and may not be comparable to children with ADHD-I given the differences in sleep habits in children and adolescents^{21,22}. Thus, sleep habits and functioning needs to be examined in children with

ADHD-I specifically. Moreover, important moderators such as comorbid psychopathology symptoms have not been extensively studied in children with ADHD-I.

1.2. Comorbidity and Sleep Functioning in Children with ADHD

Children with ADHD are at increased risk for co-occurring oppositionality, anxiety, and depression^{23,24}. Since these psychiatric symptoms are themselves associated with sleep problems in youth²⁵, several studies have examined the interplay between sleep problems and psychiatric comorbidity in youth with ADHD^{26–29}. However, we are aware of only one study to date that has examined the degree to which comorbid psychiatric symptoms are associated with sleep functioning in children with ADHD-I specifically¹⁶. In this study of 816 children with and without ADHD (ages 6–16), Mayes et al.¹⁶ found that children with ADHD-I who had a comorbid internalizing disorder ($n = 42$) had more sleep problems than children with ADHD-I alone ($n = 144$)¹⁶. Anxiety symptoms may be especially detrimental to the sleep functioning of children with ADHD^{14,30}. It is less clear if externalizing behaviors such as oppositionality are associated with sleep functioning in children with ADHD^{16,17,31–33}.

In addition, a largely separate literature has examined sluggish cognitive tempo (SCT) symptoms among individuals with and without ADHD. Characterized by symptoms such as seeming to be “in a fog,” mental confusion, drowsiness, and excessive daydreaming³⁴, it was initially hypothesized that SCT symptoms may be useful for identifying children with “pure” ADHD-I who displayed few if any symptoms of hyperactivity-impulsivity^{35–37}. However, an increasing number of studies demonstrate that SCT is both statistically distinct from ADHD and also uniquely associated with functional impairment^{34,38,39}. However, given the symptoms associated with SCT, such as lethargy, daydreaming, and slowed/sleepy behavior, it is not surprising that a link between SCT and sleep functioning (and daytime sleepiness particularly) has been proposed, as well as the possibility that SCT may simply be a proxy for, or redundant with, sleep problems^{6,40}. Until recently, however, no empirical studies had directly examined the link between SCT and sleep functioning. To date, three studies conducted with adults have examined the association between SCT and sleep. First, Langberg and colleagues⁴¹ found SCT and daytime sleepiness to be statistically distinct but highly correlated ($r = .50$) in college students with and without ADHD. In another college student sample, SCT and ADHD inattention were both associated with daytime sleepiness, but SCT (and not inattention) was also significantly associated with poorer sleep quality and increased nighttime sleep disturbance (e.g., having bad dreams, waking up in the middle of the night, feeling too hot or too cold while sleeping)⁴². Third, Voinescu et al.⁴³ found that adults with insomnia or likely ADHD had higher SCT scores than other adults.

Despite the importance of these three studies, they were all conducted with adults. Thus, no studies have examined the association between SCT and sleep in children with ADHD. It is critical to evaluate whether the association between SCT and sleep problems in children is so strong to suggest that these are redundant, overlapping constructs. In addition, of the adult studies described above, only one⁴¹ evaluated the contribution of anxiety and depression alongside ADHD symptoms. This is important since SCT is associated with internalizing symptoms^{44–47} and, as noted above, internalizing symptoms are themselves associated with

sleep problems in children with^{14,16} and without^{25,48,49} ADHD. In addition, since SCT may be more likely to be elevated in individuals with ADHD-I as opposed to ADHD-C^{35,50,51}, it is important to examine the degree to which SCT symptoms are associated with sleep functioning in children with ADHD-I specifically.

1.3. The Present Study

The purposes of the present study were to (1) describe the sleep functioning of children carefully diagnosed with ADHD-I, and (2) examine whether comorbid internalizing, oppositional, and/or SCT symptoms were associated with poorer sleep functioning. In line with previous research^{14,16,30,41,42}, we hypothesized that SCT symptoms and internalizing symptoms (anxiety specifically) would be associated with sleep problems in children with ADHD-I. This study extends the current literature by using a large, clinical sample of children with ADHD-I and by considering several comorbid psychopathology dimensions, including the first study to examine the association between SCT and children's sleep functioning.

2. Methods

2.1. Participants

Participants were 147 children (86 boys, 61 girls) diagnosed with ADHD-I between the ages of 7 and 11 ($M = 8.62$, $SD = 1.17$). Participants were recruited from the San Francisco Bay Area (California), and, per caregiver report, approximately half of the participants were Caucasian ($n = 81$), with the remaining children Hispanic ($n = 23$), Asian ($n = 15$), Black ($n = 7$), or multiracial ($n = 21$). All respondents were the primary caregiver, and most were mothers (91%); the remaining were fathers (8%) or others (e.g., grandparent; 1%). For ease of presentation, "parent" will be used hereafter to indicate the primary caregiver. Participants' annual family income ranged from less than \$10,000 to over \$150,000 ($M = \$85,000$; *Median* = \$101,000–\$150,000). In terms of parent education level, 79% of primary parents reported having completed college.

2.2. Procedures

Parents provided informed written consent and children provided written assent; study procedures were approved by the Institutional Review Boards at the institutions where data were collected. All children were recruited as part of a randomized controlled trial for evaluating the efficacy of a psychosocial treatment for children with ADHD-I. Only pre-intervention baseline data were used for the current study, and recruitment and diagnostic procedures have been described elsewhere⁵². Most families were recruited from schools via mailings to principals, school mental health providers, and learning specialists (65%). The remainder were recruited via mailings to offices of pediatricians, child psychiatrists, and psychologists (18%); postings in online parent networks or professional organizations (11%); or through word-of-mouth (6%). Inclusion criteria included having a primary *DSM-IV*⁵³ diagnosis of ADHD-I (based on the *Kiddie Schedule for Affective Disorders and Schizophrenia for School-Age Children* [K-SADS-PL]; see below)⁵⁴, IQ ≥ 80 (based on the *Wechsler Intelligence Scale for Children, Version IV* [WISC-IV])⁵⁵, and being between ages 7 to 11 (grades 2 to 5). Families of children who were taking non-stimulant psychoactive

medication, or planning to initiate or change medication treatment in the near term were excluded, as were children with significant developmental disorders (e.g., pervasive developmental disorder) or neurological illnesses.

To determine diagnostic status, parent and teacher ratings of ADHD symptoms and functional impairment were collected. The small number of children taking stimulant medication (4.1%; $n = 6$ [2 girls, 4 boys]) completed a one-week wash-out to assess behavior and obtain ratings off-medication. Parents were also interviewed by a licensed clinical psychologist and were asked about their child's clinical and developmental history and administered modules from the K-SADS-PL⁵⁴ assessing ADHD, oppositional defiant disorder (ODD), conduct disorder, anxiety disorders, major mood disorders, and psychoses. Children were assessed by a licensed clinical psychologist or trained clinician (under the supervision of a licensed psychologist) and completed the WISC-IV and questionnaires. All children met full *DSM-IV*⁵³ criteria for ADHD-I according to the K-SADS-PL. Twenty percent of randomly selected audio-recorded K-SADS-PL interviews were rated by an independent clinician with 100% agreement for an ADHD-I diagnosis ($\kappa = 1.0$). In addition, 6% met criteria for ODD, 7% met criteria for an anxiety disorder, and 1.5% met criteria for a depressive disorder.

2.3. Measures

2.3.1. Sleep functioning—Parents completed the *Parent Inventory of Children's Sleep Habits*, a sleep measure developed for this study and based on other measures of children's sleep habits and functioning^{56,57}. Parents indicated bedtime and wake time for their children (separately for school days and weekends), time to sleep onset, and the degree to which they felt their child had various sleep or waking difficulties. Table 1 provides additional detail on the specific sleep items included on this measure.

2.3.2. Comorbid symptoms—Parents completed two scales to assess for comorbid psychopathology. First, parents completed the CSI-4⁵⁸, a behavior rating scale that screens for *DSM-IV* disorders in school-aged children. The CSI-4 has acceptable internal consistency, test–retest reliability, and concurrent validity with other commonly used measures of children's emotional and behavioral functioning^{58,59}. Each item is rated on a 4-point scale (0 = *never*; 3 = *very often*) and mean symptom severity scores on the inattention (9 items), hyperactivity-impulsivity (9 items), ODD (8 items), generalized anxiety (7 items), and depression (12 items) scales were used in this study.

Parents also completed the *Kiddie Sluggish Cognitive Tempo (K-SCT) Rating Scale*⁴⁶. Factor analysis of the K-SCT items supports a three-factor model with daydreams (6 items; e.g., “gets lost in thought”, “mind seems to drift off”), working memory problems (5 items; e.g., “forgets what he/she was going to say”, “loses train of thought”), and sleepy/tired (4 items; e.g., “seems drowsy [during the daytime]”, “yawns”, “lacks energy”, “gets tired easily”) dimensions. These SCT dimensions showed good convergent and discriminant validity, including separability from ADHD inattention symptoms⁴⁶. Of particular relevance to the present study, the SCT sleepy/tired scale includes items assessing daytime drowsiness and underactivity/lethargy, as opposed to sleep problems per se.

2.4. Analyses

First, we examined the frequencies of items on the sleep measure in order to describe the sleep habits of children with ADHD-I. Second, zero-order correlation analyses were conducted to examine associations between demographic characteristics (i.e., age, sex, race) and psychopathology symptom domains with the sleep variables. Each psychopathology domain that was significantly bivariate correlated with at least one of the sleep variables at $p < .05$ was retained for inclusion as covariate in subsequent analyses. Finally, regression analyses were conducted to examine the unique effects of psychopathology symptoms on sleep functioning above and beyond child demographics. For all analyses, statistical significance was set at $p < .05$.

3. Results

3.1. Sleep Habits of Children with ADHD-I

Table 1 summarizes the sleep characteristics of the sample. On school nights, children's bedtime ranged from 7:00pm to 11:00pm (*Median* = 8:30pm), and bedtime shifted to be approximately an hour later on weekends (8:00pm to 11:30pm; *Median* = 9:30pm). Six percent of parents rated their child as being a "difficult sleeper", with another 20% indicating that their child was an "average sleeper". In terms of sleep quantity, 17% of parents indicated that their child does not get enough sleep, with the range of school night sleep being 7.5 to 11 hours (*Median* = 9.5). More specifically, 14% of children ($n = 20$) obtain fewer than the recommended 9–11 hours of sleep per night⁶⁰. Sleep onset ranged from 1 to 60 minutes (*Median* = 15 minutes), with one-third of children (31.3%; $n = 46$) having a sleep onset of greater than 20 minutes. In addition, 27% of parents indicated that it is difficult to get their child out of bed on school days and 41% of parents indicated that their child needs to catch up on sleep on the weekend at least a little.

Relatively few parents indicated that their child experiences extended night wakings (2% endorsed such wakings twice or more per week), early morning wakings (3% endorsed that their child wakes up at least an hour before needing to in the morning and can't fall back asleep), or extended sleep onset delay (*Median* time to fall asleep = 15 minutes). However, it is worth noting that these aspects of sleep functioning may be less readily observed by parents unless the child actually gets out of bed and alerts their parent in some way (or be more easily observed for the 12% of children who usually go to sleep in their parent(s)' bed).

In terms of electronic devices, parents reported that 47% of children had a radio in their bedroom, 16% had a television, 12% had a cell phone/telephone, 11% had a computer, and 8% had an electronic game console. Sixty-three percent of children had at least one electronic device in their bedroom.

3.2. Correlation Analyses

Correlations of child demographics and psychopathology dimensions with sleep functioning domains are displayed in Table 2. As shown, ADHD hyperactive-impulsive, ODD, and SCT working memory symptoms were not significantly associated with any of the sleep

functioning domains and were thus not considered further in the subsequent regression analyses.

ADHD inattentive symptoms were significantly associated with children being rated as “poor sleepers”, difficult to get up in the morning, and needing the weekend to catch up on sleep. SCT daydreaming was also significantly correlated with each of these sleep domains, in addition to being significantly associated with children being rated as not being alert after waking. As expected, SCT sleepy/tired was significantly associated with all of the sleep functioning domains with the exception of sleep onset latency, night wakings, and early morning wakings. Of note, although SCT was significantly associated with parent-reported sleep functioning, the magnitude of the correlations (strongest $r = .45$, meaning that SCT and sleep as measured in the current study share at most 20% of their variance) suggests that SCT sleepy/tired and sleep problems are not redundant constructs.

Similar to SCT sleepy/tired, anxiety was associated with most sleep functioning domains with few exceptions. Depressive symptoms were significantly associated only with children’s need to catch up on sleep on the weekends.

3.3. Regression Analyses

Next, regression analyses were conducted to examine the relative contribution of child demographics and psychopathology dimensions in relation to sleep functioning. Child age, sex (dichotomous), and race (dichotomous) were each entered in the model in addition to ADHD inattention, SCT daydreaming, SCT sleepy/tired, anxious, and depressive symptoms. Since SCT working memory, ADHD hyperactivity-impulsivity, and ODD symptoms were not bivariate correlated with any of the sleep functioning domains, they were not included in the regression analyses. Results are summarized in Table 3. Overall, modest support was found for an association between comorbid symptoms and sleep functioning, above and beyond demographic characteristics. SCT daydreaming was not significantly associated with sleep functioning in any of the regression models, and depressive symptoms were likewise unassociated with sleep functioning with the exception of depression being marginally associated with sleep duration and children being rated by their parent as a poor sleeper. ADHD inattentive symptoms were only associated with children being hard to wake in the morning, although it should be noted that restriction of range (i.e., all children had high levels of ADHD inattentive symptoms) may have impacted the lack of findings related to ADHD inattention.

The most consistent psychopathology symptoms associated with sleep functioning domains in children with ADHD-I were anxiety and SCT sleepy/tired symptoms. Above and beyond demographic characteristics and other psychopathologies, anxiety was significantly associated with shorter sleep duration and being a poorer sleeper and marginally associated with longer sleep onset latency and more frequent night wakings. SCT sleepy/tired was significantly associated with shorter sleep duration, being a poorer sleeper, being hard to wake in the morning, taking longer to be alert after waking in the morning, and needing to catch-up on sleep on weekends. In sum, SCT sleepy/tired and anxiety were both associated with shorter sleep duration and being rated as a poor sleeper in the regression analyses whereas SCT sleepy/tired was the sole psychopathology dimension significantly associated

with not being alert after waking in the morning and needing weekends to catch-up on sleep. Both ADHD inattention and SCT sleepy/tired were significantly associated with children being rated by their parents as difficult to wake in the morning.

3.4. Role of Medication

As noted above, only six children (4.1% of the sample) were taking medication for ADHD. Children's medication status was dummy-coded for use in analyses. Child age was significantly correlated with taking medication ($r = .21$, $p = .009$), and ODD and anxiety symptoms were also correlated with taking medication ($r_s = .20$ and $.25$, $p_s = .02$ and $.002$, respectively). Taking medication was not significantly correlated with any of the SCT dimensions ($r_s = -.001$ to $.08$, $p_s = .33 - .99$). In terms of sleep functioning, the only sleep domain associated with taking medication was sleep onset latency. Specifically, children taking medication for ADHD had a longer sleep onset ($M = 29.17$ minutes) than children not taking medication for ADHD ($M = 17.83$ minutes), $t(145) = -2.019$, $p = .045$.

4. Discussion

The purposes of this study were to describe the sleep habits of children rigorously diagnosed with ADHD-I and to examine the relative contribution of comorbid internalizing, ODD and SCT symptoms in relation to sleep functioning in a large sample of children with ADHD-I. Although sleep problems in children with ADHD have been noted for some time^{61,62} and identified as an important treatment target⁶³, most of what is known about the sleep functioning of children with ADHD is based on samples that wholly or disproportionately consisted of children with ADHD-C. This study offers an important contribution to the literature by describing the sleep habits of children with ADHD-I specifically, as well as by examining the degree to which comorbid psychopathology symptoms are related to these sleep habits.

4.1. What are the Sleep Habits of Children Diagnosed with ADHD-I?

Prevalence rates of sleep problems in studies of children with ADHD vary widely^{1,62} but this is the first study to our knowledge to specifically examine rates of sleep problems in children diagnosed with ADHD-I. Findings from this study indicate that at least a sizeable subset of children with ADHD-I experience impaired sleep. In terms of sleep duration, the range of school night sleep duration is 7.5–11 hours with the average being 9.5 hours. Thus, while the majority of children in this study obtain the recommended 9–11 hours of sleep per night⁶⁰, 14% of children with ADHD-I fall short of this target. This percentage matches very closely with 17% of parents indicating that their child does not get enough sleep. Our findings align closely with those of a previous study which found parent-reported sleep duration among unmedicated children with ADHD to be approximately 10 hours, in contrast to approximately 11 hours in children without ADHD⁶⁴. Approximately one-third of children with ADHD-I have a sleep onset greater than 20 minutes, a rate of sleep onset delay very similar to that reported in other samples of children with ADHD^{33,61}. Of note, and again consistent with some previous research^{61,65}, the few children who were taking medication for ADHD had a longer sleep onset latency than children who were not taking medication for ADHD (and while parents rated the ADHD symptom rating scale for study

inclusion when medication was washed out, the sleep measure was completed at the baseline visit when medicated children were taking their medication). In addition, 27% indicated that it is difficult to get their child out of bed on school days, and 41% of parents indicated that their child needs to catch-up on sleep on the weekend at least a little. Almost two-thirds (63%) of children with ADHD-I have at least one electronic device in their bedroom. Taken together, these figures indicate that while a good number of children with ADHD-I do not appear to have significant sleep problems, a sizeable minority do. It is thus necessary to examine correlates of sleep problems in this population.

4.2. Are Comorbid Symptoms Associated with Sleep Problems in Children with ADHD-I?

The second purpose of our study was to evaluate the degree to which comorbid psychopathology symptoms contribute to the sleep functioning of children with ADHD-I. Children with ADHD-I frequently display high rates of SCT symptoms^{35,50,51} and SCT symptoms are themselves associated with sleep problems in young adults^{41,42}. This is the first study to examine the association between SCT and sleep in children. Daydreaming has been identified as a key dimension of SCT³⁴ and in the present study SCT daydreaming symptoms were unassociated with the majority of the sleep functioning variables and in the three cases of a significant correlation (i.e., being a poor sleeper, not being alert after waking, and needed weekends to catch up on sleep), the correlations were small-to-medium effects that were all reduced to nonsignificance in regression analyses that included demographics and other psychopathology dimensions. In addition, and somewhat surprisingly, the SCT working memory problems dimension was not significantly bivariately correlated with any of the sleep functioning domains. It is important to note that the items on the SCT working memory scale are not the same as assessing working memory with laboratory tasks, and working memory as assessed with laboratory tasks has been associated with sleep problems in children with ADHD⁶⁶. It would be informative if future studies included both SCT working memory items in addition to neuropsychological working memory tests in order to further validate the SCT working memory items and also evaluate whether working memory tests (as opposed to SCT working memory items) are uniquely associated with children's sleep problems. Nevertheless, results from this study indicate that SCT daydreaming and working memory dimensions are generally unassociated with sleep functioning and certainly not so highly associated with sleep functioning as to be considered redundant constructs. This finding is very much in line with a study of young adults that found SCT and daytime sleepiness to be statistically distinct⁴¹.

As expected, SCT sleepy/tired symptoms were significantly correlated with most of the sleep functioning variables, and SCT sleepy/tired was the most consistent psychopathology domain associated with sleep functioning in the regression analyses. The strongest effects were found for SCT sleepy/tired being associated with children not being alert after waking and needing weekends to catch-up on sleep. However, the size of the effects between SCT sleepy/tired and sleep functioning indicates that these are not overlapping constructs, a finding consistent with studies of adults with and without ADHD^{41,42}. Moreover, SCT sleepy/tired was not associated with in the regression analyses with sleep onset latency, night wakings, or early morning wakings. Still, given the association between the SCT sleepy/tired dimension and sleep functioning, studies seeking to isolate the part(s) of SCT that are clearly

not related to sleep functioning may wish to rely on the daydreaming and working memory aspects of SCT. In addition, future research will be needed to untangle the association between SCT sleepy/tired behaviors and morning alertness or weekend sleep catch-up. The design of this study is unable to evaluate whether nighttime sleep problems contribute to the presence of daytime SCT sleepy/tired behaviors, whether SCT sleepy/tired behaviors represent an atypical circadian rhythm, or whether these behaviors are part of a more general state of underarousal that is itself linked to both SCT symptoms and fatigue. Each of these possibilities is a fruitful avenue for investigation.

In terms of other comorbid symptoms, neither hyperactive-impulsive nor ODD symptoms were correlated with any of the sleep functioning variables. It is possible that an association between hyperactivity-impulsivity and sleep was not found in the present study since, by definition, the participants had subclinical (i.e., 5 symptoms) levels of hyperactive-impulsive symptoms. It remains quite possible that clinical levels of hyperactive-impulsive symptoms are associated with sleep problems¹⁸. In addition, although studies examining ODD symptoms in relation to sleep functioning in children with ADHD have yielded mixed findings^{16,29,32,33,67}, our results align with other studies that have not found an association between comorbid ODD symptoms and sleep problems in children with ADHD^{16,33}.

Somewhat surprisingly, depressive symptoms were generally not associated with sleep functioning. This finding is in contrast to previous studies that show depression to be associated with sleep problems in adolescents with ADHD^{29,68}. Rates of both depression and sleep problems rise as children transition to adolescence², and it is possible that the association between depression and sleep also becomes more pronounced in older children and adolescents. However, we did find anxiety symptoms to be correlated with sleep problems in our sample, and anxiety remained significantly associated in the regression analyses with children being rated as poor sleepers and having a shorter sleep duration. This is an important finding since other studies with school-aged children with ADHD have typically used grouped anxiety and depression together^{16,27,69}, and our findings align with a recent study by Lycett et al.²⁸ who found that children with ADHD who had a comorbid anxiety disorder diagnosis, but not children who had a comorbid depression diagnosis, had increased odds of having moderate or severe sleep problems. Our study joins the Lycett et al.²⁸ study in underscoring the importance of distinguishing between anxiety and depression when examining the association between these comorbid psychopathologies and sleep problems in ADHD samples.

4.3. Clinical Implications

Results from this study support calls for clinicians to assess the sleep functioning of children with ADHD and, as warranted, intervene with sleep problems are present⁶³. This is especially important since sleep problems predict functional impairment in youth with ADHD^{17,29,31,70,71}. Appreciably, recent interventions have been developed that aim to directly target sleep problems in children with ADHD^{72,73}. For example, a pilot study found an elimination diet intervention to reduce sleep complaints in children with ADHD, but it is important to note that this study only included children with ADHD-C or children with ADHD Predominantly Hyperactive-Impulsive Type and excluded children with ADHD-I⁷².

More recently, a brief behavioral treatment for sleep problems was shown to have a positive impact on children's sleep, ADHD symptom severity, and quality of life, although this study relied solely on a parent-report rating scale to establish ADHD diagnoses and did not report how many children were elevated in inattention specifically⁷³. Thus, it remains unclear whether ADHD subtype moderates sleep intervention effects. It is likely that children with ADHD-I need specific treatment targets such as daytime sleepiness^{16,19,20,42}. In addition, results from this study underscores the importance of further examining how SCT sleepy/tired symptoms and anxiety symptoms are related to sleep problems in children with ADHD-I and may be important targets for intervention.

4.4. Limitations and Future Directions

This study has several strengths, including a large sample of children rigorously diagnosed with ADHD-I. In addition, we examined multiple comorbid psychopathology dimensions. In particular, we increased specificity by separating anxiety and depression, and this is the first study to examine SCT symptoms in relation to sleep functioning in children with ADHD. Despite these strengths, several limitations should also be noted. First, all measures were completed by parents, the sleep measure used in this study has not been psychometrically validated, and objective measures of sleep (e.g., actigraphy, polysomnography) were not obtained. Second, laboratory testing of endocrinological or metabolic factors that could cause or contribute to SCT and sleep disturbance were not conducted and this is a particularly important direction for future research. Thyroid abnormalities are present in approximately 5% of children referred for ADHD⁷⁴. Previously, Stein and Weiss⁷⁵ reported a greater proportion of lower Free Thyroxine Index (FTI) concentrations in children with ADHD-I, but not in children with ADHD-C, and there is also preliminary evidence that a higher concentration of serum thyroid stimulating hormone (TSH) is positively associated with SCT symptoms in children⁷⁶. Examining the interrelations of SCT, ADHD, sleep, and endocrine functioning is an important direction for future research, particularly since hypothalamic-pituitary-adrenal (HPA) axis activity is associated with sleep problems as well as emotional and behavioral problems in children^{77,78}.

Another limitation is the cross-sectional and observational design which precludes causal conclusions, and there is a clear need for more longitudinal research examining the reciprocal associations between sleep problems and comorbidity in children with ADHD². Also, very few children in our sample were taking medication, and as such the finding related to longer sleep onset latency among the medicated children should be interpreted cautiously. Likewise, null findings related to the role of medication should likewise be considered in light of the small sample size of medicated children, particularly given the complexities interrelations between ADHD, medication use, and sleep functioning³. Furthermore, our sample represents cases of ADHD-I with little psychiatric comorbidity, who may be less likely to receive pharmacotherapy. Because of the small number of children with comorbid psychiatric diagnoses, we focused on dimensional psychopathology symptoms in the present study, and effects may be different in samples with higher rates of psychiatric comorbidity. Likewise, the low rates of comorbidity and high socioeconomic status of families who participated in this study may reduce the generalizability of our findings; replication will be important to establish in subsequent research. Finally, although

we view our large sample of children with ADHD-I as an overall strength, we were unable to compare our findings to children with other ADHD subtypes or to children without ADHD.

4.5. Conclusion

This study describes the sleep habits and functioning of a large sample of children carefully diagnosed with ADHD-I. Findings indicate that a notable subset of children with ADHD-I experience impaired sleep – 14% of children with ADHD-I do not obtain adequate sleep, 31% have a delayed sleep onset, and 41% need to catch-up on sleep on weekends. Of different psychopathology dimensions, anxiety and SCT sleepy/tired are most consistently associated with the sleep functioning of children with ADHD-I. Longitudinal studies are needed to evaluate the interrelations of sleep problems and comorbid psychopathology symptoms and their impact on the daytime functioning of children with ADHD-I.

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Highlights

- A sizeable number of children with ADHD Predominantly Inattentive Type experience impaired sleep.
- Anxiety and sluggish cognitive tempo (SCT) were the psychopathology domains most consistently associated with sleep.
- SCT and sleep problems do not appear to be overlapping constructs.

Table 1**Sleep Habits in Children with ADHD Predominantly Inattentive Type (ADHD-I)**

Variable	% (n)
Is your child a good sleeper?	
Good sleeper	74% (n = 109)
Average sleeper	20% (n = 29)
Difficult sleeper	6% (n = 9)
Does your child get enough sleep?	
Mostly yes	83% (n = 122)
Mostly no	17% (n = 25)
How easy is it for your child to get out of bed on school mornings?	
Easy	42% (n = 61)
Often needs a reminder	32% (n = 47)
Difficult	27% (n = 39)
After waking up, how quickly does your child seem fully alert?	
Usually within 10 minutes	62% (n = 91)
Longer than 10 minutes but alert before leaving for school	31% (n = 45)
Seems sleepy/drowsy after leaving for school	8% (n = 11)
Does your child need to catch up on sleep on the weekend?	
No	60% (n = 88)
A little	31% (n = 45)
Definitely	10% (n = 14)
How often does your child wake during the night and can't get back to sleep for 20 minutes or longer?	
Rarely	90% (n = 132)
Once a week	8% (n = 12)
Twice a week	2% (n = 3)
How often does your child wake up at least an hour before needing to and can't fall back asleep?	
Rarely	88% (n = 130)
Once a week	8% (n = 12)
Twice or more a week	3% (n = 5)
Where does your child usually go to sleep?	

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Table 2

Correlations of Child Demographics and Psychopathology Dimensions with Sleep Functioning of Children with ADHD-I

Variable	<i>M</i> ± <i>SD</i>	Sleep onset latency	Sleep duration	Poor sleeper	Not enough sleep	Hard to get up in morning	Not alert after waking	Needs weekend sleep to catch up	Night Wakings	Early AM Wakings
<i>Child Demographics</i>										
Age	8.62 ± 1.17	.09	-.33***	.13	.15	.06	.04	.21*	.13	-.01
Sex	--	-.07	.09	-.13	-.13	-.28**	-.16	-.12	-.13	-.07
Race	--	-.05	.31***	.07	-.03	-.18*	.02	-.05	-.07	.08
<i>Psychopathology Symptoms</i>										
Hyperactivity/Impulsivity	0.83 ± 0.51	.06	.02	.05	.10	.08	.04	.05	.06	.12
Inattention	2.01 ± 0.48	.05	-.08	.14	.10	.27**	.10	.19*	.02	-.004
SCT –Daydreaming	1.30 ± 0.73	.11	.06	.21*	.09	.16	.23**	.21*	.10	.02
SCT –Working Memory	0.90 ± 0.63	.01	-.10	.04	.02	-.05	.01	.07	.03	-.03
SCT –Sleepy/Tired	0.50 ± 0.54	.03	-.18*	.29***	.24**	.26**	.38***	.47***	.06	.01
ODD	0.82 ± 0.53	-.05	-.12	.08	.04	.07	.09	.11	.14	.06
Anxiety	0.53 ± 0.45	.17*	-.19*	.33***	.27***	.15	.16	.26**	.22**	.05
Depression	0.31 ± 0.38	.06	-.08	.13	.11	.10	.13	.22**	.10	-.05

Note. *N* = 147. For sex, female = 0, male = 1. For race, non-Caucasian = 0, Caucasian = 1. For not enough sleep, 0 = gets enough sleep, 1 = does not get enough sleep. ADHD = attention-deficit/hyperactivity disorder. ODD = oppositional defiant disorder. SCT = sluggish cognitive tempo.

* $p < .05$.

** $p < .01$.

*** $p < .001$.

Table 3

Regression Analyses of Child Demographics and Psychopathology Symptoms in Relation to Sleep Functioning in Children with ADHD-I

	Sleep Onset Latency			Sleep Duration			Poor Sleeper			Hard to Wake in AM		
	B	SE	β	B	SE	β	B	SE	β	B	SE	β
	$H(8,138) = 0.93, R^2 = .05$			$H(8,138) = 6.11^{***}, R^2 = .26$			$H(8,138) = 4.25^{***}, R^2 = .20$			$H(8,138) = 4.66^{***}, R^2 = .21$		
Age	1.05	1.01	.09	-.19	.05	-.31 ^{***}	.04	.04	.09	.01	.06	.02
Sex	-1.21	2.34	-.04	.06	.11	.04	-.07	.09	-.06	-.42	.13	-.26 ^{**}
Race	-1.17	2.29	-.04	.42	.11	.28 ^{***}	.11	.09	.09	-.27	.13	-.17 [*]
ADHD Inattention	-.001	2.52	.00	-.03	.12	-.02	.05	.10	.04	.35	.14	.20 [*]
SCT Daydreaming	1.93	1.73	.10	.14	.08	.14	.05	.07	.07	.05	.09	.05
SCT Sleepy/Tired	-1.18	2.36	-.05	-.27	.11	-.20 [*]	.22	.09	.20 [*]	.26	.13	.17 [*]
Anxiety	5.48	3.21	.18 [†]	-.30	.15	-.19 [*]	.46	.13	.35 ^{***}	.03	.18	.02
Depression	-2.42	3.90	-.07	.31	.19	.16 [†]	-.28	.15	-.18 [†]	.02	.21	.01
	Not Alert After Waking			Needs Weekend Catch-up			Night Wakings			Early AM Wakings		
	B	SE	β	B	SE	β	B	SE	β	B	SE	β
	$H(8,138) = 3.51^{**}, R^2 = .17$			$H(8,138) = 6.49^{***}, R^2 = .27$			$H(8,138) = 1.46, R^2 = .08$			$H(8,138) = 0.40, R^2 = .02$		
Age	-.01	.04	-.01	.08	.04	.13 [†]	.04	.03	.12	.004	.04	.01
Sex	-.15	.10	-.12	-.09	.10	-.06	-.08	.07	-.10	-.06	.09	-.05
Race	.02	.10	.01	-.06	.10	-.04	-.05	.06	-.07	.10	.09	.09
ADHD Inattention	-.01	.11	-.01	.07	.11	.05	-.03	.07	-.04	.004	.10	.004
SCT Daydreaming	.09	.08	.10	.03	.07	.03	.05	.05	.09	.000	.07	.000
SCT Sleepy/Tired	.37	.10	.32 ^{***}	.49	.10	.40 ^{***}	-.01	.07	-.02	.01	.10	.01
Anxiety	.07	.14	.05	.20	.14	.14	.17	.09	.20 [†]	.14	.13	.12
Depression	.004	.17	.003	-.04	.17	-.03	-.05	.11	-.05	-.18	.16	-.12

Note. $N = 147$. For sex, female = 0, male = 1. For race, non-Caucasian = 0, Caucasian = 1. ADHD = attention-deficit/hyperactivity disorder. SCT = sluggish cognitive tempo.

[†] $p < .10$.

^{*} $p < .05$.

.100`>*d*

.10`>*d*
**

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