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The Impact of Comorbid Mental Health Symptoms and Sex on Sleep Functioning in Children with ADHD

Stephen P. Becker^{1,2,4}, Caroline N. Cusick¹, Craig A. Sidel³, Jeffery N. Epstein^{1,2,3}, and Leanne Tamm^{1,2}

¹Division of Behavioral Medicine and Clinical Psychology, Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio, USA

²College of Medicine, University of Cincinnati, Cincinnati, Ohio, USA

³Department of Psychology, University of Cincinnati, Cincinnati, Ohio, USA

Abstract

Children with attention-deficit/hyperactivity disorder (ADHD) display more sleep problems than their peers, but it remains unclear whether comorbid mental health symptoms [i.e., anxiety, depression, oppositional-defiant disorder (ODD)] are uniquely related to sleep functioning. It is also largely unknown whether boys and girls with ADHD differ in their sleep functioning. This study (1) examined whether boys or girls with ADHD differ in their sleep functioning, (2) evaluated comorbid symptoms as uniquely related to sleep functioning domains, and (3) explored whether sex moderated associations between comorbid symptoms and sleep. Participants were 181 children (ages 7–13; 69% male; 82% White) diagnosed with ADHD. Parents completed measures assessing their child's ADHD symptoms, comorbid symptoms, and sleep functioning. Girls had poorer sleep functioning than boys across most sleep functioning domains. Sixty percent of children met cutoff criteria for having sleep problems, though rates differed significantly between girls (75%) and boys (53%). No differences in rates of sleep problems were found between ADHD subtypes/presentations or between younger and older children. In path models including ADHD and comorbid symptom dimensions, anxiety symptoms were uniquely associated with increased bedtime resistance and sleep anxiety, ADHD hyperactive-impulsive symptoms were associated with more night wakings and more parasomnia behaviors, and ODD and depressive symptoms were associated with shorter sleep duration. Depression was also uniquely associated with increased daytime sleepiness and overall sleep problems. Sex did not moderate associations between comorbid symptoms and sleep problems. This study provides important preliminary evidence that girls with ADHD experience more sleep problems than boys with ADHD. Findings also demonstrate that the associations between comorbid symptoms and sleep functioning in children with ADHD vary based on both the specific symptoms and sleep domains examined.

⁴Address correspondence to Stephen Becker, Division of Behavioral Medicine and Clinical Psychology, Cincinnati Children's Hospital Medical Center, 3333 Burnet Avenue, MLC 10006, Cincinnati, Ohio 45229-3039; (513) 803-2066 (phone); (513) 803-0084 (fax); stephen.becker@cchmc.org.

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Keywords

attention-deficit/hyperactivity disorder; comorbidity; daytime sleepiness; gender; sex differences; sleep

Children with attention-deficit/hyperactivity disorder (ADHD) have more sleep difficulties than their typically developing peers [1–3]. For instance, in a sample of 239 children with ADHD, 44.8% of parents indicated that their child has moderate/severe sleep problems, and another 28.5% indicated that their child has mild sleep problems [4]. Not only are sleep problems common in children with ADHD, but they are also associated with greater impairment, including greater attentional difficulties [5,6], poorer family functioning [4], and neurocognitive dysfunction such as poorer working memory [6,7]. Since children with ADHD are also likely to experience comorbid mental health symptoms [8,9], there has been significant interest in the degree to which comorbid symptoms are related to sleep functioning in children with ADHD. However, as discussed below, few studies have simultaneously considered multiple comorbid symptom dimensions in relation to different domains of sleep functioning in children diagnosed with ADHD. In addition, despite the prevalence and impact of sleep problems in children with ADHD, surprisingly few studies have examined whether boys and girls with ADHD differ in their sleep functioning. The current study evaluated multiple comorbid symptom dimensions in relation to sleep functioning domains in a sample of children diagnosed with ADHD, examined sex differences sleep functioning, and explored whether sex moderates associations between comorbid symptoms and sleep difficulties among children with ADHD.

Sleep Functioning in Children with ADHD

Sleep is multifaceted and includes both behavioral and physiological components. There is evidence that children with ADHD experience greater problems than their peers across a range of sleep problems, including higher bedtime resistance, more sleep onset difficulties, more night wakings, greater sleep-disordered breathing, and higher daytime sleepiness [1]. In terms of specific sleep problems, in a study of 147 children diagnosed with ADHD Predominantly Inattentive Type (ADHD-I), 14% of parents reported that their child obtains less than the recommended 9–11 hours of sleep per night and 31% reported a delayed sleep onset (>20 minutes) [10]. Daytime sleepiness is also common, with 37–42% of youth with ADHD experiencing clinically elevated daytime sleepiness [11]. Finally, it is estimated that up to a third of children with ADHD experience parasomnia sleep disorder symptoms such as restless leg syndrome symptoms, sleep talking/sleep walking, teeth grinding, and nightmares [12]. In short, sleep problems among children with ADHD are prevalent and wide-ranging.

Comorbidity in Relation to Sleep Functioning in Children with ADHD

In addition to sleep problems, children with ADHD are also likely to experience comorbid mental health symptoms [8,9]. It is estimated that 45–84% of children with ADHD have comorbid oppositional defiant disorder (ODD), and around one third of children have a comorbid mood or anxiety disorder diagnosis [8]. Given the high rates of both sleep

difficulties and comorbid mental health symptoms in children with ADHD, a number of studies have examined the degree to which comorbid symptoms relate to sleep difficulties in children with ADHD. Recently, Moreau and colleagues [13] found that children with ADHD and comorbid mental health symptoms (defined as elevations in either anxiety/depression or aggression) had greater parent-reported bedtime resistance, shorter sleep duration, more frequent night wakings, and greater daytime sleepiness than youth with ADHD alone. In addition, among children with ADHD, only those with comorbid symptoms had poorer sleep functioning than control children on actigraphy measures of sleep. Furthermore, the investigators found that comorbid symptoms, as opposed to medication use, was associated with more severe sleep problems [13].

In considering specific comorbidity domains, although exceptions have been reported [14], studies have generally found that comorbid internalizing symptoms (or having a comorbid internalizing disorder diagnosis) are related to increased sleep problems in children with ADHD [15–19]. For instance, Virring et al. [18] found that having a comorbid internalizing diagnosis was associated with increased total sleep problems in a sample of children with ADHD. Other studies of children with ADHD have also found that having a comorbid internalizing diagnosis was associated with overall sleep problems as well as specific problems with falling asleep, more restlessness during sleep, night wakings, and greater sleep anxiety [16,19]. These studies report conflicting findings in whether or not comorbid internalizing problems are associated with shorter sleep duration, more parasomnia behaviors (e.g., nightmares, walking/talking in sleep), or increased daytime sleepiness in children with ADHD [16,19]. In the few studies that examined anxiety and depression separately, anxiety seems to be more clearly related to poorer sleep functioning, including overall sleep problems and poorer sleep quality [10,15,20]. However, other studies indicate that depression is also associated with poorer sleep functioning in children with ADHD [15,19]. For instance, comorbid anxiety and depression dimensions were similarly related to overall sleep problems in a large sample of children with ADHD [19]. Comorbid anxiety and depression symptoms may impact different sleep domains: anxiety may be more clearly associated with increased bedtime resistance and more night wakings whereas depression may be more clearly associated with shorter sleep duration [15].

In contrast to comorbid internalizing symptoms, findings related to comorbid externalizing problems such as ODD are more mixed. Multiple studies have not found comorbid ODD or conduct problem symptoms to be associated with overall sleep problems in children with ADHD [14,18,19], or with more specific sleep onset latency, sleep quality, sleep duration, or parasomnia domains [10,19,21]. However, other studies have found an association between comorbid externalizing symptoms and sleep problems in youth with ADHD [20,22]. For example, Corkum and colleagues [22] found a significant association between having a comorbid ODD diagnosis and increased dysomnia symptoms (e.g., bedtime resistance, sleep onset delay, difficulty waking) in children diagnosed with ADHD. Likewise, in a sample of adolescent boys with ADHD, ODD was specifically associated with a decreased likelihood of going to bed willingly [20].

Although the studies reviewed above have contributed significantly to our understanding of the relations between comorbidities and sleep in youth with ADHD, they are limited in a

number of respects. First, most studies examining internalizing symptoms in relation to sleep in children with ADHD have collapsed anxiety and depression together [13,17–19,23,24]. This approach reduces specificity and may mask differential associations of anxiety and mood symptoms in relation to specific sleep functioning domains. Relatedly, other studies have often focused on only a single comorbidity such as anxiety [5] or ODD [25]. Very few studies have simultaneously examined multiple comorbid symptom dimensions. Indeed, there is evidence that the children with ADHD who experience the highest rates of concurrent and persistent sleep problems are those that experience both internalizing *and* externalizing comorbidities [23,24]. Second, studies have often not considered multiple sleep functioning domains [26] or used very brief, non-validated measures of sleep functioning [10,27]. Third, studies have included only children with ADHD-I Type/Presentation [10], included only children with ADHD Combined Type/Presentation (ADHD-C) [14], or used a symptom scale as the primary method for diagnosing ADHD [23,24]. Thus, findings from these studies cannot be assumed to generalize to all children with ADHD or to samples of children diagnosed with ADHD using a diagnostic clinical interview.

Sex Differences in Sleep Functioning in Children with ADHD

The male to female ratio of ADHD in community-based samples of children is approximately 3:1 [28]. Despite an increase in studies examining ADHD in girls, far less is known about girls with ADHD as compared to boys with ADHD. Further, sex differences in ADHD have been noted as an important, yet understudied, area for investigation [29–31]. One domain that remains almost entirely unexamined in regard to sex differences among children with ADHD is sleep functioning. Indeed, many studies of sleep in children with ADHD have included only boys [20,32,33] or very few (i.e., < 10) girls [34–39].

In studies that have examined sex differences in sleep functioning among individuals with ADHD, mixed findings have been reported. In 101 children with ADHD (17 girls), Corkum and colleagues [22] did not find boys and girls to differ in parent-reported sleep functioning. Similarly, in a community-based sample of 143 children (43 girls) with ADHD, parents did not report a difference for boys and girls in “problems sleeping at night during the last year” [40]. Studies have also not found sex to predict the persistence of parent-rated sleep problems among children with ADHD [23,41]. In contrast to these findings, in a sample of 147 children (61 girls) diagnosed with ADHD-I, there was a pattern for girls to have poorer parent-rated sleep functioning than boys, with girls significantly more likely than boys to be “difficult to get up in the morning” [10]. In a study examining sex differences in adults with ADHD, women were significantly more likely than men to report a history of sleep problems, including more interrupted sleep and greater daytime sleepiness specifically [42]. Although these findings in adults with ADHD cannot be assumed to generalize to children with ADHD, they do provide some support for the possibility that girls with ADHD experience more sleep problems than boys with ADHD.

What might account for these mixed findings reported to date? Extant studies have used widely varying methodologies that generally included single-item [23,40,42] or non-validated [10,22] measures of sleep functioning. One study relied on a previous ADHD

diagnosis and symptom rating scales to diagnose ADHD [23], and another study examined a “clinical group” that included children with ADHD as well as anxiety [41]. Studies are needed that examine multiple sleep domains using validated measures of sleep in children diagnosed with ADHD. It is indeed plausible that girls with ADHD have more sleep problems than boys with ADHD. Eme [43] observed that “the sex least frequently afflicted by a disorder is the relatively more severely afflicted” (p. 362). Put another way, as noted by Arnold [30], girls “have to deviate farther from sex peers than do boys to attain a ‘diagnostic’ level of problems” (p. 559). Therefore, particularly in a clinic-referred sample of children, girls with ADHD tend to have a more severe phenotype, including potentially poorer sleep functioning as compared to boys with ADHD.

Sex Differences in the Association between Comorbid Symptoms and Sleep

It is possible that comorbid mental health symptoms are related to sleep functioning domains differently for boys or girls with ADHD, yet we are unaware of any study that has examined this possibility. Girls with ADHD tend to experience more anxiety than boys with ADHD [29,31], and anxiety is the clearest comorbid symptom correlate of sleep functioning in children with ADHD across studies to date [10,15,19]. In addition, the impact of ADHD may be more detrimental for girls than for boys. For example, Lahey and colleagues [44] found that ADHD in early childhood predicted steeper increases in anxiety and depression for girls than for boys. Other studies have also found ADHD and its concomitants (e.g., peer problems) to more detrimentally impact functioning for girls with ADHD as compared to boys with ADHD [45–47]. However, boys with ADHD have higher rates of ODD than girls with ADHD [29,31], which may contribute to delaying tactics and resistance around bedtime, as well as increased sleep onset latency, and shorter sleep duration [20,22]. Thus, the associations between comorbid symptoms and sleep problems may differ for boys with ADHD, perhaps depending on the comorbid symptom dimension and sleep domain examined. Alternatively, it is possible that comorbid symptoms, when they do occur, relate similarly to sleep functioning among boys and girls with ADHD.

The Current Study

The objectives of the present study were to (1) examine whether boys or girls with ADHD differ in their sleep functioning, (2) evaluate ADHD symptoms severity and comorbid mental health symptoms as uniquely related to sleep functioning domains and total sleep problems in children with ADHD, and (3) explore whether associations between comorbid symptoms and sleep domains differ for boys and girls with ADHD. Very few studies have examined sex differences in sleep functioning among children diagnosed with ADHD. In addition, this study adds to the extant literature by simultaneously considering multiple comorbid symptom dimensions and sleep functioning domains as assessed with well-validated measures. Since demographic characteristics (e.g., age, race) and medication use (e.g., stimulants) may impact sleep functioning in children with ADHD [48,49], we considered these variables as potential covariates. We also controlled for ADHD symptom severity in all analyses [19].

We hypothesized that girls with ADHD would have more sleep problems than boys with ADHD. Based on extant literature, we hypothesized that internalizing symptoms would be uniquely associated with increased sleep problems. Although few studies have examined anxiety and depression separately in relation to sleep functioning domains, we tentatively hypothesized that anxiety would be uniquely associated with increase bedtime resistance and sleep anxiety, as well as poorer sleep quality (e.g., night wakings), whereas depression would be uniquely associated with shorter sleep duration. We expected comorbid internalizing symptoms to be more clearly associated than comorbid ODD symptoms with total sleep problems and specific sleep domains, though we hypothesized that ODD symptoms would be uniquely associated with increased bedtime resistance. Finally, we examined whether associations between comorbid symptom dimensions and sleep functioning domains differed between boys and girls with ADHD but did not have specific hypotheses regarding possible sex differences and consider these analyses exploratory.

Methods

Participants

Participants were 181 children (125 boys, 56 girls) ages 7–13 years ($M = 8.53$, $SD = 1.47$) diagnosed with ADHD ($n = 99$ with ADHD-I; $n = 82$ with ADHD-C). Approximately 82% ($n = 149$) of the children were non-Hispanic White, and the remaining participants were African American ($n = 24$; 13.3%), Hispanic ($n = 6$; 3.3%), or other ($n = 2$; 1.1%). Based on clinical interview for DSM-IV-TR defined comorbid conditions using the *Kiddie Schedule for Affective Disorders and Schizophrenia for School-Age Children* (K-SADS) [50] interview conducted with the child's caregiver, 34 participants (18.8%) met criteria for ODD, 18 participants (9.9%) met criteria for at least one anxiety disorder, 2 participants (1.1%) met criteria for a depressive disorder, 3 participants (1.7%) met criteria for Conduct Disorder, and 1 participant (0.6%) met criteria for mania. In terms of specific anxiety disorder diagnoses, 11 participants met criteria for generalized anxiety disorder, 7 participants met criteria for specific phobia, 2 participants met criteria for separation anxiety disorder, and 1 participant met criteria for each of the following: post-traumatic stress disorder, obsessive-compulsive disorder, social phobia, and panic disorder. The majority of children ($n = 145$; 80.1%) were not on psychotropic medications at the time of their evaluation.

Procedures

This study was reviewed and approved by the Institutional Review Board (IRB) and was conducted in accordance with the ethical standards of the 1964 Declaration of Helsinki and its later amendments. Families were recruited through the standard clinical intake flow at an outpatient clinic specializing in the diagnosis and treatment of ADHD. Families seeking an evaluation for ADHD were invited to participate, with only children meeting DSM criteria for ADHD-I or ADHD-C on the K-SADS included in this study in order to compare findings to other studies of children diagnosed with ADHD. Parents provided informed consent; children provided assent.

Measures

Vanderbilt ADHD Diagnostic Parent Rating Scale (VADPRS)—The VADPRS [51] was used to assess caregiver's report of children's inattention (ADHD-IN), hyperactivity-impulsivity (ADHD-HI), and ODD symptoms. The Vanderbilt scales include all 9 inattentive and 9 hyperactive-impulsive *DSM-IV* ADHD symptoms, as well as all 8 *DSM-IV* ODD symptoms. Each item is rated on a four-point scale (0 = *never*, 3 = *very often*). Mean scores for ADHD-IN ($\alpha = .88$), ADHD-HI ($\alpha = .91$), and ODD ($\alpha = .91$) were calculated.

Revised Child Anxiety and Depression Scales, Parent Version (RCADS-P)—The RCADS-P [52,53] is a 47-item caregiver-report measure that assesses anxiety and depression disorder symptoms on a four-point scale (0 = *never*, 3 = *always*). The RCADS-P has good psychometric properties and has demonstrated excellent reliability and validity in clinical and nonclinical samples [52–54], as well as in children with ADHD specifically [55]. To eliminate potential criterion contamination, two anxiety items (“my child feels scared to sleep on his/her own”, “my child worries when in bed at night”) and one depression item (“my child has trouble sleeping”) related to sleep were removed before computing mean scale scores, resulting in a 35-item anxiety scale ($\alpha = .93$) and a 9-item depression scale ($\alpha = .77$).

Children's Sleep Habits Questionnaire (CSHQ)—The CSHQ [56] is a 33-item caregiver-report measure of sleep behavior and sleep disorder symptoms. The CSHQ is considered a well-validated measure of children's sleep functioning [57] and has demonstrated validity for use with children and has been shown to differentiate between sleep-disordered and non-sleep-disordered children [56,58]. Caregivers use a three-point scale to rate the frequency of specific sleep symptoms/behaviors during the previous week (“rarely” to “usually”). After reverse-scoring some items, the items are summed to yield a Total Sleep Disturbance score and eight subscale scores for which higher scores represent more problematic sleep: Bedtime Resistance (6 items; $\alpha = .84$), Sleep Duration (3 items; $\alpha = .83$), Sleep Anxiety (4 items; $\alpha = .68$), Night Wakings (3 items; $\alpha = .81$), Parasomnias (7 items; $\alpha = .58$), Sleep Disordered Breathing (3 items; $\alpha = .71$), Daytime Sleepiness (8 items; $\alpha = .78$), and Sleep Onset Delay (1 item). In addition, using an intersect point of sensitivity and specificity, Owens et al. [56] established a cutoff of 41 on the total sleep disturbance scale to indicate the presence of sleep problems. This cutoff score corresponded with the upper 23.3% of their control group's total scores and correctly identified 80% of their clinical sleep group [56]. We used the dimensional total sleep disturbance score in our study ($\alpha = .88$) and also classified participants with scores ≥ 41 as having sleep problems. Note that children diagnosed with ADHD-I and children diagnosed with ADHD-C were similarly categorized as having sleep problems (60.6% AND 58.5%, respectively; $\chi^2 = .08$, $p = .78$). Likewise, children ages 7–9 years ($n = 134$) and children ages 10–13 years ($n = 47$) had identical rates of sleep problems (59.7% and 59.6%, respectively; $\chi^2 = .0002$, $p = .99$).

Analytic Approach

First, independent samples *t*-tests were conducted to examine whether boys and girls with ADHD differed in their mean scores in sleep functioning. Cohen's *d* was computed as a measure of effect size, with 0.2 considered a small effect, 0.5 a medium effect, and 0.8 a

large effect [59]. We also calculated the percentage of boys and girls meeting the cutoff for sleep problems and conducted a chi-square test to examine whether girls or boys differed in their likelihood of being classified with sleep problems.

Second, zero-order correlation analyses were conducted to examine the correlations among the study variables. It was decided a priori that if race, age, or medication status was significantly correlated with any sleep domain, it would be included as a covariate in subsequent analyses.

Third, the associations between comorbid symptoms and sleep functioning domains were estimated using path models. Path modeling was conducted in Mplus Version 7.3 [60] and the robust maximum likelihood estimator (MLR) was used. Two path models were conducted to examine the main effects of sex and comorbid symptoms in relation to sleep functioning. In the first model, all eight CSHQ sleep domains were included as outcome variables. In the second model, CSHQ Total Sleep Disturbance was included as the single outcome variable. Sex was included in these models, as were ADHD-IN and ADHD-HI symptom dimensions in order to control for any association between ADHD severity and sleep functioning. Because the estimated path models were fully saturated (i.e., 0 degrees of freedom), they demonstrated perfect fit to the data and model fit statistics are therefore not used or reported.

Finally, path models were re-run to examine whether sex moderated associations between comorbid symptoms and sleep functioning. Specifically, after mean-centering all comorbid symptom variables in order to reduce multicollinearity, the two path models described above were re-run with the three interaction terms of interest also included as predictors (i.e., sex $\times$ ODD, sex $\times$ anxiety, sex $\times$ depression) [61,62]. Any significant interaction term was interpreted to indicate that the strength of the association between comorbid symptoms and sleep differed for boys and girls. Any significant interaction would be explored by re-estimating the models as multiple-group models that allowed the sex-moderated paths to vary between sexes. For all analyses, statistical significance was set at $p < .05$.

Results

Sex Differences

Table 1 summarizes the *t*-test results with Cohen's *d* effect sizes to further evaluate whether boys and girls with ADHD differed in their sleep functioning (without comorbid symptoms also in the model). As expected given the correlation and path modeling results reported above, a clear pattern emerged whereby girls had more sleep problems than boys for all sleep domains except sleep onset delay and sleep-disordered breathing. Small-to-medium effect sizes were found for the sleep duration and night wakings domains, with medium effect sizes found for the bedtime resistance, sleep anxiety, parasomnias, daytime sleepiness, and total sleep disturbance domains. 108 children (59.7%) met the sleep problem cutoff on the CSHQ, though rates differed between girls and boys. Consistent with these analyses using continuous measures of sleep functioning, 75% of girls ($n = 42$) met the established cutoff for having sleep problems, compared to 53% of boys ($n = 66$), $\chi^2 = 7.92$, $p = .005$.

Correlation Analyses

Table 2 provides the intercorrelations and descriptive statistics of the study variables. Age, race, and medication status were not significantly correlated with any of the sleep functioning variables (all p s > .05) and were thus not retained for inclusion as a covariate in the subsequent path model analyses. All of the comorbid symptom dimensions were significantly correlated with shorter sleep duration, more parasomnia behaviors, and greater total sleep disturbance. All comorbid symptom dimensions except ADHD-IN were significantly correlated with increased bedtime resistance and more night wakings. ODD, anxiety, and depression ratings were each significantly associated with both increased sleep anxiety. Disruptive behavior symptom ratings (i.e., ADHD-HI and ODD) were significantly associated with greater sleep onset delay. Only depression was significantly correlated with increased daytime sleepiness. Finally, no comorbid symptom dimension was significantly correlated with sleep-disordered breathing.

In addition to female sex being significantly correlated with poorer sleep functioning across all sleep domains except sleep onset delay and sleep-disordered breathing (see Tables 1 and 2), female sex was also significantly correlated with higher anxiety. Sex was unassociated with depression, ODD, or ADHD dimensions.

Path Analyses

Table 3 shows the unique associations (standardized partial regression coefficients) of sex, ADHD symptom dimensions, and comorbid symptoms with the sleep functioning domains. The comorbid symptom dimensions had differential unique effects in relation to sleep functioning: anxiety was significantly associated with greater bedtime resistance and sleep anxiety (p s = .006 and < .001, respectively), ADHD-HI was significantly associated with increased night wakings and parasomnias (p s = .03 and .01, respectively), depression was associated with increased daytime sleepiness (p = .04), and both ODD and depression were significantly associated with shorter sleep duration (both p s = .02). No comorbid symptom dimension was significantly uniquely associated with sleep onset delay or sleep-disordered breathing. Above and beyond comorbid symptoms, female sex was associated with increased sleep anxiety (p = .04), parasomnias (p = .02), daytime sleepiness (p = .006), as well as shorter sleep duration (p = .02).

Table 4 shows the unique associations of sex and comorbid symptoms with total sleep disturbance. Depression was the only comorbid symptom dimension to be significantly associated with increased total sleep disturbance in the path analysis (p = .01). Female sex remained significantly associated with total sleep disturbance above and beyond the comorbid symptom dimensions (p = .001).

Moderation Analyses

The path model analyses were repeated with the three interaction terms of interest also included as predictors (i.e., sex $\times$ ODD, sex $\times$ anxiety, sex $\times$ depression). No significant interactions emerged for any of the sleep functioning domains or the total sleep disturbance score (all p s > .05), indicating that associations between comorbid symptoms and sleep functioning did not differ between boys and girls with ADHD.

Discussion

This study examined comorbid mental health symptoms, sex, and their interactions in relation to sleep functioning in 181 children diagnosed with ADHD. As discussed below, the findings from this study underscore the importance of *specificity* – both in comorbid symptoms and sleep domains – while also providing preliminary evidence of sex differences in sleep functioning among children with ADHD.

Do Comorbid Mental Health Symptoms Relate to Sleep Functioning in Children with ADHD?

Substantial research attention has been devoted to examining associations between comorbid symptoms (or comorbid diagnoses) and sleep functioning in children with ADHD. To address limitations of previous studies, we (a) used validated measures of both comorbid symptoms and sleep functioning to (b) examine the unique associations of multiple comorbid symptom dimensions in (c) children diagnosed with ADHD using a semi-structured diagnostic interview. Perhaps most importantly, findings from our study add to a very small body of research that underscores the importance of considering anxiety and depression separately when examining sleep in children with ADHD [10,15,26]. We found both anxiety and depression symptoms to be uniquely associated with poorer sleep functioning, though the specific sleep domains associated with these symptoms differed. As expected, anxiety was associated with greater bedtime resistance and sleep anxiety. The bedtime resistance subscale includes items related to healthy sleep habits (e.g., “goes to bed at same time”) as well as potentially problematic sleep associations (e.g., “needs parent in room to sleep”, “falls asleep in other’s bed”). It is thus not surprising that anxiety is associated with increased bedtime resistance, though the clinical relevance of this finding should be noted. Children with ADHD may frequently experience difficulties around bedtime, and while this may be due to oppositional behaviors [20,22], it is also possible that anxiety also contributes to – or is a driving factor of – these difficulties surrounding bedtime [10,19,20]. Clinicians should carefully assess for anxiety when caregivers of children with ADHD express concerns or frustrations surrounding bedtime routines and resistance [63]. In contrast to anxiety, depressive symptoms were uniquely associated with shorter sleep duration and increased daytime sleepiness. Our results are consistent with those of Accardo et al. [15] who also used the CSHQ and found children with ADHD who had a comorbid depression diagnosis had shorter sleep duration than non-comorbid children with ADHD. It does not appear that excessive daytime sleepiness in children with ADHD is solely due to inadequate sleep duration [11,19]. It is possible that comorbid mood symptoms contribute to both shortened sleep duration and increased daytime sleepiness, and lethargy and fatigue associated with depression may likewise contribute to daytime sleepiness. The differential associations of anxiety and depression in relation to sleep functioning domains in our study may be understood within the tripartite model of anxiety and depression [64]. Specifically, the model posits that high negative affect is associated with both anxiety and depression, high physiological arousal is specific to anxiety whereas low positive affect is specific to depression [64]. It thus stands to reason that anxiety, characterized by hyperarousal, is associated with increased bedtime resistance and sleep anxiety in children with ADHD, whereas depression, characterized by low positive affect, is associated with daytime

sleepiness (linked to lassitude sleep complaints) [65]. It would be useful for future studies to directly test the tripartite model in relation to sleep functioning in youth with ADHD.

As in a number of previous studies [10,14,18,19,21], we did not find ODD symptoms to be uniquely associated with poorer sleep functioning in children with ADHD. The one exception to this was a unique association between ODD symptoms and shorter sleep duration. It is possible that oppositional behaviors lead to delaying tactics around bedtime, which in turn contributes to shorter sleep duration, though this finding will need to be replicated before drawing firm conclusions. Future studies in this area would also benefit from a measure that more directly assesses oppositional-defiant and delaying tactic behaviors around bedtime that may be more clearly associated with ODD symptoms as opposed to anxiety. In addition, although ADHD symptom dimensions were not the focus of this study, they were included in the path models in order to account for ADHD symptom severity. We found no unique associations between ADHD-IN and sleep functioning. In contrast, ADHD-HI symptoms were uniquely associated with increased night wakings and parasomnia behaviors. These findings are in line with some previous studies linking the presence of hyperactive-impulsive behaviors to more disrupted sleep, parasomnia behaviors (e.g., nightmares, talking during sleep), and sleep-related movement disorders among children with ADHD [19,66]. Once again, these findings point to the importance of thorough assessment of specific mental health and sleep functioning domains in both research and clinical care. For instance, although important intervention work addressing sleep problems in children with ADHD has recently been conducted, clinical trials have excluded children with comorbidities (particularly internalizing comorbidities) [67,68] or did not examine whether comorbidity moderates treatment effects [69]. Findings from our study, as well as the larger literature, indicate that it will be important to assess for specific comorbid symptoms when targeting sleep functioning in children with ADHD and, vice versa, to assess for sleep problems when children with ADHD present with comorbid mental health symptoms.

Do Boys and Girls with ADHD Differ in Their Sleep Functioning?

Surprisingly few studies have examined possible sex differences in sleep functioning among children with ADHD. In part this is likely due to previous studies having few, if any, girls included in the sample [20,32–39]. The previous studies that have examined sleep differences in children with ADHD have used single-item or non-validated measures of sleep functioning, with mixed findings reported [10,22,23,40]. In the present study, clear evidence was found for girls with ADHD having more sleep problems than boys with ADHD, a finding consistent across continuous and categorical measures of sleep problems.

There are several reasons why we may have found more sleep problems among girls with ADHD as compared to boys with ADHD. First, our findings are similar to those of Robison et al. [42], who examined sex differences in adults with ADHD and found women to report more sleep problems (e.g., interrupted sleep, daytime sleepiness) than men. Nationally representative and community-based samples also demonstrate that adolescent females experience more sleep problems than adolescent boys [70–72], with this difference primarily emerging as girls transition from premenstrual to postmenstrual around age 10 years [73]. We did

not have a measure of pubertal development in our study, though it is highly likely that at least a subset of the sample had entered puberty and this would be the case for more girls as compared to boys in our age range (ages 7–13 years; although age was unassociated with sleep in our study, age is not a measure of, or adequate proxy for, pubertal timing and development [74]). Another reason for our findings may be that girls with ADHD – particularly girls with ADHD who are referred to an ADHD specialty clinic – have a more severe phenotype [30,43,75]. It thus stands to reason that girls may also experience more concomitant sleep difficulties. Furthermore, girls with ADHD may have more internalizing symptoms than boys [29,31], and in the present study girls did have greater anxiety than boys. However, since sex did not moderate associations between comorbid symptoms and sleep problems, it is unlikely that our findings are due to differences in internalizing symptoms since these symptoms were associated with increased sleep difficulties similarly across boys and girls. Finally, girls with ADHD may be more adversely impacted than boys with ADHD by associated difficulties such as peer problems [45–47]. These difficulties and stressors may in turn impact sleep. Studies utilizing longitudinal designs will be needed to evaluate whether internalizing symptoms or impairments such as peer rejection mediate associations between sex and sleep problems in youth with ADHD. In any event, given the paucity of research examining sex differences in sleep functioning among children with ADHD, and previous mixed findings in the literature, our findings should be considered preliminary until replicated in other samples.

Strengths, Limitations, and Future Directions

Strengths of this study include a sample of clinic-referred children diagnosed with ADHD using a well-validated semi-structured interview, and validated measures of both comorbid symptoms and sleep functioning were also used. In addition, we had a sizeable number of girls in our sample that allowed us to examine sex differences. Nevertheless, several limitations are important to note. First, this was a cross-sectional study that cannot speak to causality. There is a clear need for longitudinal research in this area. For example, a longitudinal study found sleep problems prospectively to predict increased oppositional behaviors and depressive symptoms, but not anxiety symptoms, in adolescents with ADHD over a one-year period [26]. Studies are needed to evaluate possible bi-directional and cascading associations. For example, it is possible that anxiety predicts increases in sleep problems which in turn predicts increases in depression [76]. Also, fewer children in our sample met criteria for comorbid diagnoses as compared to other samples of children with ADHD [15,18,19], and mean scale scores on the comorbidity symptom dimensions used in analyses were generally low. Our findings may thus be limited in their generalizability to more severe samples of children with ADHD who have higher rates of comorbid mental health symptoms. It would be informative to evaluate whether results from our study are replicated in more severe clinical samples, as well as community samples of children with ADHD. In addition, our study relied solely on parent-report rating scales which may have contributed to mono-informant biases. It likewise remains unclear if comorbid symptoms are related to objective measures of sleep functioning, such as actigraphy and polysomnography, in children with ADHD [13,77], or whether comorbid symptoms impact intraindividual variability of sleep functioning that appears to be common in children with ADHD [78]. Studies using a multi-informant, multi-method design would be highly informative for better

understanding comorbid mental health symptoms in relation to sleep functioning, as well as possible sex differences. Such studies would be highly informative to further extend our findings that point the importance of considering specificity in both comorbid symptom dimensions and sleep functioning domains, as well as the important finding that girls with ADHD may experience more sleep problems than boys with ADHD.

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Table 1

Sex Differences in Sleep Functioning among Children with ADHD

Variable	Females (<i>n</i> = 56)		Males (<i>n</i> = 125)		Sex Differences	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>t</i>	<i>d</i>
Bedtime Resistance	9.04	3.53	7.76	2.61	2.42*	0.41
Sleep Anxiety	6.39	2.58	5.30	1.73	2.90**	0.50
Sleep Onset Delay	1.71	0.87	1.64	0.75	0.56	0.09
Sleep Duration	4.45	1.89	3.78	1.48	2.33*	0.39
Night Wakings	4.14	1.58	3.68	1.37	2.01*	0.31
Parasomnias	9.46	2.35	8.58	1.72	2.52*	0.43
Sleep Disordered Breathing	3.43	1.20	3.17	0.42	1.58	0.29
Daytime Sleepiness	13.71	3.77	12.09	3.23	2.97**	0.46
Total Sleep Disturbance	49.23	11.68	43.37	8.13	3.41**	0.58

Note. ADHD = attention-deficit/hyperactivity disorder.* $p < .05$.** $p < .01$.

Table 2

Intercorrelations and Descriptive Statistics of Study Variables

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Sex	--																	
2. Race	.10	--																
3. Age	-.01	.01	--															
4. Medication Use	-.06	.08	.07	--														
5. ADHD-IN ^a	-.06	-.17 [*]	.12	.06	--													
6. ADHD-HI ^a	.07	-.10	-.11	.11	.45 ^{***}	--												
7. ODD ^a	-.04	-.05	.02	.11	.40 ^{***}	.57 ^{***}	--											
8. Anxiety ^b	-.24 ^{**}	-.23 ^{**}	.09	.05	.30 ^{***}	.17 [*]	.39 ^{***}	--										
9. Depression ^b	-.10	-.11	.18 [*]	.03	.24 ^{**}	.06	.33 ^{***}	.52 ^{***}	--									
10. Bedtime Resistance ^c	-.20 ^{**}	-.08	-.06	.05	.10	.15 [*]	.23 ^{**}	.41 ^{***}	.31 ^{***}	--								
11. Sleep Anxiety ^c	-.24 ^{**}	-.03	-.06	.10	.08	.11	.18 [*]	.48 ^{***}	.28 ^{***}	.84 ^{***}	--							
12. Sleep Onset Delay ^c	-.04	.02	-.09	.03	.06	.15 [*]	.18 [*]	.14	.13	.44 ^{***}	.35 ^{***}	--						
13. Sleep Duration ^c	-.19 [*]	.02	.06	.07	.17 [*]	.22 ^{**}	.35 ^{***}	.21 ^{**}	.30 ^{***}	.45 ^{***}	.39 ^{***}	.60 ^{***}	--					
14. Night Wakings ^c	-.15 [*]	-.12	-.12	-.02	.12	.24 ^{**}	.27 ^{***}	.27 ^{***}	.23 ^{***}	.54 ^{***}	.44 ^{***}	.38 ^{***}	.47 ^{***}	--				
15. Parasomnias ^c	-.21 ^{**}	.003	-.10	.04	.18 [*]	.26 ^{***}	.31 ^{***}	.29 ^{***}	.22 ^{**}	.43 ^{***}	.46 ^{***}	.33 ^{***}	.52 ^{***}	.58 ^{***}	--			
16. SDB ^c	-.13	-.02	.02	-.07	-.05	-.02	.03	.02	-.01	.19 [*]	.14	.05	.20 ^{**}	.24 ^{**}	.39 ^{***}	--		
17. Daytime Sleepiness ^c	-.22 [*]	-.01	.04	-.07	.15	-.01	.14	.11	.20 ^{***}	.28 ^{***}	.26 ^{***}	.23 ^{**}	.34 ^{***}	.35 ^{***}	.32 ^{***}	.24 ^{**}	--	
18. Total Sleep Disturb. ^c	-.28 ^{***}	-.05	-.04	.01	.18 [*]	.19 ^{**}	.32 ^{***}	.36 ^{***}	.34 ^{***}	.76 ^{***}	.71 ^{***}	.56 ^{***}	.71 ^{***}	.73 ^{***}	.73 ^{***}	.38 ^{***}	.68 ^{***}	--
<i>Mean</i>	--	--	8.53	--	2.17	1.55	1.14	0.48	0.38	8.15	5.64	1.66	3.99	3.82	8.86	3.25	12.59	45.18
<i>SD</i>	--	--	1.47	--	0.56	0.76	0.73	0.37	0.34	2.98	2.09	0.78	1.64	1.45	1.98	0.76	3.48	9.73
<i>Minimum</i>	--	--	7	--	0.33	0.11	0.00	0.00	0.00	6	4	1	3	3	7	3	8	33
<i>Maximum</i>	--	--	13	--	3.00	3.00	3.00	2.06	1.71	17	12	3	9	9	20	9	23	93

Note. N = 181. For sex, 0 = female, 1 = male. For race, 0 = non-White, 1 = White. ADHD = attention-deficit/hyperactivity disorder; HI = hyperactivity-impulsivity; IN = inattention; ODD = oppositional defiant disorder; SDB = sleep-disordered breathing.

^aScores from the Vanderbilt ADHD Diagnostic Parent Rating Scale (VADPRS).

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^b Scores from the Revised Child Anxiety and Depression Scales–Parent Version (RCADS-P).

^c Scores from the Children’s Sleep Habits Questionnaire (CSHQ).

* $p < .05$.

** $p < .01$.

*** $p < .001$.

Table 3

Standardized Unique Effects of Sex and Symptom Dimensions on Sleep Functioning Domains

Predictors	Dependent Variables: Sleep Functioning Domains						
	Bedtime Resistance	Sleep Anxiety	Sleep Onset Delay	Sleep Duration	Night Wakings	Parasomnias	Sleep-Disordered Breathing
	β (SE)	β (SE)	β (SE)	β (SE)	β (SE)	β (SE)	Daytime Sleepiness
Sex	-0.13 (0.07)	-0.15 (0.07)*	-0.03 (0.08)	-0.18 (0.07)*	-0.12 (0.07)	-0.18 (0.08)*	-0.20 (0.07)**
ADHD-IN	-0.10 (0.08)	-0.11 (0.08)	-0.07 (0.09)	-0.01 (0.08)	-0.09 (0.07)	-0.03 (0.08)	0.12 (0.07)
ADHD-HI	0.13 (0.09)	0.12 (0.08)	0.12 (0.10)	0.09 (0.09)	0.21 (0.09)*	0.19 (0.08)*	-0.13 (0.10)
ODD	0.03 (0.09)	-0.04 (0.08)	0.09 (0.09)	0.24 (0.11)*	-0.09 (0.10)	0.13 (0.09)	0.14 (0.10)
Anxiety	0.31 (0.11)**	0.43 (0.09)***	0.07 (0.11)	-0.06 (0.10)	0.13 (0.10)	0.13 (0.08)	-0.10 (0.10)
Depression	0.15 (0.09)	0.07 (0.08)	0.07 (0.10)	0.23 (0.09)*	0.13 (0.08)	0.09 (0.07)	0.17 (0.08)*

Note. $N = 181$. For sex, 0 = female, 1 = male. ADHD = attention-deficit/hyperactivity disorder. HI = hyperactivity-impulsivity. IN = inattention. ODD = oppositional defiant disorder. SE = standard error.

* $p < .05$.

** $p < .01$.

*** $p < .001$.

Table 4

Standardized Unique Effects of Sex and Symptom Dimensions on Total Sleep Disturbance

Dependent Variable: Total Sleep Disturbance	
Predictors	β (SE)
Sex	-0.23 (0.07) **
ADHD-IN	-0.02 (0.07)
ADHD-HI	0.10 (0.09)
ODD	0.15 (0.09)
Anxiety	0.15 (0.10)
Depression	0.19 (0.08) *

Note. $N = 181$. For sex, 0 = female, 1 = male. ADHD = attention-deficit/hyperactivity disorder. HI = hyperactivity-impulsivity. IN = inattention. ODD = oppositional defiant disorder. SE = standard error.

*
 $p < .05$.

**
 $p < .01$.

***
 $p < .001$.