HHS Public Access

Author manuscript

Sleep Med. Author manuscript; available in PMC 2020 March 21.

Published in final edited form as:

Sleep Med. 2017 September ; 37: 180–186. doi:10.1016/j.sleep.2017.02.006.

The association between Disruptive Mood Dysregulation Disorder symptoms and sleep problems in children with and without ADHD

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Abstract

Background: Many youth experience persistent irritability and recurrent temper outbursts, conceptualized by DSM-5 as Disruptive Mood Dysregulation Disorder (DMDD). Sleep deprivation impairs emotion regulation which could increase rates of DMDD symptoms, especially in those with preexisting regulatory impairments, as seen with ADHD. However, there has been little examination of the relationship between chronic sleep problems and DMDD symptoms.

Methods: Associations between DMDD symptoms and sleep parameters in children were assessed using parent-report and objective measures of sleep in a general population sample (N = 665) and an ADHD sample (N = 784). Irritability, temper outbursts, sleep problems and other psychological problems were assessed with the Pediatric Behavior Scale. The general population study also completed overnight polysomnography (PSG).

Results: DMDD symptoms were reported in 9.2% of the community sample and 31.4% of the ADHD sample. In both samples, children with DMDD symptoms had significantly higher parent-reported sleep problems than children without DMDD symptoms. Children with sleep problems had significantly higher DMDD scores than children without sleep problems. However, DMDD symptoms were most strongly associated with oppositional behavior. Sleep problems were not a significant contributor. Hyperactivity-impulsivity was most strongly associated with sleep problems, and DMDD was not a significant contributor. Children with and without DMDD symptoms did not differ significantly on any PSG parameter.

Conclusions: Associations between parent-reported sleep problems and DMDD symptoms were due to their shared relationship with other behavioral problems. Therefore, chronic sleep problems do not appear to be a primary source of DMDD symptoms in children with or without ADHD.

Keywords

ADHD; Mood dysregulation; Polysomnography; Sleep problems

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Conflict of interest

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: http://dx.doi.org/10.1016/j.sleep.2017.02.006.

1. Introduction

Empirical research is increasingly recognizing that a large number of youth experience persistent, nonepisodic irritability in combination with recurrent temper outbursts, leading to the creation of the new psychiatric diagnosis of Disruptive Mood Dysregulation Disorder (DMDD) [1]. DMDD requires the presence of persistent irritability and recurrent temper tantrums for 12 months in at least two settings prior to the age of ten. Children with DMDD are more impaired compared to children diagnosed with externalizing behavioral disorders alone, such as ADHD and Oppositional Defiant Disorder (ODD) [2–4], and DMDD increases the risk for a wide range of adverse outcomes in adulthood, ranging from depression to substance abuse [5]. Many children with elevated rates of irritability and temper outbursts will not meet full criteria for DMDD [2]; however, the persistent presence of the two core DMDD symptoms, regardless of full DMDD status, has been found to increase the risk for anxiety and depression, even when controlling for other psychopathology [6,7]. Moreover, these symptoms are associated with a host of impairments in future educational functioning and work performance [8]. Given these findings, it is imperative to examine modifiable factors that might alter the impact of persistent irritability and recurrent temper tantrums as a first step toward developing effective interventions for DMDD.

Sleep problems, especially delayed sleep onset, predict worse behavioral problems in youth drawn from clinical and community samples [9–11]. There is increasing evidence that sleep problems are a risk factor for a wide range of internalizing and externalizing disorders, leading to suggestions that normalizing sleep patterns in children could improve mood and behavior [12]. Sleep loss acutely impairs the executive functions necessary for effective emotion regulation, especially when faced with frustration [13–15]. The brain regions responsible for exerting top down control are particularly sensitive to sleep deprivation. For example, connectivity between the amygdala and medial PFC is reduced with sleep deprivation [13,16], leading to greater amygdala activation in response to negative emotional stimuli [17]. Consolidation of emotional memories preferentially occurs during REM sleep [18]. Sleep debt impacts the capacity to appraise ambiguous situations, recognize facial affects and process negative emotional stimuli [19]. In children, impairments in these cognitive processes are theorized to manifest as irritability and temper outbursts [20], suggesting that improved sleep could translate to reduced levels of these symptoms.

Less is known about the links between chronic sleep problems and sustained impairments in emotion regulation, especially in children [21]. In patients with borderline personality disorder where mood dysregulation is a core feature, sleep problems are associated with greater social emotional impairment, even after adjusting for other psychiatric comorbidity [22]. A study in seven-year-old children found that sleep disturbances were most strongly associated with emotional instability amongst a wide array of behavioral problems [23]. Not surprisingly, chronic sleep deprivation has been theorized to predict the development of DMDD symptoms [24], leading to the suggestion that treatment for DMDD should focus on improving sleep [25].

Despite the theoretical associations, there has been little formal examination of the role of sleep problems on the manifestation of DMDD symptoms. Prior work has focused on the impact of sleep on a broad range of behavioral and emotional problems without examining specific associations with irritability or temper outbursts [21,26]. A complicating factor when examining the associations between sleep and DMDD symptoms is the high rates of comorbid psychopathology that occurs in children with DMDD symptoms [1]. Sleep problems have been linked to a wide variety of psychological disorders, from ADHD to depression; therefore, observed associations with sleep and DMDD symptoms may be due the presence of other psychological problems [12]. In addition, most studies have relied on parent report to measure sleep, which has sizable limitations [27]. To address these limitations in the literature, we examined the correlation between the DMDD symptoms of irritability and temper outbursts and sleep problems, using both parent report and polysomnography in children drawn from a general population sample while controlling for the impact of comorbid psychological problems.

Chronic sleep problems may be most likely to lead to meaningful elevations in irritability and temper outbursts in children already at increased risk for these behaviors due to the presence of other regulatory deficits. Most children with DMDD also meet criteria for ADHD [3], and between 25 and 50 percent of youth with ADHD have impairments in emotion regulation [28]; however, little is known about factors that are associated with the development of DMDD symptoms in youth with ADHD. Chronic sleep problems are one strong candidate. Not only have chronic sleep problems been associated with emotional dysregulation in general, as noted above, but they have also been found to predict the worsening of a variety of mood and behavior problems in ADHD youth [29]. Considered together, this suggests that chronic sleep problems merit exploration as correlates of DMDD symptoms in youth with ADHD. Therefore, we also examined associations between DMDD and sleep problems in a clinical sample of children with ADHD.

2. Methods

2.1. Sample

The general population sample was comprised of 665 children ages 6–12 from an epidemiologic study of the prevalence of sleep disorders in children [30]. The governing IRB approved the larger protocol, with parents providing written consent and children providing assent in accordance with the Declaration of Helsinki. The 784 children ages 6–12 in the ADHD sample were evaluated in our psychiatry diagnostic clinic and diagnosed with ADHD-Combined (n = 550) or ADHD-Inattentive (n = 234) with or without comorbid ODD, conduct disorder (CD), anxiety, and/or depression. Exclusionary diagnoses were autism, psychosis, PTSD, acquired brain injury, bipolar disorder, and reactive attachment disorder, or an IQ below 70. All children had a diagnosis of ADHD derived from a comprehensive psychological evaluation that collected information from the child, parents and teachers, as well as psychological testing. ADHD symptoms were assessed across raters using the Pediatric Behavior Scale (PBS) [31]. An identical battery has been used to classify ADHD across multiple studies [32,33]. Data for the ADHD sample were obtained

retrospectively by reviewing existing clinical records. This was approved by the IRB, which waived informed consent. Demographic data for both samples are presented in Table 1.

2.2. Assessments

2.2.1. Pediatric Behavior Scale (PBS)

2.2.1.1. DMDD symptoms.: Mothers rated their children's behavior during the past 2 months (0 = not at all or almost never a problem, 1 = sometimes a problem, 2 = often a problem, and 3 = very often a problem) on the two PBS items that assess the DMDD symptoms of irritable-angry mood ("irritable, gets angry or annoyed easily") and severe temper outbursts ("loses temper, has temper tantrums"). Children were classified as having elevated levels of DMDD symptoms if irritable-angry mood and temper outbursts were both rated as often or very often a problem. We have used identical methods to examine the prevalence and persistence of DMDD symptoms [34] and others have used similar methods examine the associations of irritability with global functioning and a range of psychiatric outcomes [6,7,35].

2.2.1.2. Sleep problems.: Parent-reported sleep problems were coded using the PBS items: sleeps less than other children, trouble falling asleep, restless or disturbed sleep, wakes often during night, nightmares, talks, walks, or cries out in sleep, and wakes too early in morning. Items were analyzed individually and added together to obtain a Total Sleep Problem score. The 165-item PBS has established psychometrics in school aged populations [31] and has been found to reliably differentiate psychiatric diagnoses [32,36]. High correlations have been observed between the PBS sleep sub-scale and other established measures of pediatric sleep problems [30,37].

2.2.1.3. Other psychological problems.: Additional variables were raw scores on the PBS subscales measuring inattention, hyperactivity-impulsivity, conduct problems (eg, lying, stealing, and aggression), anxiety disorders, depressive disorder, and oppositional behavior (ie, disobedient, uncooperative, argumentative, and defiant). The two core DMDD symptoms of irritability and temper outbursts were excluded from the oppositional behavior and conduct problems scores. Likewise, sleep items were not included in the depression subscale.

2.2.2. Polysomnography—All children in the general population sample underwent a full-night polysomnography (PSG) with a parent present in a sound-attenuated and light- and temperature-controlled room in our research center. Each child was monitored with an infrared video and a computerized system using Gamma software that includes an electroencephalogram, two-channel bilateral electroculogram, and chin and anterior tibial electromyogram. Respiration, snoring sounds, and all night hemoglobin were measured using standard criteria [38]. An apnea event was defined as a cessation of airflow for a minimum of 5 s and an out-of-phase strain gauge movement. Hypopnea was defined as a reduction in airflow with an associated decrease in oxygen saturation of at least 3% or an associated arousal.

Fourteen objective PSG sleep parameters were used in the data analyses: sleep latency in minutes, awakenings (number of wake periods >30 s after sleep onset), total sleep time, sleep efficiency (time asleep divided by total time in bed), percentages of stage 1, 2, 3, and rapid eye movement (REM) sleep, REM latency (minutes from sleep onset to first REM sleep), arousal index (mean number of arousals >3 s per hour), frequency of snoring (none, intermittent, and continuous), snoring severity (none, mild, moderate, and severe), apneaehypopnea index (AHI, number of apnea or hypopnea events per hour of sleep), and mean oxygen saturation percentage during sleep. PSG data were not available for the ADHD sample.

2.3. Data analyses

Differences in sleep problems between children with and without DMDD symptoms were analyzed using independent *t*-tests and Cohen's *d*. Relationships between the sleep, DMDD, and psychological problem scores (oppositional behavior, inattention, hyperactivity-impulsivity, conduct problems, anxiety, and depression) were determined using Spearman correlations and explained variance. Regression analyses (stepwise and simultaneous) were conducted to identify the strongest concurrent correlates of sleep problems using the DMDD and psychological problems scores.

The psychological problem scores were used in the model to determine the importance of DMDD symptoms, relative to other psychological problems, in predicting sleep problems as well as to determine if DMDD symptoms contributed meaningfully to the prediction of sleep problems beyond that explained by the other psychological problems. Regression analysis was repeated using the sleep and psychological problem scores to examine associations with DMDD symptoms. All tests of significance were two-tailed. Key analyses were repeated, limiting to only children not taking psychotropic medication. A Bonferroni correction was made to control for multiple comparisons in all analyses. Some research suggests that extreme sleep and REM latencies may be related to behavioral problems including irritability [39,40]. Therefore, DMDD scores were compared for children with and without extreme latencies in the general population sample. In the ADHD sample, extremes were analyzed by comparing DMDD scores between children with no parent-reported sleep problems and children whose mean score across all PBS sleep items was often (2) or greater.

3. Results

3.1. General population sample

Correlations between the parent-reported total sleep score and the 14 PSG parameters were very small (.01–.13), explaining 1% or less of the variance between scores. As shown in Table 2, children with and without elevated levels of DMDD symptoms did not differ significantly (p's > 0.05) on any of the 14 PSG parameters (t's = 0.1–2.1). Spearman correlations between DMDD and PSG parameters were significant (p = 0.02) for percent Stage 2 sleep (r = 0.13) and percent slow wave sleep (r = 0.13), but explained only 1.7% of the variance. All other correlations were nonsignificant at 0.05 and explained less than 0.7% of the variance. The 14 PSG parameters combined together in a regression analysis were

significantly associated with the DMDD score ($R = 0.21$, $F = 1.8$, $p = 0.03$) but only explained 4.3% of the variance.

Children whose sleep onset ($n = 68$) and REM latencies ($n = 67$) were >90th percentile did not differ from the remainder of the sample in DMDD scores ($t = 0.0$, $p = 0.97$ and $t = 0.7$, $p = 0.51$). Similarly, DMDD scores did not differ between latency groups (<25th percentile, 25–75th percentile, >75th percentile) for REM latency ($F = 1.4$, $p = 0.24$, $n = 164, 335, 166$) and sleep onset latency ($F = 0.2$, $p = 0.82$, $n = 159, 338, 168$).

3.1.1. Relationship between parent-reported sleep problems and DMDD symptoms—

The prevalence of elevated DMDD symptoms was 9.2% (61/665). Children with DMDD symptoms had significantly higher parent-reported sleep problems than children without DMDD symptoms (Table 3). Conversely, children with elevated sleep problems had significantly higher levels of DMDD symptoms than children without sleep problems ($t = 5.1$, $p < 0.0001$). The correlation between the parent-reported DMDD scores and Total Sleep Problem scores (0.38) was significant ($p < 0.05$) and explained 14.7% of the variance.

3.1.2. Relationship between sleep, DMDD symptoms, and other psychological problems—

The mean correlation between the Total Sleep Problem score and the other psychological problem scores on the PBS (see Table 4) was 0.38 ($p < 0.05$) with a range of 0.34 (conduct problems) to 0.44 (hyperactive impulsive symptoms). The mean correlation between the DMDD and other psychological problem scores was 0.46 ($p < 0.05$), with a range from 0.37 (inattention) to 0.63 (oppositional behaviors).

3.1.3. Correlates of DMDD symptoms—

In a simultaneous regression analysis, the seven parent-reported sleep problem scores were all significantly associated with the DMDD score ($R = 0.45$, $F = =38.7$, $p < 0.0001$), explaining 20.0% of the variance. Four of the seven sleep scores (trouble falling asleep, restless sleep, sleeps less than normal, and talks, walks or cries in sleep) were significant in a stepwise regression analysis ($R = 0.44$, $F = 39.5$, p < .0001, explained variance 19.3%) (see Table 5a). Using sleep and other psychological problem scores, oppositional behaviors had the strongest association with DMDD symptoms in the regression analysis (explaining 47.9% of the variance). Explained variance increased to 51.9% with the addition of the conduct problem score. The sleep and other PBS problem scores increased explained variance by less than 1.8%. Limiting the analyses to only unmedicated children did not significantly alter the results.

3.1.4. Correlates of sleep problems—

The hyperactive-impulsive score was most strongly associated with the Total Sleep Problem score in the regression analysis (explaining 19.0% of the variance) (see Table 5b). Explained variance increased to 25.0% with the addition of the anxiety score and to 28.5% with the addition of the oppositional behavior scores. The DMDD and other PBS problem scores were not significant contributors.

3.2. ADHD sample

3.2.1. Relationship between parent-reported sleep problems and DMDD symptoms—

The prevalence of elevated levels of DMDD symptoms in the ADHD sample

was 31.4% (246/784). Children with elevated DMDD symptoms had significantly higher parent-reported sleep problems than children without DMDD symptoms (Table 3), and children with sleep problems had significantly higher DMDD symptoms than children without sleep problems ($t = 5.4$, $p < 0.0001$). The correlation between the DMDD and sleep problems total score (0.28) was significant ($p < 0.05$) and explained 8.1% of the variance.

3.2.2. Relationship between sleep, DMDD symptoms, and psychological problems—The mean correlation between the Total Sleep Problem score and the other psychological problem scores on the PBS was 0.31 ($p < 0.05$) with a range of 0.26 (inattention) to 0.36 (hyperactive impulsive) (Table 3). The mean correlations between DMDD and other psychological problem scores was 0.46, with a range from 0.27 (inattention) to 0.69 (oppositional behaviors). The correlation between sleep and DMDD was 0.28.

3.2.3. Correlates of DMDD symptoms—In a simultaneous regression analysis, the seven parent-reported sleep problem scores combined explained 10.0% of the variance in the DMDD score ($R = 0.32$, $F = 12.3$, $p < 0.000$). Four of the seven sleep scores (trouble falling asleep, restless sleep, wakes early, and nightmares) were significant in stepwise regression analysis ($R = 0.31$, $F = 20.2$, $p < 0.0001$, 9.4% explained variance) (see Table 5a). Using sleep and other psychological problem scores, oppositional behaviors were most strongly associated with DMDD symptoms in the regression analysis and explained 47.7% of the variance. Explained variance increased to 54.8% with the addition of the depression and conduct problems scores. The sleep and other PBS problem scores increased variance by less than 1.3%. Limiting the sample to only unmedicated children did not significantly alter the results. The regression analyses were rerun comparing the 39 ADHD youth with the highest level of parent-reported sleep problems to the 175 children rated as having no sleep problems. Oppositional behavior still explained most of the variance in DMDD symptoms with sleep increasing explained variance by only 1%.

3.2.4. Correlates of sleep problems—The hyperactive-impulsive score was most strongly associated with the Sleep Problem Total score in the regression analysis (explaining 13.6% of the variance) (see Table 5b). Explained variance increased to 21.2% with the addition of the anxiety score. DMDD and other PBS problems scores added little to the model.

4. Discussion

As sleep deprivation impairs emotion regulatory capacities, chronic sleep problems may lead to the development of persistent irritability and frequent temper outbursts, especially in at-risk youth, such as those with ADHD. This was the first study to examine the specific associations between parent-reported and objective sleep impairments and DMDD symptoms in both a general and a high-risk clinical sample. There was a significant correlation between parent-reported sleep problems and DMDD symptoms that dissipated when other psychological symptoms were taken into account. No association between objective sleep impairments and DMDD symptoms were observed.

Nearly 10% of the general sample exhibited elevated symptoms of DMDD, with the rates being three times higher in the ADHD sample. Results are consistent with prior reports by on the prevalence of DMDD symptoms [2,4,41]. These rates reinforce that irritability and temper outbursts are common problems in school-aged children, especially in youth with ADHD; however, the majority of children with ADHD did not manifest elevated symptoms of DMDD. Hence, it appears that ADHD symptoms are neither sufficient nor necessary for the presence of DMDD symptoms, and that other factors likely contribute to the development of these problematic behaviors.

Numerous studies using cross sectional [11,42] and longitudinal designs [21,43] have observed elevated rates of parent-reported sleep problems in youth with behavioral problems. The significantly higher rate of sleep problems in children with both ADHD and DMDD symptoms versus those with just ADHD has not been reported elsewhere, but is consistent with studies supporting the link between oppositional behaviors and sleep in children with ADHD [9,42] Amongst the individual sleep items, difficulty falling asleep and restless sleep were both associated with DMDD symptoms across the two samples and were the two most commonly reported sleep problems by parents. Irritability and temper outbursts may interrupt the evening routine and make implementation of effective sleep hygiene practices particularly challenging. Elevated rates of restless sleep and periodic limb movements are more common in children with ADHD and have been linked to daytime irritability [42,44].

While plausible pathways exist to explain the correlation with sleep problems and DMDD symptoms, our results suggest that it is the presence of other psychological problems that primarily drives this association. DMDD is associated with high rates of Oppositional Defiant Disorder, ADHD, and anxiety disorders [1,3], all of which have been linked to elevated rates impaired sleep as reported by parents [9,45]. DMDD symptoms were most strongly associated with oppositional behaviors in both samples, even when excluding overlapping items between ODD and DMDD. Therefore, it appears that the association between DMDD symptoms and sleep problems are driven by the strong correlations between irritability and other oppositional behaviors.

Results are similar to the study by Legenbauer and colleagues, where, in a sample of youth recruited from local elementary schools, associations between parent-rated sleep problems and affective dysregulation became nonsignificant once other variables were entered into the model [46]. These combined results do not refute the potential impact of sleep on emotion regulation or other aspects of behavior as this association has been well established in children and adults [12,14,47]. However, they do suggest that chronic sleep problems are unlikely to be a useful predictor of which children will develop impairing symptoms of DMDD. In addition, they suggest that simply normalizing sleep patterns without also addressing other comorbid psychological problems is unlikely to meaningfully reduce symptoms of DMDD. There is emerging evidence that treatment of oppositional behaviors and other comorbid conditions leads to meaningful improvements in DMDD symptoms. Recently, a group therapy program integrating evidence based techniques for depression, aggression, and other oppositional behaviors was found to be effective for improving parent-

reported irritability in children with DMDD [48]. Likewise, pharmacological treatment of ADHD has been found to improve irritability [35].

No clinically significant associations were found between PSG variables and DMDD symptoms, even in those with the longest sleep latencies. These negative PSG results are similar to what has been reported for other externalizing behavior disorders [49]. Likewise, these discrepancies are not unique to children, as substantial literature has found poor correlations between adult's self-reported sleep problems and objective impairments in sleep [50]. The failure to observe a significant correlation between PSG data and DMDD symptoms suggests that the relationship between parental-reported sleep problems and DMDD symptoms may be in part due to shared variance and halo effects.

Sleep problems were most strongly associated with hyperactive-impulsive symptoms. Prior work by this group and others has also shown a preferential association of short sleep duration and other sleep problems with hyperactive-impulsive symptoms [10,37]. As such, these results emphasize the importance of assessing sleep patterns in any child with prominent hyperactivity or impulsivity.

The primary limitation is the cross-sectional nature of the analyses. Many children with elevated levels of irritability and temper outbursts will not meet full diagnostic criteria for the disorder [2]. Therefore, the reliance on symptom reports of DMDD, rather than assessment of full DSM-5 diagnostic criteria, including cross domain impairment, is an additional limitation. However, prominent levels of irritability are associated with appreciable impairment in youth not meeting full DMDD criteria, suggesting the utility of screening for symptoms of DMDD [8]. The sample was predominantly Caucasian, which may impact the ability to generalize results. In the clinical sample, sleep and psychological symptoms were assessed using the same measure and informant. While the addition of PSG data in the general population sample did not lead to differential results, it is possible that the same may not have been true for the clinical ADHD sample. A few studies using PSG have shown lower sleep efficiency and greater number of stage shifts per hour sleep in clinical samples of children with ADHD; however, parent reports routinely document a higher level of sleep impairments than PSG across studies [49], which is consistent with our findings above. Thus, it is likely that parent reports in children with ADHD better capture the range of "typical" sleep problems that occur in the home environment, from sleep fragmentation to oppositional behaviors seen with bedtime resistance [49]. Actigraphy or other longitudinal assessments of sleep were not employed, precluding assessment of circadian rhythm disorders which may be preferentially associated with impairments in self-regulation [51]. Future studies should consider employing multiple measures of sleep and psychological symptoms over an extended time period. These could include objective measures of emotion regulation such as heart rate variability (HRV), which is correlated with self-reported sleep quality in adults with internalizing disorders [52,53]. Related physiological indices have recently been used to categorize children with ADHD and merit exploration in children with DMDD [54].

5. Conclusions

In children with or without ADHD, sleep problems are more likely to be reported in youth with symptoms of DMDD, such as irritability and temper outbursts. However, DMDD symptoms were most strongly associated with other oppositional behaviors, while chronic sleep problems were most strongly correlated with hyperactive-impulsive symptoms. Objective evidence of disturbed sleep was not observed in youth with DMDD symptoms, and little evidence of a direct association between impaired sleep and DMDD symptoms was found. Therefore, it seems unlikely that sleep problems are the primary cause of DMDD symptoms in children or that treatment efforts focusing primarily on improving sleep would lead to meaningful reductions in persistent irritability or frequent temper outbursts for the majority of youth.

Funding

This work was supported by the National Institutes of Health HLB [grant numbers RO1 HL063772, MO1 RR10732, and CO6 RRO16499]. Study sponsors had no role in the design or conduct of the study, interpretation of study results or the writing of this manuscript.

Abbreviations:

DMDD	Disruptive Mood Dysregulation Disorder
PSG	polysomnography

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Table 1

Demographic data.

Group	*n*	Age			IQ			Other demographics (%)			
		M	*SD*	Range	*M*	*SD*	Range	Male	Caucasian	Professional[a]	Psychotropic[b]
General population	665	8.7	1.7	6–12	106.3	13.1	71–147	52.6	80.5	48.9	6.3
ADHD	784	8.3	1.8	6–12	104.0	14.2	70–149	67.9	91.7	39.4	31.4

[a]Percent with one or both parents having a professional or managerial occupation.

[b]Percent using any psychotropic medication. ADHD = Attention Deficit Hyperactivity Disorder.

Table 2

Mean PSG parameters for children with and without DMDD symptoms and Spearman correlations between DMDD and PSG parameters.

	Children without DMDD *n* = 604		**Children with DMDD *n* = 61**		**Correlation with DMDD scores**	
	Mean	***SD***	**Mean**	***SD***	***t***	***r***
Sleep latency, minutes	28.7	24.0	27.8	21.8	0.3	−0.02
Awakenings, #	0.7	1.1	0.7	1.1	0.1	−0.08
Total sleep time, minutes	454.1	47.9	464.2	46.8	1.6	0.08
Sleep efficiency, %	86.1	8.2	87.3	8.2	1.1	0.07
Stage 1, *%*	3.4	3.1	3.4	2.9	0.1	−0.06
Stage 2, %	46.1	11.4	48.9	9.7	1.9	0.13
Stage 3, %	30.4	11.0	27.3	8.6	2.1	−0.13
Stage REM, *%*	20.1	5.6	20.3	6.1	0.2	−0.01
REM latency, minutes	156.4	66.9	161.5	56.5	0.6	0.05
Arousal index, #	3.4	2.5	3.8	2.6	1.3	0.06
Snoring, frequency	0.3	0.6	0.3	0.5	0.9	−0.03
Snoring, severity	0.3	0.6	0.3	0.5	1.1	−0.03
AHI, events/hour	0.7	1.1	0.6	0.7	0.8	0.04
SpO_2, %	94.2	2.2	94.6	2.1	1.1	−0.04

Note: All *t*-tests are nonsignificant at 0.05, and all correlations are nonsignificant at 0.01. DMDD = Disruptive Mood Dysregulation Disorder.

Table 3

Parent-reported sleep problem scores[a] for children with and without DMDD symptoms.

	General population sample						ADHD sample					
	DMDD (n = 61)		No DMDD (n = 604)				DMDD (n = 246)		No DMDD (n = 538)			
	M	*SD*	*M*	*SD*	*t*	*d*	*M*	*SD*	*M*	*SD*	*t*	*d*
Sleeps less than other children	0.7	1.1	0.2	0.6	3.6	0.6	0.7	1.0	0.3	0.7	5.5	0.5
Trouble falling asleep	1.4	1.2	0.6	0.8	5.3	0.8	1.2	1.2	0.7	1.0	5.9	0.5
Restless/disturbed sleep	1.5	1.2	0.8	0.9	4.6	0.7	1.2	1.1	0.6	0.9	6.1	0.6
Wakes often during night	1.0	1.0	0.5	0.8	3.8	0.6	0.8	1.0	0.5	0.8	4.7	0.3
Nightmares	0.9	0.9	0.5	0.7	3.5	0.5	0.8	0.9	0.5	0.7	4.7	0.4
Talks/walks in sleep	1.0	1.1	0.5	0.7	4.0	0.6	0.6	0.8	0.5	0.8	1.7	0.1
Wakes too early in morning	0.8	1.1	0.4	0.7	3.2	0.4	0.8	1.0	0.4	0.8	4.9	0.4

Note. All *t*-test comparisons were significant at the 0.05 level (using a Bonferroni correction), with the exception of "talks/walks in sleep," which was nonsignificant.

[a] 0 = *almost never or not at all* a problem, 1 = *sometimes* a problem, 2 = *often* a problem, and 4 = *very often* a problem. ADHD = Attention Deficit Hyperactivity Disorder; DMDD = Disruptive Mood Dysregulation Disorder; *d* = *cohen's d*.

Table 4

Correlations between total sleep problem, DMDD, and other psychological problem scores.

	Correlations with Total Sleep Problems		Correlations with DMDD	
	General population	ADHD	General population	ADHD
Total Sleep Problems			0.38	0.28
DMDD	0.38	0.28		
Oppositional behavior	0.41	0.27	0.63	0.69
Hyperactive-impulsive	0.44	0.36	0.50	0.43
Conduct problems	0.34	0.34	0.56	0.63
Anxiety	0.34	0.30	0.36	0.29
Depression	0.40	0.33	0.49	0.46
Inattention	0.40	0.26	0.37	0.27

Note: All correlations $p < 0.05$. ADHD = Attention Deficit Hyperactivity Disorder; DMDD = Disruptive Mood Dysregulation Disorder.

Table 5a

Significant predictors of the DMDD total score using the sleep and psychological problem scores in stepwise regression in general population and ADHD samples.

Predictor variables	General population Regression β	ADHD Regression β
Sleep problems only		
Sleeps less than other children	0.16	
Trouble falling asleep	0.18	0.16
Restless or disturbed sleep	0.14	0.08
Wakes often during night		
Nightmares		0.09
Talks, walks, or cries out in sleep	0.11	
Wakes too early in the morning		0.09
R^2	0.19	0.09
F	39.5*	20.2*
Sleep and psychological problems		
Sleeps less than other children		
Trouble falling asleep		
Restless or disturbed sleep		
Wakes often during night		
Nightmares		
Talks, walks, or cries out in sleep		
Wakes too early in the morning		
Inattention		
Hyperactivity-impulsivity		
Conduct problems	0.26	0.23
Anxiety		
Depression		0.19
Oppositional behavior	0.53	0.45
R^2	0.52	0.55
F	357.0*	315.2*

Note: Variables without beta values increased explained variance by <3%.

*$p < 0.0001$.

ADHD = Attention Deficit Hyperactivity Disorder; DMDD = Disruptive Mood Dysregulation Disorder.

Table 5b

Significant predictors of the sleep problems total score using the psychological problem scores in stepwise regression in general population and ADHD samples.

Predictor variables	General population regression β	ADHD regression β
Inattention		
Hyperactivity-impulsivity	0.25	0.34
Conduct problems		
Anxiety	0.22	0.28
Depression		
Oppositional behavior	0.23	
R^2	0.29	0.21
F	87.8*	104.9*

Note: Variables without beta values increased explained variance by <2%.

*$p < 0.0001$.

ADHD = Attention Deficit Hyperactivity Disorder; DMDD = Disruptive Mood Dysregulation Disorder.