ORIGINAL ARTICLE

Sleep Quality in Children with Attention Deficit Hyperactivity Disorder: Is one night polysomnography as good as two nights?

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Abstract

Objective: One of the factors that possibly account for conflicting results from research studies examining sleep problems in children with attention-deficit/hyperactivity disorder (ADHD) is sleep lab adaptation. The aim of the present study was to study sleep quality in children with ADHD and investigate the presence of a first night effect in children with ADHD using polysomnography (PSG) in a sleep lab.

Methods: Sleep architecture and sleep quality were assessed in children with ADHD using two consecutive nights of PSG and parent reported sleep questionnaires.

Results: A total of 13 children diagnosed with ADHD were studied over a period of 1 year. Sleep disturbances most frequently reported by parents included bedtime resistance, excessive daytime sleepiness, parasomnias and restless legs syndrome. Comparison of sleep latency, sleep efficiency, wakefulness, REM latency, total sleep time, N1, N2, N3, AHI, arousal index, REM and PLMI revealed no difference between 1st and the 2nd night of polysomnography.

Conclusion: Children with ADHD have disturbed sleep but do not show a first night effect during PSG, and hence, a single night PSG has been shown to suffice in assessment of sleep among patients with ADHD.

***Keywords*:** attention-deficit/hyperactivity disorder, sleep quality, polysomnography, sleep lab adaptation, first night effect.

Introduction

Attention deficit hyperactivity disorder (ADHD) is one of the most common neurodevelopmental disorders of childhood affecting 3-5% of school going children[1]. The core symptoms of ADHD include inattention, hyperactivity/impulsivity or both. The Diagnostic and Statistical Manual of Mental Disorders fourth edition (DSM-IV) has specified that symptoms should be present before 7 years of age and impaired functioning must be present in 2 settings to make a clinical diagnosis[2]. It has further classified the disorder into 3 subtypes: predominantly inattentive, predominantly hyperactive/ impulsive and the combined sub type. Sleep disturbances are among the many co-morbid conditions associated with ADHD. Anecdotal reports of practicing clinicians have long suggested that

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sleep of children with ADHD is disturbed and the DSM-III listed sleep disturbance as one of the defining characteristics of ADHD[3]. Neuroimaging research has documented under aroused cortical functioning in the frontal lobes of the brain among patients with ADHD. Thus the association between ADHD and the arousal system has direct implications for the influence of ADHD on the autonomic processes associated with the regulation of sleep. Previous research has further established this link by demonstrating positive associations between physiological indices of arousal from children during the day and a history of sleep disturbance. Over the last decade, there has been a growing interest in the association between sleep disturbances and ADHD. Research studies have used objective methods as well as subjective methods to study the same. It has been found that parents report more sleep problems in children with ADHD as compared to what was seen using objective measures like polysomnography[4] (PSG). PSG studies have revealed conflicting and inconsistent results. The major domains assessed in these studies include sleep architecture, sleep disordered breathing and periodic limb movement disorder. Discordant results of these studies may be due to the variation in the diagnostic criteria used for ADHD, wide age range of participants, gender representation, source of patient referrals and the number of PSG nights. Meta analytic studies examining sleep and ADHD have suggested inclusion of an adaptation night (i.e. PSG on two consecutive nights) to account for first night effect[5]. The first night effect has been documented as the occurance of poor sleep quality on the first night of PSG when more than one consecutive nights of PSG is done in a sleep laboratory. A first night effect is characterized by lower sleep efficiency, less total sleep time, less REM sleep, longer latency to REM sleep and a higher number of night awakenings[6,7]. Studies examining the first night effect in children and especially those with neurodevelopmental disorders have been very few as compared to those conducted in adult populations. The present study is an attempt at analyzing the difference in sleep quality due to the first night effect in children with ADHD using 2 consecutive nights of polysomnography at a sleep lab.

Subjects and Methods

The present study is part of an ongoing doctoral thesis work entitled 'Sleep Disturbances in Children with Attention Deficit Hyperactivity Disorder'. The study protocol has been approved by the Institution's ethics committee. Written informed consent from parents and assent from the children was obtained before commencing the study. Our study subjects were recruited from among outpatients of the Child Guidance Clinic of our hospital, a tertiary care referral center. Recruitment was aimed at children with ADHD coming for initial psychiatric assessment before pharmacotherapy was started. The inclusion criteria were as follows: (1) ADHD diagnosed based on the DSM-IV criteria (2) medication naïve (i.e. no prior pharmacological treatment both psychotropic and general) (3) IQ > 80. Exclusion criteria were as follows: (1) history of chronic medical illness (including obesity), chronic sleep disorder, neurological or other psychiatric disorders (2) Presence of cranio-facial abnormalities on clinical assessment.

All participants underwent a psychiatric, psychological and neurological examination. Information about their sleep habits and sleep disturbances was obtained from the parents and children by means of a detailed clinical interview, Epworth Sleepiness scale[8] (modified for children), Child Sleep Habits Questionnaire[9], Morningness Eveningness Scale[10], and a pre-structured questionnaire for diagnosis of the Restless Leg syndrome. The diagnosis of ADHD was established by means of a detailed clinical interview and DSM –IV diagnostic criteria for ADHD. The Connors global Index (both parent and teacher version)[11,12] were used to screen for ADHD symptoms and Conners Parent Rating Scale Short revised version[13] was used to assess symptom severity. The Mini International Neuropsychiatric Interview for Kids (MINI-KID)[14] was used to rule out co-morbid psychiatric conditions and for the classification of ADHD subtypes. The IQ level was assessed by means of Malin's Intelligence Scale for Indian Children (MISIC)[15] which is the Indian adaptation of Weschler Intelligence Scale for Children (WISC) and International Obesity Task Force (IOTF) criteria was used to assess for BMI[16].

Measures

All children underwent video polysomnography (Care fusion, Nicolet One PSG system, US) for two consecutive nights in the sleep laboratory. The children's bedtime was similar to that at home and their waking times were between 6:00 am and 6:30am, which were also as per their regular schedule. All polysomnography studies were conducted on a Nicolet One long-term monitoring and Sleep system, with standard electroencephalographic montage (F4-C4, C4-P4, F3-PC3, C3-P3, C4-A1 and C3-A2), horizontal electrooculography, submental and bilateral anterior tibialis electromyography, as per recommendations of the American Academy of Sleep Medicine.[17] Electrocardiography and video recording was done using an infrared-light camera. Oronasal airflow was monitored with thermistors. Thoracic and abdominal respiratory movements were recorded using belts with piezo sensors. Respiratory sounds were studied through microphones. Pulse oximetry was used to measure oxyhaemoglobin saturation. Nasal cannula was used for recording esophageal pressure. Leg movements were recorded by placement of electrodes over the right tibialis anterior muscle. Sleep stages were visually scored in 30–s epochs keeping in consideration the rules for pediatric visual scoring as specified by the American Academy of Sleep Medicine (AASM, 2007)[17]. The following sleep parameters were evaluated: total sleep time, sleep efficiency, sleep onset latency, REM sleep latency, percentage of sleep stages and movement time. Apnea and Hypoapneas were scored following definitions to determine the apnea index (AI) and apnea -hypopnea index (AHI) in children. AHI >1 was considered the criterion for sleep-disordered breathing. Periodic Limb movements were scored according to standard ICSD-2 criteria as well as the recommendations from American Academy of Sleep Medicine and the International Restless Legs Study Group[18]. The periodic limb movement index (PLMI) was calculated as the number of PLM per hour of sleep. PLMI> 5 per hour of sleep was taken as the cut off for Periodic Limb Movement Disorder. Statistical analysis was done using SPSS version 13.

Table 1: Sociodemographic Data of children with ADHD

Males	84%
Females	15%
Age	7.6 ± 1.5
Level of Education of the child	Class 2 (2 years of primary school)
Monthly Income	≠ 45,769 ± 24987
Years of education of Mother	76% (at least 12 years), 15% (at least 10 years), 7% (at least 8years)
Years of education of Father	85% (at least 12 years), 15% (at least 10 years)
Family structure	Joint (38%), Nuclear (61%)
Presence of Marital Discord	15%
Non biological child (Adopted)	7%
Single child	38%

Table 2: Test Findings: MINI-KID, MISIC, BMI

ADHD Inattentive subtype	1, (7%)
ADHD Hyperactive-Impulsive subtype	2, (15%)
ADHD Combined subtype	10, (76%)
IQ	92.61 ± 7.27
BMI	15.26 ± 4.37

Table 3: Conners Global Index- (Parent) and Conners Global Index-(Teacher) Ratings

CGI-Parent (n=13)			CGI-Teacher (n=5)		
Restless-Impul sive (perc entile)	Emotional Lability (perc entile)	ADHD Index (perc entile)	Restless-Impul sive (perc entile)	Emotional Lability (perc entile)	ADHD Index (perc entile)
79.23±7.58	73.07±10.24	79±7.39	63±10.51	67.8±12.73	68.8±15.73

Results

In total, 13 children with diagnosed ADHD (11 boys, 2 girls, mean age 7.6 ± 1.5, age range 5-11 years, body mass index-BMI 15.26 ± 4.37) were enrolled [Table1 and 2]. Combined type of ADHD was predominant (10 patients) followed by two patients with hyperactive/ impulsive subtype of ADHD and one with inattentive type of ADHD [Table 2]. Mean IQ score was 92.61 ± 7.27 which implies that most children had a population average level of intellectual functioning [Table 2]. Parents rated their children higher for all the three indices i.e Restless-Impulsive (79.23±7.58) , Emotional Lability (73.07±10.24) and ADHD Total Index of Connors Global Index questionnaires as compared to the teacher ratings for the same indices i.e.Restless-Impulsive (63±10.51), Emotional Lability (67.8±12.73) and ADHD Total Index (68.8±15.73) ([Table 3]. Only 5 out of 13 teachers consented to give teacher reports due to restrictions placed by school authorities regarding dissemination of student information. On the domains assessed by the Connors Parent Rating Scale (i.e. Cognitive problems/Inattention, Oppositional behaviour, Hyperactivity/Impulsivity and ADHD Index) the hyperactivity/impulsivity had the highest percentile value of 82.53±11.71 [Table 4]. Forty six percent (6/13) of

Table 4: Conners Parent Rating scale (Revised) Short version

Domains	Percentile values (Mean ±SD)
Cognitive problems/Inattention	77.61±7.7
Oppositional Behavior	72.38±11.88
Hyperactivity/Impulsivity	82.53±11.71
ADHD Index	77.38±5.82

Table 5: Excessive daytime sleepiness assessed by Epworth Sleepiness Scale

	Enough sleep	Very Sleepy
ADHD Combined subtype	4, (26%)	6, (46%)
ADHD Inattentive Subtype	1, (7%)	0, (0%)
ADHD Hyperactive/ Impulsive Subtype	2, (15%)	0, (0%)
Total	7, (53%)	6, (46%)

Table 6: Morningness- Eveningness Scale

	Morningness	Eveningness
ADHD Combined subtype	6, (46%)	4, (30%)
ADHD Inattentive Subtype	0, (0%)	1, (7%)
ADHD Hyperactive/ Impulsive Subtype	0, (0%)	2, (15%)
	7, (53%)	6, (46%)

children with ADHD all of whom were diagnosed with the combined subtype had excessive daytime sleepiness as assessed by the Epworth Sleepiness Scale -modified for children [Table 5]. An eveningness preference was noted in fifty three percent (7/13) of the participants as reported on the Morningness-Eveningness Scale [Table 6]. The child sleep habits questionnaire revealed that sleep disturbances most frequently reported were bedtime resistance (76%, 10/13), Excessive daytime sleepiness (76%, 10/13) and parasomnias (45%, 6/13) [Table 7]. Restless legs syndrome was found to be present in thirty eight percent of the participants (5/13) [Table 8]. Average sleep latency on the first night was 56.78±63.38 minutes, in comparison with 41.69±68.39 minutes on the second night (p=0.534).Similarly REM latency on the first night was found to be 167.53±108.49 minutes (mean±SD), as opposed to 145.76±63.24 minutes (mean±SD) on the second night (p=0.459). While average sleep latency and REM latency were the only two parameters which appeared different on first night evaluation versus the second night comparison, these differences were not clinically or statistically significant (Table 9). In all other parameters like average total sleep time, arousal index, REM, PLMI and AHI there were no apparent differences also between first night and second night PSG observations; and on analysis using paired samples t-test, (alpha level = 0.05), the following values were obtained: sleep latency (p=0.53), REM Latency (p=0.45), Wakefulness (p=0.926), Total Sleep Time (p=0.274), Sleep Efficiency (p=0.84), Stage N (p=0.55), Stage N2 (p=0.07), Stage N3(p=0.89), Stage REM(p=0.88), AHI (p=0.45), AI (p=0.77) and PLMI (p=0.621)[Table 9]. To account for the high standard deviation associated with each of the parameters Wilcoxon's Signed ranks test was applied

Table 7: Parent reported sleep problems for children (assessed by Child Sleep Habits Questionnaire)

	Bedtime resistance	Sleep onset delay	Sleep duration	Sleep anxiety	Night waking	Parasomnias	Sleep disordered breathing	Daytime sleepiness
ADHD Combined Subtype	8 (61%)	3 (23%)	2 (15%)	4 (30%)	3 (23%)	4 (30%)	3 (23%)	8 (61%)
ADHD Inattentive Subtype	1 (7%)	1 (7%)	0 (0%)	1 (7%)	0 (0%)	0 (0%)	1 (7%)	1 (7%)
ADHD Hyperactive/ Impulsive Subtype	1 (7%)	1 (7%)	2 (15%)	0 (0%)	2 (15%)	2 (15%)	0 (0%)	1 (7%)
Total	10 (76%)	5 (38%)	4(30%)	5(38%)	5(38%)	6(45%)	4(30%)	10(76%)

which then confirmed that there were no significant differences in any of the sleep parameters observed on both the nights [Table10].

Table 8: Restless Legs Questionnaire Screening

N=13	ADHD Combined subtype	ADHD Hyperactive subtype	ADHD Inattentive subtype	Total
RLS	4 (30%)	1 (7%)	0 (0%)	5 (38%)

Table 9: Polysomnographic findings Paired samples T test

Sleep Parameters	Night 1 *(Mean±SD)	Night 2 *(Mean±SD)	p<0.05
Sleep Latency	56.78±63.38	41.69±68.39	0.534
Sleep Efficiency	83.12±10.50	81.71±26.01	0.844
Wakefulness	3.46±3.84	3.59±3.37	0.926
REM Latency	167.53±108.49	145.76±63.244	0.459
Total Sleep Time	393.76±72.19	428.65±129.19	0.274
N1	6.31±7.49	4.15±9.71	0.553
N2	40.38±21.05	26.38±16.31	0.078
N3	54.15±44.86	52.23±25.54	0.891
AHI	1.40±1.76	0.9177±1.12	0.454
Arousal Index	11.76±9.48	12.29±6.73	0.773
REM	13.73±7.84	13.38±7.74	0.881
PLMI	1.01±1.09	1.20±1.06	0.621

*Unit of measurement -minutes

Table 10: Non- Parametric Tests: Wilcoxon Signed ranks Test

Sleep Parameters	Night 1 *median (min, max)	Night 2 *median (min, max)	p<0.05
Sleep latency	34.50 (2.00, 241.75)	18 (1.00, 255.00)	0.133
Sleep efficiency	85.00 (61.30, 98.70)	91.90 (7, 96.20)	0.463
Wakeful-ness	3.00 (0.00, 11.00)	3.00 (0.00, 13.00)	0.838
REM Latency	159.50 (31.50, 412.00)	163.5 (0.00, 227.00)	0.422
Total Sleep Time	407.50 (236.00, 526.00)	466.00 (154.00, 557.00)	0.196
N1	4.00 (0.00, 27.00)	1.00 (0.00, 36.00)	0.195
N2	38.00 (0.00, 77.00)	32.00 (1.00, 49.00)	0.064
N3	37.00 (19.00, 182.00)	54.00 (8.00, 93.00)	0.311
AHI	0.56 (0.00, 6.27)	0.47 (0.00, 3.53)	0.727
Arousal Index	9.40 (1.40, 32.1)	10.9 (5.60, 27.90)	0.754
REM	12.00 (5.00, 28.00)	13.00 (0.00, 27.00)	1.000
PLMI	1.00 (0.00, 3.30)	1.10 (0.00, 3.90)	0.326

* Unit of measurement-minutes

Discussion

This study, aimed at assessing differences in PSG findings on first night versus second night recordings, shows similar values for all PSG parameters on both night recordings in a group of 13 children diagnosed with ADHD. Polysomnography (PSG) studies in children with ADHD have not revealed consistent findings in sleep quantity and sleep architecture. Up to now, the most consistent finding has been increased nocturnal motor activity. Four studies have found that children with ADHD suffer from periodic limb movement in sleep (PLMS) more often than do healthy controls (Huang, Chen, Li et al., 2004; Picchietti, England, Walters, Willi,& Verrico, 1998; Picchietti, Underwood, & Farris,1999; Golan N, Shahar E, Ravid S, Pillar G, 2004)[19,20,21,22] and 1 study with video analysis revealed increased nocturnal limb movements (Konofal, Lecendreux, Bouvard & Mouren-Simeoni, 2001)[23]. In line with the finding of increased nocturnal motor activity, children with ADHD are more likely to meet the criteria for periodic limb movement disorder (Picchietti, England, Walters, Willi,& Verrico, 1998; Picchietti, Underwood, & Farris,1999)[21,22] and vice versa, comorbid ADHD is often diagnosed in children with PLMD (Phillipson et al ,2005)[24].

Sleep assessments have been carried out using both subjective methods such as parent reported questionnaires and objective methods using actigraphy and polysomnography. There has been a lack of consistency in the results of these studies. A recent meta-analysis revealed that there were certain methodological limitations of these studies such as not having a control group, using only clinical samples, using co-morbid conditions, not examining sleep patterns specific to each subtype of ADHD, using age and sex as non-moderating factors, not checking for medication status, not using a standardiseddiagnostic criteria for ADHD, using small sample sizes and using single night polysomnography that could have contributed to the variability of the results observed[5]. Following rigorous procedures to account for each of these factors Prihodova et al found a first night effect in children with ADHD (age 6-12, n=31) where there was an increase in sleep efficacy, a decrease in wakefulness and shortened sleep latency on the second night where as the control group which were age and sex matched did not show a first night effect[25]. However no such effect was observed (Bessey & Corkum, 2013) in study that examined sleep lab adaptation effects in children with ADHD and their typically developing peers using actigraphy for 6 nights followed by polysomnography in a sleep lab[26]. The researchers concluded that children with ADHD did not adjust to the sleep lab differently than their typically developing peers on sleep parameters that included sleep latency, wake after sleep onset and sleep duration. An interesting observation was that their typically developing peers had better sleep efficiency (a 6% increase) in the sleep lab as compared to home, which was not the case with the ADHD group. A possible explanation suggested by the authors is that while the ADHD group were not negatively affected by the sleep lab they were however unable to gain from the positive benefits of the sleep lab (being present in a highly structured environment with no distracters, no siblings or pets).

Studies examining the first night effect have been conducted on pediatric population the largest of which was conducted in 1984 on 87 healthy children (age range 6-15). An increased total sleep time and a decreased sleep latency was observed for night two along with decreased REM latency, increased REM percentage and better sleep efficiency[27]. These findings have been corroborated in similar studies conducted on adults. In a home based PSG study done by Palm et al in 1989 done on 18 children within the age range of 8-12 years it was found that there was no first night effect present but instead the researchers reported an increase in sleep latency, an increase in percentage of N1 sleep stage and an increase in REM latency on the second night of PSG[28]. Studies examining children at risk for sleep disordered breathing, those with obesity and clinical indications for sleep disordered breathing have shown that although a first night effect was present for WASO and REM percentage but the same was not the case for respiratory parameters[29]. Buckley et al, studied the first night effect in children with autism, they did not find a first night effect for total sleep time and REM parameters[30].

We observed no significant differences in sleep architecture between two consecutive nights of PSG using paired samples t-Test and non parametric test for statistical analysis. The standard deviation for each of the parameters for both the night was high which suggests presence of individual differences that could have contributed to the results. These individual differences may be better accounted for by using a larger sample size. Most of our patients belonged to middle SES and low SES. The laboratory conditions were comfortable (temperature control, comfortable foam bed, low light and noise levels) and one parent was with the child. These were as good as or better than what they are used to on a typical day at their homes. Our results differ from what has been observed by the only study published so far that has examined the effect of an adaptation night in children with ADHD undergoing 2 consecutive nights of PSG where a first night effect has been observed especially for sleep efficiency, sleep latency and night wakings. As mentioned above, this may be related to the relatively comfortable conditions in the sleep lab, compared to home sleep environment, which remained similar on both nights, hence, neutralizing the first night effect.In support of our results sleep lab adaptation in children with ADHD was not found to be any different from their typically developing peers, and similar studies done on children with autism also failed to find a first night effect in these children. The studies that have found a first night effect to be present have used larger samples, which may account for the difference. The generalization of our findings is limited by our small sample size, and the lack of comparison with controls. However the strength of our study is that we used rigorous diagnostic criteria, controlled for medication status and ruled out other comorbid conditions.

Conclusion

This study highlights the presence of sleep disturbances in children with ADHD, but more importantly establishes that sleep of children with ADHD can be sufficiently evaluated by a single night PSG alone, since no significant differences in sleep quality or abnormalities were found on the first night PSG recording versus the second night recordings.

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