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Original Article

Sleep disorders and daytime sleepiness in children with attention-deficit/hyperactivity disorder: A two-night polysomnographic study with a multiple sleep latency test

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ABSTRACT

Objective: To evaluate sleep macrostructure, sleep disorders incidence and daytime sleepiness in attention-deficit/hyperactivity disorder (ADHD) affected children compared with controls.
Methods: Thirty-one patients (26 boys, 5 girls, mean age 9.3 ± 1.7, age range 6–12 years) with ADHD diagnosed according to DSM-IV criteria, without comorbid psychiatric or other disorders, as never before pharmacologically treated for ADHD. The controls were 26 age- and sex-matched children (22 boys, 4 girls, age range 6–12 years, mean age 9.2 ± 1.5). Nocturnal polysomnography (PSG) was performed for two nights followed by the multiple sleep latency test (MSLT).
Results: No differences between the two groups comparing both nights were found in the basic sleep macrostructure parameters or in the time (duration) of sleep onset. A first-night effect on sleep variables was apparent in the ADHD group. Occurrence of sleep disorders (sleep-disordered breathing [SDB], periodic limb movements in sleep [PLMS], parasomnias) did not show any significant differences between the investigated groups. A statistically significant difference ($p = 0.015$) was found in the trend of the periodic limb movement index (PLMI) between two nights (a decrease of PLMI in the ADHD group and an increase of PLMI in the control group during the second night). While the mean sleep latency in the MSLT was comparable in both groups, children with ADHD showed significant (sleep latency) inter-test differences (between tests 1 and 2, 1 and 4, 1 and 5, $p < 0.01$).
Conclusion: After the inclusion of adaptation night and exclusion of psychiatric comorbidities, PSG showed no changes in basic sleep parameters or sleep timing, or in the frequency of sleep disorders (SDB, PLMS) in children with ADHD compared with controls, thus not supporting the hypothesis that specific changes in the sleep macrostructure and sleep disturbances are connected with ADHD. A first-night effect on sleep variables was apparent only in the ADHD group. Though we found no proof of increased daytime sleepiness in children with ADHD against the controls, we did find significant vigilance variability during MSLT in the ADHD group, possibly a sign of dysregulated arousal.

1. Introduction

Attention-deficit/hyperactivity disorder (ADHD) is the most frequent neurobehavioral disorder of childhood with an estimated prevalence of 3–5% of all school children [1]. It is characterised by developmentally inappropriate symptoms of inattention, hyperactivity and impulsivity that begin in early childhood. According to the American Psychiatric Association diagnostic guideline (Diagnostic and Statistical Manual, version IV [DSM-IV]) [2], ADHD is classified into three subtypes: predominantly inattentive, predominantly hyperactive-impulsive and combined. The diagnosis of ADHD is based on clinical evaluation of a child's behavior and on the criteria of DSM-IV [2].

According to questionnaire studies, sleep problems are so common in children with ADHD (in 50–60%) [3–5] that they were also included in the diagnostic criteria of the previous Diagnostic and Statistical Manual of Mental Disorders (DSM-III) [6]. This fact inspired the hypothesis that sleep disorders in ADHD might be caused by the same neurochemical and structural abnormity responsible for the development of ADHD, i.e., a disorder of neurotransmitters (mainly dopamine and noradrenaline) as well as by structural abnormalities in the prefrontal cortex and those subcortical areas which are important for the control of behavioral

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responses such as attention and executive function but also for the control of arousal [7].

The results of objective studies for the detection of ADHD-specific sleep disorders are rather heterogeneous. Some authors accordingly found rapid eye movement (REM) sleep reduction and longer REM sleep latency in children with ADHD in what they believe is an ADHD-specific feature [8–12]. However, according to overviews and meta-analytic studies, no specific sleep macrostructure change has yet been proved [13–17], while changes in the duration and timing of sleep (as reported in questionnaire studies) appear to be influenced rather by emotional and behavioral factors [13,15]. To go by other studies, the specific intrinsic problem of underlying ADHD rests in arousal dysregulation [12,18]. This idea is supported in two studies which found evidence of hypoarousal state in increased daytime sleepiness in children with ADHD [19,20] and in another study which discovered abnormalities in the microstructure of sleep-reduced cyclic alternating patterns in patients with ADHD [21].

Currently under discussion is the relationship between ADHD and sleep disturbances, especially sleep-disordered breathing (SDB) and periodic limb movements in sleep/periodic limb movement disorder (PLMS/PLMD) as these disorders of sleep coupled with sleep disruption are known to cause behavioral and cognitive disorders that may mimic ADHD [16,22]. Present-day studies fall into those which find a higher rate of SDB [20,23–25] and PLMS/PLMD [20,25–31] in children with ADHD to speculate about their crucial significance in this disease, and those in which ADHD is seen as an independent entity different from ADHD-like symptoms caused by sleep disorders connected with sleep fragmentation [8,14–16,22,32–34]. The authors of latter studies presume that sleep disorders in most patients with ADHD have no major role to play in the pathogenesis of this disorder.

The outcome of PSG studies of ADHD depends on the choice of the cohort, on the presence of comorbidities, current medication with psychostimulants and other drugs, on methodological limitations such as the absence of the adaptation night, on insufficient testing for concomitant psychiatric disorders (particularly anxiety and depression) that can influence sleep, or on the absence of controls [13–16].

The aim of our study was to evaluate the sleep macrostructure including an adaptation night, but also the rate of sleep disorders and level of daytime wakefulness in the ADHD group, without concurrent psychiatric involvement and without pharmacological treatment. The data obtained were compared with controls.

2. Subjects and methods

2.1. Participants

Our study subjects were recruited from among outpatients of paediatric neurologists and psychiatrists and referred to our departments of psychiatry and neurology where the study was conducted. Recruitment was aimed at children with ADHD coming for initial psychiatric assessment before stimulant or other pharmacotherapy was started. In total, 31 children with diagnosed ADHD (26 boys, 5 girls, mean age 9.3 ± 1.7, age range 6–12 years, body mass index-BMI 18.1 ± 2.5) were enrolled. The enrollment criteria were as follows: (1) ADHD diagnosed on the basis of DSM-IV [2], (2) no previous pharmacological treatment for ADHD, (3) no history of any chronic physical condition (including obesity), chronic sleep disorder, neurological or other psychiatric disorders (including mental retardation and autism) based on a complete pediatric report and on a neurological and psychiatric examination, (4) no current medication (psychotropic or general) and (5) the patient's and his/her parents' willingness to participate in the study and informed consent signed by the parents.

All participants were in the prepubertal or early pubertal stages as assessed by Tanner scale (Tanner stage 1–2) [35]. All were of Caucasian origin. They underwent psychological, psychiatric and neurological testing. Information about their sleep habits and sleep disturbances was collected from the parents and children by means of a detailed clinical interview and Pediatric Sleep Questionnaire [36]. Reported sleep problems were not taken as a reason for exclusion.

The diagnosis of ADHD was established by means of a detailed clinical interview which included a structured psychiatric examination (Children's Psychiatric Rating Scale) [37] and DSM-IV diagnostic criteria for ADHD [2]. These criteria were also used for the classification of ADHD subtypes. A combined-type of ADHD was predominant (27 patients), and four had inattentive type of ADHD. Parentally reported onset of symptoms was between 4 and 6 years in all children. The Conners' Parent Rating Scale [38] was also employed to assess the severity of ADHD symptoms (a score of at least 2 SD above the mean on this scale and ADHD index were used to classify the children as having significant ADHD symptoms). To exclude emotional and behavioral problems the following additional tools were employed: Child Behavior Checklist for parents, Children's Manifest Anxiety Scale and Children's Depression Inventory. The IQ level was assessed by means of the Wechsler Intelligence Scale for Children-Revised (WISC-III); all children had IQ > 80, and WISC-III full scale values were 104.9 ± 12.3.

The control group was recruited from the same district area (through schoolmates of participants with ADHD, children of friends and relatives of medical staff) and was made up of 26 healthy non-obese prepubertal or early pubertal (Tanner stage 1–2) children matched for age and sex, 22 boys and 4 girls, age range 6–12 years, mean age 9.2 ± 1.5, BMI 17.5 ± 1.4. All were without any chronic disease (as established from a complete pediatric report) and without any medication. The diagnosis of ADHD was ruled out according to DSM- IV criteria. The Conners' Parent Rating Scale and Child Behavior Checklist were also administered. The IQ level was not examined in the control group (all children in the control group had moderate or above moderate school achievements). Information on the subjects' sleep habits and disorders was obtained from the Pediatric Sleep Questionnaire and in detailed clinical interviews with the parents and children. The results of psychiatric scales are summarized in Table 1.

2.2. Measures

Children with ADHD and the controls had nocturnal video-polysomnography (PSG) performed for two consecutive nights in the sleep laboratory followed by a multiple sleep latency test (MSLT). The first one was rated as an adaptation night. The children's bedtime was very much like their usual bedtime back home as was their usual weekday regimen rising time after each PSG, i.e., between 6:30 and 7 a.m.

A Schwarzer polygraph was used for all polysomnography studies with standard electroencephalographic montage (F4–C4, C4–P4, F3–C3, C3–P3, C4–A1 and C3–A2), horizontal electrooculography, submental and bilateral anterior tibialis electromyography, electrocardiography and video recording using an infrared-light

Table 1
Characteristics of participants: results of psychiatric scales.

Psychiatric scale	ADHD (n = 31)	Controls (n = 26)	P value t-test
CPRS global index total	76.9 ± 13.1	46.7 ± 5.3	$p < 0.001$
ADHD index	86.5 ± 17	46.4 ± 2	$p < 0.001$
CBCL total	73.8 ± 17.3	47.5 ± 8.1	$p < 0.001$

T-scores are provided. Data are presented as mean ± standard deviation.