

# Instability of Sleep Patterns in Children With Attention-Deficit/Hyperactivity Disorder

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## ABSTRACT

**Objective:** To compare the stability of the sleep-wake system of children with attention-deficit/hyperactivity disorder (ADHD) and controls by objective and subjective measures. **Method:** Thirty-eight school-age boys with diagnosed ADHD and 64 control school-age boys were examined using actigraphic monitoring and sleep diaries, over 5 consecutive nights. **Results:** Increased instability in sleep onset, sleep duration, and true sleep were found in the ADHD group compared with the control group. Discriminant analysis revealed that children's classification (ADHD versus control) could be significantly predicted on the basis of their sleep measures. **Conclusions:** The findings support the hypothesis that instability of the sleep-wake system is a characteristic of children with ADHD. Given the potential negative effects of disturbed or unstable sleep on daytime functioning, it is recommended that a thorough sleep assessment be conducted when a sleep disturbance is suspected or when symptoms associated with daytime sleepiness or decreased arousal level are present. *J. Am. Acad. Child Adolesc. Psychiatry*, 2000, 39(4):495–501. **Key Words:** attention-deficit/hyperactivity disorder, sleep, actigraph, instability.

Sleep problems have often been associated with attention-deficit/hyperactivity disorder (ADHD) in children. The core symptoms of ADHD, i.e., inattention, difficulty in regulating behavior and emotions, and hyperactivity, are strikingly similar to the difficulties caused by disrupted sleep and sleep deprivation as has been addressed by numerous investigators and clinicians (e.g., Dahl et al., 1991; Guilleminault et al., 1982; Kleitman, 1965; Weinberg and Brumback, 1990). Disrupted or shortened sleep has been associated with ADHD-like symptoms (Anders et al., 1978; Chervin et al., 1997; Dahl, 1996; Guilleminault et al., 1982; Navelet et al., 1976), as well as with difficult temperament in early childhood (e.g., Carey, 1974; Sadeh et al., 1994a; Weissbluth and Liu, 1983; Zuckerman et al., 1987) and with behavior problems in late childhood (e.g., Jenkins et al., 1980; Richman et al., 1982). In addition, parents of children with ADHD consistently report disturbances in the sleep of their children

(e.g., Kaplan et al., 1987; Ross and Ross, 1982). Moreover, the association between sleep and ADHD was considered central and prevalent enough to be included as one of the diagnostic criteria of the syndrome in earlier versions of the *DSM* (American Psychiatric Association, 1980), as well as in commonly used rating scales for diagnosing ADHD such as the Conners Rating Scale for parents (Goyette et al., 1978). In later versions of the *DSM*, sleep problems were appropriately excluded from the diagnostic criteria of ADHD due to the realization that they are neither specific nor necessary for the diagnosis of ADHD (American Psychiatric Association, 1994).

Parents and clinicians have subjectively reported the high prevalence of sleep disturbances in children with ADHD. In contrast, studies using objective measures of sleep have not provided clear or specific evidence to support these subjective reports (e.g., Busby et al., 1981; Greenhill et al., 1983; Khan, 1982). In light of the prevailing clinical reports associating sleep difficulties with ADHD, the limited objective evidence for sleep difficulties in children with ADHD is surprising.

In a recent review, Corkum et al. (1998) examined findings that have been accumulated from 16 studies comparing different aspects of sleep in children with ADHD and in normal controls over the past 28 years. They discuss the inconsistent nature of the findings of studies that have used objective measures of sleep, yield-

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ing contradictory results regarding sleep onset time, sleep efficiency, and movement during sleep in children with ADHD. Corkum et al. (1998) list a number of potential methodological issues in sleep research with ADHD that might have contributed to these conflicting findings. They highlight possible confounding factors including small sample sizes (16 subjects in the largest study), inconsistent diagnostic criteria, lack of exclusion diagnostic criteria, inadequate control procedures, heterogeneity of sleep parameters, and difficulties with adaptation to the procedure required for going through assessment of sleep in a laboratory. While these methodological shortcomings are relevant, we would like to examine another issue.

Developmental psychologists have emphasized the role of stability and instability in developing neurobehavioral systems (Thelen, 1993). According to this view, a high level of variability is an indication of an unstable system.

In sleep research, several studies have emphasized the importance of individual variability, as opposed to group differences, in the organization of the sleep-wake system as a means of predicting developmental abnormality (Thoman, 1990; Thoman et al., 1981; Tynan, 1986). For example, Thoman et al. (1981) used a statistical index of the consistency of sleeping and waking behaviors over 3 successive weeks of observations. A greater degree of instability of these behaviors was found to predict later severe medical or behavioral problems. The underlying assumption in these studies was that the consolidation of behavioral and physiological states into distinct periods of sleeping and waking and their organization into stable cycles reflects the maturation of the CNS and the development of brain inhibitory and feedback controlling systems (Halpern et al., 1995; Parmelee and Stern, 1972). Thus, the night-to-night variability in sleep patterns may be a key factor to understanding the relationship between sleep difficulties and ADHD.

We hypothesized that instability of the sleep-wake system is a characteristic of children with ADHD. According to the systemic view, greater variability of a system might lead to further mutual influences on other related systems. The interactions between higher cognitive functions and the regulation of sleep and affect appear to be modulated by the prefrontal cortex, which acts as the interface of the sleep/arousal system, the affective system, and higher cognitive-neurobehavioral systems (Dahl, 1996). Thus, having an unstable sleep-wake system is expected to be related to the instability of systems such as the attentional, behavioral, and emotional systems as seen in ADHD.

The common practice in most sleep studies has been to average sleep measures across the nights of the study and to treat daily variation as a source of error. This practice may have evolved from the fact that most laboratory studies involve only 1 or 2 nights, which renders the evaluation of night-to-night variability practically impossible. In addition, laboratory studies often impose an unnatural sleep-wake schedule, which also precludes appropriate evaluation of the natural sleep-wake schedule of the child.

In recent years, actigraphy—activity-based monitoring—was established as a reliable and valid instrument to document sleep-wake patterns for extended periods (Acebo et al., 1999; Sadeh, 1994; Sadeh et al., 1991, 1995). Actigraphy refers to continuous activity monitoring using a wrist solid-state actigraph (a wristwatch-like device) for prolonged periods (e.g., a week). Actigraphy provides a special opportunity to perform a naturalistic study of children's sleep-wake patterns and enables obtaining a reliable description of both the sleep-wake organization and quality of sleep.

In the current study we used actigraphy to assess sleep in children with ADHD and control children. The variability/stability dimension of the organization of sleep across nights, as was reflected by the standard deviation of sleep measures (within each individual subject), was used as an index of the level of night-to-night stability of the sleep-wake system.

Our measure for such instability is the variability of the sleep parameters as reflected in the size of their standard deviations for each individual during 5 days of evaluation. The more varied, i.e., unstable, the sleep-wake parameters, the larger the standard deviations of these measures. Thus, comparing the standard deviations of children with ADHD and control children might reveal group differences that were not revealed by the comparison of the groups' averaged measures.

Our assumption was that major differences between children with or without ADHD might be related to a difficulty in regulating and organizing the sleep-wake system as might be indicated by greater variability of sleep measures. Thus, this variability could be a characteristic of sleep in children with ADHD.

## METHOD

### Subjects

Participants were 38 boys (age range: 6–14 years; mean = 9.6, SD = 2.7) who met the *DSM-IV* (American Psychiatric Association, 1994)

criteria for ADHD by ratings of their teachers and at least one parent and 64 boys (age range: 7.5–11.5; mean = 9.4, SD = 1.7) from a normative sample. The children in both groups were recruited from the same school district (many of them shared classes) with very homogeneous psychosocial characteristics and cultural background.

The diagnosis of ADHD was based on both parents' and teachers' ratings on a *DSM-IV* symptoms checklist. Diagnosis was considered positive if, based on the teachers' and the parents' ratings, *DSM-IV* criteria for ADHD were unequivocally met.

To enable us to assess behavior problems in addition to ADHD, the parents of both the ADHD and control children completed the parent's version of the Child Behavior Checklist (CBCL) (Achenbach, 1991). Children in both groups were excluded if they had clinically significant behavior problems (according to the Israeli norms) (Zilber et al., 1994) beyond ADHD symptoms. Exclusion criteria for the control group included ADHD symptoms, acute physical illness, clinically significant behavior problems, and identified learning disabilities. All children were ADHD medication-naïve, and none were taking any medication during the week of assessment and the prior week. Children were included in the ADHD study group only if both of their separate parents' and teacher's ratings met the *DSM-IV* criteria. The children in both groups were recruited from several regular elementary schools in a district whose residents predominantly belong to the middle and upper socioeconomic classes.

## Procedure

A 2-stage procedure was used to recruit the ADHD sample. The first stage was a meeting with the teachers of children in classes of relevant ages in various regular elementary schools. The teachers were asked to complete a checklist based on the *DSM-IV* criteria while they were blind to the purpose of the study. After the teachers completed this procedure, they were debriefed about the purpose of the research. The diagnostic questionnaires of the teachers were scored according to the guidelines of the *DSM-IV* (American Psychiatric Association, 1994). To meet the *DSM-IV* criteria, the child had to be rated positive (symptom present) on at least 6 symptoms of inattention *or* at least 6 symptoms from the hyperactive-impulsive subtype. Children from the control sample did not meet these ADHD criteria. Five percent of the children in the regular classes met *DSM-IV* criteria for the diagnosis of ADHD. The teachers contacted the parents by a letter from the investigators describing the research and asking their consent. Parents who agreed to participate in the study were then contacted directly by a research assistant to continue with the evaluation procedure. Parents of 3 children whose teachers' ratings met the ADHD criteria refused to participate in the study (93% consent rate). The control children were recruited for a normative study of children's sleep-wake patterns within regular classes, with a consent rate of greater than 95%. All parents were informed that their children were participating in a study on sleep and school functioning in children.

After signing the informed consent forms, parents were asked to complete a biographical and background questionnaire. In the ADHD sample, parents of children who were identified by their teacher as meeting the diagnostic criteria for ADHD completed separate questionnaires reflecting the translated *DSM-IV* criteria for ADHD. Of the 38 children who met the *DSM-IV* criteria for ADHD, 14 met only the criteria for the inattentive subtype, 4 met only the criteria for the hyperactive-impulsive subtype, and 20 met the criteria for both inattentive and impulsive. In both the control and the ADHD samples, each child's sleep was monitored with an actigraph attached to his or her nondominant wrist for 5 consecutive nights from bedtime to morning awakening and the child was asked to complete a sleep log for each of these nights.

Parents were instructed to maintain the child's regular sleep schedule and routines. All children were monitored during regular school days (excluding weekends and holidays) to eliminate variability related to sleep-schedule disruptions associated with weekends and holidays.

## Measures

**ADHD Symptom Checklist.** A *DSM-IV* symptom checklist translated to Hebrew was developed on the basis of the symptoms listed in the *DSM-IV* (American Psychiatric Association, 1994). The checklist consisted of 18 items describing *DSM-IV* criteria and requiring a confirmation/rejection response (yes/no). To meet the *DSM-IV* criteria, the child had to be rated positive on at least 6 symptoms of inattention *or* at least 6 symptoms from the hyperactive-impulsive subtype. A standardized format was used for rating the presence or absence of the symptoms. The Cronbach coefficient  $\alpha$  calculated in our study for ratings of 99 parents of children suspected of having ADHD (screened for the study) was .88. The Pearson correlation between 40 pairs of fathers' and mothers' ratings of their child was 0.63 ( $p < .0001$ ).

**Child Behavior Checklist.** The CBCL (Achenbach, 1991; Achenbach and Edelbrock, 1983) is a parent report questionnaire that surveys behavior problems in children. It contains 113 items and produces multiple age and gender norms of psychopathological scales. The questionnaire has been translated to Hebrew and validated for use in Israel (Zilber et al., 1994).

**Objective Evaluation of Sleep.** To obtain objective measures of sleep and of the night-to-night variability, actigraphy was used as a method for assessing sleep. The reliability of actigraphy as a method for assessing sleep in infants, children, and adults has been established in the past decade (Sadeh, 1994; Sadeh et al., 1991, 1995). In the present study, each child was monitored for 5 nights, which ensured good reliability of the measures (Acebo et al., 1999). This reliability implies that the aggregated measures constitute a valid representation of the child's sleep patterns despite the significant night-to-night variability that exists in children's sleep patterns.

The raw actigraphic data of 5 consecutive nights were translated to sleep measures using the Actigraphic Scoring Analysis program for IBM-compatible personal computers. These sleep-wake measures have been validated against polysomnography with agreement rates for sleep-wake identification higher than 90% (Sadeh et al., 1991, 1994b). Actigraphic sleep measures included the means and the standard deviations (night-to-night variability) of the following measures: (1) sleep onset time; (2) total sleep period (from sleep onset time to morning awakening); (3) sleep percent (percentage of actual sleep time from total sleep period); (4) true sleep time (sleep time excluding all periods of wakefulness); (5) longest sleep period (the longest period of continuous sleep without any wakefulness); (6) quiet sleep (percentage of sleep without any motion); and (7) number of night wakings which lasted for at least 5 minutes.

**Daily Sleep Logs.** The daily sleep logs completed by the children included information about children's sleep schedule (bedtime, waking time), sleep quality (night waking, sleep latency), and tiredness during the day. It was recently demonstrated that within this age group, the children's self-reports on sleep were better correlated with actigraphic measures of sleep than their parents' reports (Gruber et al., 1997).

## Data Analysis

Each group comparison was based first on multivariate analysis of covariance (MANCOVA) using group as the independent variable, age as a covariate, and the different sets of sleep measures as dependent variables. This analysis was conducted to test the hypothesis that there are group differences on the specific set of sleep measures while

controlling for multiple comparisons. Only when the MANCOVA revealed group differences, the following stage was to run separate group comparisons (analysis of covariance) for each sleep measure.

The final group comparison was based on discriminant analysis that was used to assess the possibility of discriminating between the groups using a multivariate discriminant function.

## RESULTS

### Averaged Actigraphic Sleep Measures

No significant differences between the groups were found on the MANCOVA using the averaged measures of sleep as the dependent variables ( $F = 0.49$ ; not significant [NS]) (Table 1).

### Night-to-Night Variability of Actigraphic Sleep Measures

The MANCOVA using the standard deviation of the sleep measures revealed significant group differences ( $F = 4.87$ ;  $p < .0001$ ). Results of the separate ANCOVAs for each sleep measure revealed significant group differences on the duration of sleep, true sleep, and sleep onset time, indicating an increased instability of these measures in the ADHD group (Table 2 and Fig. 1).

### Averaged Subjective Sleep Measures

Results of MANCOVA on the subjective averaged measures of sleep revealed no significant group difference ( $F = 0.8$ ; NS). No further univariate analyses were performed to preclude chance findings from multiple comparisons.

### Night-to-Night Variability of Subjective Sleep Measures

Results of MANCOVA on the standard deviations of the sleep measures revealed no significant group difference ( $F = 1.62$ ; NS). Likewise, no further univariate analyses were performed.

**TABLE 1**  
Averaged Actigraphic Sleep Measures  
(Group Means  $\pm$  Standard Deviations)

Measure	ADHD	Controls	<i>F</i>
Sleep onset time	22.3 $\pm$ 0.8	22.1 $\pm$ 0.6	1.77
Sleep duration	514.3 $\pm$ 44.5	522 $\pm$ 30.4	1.45
True sleep	480.6 $\pm$ 44.4	485.7 $\pm$ 40.9	0.47
Sleep percent	93.5 $\pm$ 3.9	93.1 $\pm$ 4.1	0.26
Night wakings	2.7 $\pm$ 1.6	3 $\pm$ 1.7	0.41
Longest sleep period	1.9 $\pm$ 63.5	181.4 $\pm$ 76	0.07

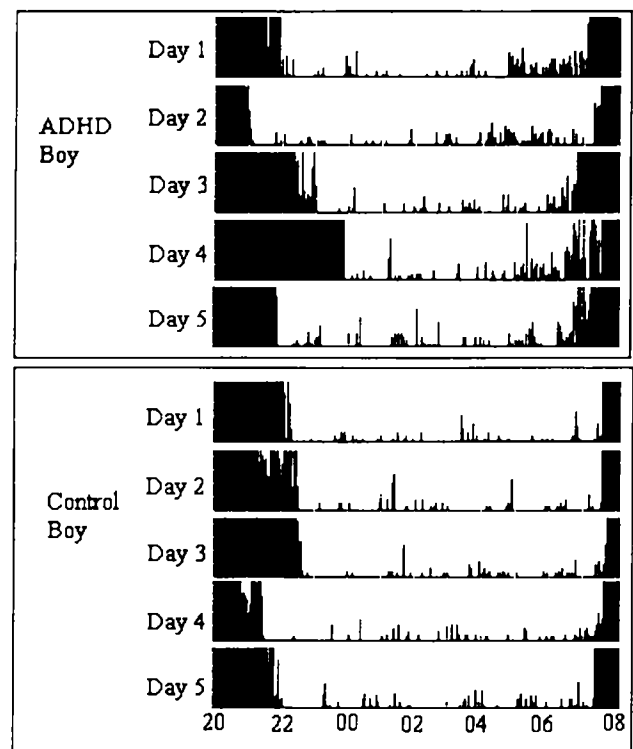
*Note:* Standard deviations were calculated first for each child across the 5 days of monitoring, and then averaged for each group. None of the *F* values is statistically significant. ADHD = attention-deficit/hyperactivity disorder.

**TABLE 2**  
Standard Deviations of Actigraphic Sleep Measures  
(Group Means  $\pm$  Standard Deviations)

Measure	ADHD	Controls	<i>F</i>
Sleep onset time	0.66 $\pm$ 0.3	0.45 $\pm$ 0.3	10.92*
Sleep duration	48 $\pm$ 20.7	29 $\pm$ 15.9	27.77***
True sleep	48.8 $\pm$ 16.7	30.1 $\pm$ 17.7	27.15***
Sleep percent	3 $\pm$ 1.8	3.1 $\pm$ 2.2	0.14
Night wakings	1.4 $\pm$ 0.5	1.5 $\pm$ 0.7	1.31
Longest sleep period	63.2 $\pm$ 39.4	61.1 $\pm$ 44.8	0.06

*Note:* Standard deviations were calculated first for each child across the 5 days of monitoring, and then averaged for each group. ADHD = attention-deficit/hyperactivity disorder.

\*  $p < .05$ ; \*\*\*  $p < .0001$ .



**Fig. 1** Raw activity data of 2 boys during the nocturnal monitoring period (from 2000 to 0800 [8 P.M. to 8 A.M.]). Each black bar represents the mean level of activity at a given 3-minute period. The level of activity is derived from the number of detected movements registered in the actigraph's memory. For visual impression, sleep can be characterized by areas with low activity data and wakefulness by increased (dark) activity levels. Sleep onset can be characterized at the point of transition from increased movements (dark area at the first hours of monitoring) to a low activity data (area with a very low and sporadic activity). It is noticeable that the boy with ADHD has an irregular onset of sleep at 2200, 2100, 2300, midnight and 2200 on the subsequent 5 nights, whereas the control boy has a narrow range of sleep onset between 2130 and 2230. These individual differences in the stability of sleep onset and sleep duration reflect the significant group differences of these measures (see Table 2). ADHD = attention-deficit/hyperactivity disorder.

### Stepwise Discriminant Analysis

To assess the ability to distinguish between children with ADHD and controls on the basis of the objective sleep measures, a multivariate, discriminant approach was used. We used stepwise discriminant analysis to assess which sleep measures have unique contributions to the discriminant function, and then we used discriminant analysis to assess the predictive power of the resultant discriminant function (SAS Institute, 1990).

The stepwise discriminant analysis yielded 2 sleep measures with unique and significant contribution to the discriminant function. The first and most significant measure was the standard deviation of true sleep, which explained 21.6% of the variance ( $F = 27.5$ ;  $p < .0001$ ). The second variable was the quiet sleep percent, which explained additional 3.3% of the variance ( $F = 4.4$ ;  $p < .05$ ). Discriminant function analysis based on these variables correctly assigned 73.4% of the control children and 76.3% of the children with ADHD.

### DISCUSSION

The purpose of the current study was to compare sleep patterns of children with ADHD and non-ADHD controls. To the best of our knowledge, this is the largest study using objective measures of sleep and the only study addressing the issue of night-to-night variability.

A comparison of the stability of the children's sleep over 5 consecutive nights revealed increased variability of the sleep measures, reflecting instability of the sleep-wake system in the ADHD group compared with controls. Children with ADHD were characterized by significantly higher standard deviations on the measures of sleep onset time, sleep duration, and true sleep time. This increased instability is a strong characteristic that enabled correct discrimination of children with ADHD from controls with a greater than 70% success rate. This finding is particularly interesting considering that all the children were studied during school days, when their morning rising time is determined by the time that school starts. This distinct feature would have been completely lost if the traditional method using only sleep measures that were averaged over the nights had been used. Similar to previous studies using objective measures, no group differences were found when this traditional method was applied.

The subjective sleep measures failed to detect significant group differences. This discrepancy between objective and subjective sleep measures is not surprising considering the

literature on the limitations of subjective sleep measures (Sadeh, 1994, 1996; Thoman and Acebo, 1995) and the discrepant findings that have been previously reported on the basis of subjective and objective sleep studies in ADHD (see Corkum et al., 1998, for a review).

To the best of our knowledge, the effects of unstable sleep patterns on the daily functioning of children or adults have not been systematically investigated. However, a recent study found that adolescent students with more irregular sleep schedules had more behavior problems and lower academic achievement than students with stable sleep schedules (Wolfson and Carskadon, 1998). Our preliminary findings suggest that this factor of instability of the sleep-wake schedule should be intensively explored in normal children as well as in children suffering from behavior problems or diagnosed psychopathology. Assuming that such an unstable pattern of sleep is indeed a constant feature of sleep of children with ADHD, its influence on daytime functioning could be compared to the phenomenology of persistent partial sleep deprivation. Partially sleep-deprived individuals may suffer significantly in behavioral, cognitive, and medical terms (e.g., Babkoff et al., 1991; Bonnet, 1985). In the few studies that have examined the influence of partial sleep deprivation on the functioning of children and adolescents, a relationship was found between shortened sleep and learning and behavior problems (Dahl, 1996; Kahn et al., 1989; Quine, 1992; Randazzo et al., 1998; Thorpy et al., 1988). Thus, irregularities in the quality and quantity of sleep could be a mediating factor that either exacerbates or directly contributes to the problems of children with ADHD. Future research, specifically manipulating the amount and the organization of sleep in a controlled manner, is needed to further clarify this issue.

The findings of this study indicating instability of the sleep-wake system in children with ADHD are consistent with the literature that considers ADHD as an impairment in arousal regulation (e.g., Douglas and Peters, 1979; Zentall and Zentall, 1983). The underlying mechanism associating ADHD with a deficit in arousal regulation has not been established by previous research. Our findings suggest that instability of the sleep-wake system may have a role in the irregularity of the arousal level. Having an unstable sleep schedule could be a result of biological immaturity or a dysfunction of a related brain systems. Yet it is possible that environmental influences such as inconsistent or inappropriate bedtimes set by parents might have also contributed to the instability of the child's sleep-wake cycle.

From a methodological perspective, it is possible that the finding of unstable sleep patterns in children with ADHD could explain the inconsistent findings in this field. It is possible that while parents are more likely to report sleep problems on the basis of problematic nights intermixed with better nights, objective studies are more likely to average and miss this "pendulum" effect. Therefore, we suggest that researchers who have collected objective data from children with ADHD in their natural environment on multiple nights reanalyze their data to test this hypothesis.

In summary, our findings support the hypothesis that an instability of the sleep-wake system is a characteristic of children with ADHD. Assessment procedures aimed at evaluating ADHD should include sleep evaluation for several consecutive nights. In this way, it would be possible to reveal the overall sleep pattern as well as the variability of sleep, rather than obtain single-night evaluations.

#### Limitations

A number of limitations of the study need to be addressed. First, the only clinical group in the study was of children with diagnosed ADHD. Although we used agreement of 2 informants to diagnose ADHD on the basis of *DSM-IV* criteria, no other diagnostic procedures were used to validate this diagnosis and to explore comorbid psychopathology. The use of the CBCL to exclude behavior problems does not address all the relevant issues of comorbidity. Therefore, special caution should be used in interpreting our results as *unique* to ADHD. Further research with other distinct clinical groups and with more comprehensive diagnostic procedures to assess comorbidity is needed to address the issues of reliability, specificity, and sensitivity of our findings.

A second limitation is related to our decision to use actigraphy to monitor only nocturnal sleep. Actigraphy could be used continuously to record daytime activity levels and possible daytime naps. It is important to note in this context that actigraphy has never been validated for detecting short daytime naps, and a reported daytime nap was a very rare event in our sample. However, it has been shown that activity monitors could be used to distinguish between activity levels of children with ADHD and controls (e.g., Porrino et al., 1983).

Another limitation of the study is the lack of direct, objective measures of sleepiness or alertness (e.g., the Multiple Sleep Latency Test or the Maintenance of Wakefulness Test). Such measures could indicate whether day-

time sleepiness or reduced alertness is indeed associated with the instability of the sleep-wake system found in our clinical sample. Therefore, the hypothesized relationships between the instability of sleep and the daytime alertness and functioning in children with ADHD require additional direct research efforts and validation.

#### Clinical Implications

Our finding of unstable patterns of sleep in children with ADHD stresses the need for including an inquiry on sleep patterns as an integrated part of a comprehensive assessment procedure aimed at evaluating ADHD. If a sleep problem is suspected, then a more thorough sleep assessment should be considered.

We recommend that for research purposes, evaluating sleep for at least 4 to 5 consecutive nights should replace the more common single-night laboratory evaluation. In addition, we recommend using objective measures of sleep rather than subjective measures such as sleep diaries. Subjective reports, as well as single-night laboratory sleep evaluation, would not be sufficient for disclosing a disturbed pattern of sleep. Measuring sleep objectively for at least 5 nights would enable revealing the overall sleep pattern as well as the variability of sleep, rather than obtaining single-night evaluations.

Our findings highlight the possible contribution of sleep instability to the overall difficulties manifested in ADHD. This may be true for some of the children with diagnosed ADHD as well as for children with other clinical syndromes that have not been investigated using our paradigm. It is yet to be determined whether stabilization of the sleep-wake system using behavioral techniques could lead to a clinical improvement in sleep, as well as in the behavioral and attentional systems of children with ADHD.

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