Original Article

Sleep-Wake Patterns in Children With Intrauterine Growth Retardation

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ABSTRACT

The purpose of this study was to characterize the sleep patterns of children with intrauterine growth retardation, known to be at risk for neurodevelopmental disorders, and seek a possible correlation with behavior, concentration, and attention problems. The sleep patterns of 26 children with intrauterine growth retardation aged 4 to 7 years were compared with those of 47 control children using activity monitors (actigraphs), In addition, data were collected from the parents regarding sleep habits, behavior, concentration, and attention. Children with intrauterine growth retardation aged 4 to 7 years were found to have a tendency toward poorer quality of sleep than their matched controls. This inclination was statistically significant only for one sleep measure, the true sleep time. A tendency toward increased fragmentation of sleep, prolonged wakes, and decreased sleep efficiency, although not statistically significant in this study, was demonstrated. Our results showed that 58% of the children with intrauterine growth retardation, compared with 40% of the children in the control group, could be defined as "poor sleepers" (sleep efficiency lower than 90 or three or more waking episodes per night). This disturbed sleep profile is probably an integral part of the neurodevelopmental profile typical of these at-risk children. No significant correlations were found between sleep quality and behavior, concentration, and attention problems. (*J Child Neurol* 2002;17:872–876).

Consolidating a sleep-wake cycle in early childhood, and concentrating sleep into one continuous period at night, is a compound and vulnerable process. This fact explains the high prevalence of sleep disturbances, mainly those of entering sleep and frequent night awakening in normal infants and toddlers (20–30%), with a decline in the reported prevalence during school age (1–4%).[1–4] Significant sleep disruptions, left undiagnosed and untreated, may bring about a cumulative sleep deficit, which may affect the child's well-being and performance during the day.[5–8] Conversely, sleep problems may be caused or exacerbated by stress or the emotional state of a child.9 Children suffering from sleep disturbances often have additional adjustment difficulties and may be viewed as "problematic" or "difficult."[10] Moreover, sleep disturbances are an important component in major psychopathologies, such as affective, anxiety, and post-traumatic stress disorders and hyperactivity.[5,8,9,11] A few recent studies have implied a causal relationship between sleep disturbances and symptoms of decreased attention, hyperactivity, impulsivity, and depression.[5,12,13] Sleep deprivation and resultant sleepiness could lead to attention-deficity hyperactivity disorder (ADHD)-like symptoms.[14–16]

Recent research by Sadeh and colleagues, which examined sleep quality in preschool and school-aged children,[14,17,18] showed a higher incidence of sleep disturbances than previously known: 41% for preschoolers and 18% for school-children. Poor sleep quality in school-aged children was associated with low achievements in attention tasks, with an increased tendency to accidents.[14]

The goal of the present study was to examine the prevalence of sleep disorders among children with intrauterine growth retardation in an attempt to detect a possible asso-

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Table 1. Sample Characteristics

	Children With Intrauterine Growth Retardation		*Controls*	
	n (%)	*Age ± SD*	*n (%)*	*Age ± SD*
Males	8 (31)	5.85 ± 1.17	23 (49)	5.66 ± 0.37
Females	18 (69)	5.37 ± 0.71	24 (51)	5.76 ± 0.36
Total	26	5.52 ± 0.88	47	5.71 ± 0.36

ciation between sleep disturbances and behavioral and attention disorders known to exist in this high-risk group.

To date, no published data exist regarding sleep disorders in children with intrauterine growth retardation. The paucity of data on sleep in infants and children results from the low availability and high cost of the conventional method of sleep study, that is, polysomnography. This examination takes place in a sleep laboratory and involves connection to monitors, interfering with the child's sleep and decreasing the reliability of the test. In contrast to polysomnography, actigraphy (activity-based monitoring) provides a continuous, nonintrusive way of measuring sleep-wake patterns, performed at the child's home. It has been established as a valid and reliable technique of assessing sleep-wake patterns.[19–21] No special installation is required (ie, it is simply attached to the child's wrist). The actigraph provides data on sleep schedule, night arousals, and sleep quality. This method was used to examine, in a more natural manner, the sleep pattern of children with intrauterine growth retardation in comparison with normal control children.

METHODS

Participants

Seventy-three children participated in the present study (Table 1). Parental informed consent was obtained for all participants. The study group comprised 8 boys and 18 girls, aged 4 to 7 years, recruited for a larger prospective study of children with intrauterine growth retardation.[22] The control group comprised 23 boys and 24 girls matched by age and gender, who were randomly recruited from Tel Aviv kindergartens. A detailed study of this control group was published.[18] Exclusion criteria were the presence of any chronic disease, neurologic or sensory deficits, and any use of medications. A nonsignificant tendency of the girls from the intrauterine growth retarded group to be younger than the boys in this group was noted ($P = .06$).

Procedure and Instruments

The actigraph (AMA-32, Ambulatory Monitoring Inc, Ardsley, NY) is a tool for ambulatory, long-term investigation of sleep-wake patterns using a portable, noninvasive "sleep-watch," with a computerized action meter that measures body movements. The actigraph is worn on the child's nondominant wrist during the night and records objective and reliable parameters of sleep duration.[19–21]

Actigraphic Sleep Measures

Actigraphic raw data were translated to sleep measures using the Actigraphic Scoring Analysis program for IBM-compatible personal computers. These sleep-wake measures have been validated in the past in comparison with polysomnography, with agreement rates for sleep-wake identification higher than 90%.[19–21] The measures defined were as follows:

1. Sleep onset time: the first minute after reported bedtime that was identified as sleep by the Actigraphic Scoring Analysis sleep-wake algorithm[19–21] and that was followed by at least 15 minutes of uninterrupted sleep
2. Sleep period: the number of minutes between sleep onset time and the time of morning arousal (the last minute identified as sleep that was preceded by 15 minutes of uninterrupted sleep)
3. True sleep time: the duration of sleep in minutes, excluding all periods of wakefulness during the night
4. Sleep efficiency: the percentage of the sleep period that was true sleeping time
5. Number of waking episodes: waking episodes lasting 5 minutes or longer that were preceded and followed by at least 15 minutes of uninterrupted sleep
6. Motionless sleep percentage: percentage of the sleep period in which there was no recorded activity

Of all of these parameters, the two that have the largest influence over the quality of sleep are sleep efficiency and waking episodes, and that influence is expressed in the general definition of "poor sleeper" versus "good sleeper" mentioned below.

General Sleep Quality Category

In addition to the special sleep patterns obtained from the actigraph measurements, the tested children were generally defined as "good" or "poor" sleepers.[17,18]

The child was defined as poor sleeper when he had at least one of the following: (1) sleep efficiency lower than 90 (ie, the child spends more than 10% of the sleep period, after sleep onset, in wakefulness) or (2) three or more waking episodes per night. Children with sleep efficiency 90 and up, or with less than three waking episodes per night, were defined as good sleepers.

Study Design

After obtaining informed consent, a pediatrician brought the actigraph to the patients' home and explained its use to the parents. The child wore the actigraph for four consecutive nights during weekdays. It was worn from 1 hour before going to sleep until morning rise time.

In addition, the parents completed the following questionnaires:

1. Sleep Habit Questionnaire regarding the sleeping habits of the child. This questionnaire is a 20-item, 4-point, Likert-type scale

Table 2. Actigraphic Sleep Measures

	Children With Intrauterine Growth Retardation	*Controls*	*P*
	Mean ± SD	*Mean ± SD*	
Sleep onset time (min)	21.66 ± 0.80	21.44 ± 0.67	.20
Sleep period (min)	555 ± 34.07	570 ± 38.82	.10
Sleep efficiency (%)	89.7 ± 4.52	91.4 ± 5.16	.18
Waking episodes	2.93 ± 1.48	2.59 ± 1.37	.32
True sleep time (min)	498 ± 36.7	520 ± 42.8	.03*
Motionless sleep (%)	58.01 ± 9.86	62.31 ± 9.58	.08

*P < .05.

that includes items on sleep habits, sleepiness, and fatigue. Factor analysis had previously yielded two comparable factors[17]:
(a) Sleepiness factor: composed of items related to the child's tendency to go to sleep very late, the child's tendency to have very little sleep, and the related daytime sleepiness and fatigue
(b) Sporadic daytime sleep factor: composed of items such as daytime naps and uncontrollable sleep episodes

2. Child Behavioral Checklist with Israeli modification[23]
3. Conners' Questionnaire for symptoms of ADHD[24]

The following data were retrieved from the larger prospective study of children with intrauterine growth retardation[22]:

4. Risk Questionnaires: neonatal, parental, socioeconomic, and obstetric risk questionnaires (available for the children with intrauterine growth retardation only)
5. Neurobehavioral Examination and Psychological Evaluation Questionnaire at age 4 years (available for the children with intrauterine growth retardation only)
6. Biometric data (available for the children with intrauterine growth retardation only).

RESULTS

Actigraphic Measures

Twenty-six children with intrauterine growth retardation were monitored by actigraphy. Forty-seven measurements were obtained from the control group.

To assess the influence of age on actigraphic sleep measures while controlling for the multiple comparisons, we used analyses of variance (ANOVA) with age as covariate, group and gender as independent variables, and actigraphic sleep measures as the dependent variables. We found no significant effect for gender. Significant age differences were manifested for the sleep onset time (eg, older children fell asleep later than younger children [$P = .004$]).

Table 3. General Sleep Quality Category

	Children With Intrauterine Growth Retardation	*Controls*
	n (%)	*n (%)*
Poor sleepers	15 (58)	19 (40)
Good sleepers	11 (42)	28 (60)
Total	26	47

On the specific actigraphic sleep measures, we found a tendency in the children with intrauterine growth retardation to spend less time in bed and to have less efficient sleep (Table 2). This tendency was found to be statistically significant in only one parameter, that of true sleep time (498 ± 36.7 minutes for the children with intrauterine growth retardation and 520 ± 42.8 minutes for the control groups; $P = .03$).

On the general sleep quality category, 15 of 26 children (58%) in the study group met the definition of poor sleeper versus 19 of 47 (40%) in the control group. This difference was not statistically significant ($\times 2 = 2.01$; $P = .16$) (Table 3).

Behavioral Questionnaires

No significant differences were found between children with intrauterine growth retardation and control groups in both the Child Behavioral Checklist Questionnaire and the Conners' Parent Rating Scales (Table 4).

Sleep Habit Questionnaire

Significant differences were found for the sleepiness scale calculated from the sleep habit questionnaire. Parents of children with intrauterine growth retardation reported that their children were sleepier ($P = .05$), more tired in the morning ($P = .0005$), and less alert in the evening ($P = .005$) compared with the reports of the control group parents.

Correlation Between Risk Questionnaires of Children With Intrauterine Growth Retardation and Their General Sleep Quality

No correlation was found between the total score of the obstetric and neonatal intrauterine growth retardation risk questionnaires and the quality of sleep as measured in the present study (poor versus good sleep). Significant correlation was found between the cumulative score of the parental risk questionnaire and sleep quality ($P = .035$). The only single item in this questionnaire significantly correlated with sleep quality was the number of siblings of the father.

Correlation Between Biometric Measures and General Sleep Quality

We found no significant correlation between the general sleep quality as measured in the present study and any of the biometric measures evaluated, including birthweight, cephalization index (the ratio between body weight and

Table 4. Behavioral Questionnaires

	Children With Intrauterine Growth Retardation (n = 26)	*Controls (n = 47)*	*P*
	Mean ± SD	*Mean ± SD*	
Child Behavioral Checklist Questionnaire	17.50 ± 17.03	18.37 ± 12.11	.79
Parental Conners' questionnaire	6.00 ± 4.82	5.60 ± 4.19	.71

head circumference at birth), gestational age, and height and head circumference at 4 years.

Correlation Between Outcome and General Sleep Quality

No correlation was found between the general sleep quality and neurobehavioral and psychologic outcome as measured at age 4 years.

DISCUSSION

Children with a history of intrauterine growth retardation have been shown to be at risk for developing later learning disorders, attention, and graphomotor and visuospatial difficulties.[22]

For the first time, the sleep characteristics of this at-risk population were evaluated by means of actigraphy. We hypothesized that a higher prevalence of sleep disturbances in this group could be associated with the aforementioned neurodevelopmental profile.[11,25–27]

The results of this study indicate that both at-risk intrauterine growth retardation children and control children aged 4 to 7 years have a high prevalence of sleep disturbances when measured by actigraphy. This previously published finding[6,17] emphasizes the need to view sleep disturbances as a common condition in children in general and in high-risk groups in particular.

In this study, children with intrauterine growth retardation aged 4 to 7 years had a tendency toward poorer quality of sleep than their matched controls. This inclination was statistically significant only for one sleep measure: true sleep time, which probably emerges from a general tendency of children with intrauterine growth retardation to have more and longer waking episodes than their age- and gender-matched controls. The tendency toward a more fragmented pattern of sleep, although not statistically significant in this study, was also demonstrated by a higher percentage of children with intrauterine growth retardation defined as poor sleepers (58% versus 40%). We speculate that a larger study group could possibly validate this tendency.

Another significant difference was noted in the Sleep Habit Questionnaire, in which parents of children with intrauterine growth retardation reported their children to be generally more tired than their age-matched controls. No other significant behavioral differences were reported by the parents of children with intrauterine growth retardation as recorded by Child Behavioral Checklist Questionnaire and the Conners' Parent Rating Scales.

In an effort to correlate sleep measures with biologic and environmental parameters and with the outcome of children with intrauterine growth retardation at age 4 years, we compared the children with intrauterine growth retardation defined as poor sleepers with the children with intrauterine growth retardation defined as good sleepers. Biologic risk factors (neonatal and obstetric questionnaires and biometric data) were not found to correlate with the good and poor sleeper categories, nor was there any significant correlation between this general sleep quality rating and neurobehavioral and psychologic outcome at age 4 years. The only risk parameter statistically correlated with the good and poor sleeper categories was the number of siblings in the parental risk questionnaire, and we assume that this is a clinically nonsignificant correlation.

In summary, as we initially hypothesized, children with intrauterine growth retardation tend to have poorer sleep quality than their age-matched controls (manifested by the shorter true sleep time measured by actigraphy) and increased daytime tiredness as reported by their parents. This poorer sleep profile is probably an integral part of the neurodevelopmental profile typical of these at-risk children. A larger study group will be necessary to further validate these sleep disruptions and correlate them with specific biologic risk factors.

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