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ORIGINAL PAPER

Sleep Patterns of School-Age Children with Asperger Syndrome or High-Functioning Autism

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Abstract Sleep patterns of 32 school-age children with Asperger syndrome (AS) and high-functioning autism (HFA) were compared to those of 32 typically developing age- and gender-matched children, using parent survey and one week of diary and actigraphic monitoring. Parents of children with AS/HFA more commonly reported that their children had difficulty falling asleep. One week of sleep recording with diary and actigraphy confirmed that children in the AS/HFA group spent a longer time awake in bed before falling asleep than children in the control group, possibly because the children in the AS/HFA group had earlier bedtimes. Other essential aspects of sleep patterns coincided between the groups. The sleep patterns of children with AS and HFA did not differ.

Keywords Sleep · Asperger syndrome · High-Functioning autism · Actigraphy · Sleep diary

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Several authors suggest that disordered sleep is common in children and adults with the Pervasive Developmental Disorders (PDD) of Asperger syndrome (AS) and high-functioning autism (HFA) (Paavonen, Nieminen-von Wendt, Vanhala, Aronen, & von Wendt, 2003; Patzold, Richdale, & Tonge, 1998; Richdale, 2001; Richdale & Prior, 1995; Tani et al., 2003). However, there is still a paucity of systematic data about the sleep patterns in children with AS and HFA and a need for further studies that include comparisons with typically developing children (Richdale, 1999, 2001).

Many children, adolescents, and adults with AS or HFA are troubled by coexisting behavioral or psychiatric disorders (Ghaziuddin, Weidmer-Mikhail, & Ghaziuddin, 1998; Kim, Szatmari, Bryson, Streiner, & Wilson, 2000; Nass & Gutman, 1997; Tonge, 1999), including sleep abnormalities (Paavonen et al., 2003; Patzold et al., 1998; Richdale, 2001; Richdale & Prior, 1995). Difficulties with sleep may be associated with daytime sleepiness as well as behavioral and learning problems (Paavonen et al., 2003; Patzold et al., 1998; Richdale & Prior, 1995), and may severely disrupt the sleep of parents and other family members (Patzold et al., 1998). Moreover, some researchers have suggested that the characteristic psychopathology of individuals with PDDs may be directly associated with disturbed sleep (Hoshino, Watanabe, Yashima, Kaneko, & Kumashiro, 1984; Patzold et al., 1998; Richdale & Prior, 1995). A study by Segawa, Katoh, Katoh, and Nomura (1992), for example, indicated that improved sleep in children with PDD was related to improved social relatedness and reduced insistence on sameness.

When reviewing the literature regarding the sleep of individuals with AS and HFA, it needs to be recognized that AS only recently was acknowledged as a separate diagnostic PDD category in both the *Diagnostic and*

Statistical Manual of Mental Disorders (DSM-IV) (American Psychiatric Association, 1994), and in the *International Classification of Diseases (ICD-10), Classification of Mental and Behavioural Disorders* (World Health Organization, 1992). AS is distinguished from HFA by a lack of clinically significant cognitive or language delay (American Psychiatric Association, 1994). Thus, it may also be relevant to discuss earlier studies on sleep in children with HFA, because these studies presumably may have included individuals with AS.

In one previous sleep study that may have included individuals with AS or individuals with HFA, Hoshino et al. (1984) compared the sleep patterns of 75 children with PDDs (age range 3–15 years) with those of 75 typically developing children in a questionnaire-based study. Twenty-four children in the PDD group constituted a high-functioning (''relatively well developed'') subgroup. This high-functioning subgroup displayed a lower rate of sleep disturbance than the low-functioning subgroup (Hoshino et al., 1984).

In another sleep study that was based on parentally reported sleep diary data, 27 high-functioning children with autism (age range 4–14 years) were included among a total of 39 children with PDD. The sleep patterns of the children with PDD were compared with the sleep patterns of age-, gender- and IQ-matched controls (Richdale & Prior, 1995). The high-functioning children with autism had more difficulties initiating sleep, shorter sleep duration, longer nighttime awakenings, and earlier morning wake times than the children in the control group. In contrast to the children in the study by Hoshino et al. (1984), the high-functioning children with autism in the report of Richdale and Prior (1995) displayed more disturbed current sleep behavior than the low-functioning children with autism.

Utilizing the methods outlined by Richdale and Prior (1995) in the study mentioned above, Patzold et al. (1998) compared the sleep of 38 children with PDD (age range 3–12 years) with the sleep of age-, gender- and IQ-matched controls. Twenty-one children, seven of them with a diagnosis of AS, constituted a high-functioning PDD subgroup. The entire PDD group fell asleep later, exhibited longer sleep latency, longer duration of nighttime awakenings, and shorter sleep duration than the control group. The results of the study by Patzold et al. (1998) suggested that sleep problems were related to the level of psychopathology, and not to the overall level of intellectual functioning. The authors concluded that their results provided support for the notion that sleep problems may be related to some particular deficits found in autism, rather than to an intellectual impairment per se. Unlike Richdale and Prior (1995), Patzold et al. (1998) found no differences in sleep variables between high-functioning children with autism and low-functioning children with autism.

Moreover, the sleep of eight individuals with AS (age range 7–53 years) was compared with that of age- and gender-matched controls in a polysomnographic study (Godbout, Bergeron, Limoges, Stip, & Mottron, 2000). Difficulties initiating and maintaining sleep were reported for the AS group. Further, 15 children (age range 6–17 years) with AS, suffering from difficulties initiating and/or maintaining sleep, were treated with melatonin in an open clinical trial (Paavonen et al., 2003). The melatonin treatment resulted in significant improvement in sleep, daytime behavior, and well-being in those children. The studies by Godbout et al. (2000) and Paavonen et al. (2003) both used the criteria for AS found in the *Diagnostic and Statistical Manual of Mental Disorders (DSM-IV)* (American Psychiatric Association, 1994).

Thus, sleep studies that have included individuals with AS and HFA suggest that sleep problems are frequently related to the timing (Hoshino et al., 1984; Patzold et al., 1998; Richdale & Prior, 1995), duration (Patzold et al., 1998; Richdale & Prior, 1995), initiation, and maintenance of sleep (Bergeron, Godbout, Mottron, & Stop, 1997; Godbout et al., 2000; Paavonen et al., 2003; Patzold et al., 1998; Richdale & Prior, 1995).

A review of sleep studies undertaken with individuals who have AS and HFA suggests that the studies have had some limitations. For example, few studies have yet used the current diagnostic criteria for AS, participants have had wide age ranges, and only a few studies have used objective measures (e.g., actigraphy or polysomnography). Parents are considered to be good informants with regard to recording their children's sleep behavior (Stores, 2001), but actigraphy (movement-based computerized sleep–wake detection) is recommended as the objective technique for home monitoring of the timing, duration, and continuity of sleep (Ancoli-Israel et al., 2003). In order to obtain reliable measures of sleep in children and adolescents, it is considered advisable to obtain five or more nights of usable actigraphic recordings (Acebo et al., 1999). The few actigraphic studies that have been performed with children with AS (Paavonen et al., 2003) or autism (Hering, Epstein, Elroy, Iancu, & Zelnik, 1999), have included only 72 h of monitoring.

In general, it is well established that many school-age children in the general population display irregular sleep–wake schedules and a delay in the timing of sleep on weekends (Dahl & Carskadon, 1995; Laberge et al., 2001; Mindell & Owens, 2003). An average school day–weekend difference is approximately 1 h at age 10, and the discrepancy increases between ages 10 and 13 (Anders, Carskadon, Dement, & Harvey, 1978; Laberge et al., 2001). To our knowledge, there have been no previous studies of children with AS and HFA that have separately analyzed sleep variables on school days and weekends.

Taking into consideration the aforementioned issues, the aim of the present study was to elucidate whether disordered sleep should be perceived as a characteristic aspect of childhood AS and/or HFA. Comparisons were made between school-age children with AS/HFA, without coexisting serious health problems and current medication, and age- and gender-matched typically developing children. Both objective and subjective sleep monitoring methods were used and the sleep variables on school days and weekends were analyzed separately. Further, separate analyses were made within the index group to investigate whether sleep patterns differed between children with AS and children with HFA, and also whether sleep patterns differed between children with and those without parent-reported sleep problems.

Method

Participants

Selection of the Index Group

The index group consisted of 32 children (M=10.8 years, range 8.5–12.8), of whom 28 were boys and 4 were girls. All children in the index group had a clinical diagnosis of AS, had no history of serious physical health problems, and did not currently take medication. These 32 children were selected from a group of 122 children with a clinical diagnosis of AS. The clinical AS diagnoses of the children in the index group were based on comprehensive multidisciplinary assessments (including neuropsychiatric examination, speech and communication testing, and neuropsychological testing) performed on average 40 months earlier by clinicians at child psychiatric and pediatric clinics. These clinicians were independent and not involved in any way in the current research project. All of the 122 children with AS were registered at three PDD-habilitation centers in Stockholm. PDD-habilitation centers are the public institutions that provide help to the families of children with PDDs, in the form of psychological counseling, special education, speech therapy, and neuropsychiatric evaluation and treatment.

The index group was selected using a two-stage procedure. In the first selection stage, the medical records of the 122 children with AS were reviewed in order to exclude children with epilepsy, physical disabilities, or ongoing medication, which are factors known to have an impact on sleep (Brown, 1996; Mindell & Owens, 2003). In addition, essential language delay, which is inconsistent with ICD-10 diagnosis of AS, was used as an exclusion criterion in this selection stage. Thirty-four of the 122 children with AS were excluded: 5 due to epilepsy, 5 due to essential language delay, 4 due to physical disabilities (2 had severe allergic complaints, 1 had ataxia, and 1 had ataxia with a visual impairment), and 20 due to pharmacological treatment (10 were taking psychostimulants, 8 were taking antidepressants, and 2 were taking neuroleptics). The initial review of the medical records did not indicate mental retardation in any of these children.

In the second selection stage, the remaining 88 families were asked by mail to participate in the study. Fifty-one families expressed willingness to take part in the investigation. However, further communication between the first author and the parents, along with a second review of medical records, resulted in 19 more exclusion in this stage of selection. Fifteen of the 19 children were excluded due to ongoing psychotropic medication (9 were taking psychostimulants, 3 were taking neuroleptics, and 3 were taking antidepressants). Also, 4 of the 19 children were excluded since further scrutinizing of the available information showed that mental retardation could not be ruled out. Furthermore, we decided to retain children with a comorbid diagnosis of Tourette syndrome (n=3) in the index group. It was later found that the sleep data for these children compared with the other children in the index group did not differ significantly. Consequently, 32 children with clinical diagnoses of AS constituted the index group.

Seven out of 32 children in the index group had previously received help for disturbed sleep. We cannot rule out that some families of children in the index group had received advice concerning possible sleep problems from the PDD-habilitation centers. However, we lack detailed information about the nature of this treatment, and whether the help was provided by the PDD-habilitation centers.

The medical records of these 32 index-group children showed that all were of normal intellectual capacity according to one or more of four individually administered tests of intelligence (the Wechsler Intelligence Scale for Children [WISC-R], the Leiter International Performance Scale, the Wechsler Preschool and Primary Scale of Intelligence [WPSSI], or Griffiths' Development Scale). These assessments were performed on average 40 months before the start of present study. In the majority (n=21) of the children in the index group, IQ was assessed using the WISC-R.

Diagnostic Reassessment of the Index Group

A diagnostic reassessment was made by the first author in order to ensure that children in the index group fulfilled ICD-10 research criteria for AS (World Health Organization, 1993). The reassessment was based on interviews with parents and children, and an additional review of medical records, and did not lead to any exclusion of participants. Unexpectedly, 13 children (11 boys and 2 girls) with a clinical diagnosis of AS displayed a history of essential

language delay. These children were rediagnosed with HFA and retained in the index group. Nineteen children in the index group (17 boys and 2 girls) fulfilled ICD-10 research criteria for AS (Appendix A1).

We cannot establish why our diagnostic reassessment for this study differed from the results of the previous clinical evaluation. For some children, the medical records did not clearly specify the diagnostic criteria in detail. Notably, in spite of the history of language delay, some children had been assigned a diagnosis of AS.

The Issue of Language Delay

The initial aim of our study was merely to study sleep patterns in children with a diagnosis of AS. According to the ICD-10 and the DSM-IV, there is a requirement of none clinically significant language delay in the diagnosis of AS. Consequently, during the earliest stages of our investigation, we excluded children whose medical records had a clear indication of essential language delay. However, the further diagnostic reassessment revealed that 13 out of the 32 children with the clinical diagnosis of AS displayed a history of early language delay and fulfilled the ICD-10 research criteria for autistic disorder. We decided to retain them in our sample, and the final aim of our study was changed in order to allow us to investigate sleep patterns of school-age children with both AS and HFA.

Selection of the Control Group

The control group (M=10.9 years, range 8.5–13.4) was recruited via school nurses from the same local communities as the children in the index group. After review of school medical records, children without mental, developmental, or physical disabilities (n=32) were selected. Physical health was defined as absence of any known chronic physical or developmental disabilities. The children in the index and control groups were matched pairwise for age and gender. Thus, the control group consisted of 28 boys and 4 girls, who were not currently taking medication and who participated in the study with the informed consent of their parents.

Sociodemographics

Descriptive statistics regarding sociodemographics (including gender, age, school situation, number of children in the family, family status, and number of parents employed full time) are provided in Table 1. Statistically significantly fewer children in the index group lived in nuclear families (65.6% vs. 87.5% in the control group, $P<.05$, Wilcoxon test). Also, the school situation of the children in the two groups differed. All children in the control group attended regular classes in mainstream schools. Only 13 of the children with AS/HFA attended regular classes in mainstream schools; 4 of these 13 children received extra support from school assistants. Nineteen children from the index group attended classes or schools for children with various special needs.

Measures

Measures of Sleep

Parent-Reported Sleep Problems Parents both in the index and control group answered a global question about whether or not their child was affected by sleeping problems. They chose from four possible responses: ''No,'' ''Yes, by mild problems,'' ''Yes, by definite problems,'' or, ''Yes, by severe problems.'' Parents who responded that their children did have sleep problems specified their primary concerns by answering an open-ended question (''If your child has a current sleep problem, please describe the major concerns about your child's sleep'').

Child Sleep Diary On each consecutive night for 1 week parents recorded six items of information: the time when the child went to bed (*bedtime*), the number of minutes required for the child to fall asleep (*sleep onset latency*), whether or not the child awakened at night (on a yes–no basis) (*nighttime awakening*), the time when the child woke up in the morning (*get up time*), parent's estimation of the duration of the child's nighttime sleep (*total sleep time*), and parent's rating on a 5-point scale of the quality of the child's nighttime sleep (*sleep quality*) (1=very poor,

Table 1 Sociodemographic data regarding the children with AS/HFA and the children in the control group

	Children with AS (n=19)	Children with HFA (n=13)	Controls (n=32)
Gender			
Girls	2	2	4
Boys	17	11	28
Age (mean, SD)	11.0 (1.2)	10.5 (1.3)	10.9 (1.3)
School situation			
Secondary school	8	5	32
Special class or school	11	8	0
No. of children in family (min–max)	1.7 (1–3)	2.3 (1–4)	2.5 (1–4)
Family status			
Nuclear	13	8	28
Single parent	3	2	2
One step-parent	3	3	2
Parents employed full time			
Mothers	7	7	19
Fathers	18	9	27

2=quite poor, 3=neither poor nor good, 4=quite good, 5=very good).

Actigraphy Objective measures of sleep were evaluated by 1 week of actigraphic monitoring. The actigraph used in the current study, Actiwatch (Cambridge Neurotechnology, Ltd, Cambridge, UK), is a self-contained minicomputer the size of a wristwatch that is worn on the child's nondominant arm. It contains a piezoelectric accelerometer that records all movements exceeding the 0.05 g threshold, and translates these movements into electrical signals. Movements were sampled at the medium sensitivity level with the epoch length 30 s and stored as activity counts per epoch in the Actiwatch's 16-K memory. Data from the actigraph's memory were thereafter downloaded to the Actiwatch Sleepwatch software (The Actiwatch Activity Monitoring System, 1999).

In the present study, we focused on seven actigraphic measures that cover timing, duration, initiation, and maintenance of sleep. Bed- and get up times obtained from sleep diaries were manually entered into the software program. *Sleep start* was defined as the first minute after bedtime (reported by parents in the sleep diary) that was identified as sleep by the Actiwatch Sleepwatch algorithm and was followed by at least 10 consecutive minutes of recorded immobility. *Sleep latency* was defined as the latency before sleep start following *bedtime*. *Sleep end* was classified as the last epoch of immobility before the start of at least 10 min of consecutive activity. *Actual sleep time* was the calculated difference between sleep end and sleep start in minutes minus actual time spent awake during the sleep period. *Number of night wakings* was defined as a number of manually scored wakings lasting 5 min or longer, preceded and followed by at least 15 min of uninterrupted sleep (Sadeh, Raviv, & Gruber, 2000). *Duration of night wakings* was the total duration of these night wakings (≥5 min). *Sleep efficiency* was defined as the percentage of time spent asleep while in bed.

The High-Functioning Autism Spectrum Screening Questionnaire

The High-Functioning Autism Spectrum Screening Questionnaire (ASSQ) is a 27-item checklist for screening for AS and HFA in children 7–16 years of age (Ehlers, Gillberg, & Wing, 1999). In this study, the ASSQ was used to rule out the possibility that participants in the control group displayed symptoms indicative of AS or HFA. Twenty-seven items, 11 of these covering impairments in social interaction, 5 covering restricted and repetitive behavior, 6 covering communication problems, and 5 covering motor clumsiness and associated symptoms, are rated on a 3-point scale (Ehlers & Gillberg, 1993). Parent as well as teacher ASSQ versions have revealed satisfactory test–retest reliability, inter-rater reliability, and validity for ASSQ total scores (Ehlers et al., 1999).

Procedure

Each of the families (n=64) was visited at home by the first author, who is a pediatrician trained in neuropsychiatry. Sleep diaries, actigraphs, and ASSQ (both teacher and parent versions) were distributed to the families. Parents were asked to convey ASSQ teacher versions to their child's teacher, and teachers mailed the completed forms to the first author. Participants were instructed in the use of actigraphs and how to complete sleep diaries and ASSQs. During the home visit, parents were given a detailed verbal instruction on how to fill in the sleep diaries. One week of parallel actigraphic and sleep diary recording commenced in conjunction with the first home visit. Following the monitoring period, actigraphs, sleep diaries, and ASSQs were returned to the first author via a second home visit, a parental visit to the clinic, or by mail. Parents were asked to complete any missing information in the questionnaires at the time of the second home visit or over the telephone.

Sixty-two participants, 30 children from the index group and 32 children from the control group, were monitored for 7 days, and 2 children from the index group were monitored for 6 days. One of these 2 children forgot to put the device back on after a shower and the other slept in a place far from home and forgot to take along the device; this is why the monitoring period for each of these children was shortened by one day. All participants cooperated well. The children within each pair were examined within 2–4 weeks of one another using the same set of actigraphs. The same set of actigraphs was used in order to compensate for possible interdevice variability in the sensitivity of different actigraphs (Sadeh, Sharkey, & Carskadon, 1994).

Statistical Analysis

Statistical analyses were divided into two main sections: (1) comparisons between children in the index group and children in the control group, and (2) comparisons between children within the index group. These two main sections were divided into a total of five subsections. Section 1 was divided into (a) parent-reported sleep problems, (b) sleep diary and actigraphy, and (c) ASSQ data. Section 2 was divided into (d) AS and HFA, and (e) children with and those without parent-reported sleep problems.

In part 1, subsection *a*, Mantel–Haenszel test was used in order to calculate the odds ratio for parent-reported sleep problems in the index group. The four-point rating scale

was dichotomized into two alternatives in order to divide the children in the index group into two definite subgroups, those with sleep problems and those without sleep problems (yes=''Yes, by mild problems,'' ''Yes, by definite problems,'' ''Yes, by severe problems'', and no=''No''). This dichotomy was also used in the ANOVA analyses (see below).

In subsections *b*, *d*, and *e*, five variables from the sleep diary (*bedtime*, *sleep onset latency*, *get up time*, *total sleep time,* and *sleep quality*) (Table 2), and seven actigraphic variables (Table 3) were averaged into *school day* and *weekend* mean values, using the occurrence of school attendance the next day as the definition of a school day (school day: Sunday, Monday, Tuesday, Wednesday, Thursday; weekend: Friday, Saturday), and analyzed by repeated-measures analysis of variance (ANOVA), with group (AS/HFA vs. control) and day of the week (school day vs. weekend) as two *within subject factors.*

In subsection *b*, data about timing and duration of sleep and initiation and maintenance of sleep were presented separately. In subsection *d*, the two diagnostic groups within the index group (AS or HFA) were used as *between subject factors* in repeated measures ANOVA. In subsection *e*, the presence or absence of parent-reported sleep problems in the index group was used as *between subject factors* in repeated measures ANOVA.

In addition, continuous sociodemographic data (Table 1) and ASSQ scores were analyzed by using *t* tests for paired samples. The Wilcoxon test for paired samples was used for comparisons of categorical sociodemographic data. Pearson bivariate correlations were used for comparisons between sleep diary and actigraphic variables.

The Statistical Package for Social Sciences (SPSS) was used for all analyses (*SPSS base 9.0 : User's guide*, 1999).

Ethical Considerations

The study was approved by the Ethical Committee at the Karolinska Hospital, Stockholm, Sweden.

Results

Comparisons between children in the index group and children in the control group

Parent-Reported Sleep Problems

The odds ratio for parental report of global sleep problems in the index group was 6.3 (95% confidence interval: 1.8–21.4, $P < .01$). Nineteen of the children in index group (59.2%) and 3 of the children in the control group (9%) had parent-reported sleep problems. The sleep problems were perceived as mild in 10 of the children in the index group (31.2%) vs. in 1 of the controls (3.1%), and as definite in 9 of the children in index group (28.1%) vs. in 2 of the children in the control group (6.2%). Parents' reply to an open-ended question revealed that bedtime resistance was a concern in 3 index group children and in 1 control group child. Difficulties falling asleep were reported in 12 index group children, nighttime awakenings with difficulty going back to sleep were described in 2 index group children, restlessness during sleep was reported in 1 index group child, ''increased need for sleep'' was described as a problem in 1 index group child, and bed-wetting and nightmares were described as concerns in 1 control group child.

Sleep Diary and Actigraphy

Descriptive data, mean values, and standard deviations of sleep diary variables are presented in Table 2 and of actigraphic variables in Table 3.

Timing and duration of sleep Sleep diary data on bedtime, get up times, and total sleep time, as well as actigraphic data on sleep start, sleep end, and actual sleep time were used to determine the timing and duration of sleep. The correlation quotient between parent-recorded total

Table 2 Sleep variables for children with AS/HFA and children in the control group according to sleep diary

Sleep variable	Measurement	Day	AS/HFA (*n*=32)	Controls (*n*=32)	AS/HFA with sleep problems (*n*=19)	AS/HFA without sleep problems (*n*=13)
Bedtime	Time (PM)	School day	09:15 (34.9)	09:26 (35.6)	09:23 (34.6)	09:04 (33.7)
	(SD-min)	Weekend	10:14 (54.3)	10:54 (59.5)	10:18 (56.3)	10:09 (53.0)
Sleep onset latency	Mean	School day	31.7 (20.9)	17.2 (14.7)	40.1 (21.8)	19.2 (11.4)
	(SD-min)	Weekend	18.3 (13.7)	11.4 (10.3)	21.7 (15.8)	13.2 (7.9)
Get up time	Time (AM)	School day	07:05 (30.2)	07:11 (22.5)	07:04 (21.3)	07:02 (40.8)
	(SD-min)	Weekend	07:56 (55.0)	08:36 (51.6)	08:16 (58.1)	07:28 (35.7)
Total sleep time	Mean	School day	542 (39.3)	556 (33.0)	526 (34.7)	566 (33.9)
	(SD-min)	Weekend	553 (51.4)	566 (47.6)	562 (49.4)	541 (53.7)
Sleep quality	Mean	School day	4.0 (0.6)	4.6 (0.6)	3.9 (0.6)	4.3 (0.6)
	(SD)	Weekend	4.4 (0.6)	4.6 (0.6)	4.2 (0.6)	4.7 (0.4)

SD-min = Standard Deviation in minutes

Table 3 Sleep variables in children with AS/HFA and children in the control group according to actigraphy

Sleep variable	Measurement	Day	AS/HFA (*n*=32)	Controls (*n*=32)	AS/HFA with sleep problems (*n*=19)	AS/HFA without sleep problems (*n*=13)
Sleep start	Time (PM)	School day	09:47 (40.1)	09:42 (32.5)	10:01 (34.2)	09:28 (41.7)
	(SD-min)	Weekend	10:36 (54.6)	11:06 (58.7)	10:43 (52.5)	10:26 (58.0)
Sleep latency	Mean	School day	32.2 (17.9)	15.7 (10.6)	37.9 (18.5)	24.0 (13.8)
	(SD-min)	Weekend	21.5 (20.0)	11.4 (10.3)	25.1 (23.6)	16.4 (12.2)
Sleep end	Time (AM)	School day	07:00 (30.3)	07:04 (23.2)	07:08 (21.5)	06:58 (40.9)
	(SD-min)	Weekend	07:51 (53.7)	08:31 (53.4)	08:10 (56.7)	07:22 (34.3)
Actual sleep time	Mean	School day	511 (34.7)	523 (35.0)	500 (31.4)	528 (33.8)
	(SD-min)	Weekend	514 (44.4)	522 (42.5)	523 (42.7)	500 (44.7)
No. of night wakings (≥5 min)	Mean	School day	1.1 (0.7)	1.0 (0.9)	1.1 (0.8)	1.1 (0.7)
	(SD)	Weekend	1.1 (0.9)	1.1 (0.8)	1.2 (1.0)	0.9 (0.9)
Duration of night wakings (≥5 min)	Mean	School day	10.9 (8.5)	7.9 (6.7)	10.4 (9.4)	11.7 (7.4)
	(SD-min)	Weekend	9.5 (10.3)	8.1 (6.5)	10.5 (11.1)	8.2 (9.5)
Sleep efficiency	Mean	School day	87.1 (3.6)	90.3 (4.1)	86.2 (3.7)	88.4 (3.2)
	(SD-%)	Weekend	88.6 (4.7)	90.1 (4.1)	87.9 (5.3)	89.7 (3.7)

SD-min = Standard Deviation in minutes

sleep time and the actigraphic actual sleep time was (r)=.73 for the index group and (r)=.64 for the control group on school days. Sleep diary data displayed significant group-by-day interactions for bed time [$F(1, 31)=7.04$, $P<.05$] and get up time [$F(1, 31)=7.03$, $P<.05$]. Contrast analysis revealed that the interactions depended on differences between children in the index group and children in the control group on weekends. The bedtime of the children with AS/HFA was an average 39 min earlier than the bedtime of the corresponding children in the control group, and the morning get up time of the children with AS/HFA was an average 40 min earlier than the morning get up time of the corresponding children in the control group on weekends (Table 2). Notably though, children in both groups displayed significant sleep phase delays in bed- and get up times on weekends; i.e., both groups went to bed later and woke up later on weekends. However, the weekend sleep phase delay was more pronounced among the children in the control group than among those in the index group.

There were statistically significant group-by-day interactions for sleep start [$F(1, 31)=11.52$, $P<.01$] and sleep end [$F(1, 31)=7.82$, $P<.01$]. The interactions were due to the differences in sleep start and sleep end times on weekends. On weekends the actigraphic sleep start of index group children occurred an average of 30 min earlier, and the sleep end an average of 40 min earlier than in the corresponding children in the control group (Table 3). Actigraphic data confirmed the sleep diary findings of a significant weekend sleep phase delay in sleep start and sleep end times among children in both the index group and the control group. Weekend sleep phase delay was more pronounced in control group children than in the children in the index group.

Sleep duration was measured by sleep diary data on total sleep time and actigraphic data on actual sleep time. A trend toward shorter sleep duration was found in the index group; however, it was not statistically significant.

Initiation and maintenance of sleep Sleep diary data on bedtime and sleep onset latency, and actigraphic data on sleep latency were used to determine the initiation of sleep. The correlation quotient between sleep onset latency from sleep diary and actigraphic sleep latency was (r)=.80 for the index group and (r)=.55 for the control group on school days. Sleep diary data showed a significant group-by-day interaction for sleep onset latency [$F(1, 31)=4.63$, $P<.05$]. The interaction mainly depended on differences on school days. On school days, children in the index group required 15 min longer to fall asleep than the children in the control group (Table 2). Additionally, the sleep diary showed that both index and control group children displayed significantly shorter sleep onset latency times on weekends than on school days. The actigraphic data confirmed a significantly longer sleep latency in the index group; i.e., the children in the index group spent a longer time awake in bed before sleep start than the corresponding children in the control group. Sleep latency differed between the groups on school days [$F(1, 31)=21.62$, $P<.001$] as well as on weekends [$F(1, 31)=6.81$, $P<.05$]. Children with AS/HFA had approximately 17 min longer sleep latency on school days and 10 min longer sleep latency on weekends than the corresponding children in the control group (Table 3).

Sleep diary data on nighttime awakenings and sleep quality, and actigraphic data on number of night wakings (≥5 min), duration of night wakings, and sleep efficiency were used to investigate the maintenance of sleep. *T*-tests for paired samples did not reveal differences between the index and the control group children regarding diary-recorded nighttime awakenings. Repeated measures

ANOVA displayed slightly lower parentally rated sleep quality among the children in the index group than among the children in the control group on school days [$F(1, 31)=7.15$, $P<.05$]. The actigraphic recordings showed that the index group and control group children did not differ with respect to the number of estimated night wakings (≥5 min) and total duration of these wakings. Finally, actigraphic data and computations showed slightly lower sleep efficiency in the children in the index group than in the corresponding children in the control group on school days [$F(1, 31)=15.60$, $P<.001$].

ASSQ Data

None of the children in the control group reached cutoff scores that would suggest AS or HFA. The mean parental and teacher ASSQ scores for the index group were 21.2 (*SD*=8.7) and 21.0 (*SD*=10.1), vs. 0.8 (*SD*=1.7) and 1.7 (*SD*=2.3) for the control group ($P<.0001$, *t*-test for paired samples). There were no statistically significant differences in parental and teacher ASSQ scores between children with AS and children with HFA.

Comparisons Between Children Within the Index Group

AS and HFA

Parents' retrospective reports indicated that 11 of the 19 children with AS (57%), and 8 of the 13 children with HFA (61%) evinced sleep problems. Statistical analysis of all diary and actigraphic data, with AS and HFA as *between subject factors* in repeated measures of ANOVA, did not provide evidence that the sleep of index group children with AS differed from the sleep of index group children with HFA.

Children with and those Without Parent-Reported Sleep Problems

Parent-reported global sleep problems in the index group were dichotomized into *yes* and *no* alternatives and used as the *between subject factors* in repeated measures ANOVA. Statistically significant differences between these two subgroups were found for diary-recorded sleep onset latency [$F(1, 31)=6.2$, $P<.05$] as well as for actigraphic sleep latency [$F(1, 31)=6.1$, $P<.05$]. Children with AS/HFA and sleep problems displayed 20.9 min longer sleep onset latency on school days, and 8.5 min longer sleep onset latency on weekends than those without sleep problems, according to sleep diary data (Table 2). Actigraphic data revealed 13.9 min longer sleep latency on school days and 8.7 min longer sleep latency on weekends for the parent-reported sleep-disordered group (Table 3). Children with sleep problems and AS/HFA also evinced more variable sleep latency, reflected in a higher standard deviation, according to both sleep diary and actigraphy data.

Discussion

The goal of the present study was to explore the question of whether or not childhood AS and HFA are associated with abnormal sleeping patterns. The study was based on comparisons between matched pairs of children with AS or HFA and typically developing children. Our main findings were difficulties in falling asleep, lower sleep efficiency, and lower parent-rated sleep quality in children with AS/HFA. However, other essential aspects of nighttime sleeping patterns coincided between the children who had PDD and the corresponding children in the control group. Separate analyses within the index group showed no differences in the sleep of children with AS and children with HFA. However, children in the index group with a parental report of a global sleep problem took longer to fall asleep and evinced more night-to-night variability than children in the index group without a parental report of a global sleep problem.

Our study used both subjective and objective measures to collect data on nighttime sleep in both the index and the control group. We focused on four basic aspects of nighttime sleep: timing, duration, initiation, and maintenance of sleep. Parental report of a global sleep problem showed that disturbed sleep, especially difficulties in falling asleep, was common in the children in the AS/HFA group. One week of sleep monitoring using sleep diaries and actigraphy confirmed more difficulty in falling asleep in the children with AS/HFA. They also went to bed earlier and spent a longer time in bed before sleep was initiated. However, the objective measures of sleep start and sleep end did not differ between the children with PDD and the corresponding children in the control group on school days, and the children in the index group fell asleep and woke up somewhat earlier than the corresponding children in the control group on weekends. Moreover, children in the index group displayed lower sleep efficiency and parent-rated sleep quality on school days. Further, we found that sleep duration, number of parent-recorded nighttime awakenings, number of actigraphic wakings lasting at least 5 min, and the total duration of the actigraphic wakings (≥5 min) did not differ between the index and the control groups.

The finding that many parents of children with AS/HFA reported sleep problems, especially difficulties in falling asleep, coincides with previous reports (Paavonen et al., 2003; Patzold et al., 1998; Richdale & Prior, 1995). Our findings on sleep latency in children with AS/HFA, based

on the sleep diary and the actigraphic data, are consistent with previous reports. The mean sleep onset latency we found, on average half an hour on school days, is remarkably similar to the findings reported by Richdale and Prior (1995), Patzold et al. (1998), and Paavonen et al. (2003). However, our study differed from these previous studies in that we analyzed sleep latency on school days separately from sleep latency on weekends, and found that the difficulties in falling asleep were mainly present on school days. Moreover, the children in the AS/HFA group in our study had a more limited age range (8–12 years) than the participants in the previous assessments.

One hypothetical explanation of the prolonged sleep latency in the AS/HFA group might be that these children had earlier bedtimes than children in the control group. Going to bed too early, before an individual is sufficiently sleepy, may obviously cause prolonged sleep latency and complaints of inability to fall asleep. When speculating about why parents of children with PDD might put their children to bed before the children are ready for sleep, it is important to keep in mind that PDD in children is often associated with a great burden on their parents (Fombonne, Simmons, Ford, Meltzer, & Goodman, 2001). It is possible that putting children with PDD to bed early could be a coping mechanism used by exhausted parents in need of evening and nighttime rest. On the other hand, the earlier bedtimes in the AS/HFA group could simply be a part of good parenting that includes regular routines and beneficial sleep hygiene. Thus, the parents may have instituted what they considered optimal routine bedtimes with the intention of helping their child fall asleep. The role of regular sleep routines and of good sleep hygiene for solving sleep problems in children with impairments has been emphasized by several authors (Hoshino et al., 1984; Mindell & Owens, 2003; Richdale & Prior, 1995; Stores, 2001). A third explanation of the earlier bedtimes in the AS/HFA group might be that these children were sleepy at bedtime, but required somewhat longer time in bed before sleep start. Furthermore, it has been suggested that factors such as anxiety, high physiological arousal, more problematic daytime behavior, fear, and problems with social relatedness may be related to the prolonged sleep latency in children with AS/HFA (Patzold et al., 1998; Richdale, 1999; Richdale & Prior, 1995). In a future study, we plan to investigate the impact of these types of factors on sleep in children with AS/HFA.

The children with AS/HFA fell asleep and woke up at approximately the same time as the corresponding children in the control group on school days. This could indicate that both groups have a similar ability to adapt to school-day time schedules. Notably, children in both groups went to bed and woke up later on weekends than on school days. The finding of a weekend sleep phase delay corresponds with previous reports on typically developing school-age children (Anders et al., 1978; Laberge et al., 2001). The finding of a shorter weekend sleep phase delay in the index group children might suggest that the basic sleep–wake rhythm was more stable and regular in the AS/HFA group. The earlier bed- and sleep start times that we found for children with AS/HFA are in contrast to the findings of Richdale and Prior (1995) and Patzold et al. (1998). However, the discrepancy between our finding and these previous findings could be related to the methodological differences between studies, e.g., the participants' level of cognitive functioning, as well as differences in assessment methods.

Duration or maintenance of nighttime sleep did not differ significantly between the children with AS/HFA and children in the control group in our study. We used three different measures to explore the maintenance of sleep: number of parent-recorded nighttime awakenings, number of actigraphic wakings lasting at least 5 min, total duration of actigraphic wakings (lasting at least 5 min). Our finding, that the children in the index and control groups did not differ on duration and maintenance of sleep, is different from the findings of Richdale and Prior (1995) and Patzold et al. (1998), who found an average half an hour shorter sleep duration and significantly longer periods of nighttime wakings in children with HFA (Patzold et al., 1998; Richdale & Prior, 1995).

Furthermore, we did not discover any differences in sleep patterns between the children with ICD-10 diagnosed AS and ICD-10 diagnosed HFA. A similar finding has been reported earlier by Patzold et al. (1998). However, only 21 children formed the high-functioning group with autism in the study by Patzold et al. (1998), of whom 7 were diagnosed as having AS. Our data on sleep add to the knowledge about possible similarities between AS and HFA (Dickerson Mayes, 2001a, b; Gilchrist et al., 2001; Howlin, 2003).

The association between prolonged and more variable sleep latency and the presence of parent-reported global sleep problems in the index group is also of interest. Our findings indicate that parental report of a global sleep problem is confirmed by objective measures.

The main strengths of our study are the limited age range (8–12 years), the 1-week parallel sleep diary and actigraphic monitoring, the inclusion of only nonmedicated children without significant health problems, and the comparisons with age- and gender-matched typically developing children.

However, our study has potential limitations. In similarity to other highly selected clinical samples, it is difficult to know if our sample of individuals with PDD was representative of children with AS/HFA in general. Two types of selection biases with respect to sleep may have affected our sample. On the one hand, it is possible that more families

that have children with PDD and disturbed sleep accepted the offer to participate in the study. On the other hand, exclusion criteria resulted in the selection of healthy and nonmedicated children. It is well established that medication affects sleep (Brown, 1996; Mindell & Owens, 2003). Severely sleep-disturbed children who received medication for sleep problems may have been excluded from our sample. Though none of the excluded children received medication for sleep, some of them received psychotropic medication, and could have been troubled by severe sleep problems. Hence, the two described types of selection biases may have worked in two directions, including children with parentally perceived sleep problems and simultaneously excluding severely sleep-disturbed individuals.

Another possible limitation of the study was the 1-week observation period, a rather short and therefore possibly insufficiently representative period of time in the life of a child. The need for at least 14 days of sleep diary recording in order to obtain valuable information has been emphasized (Stores, 2001). Another limitation is the fact that we focused on the basic aspects of nighttime sleep and did not take into account the possibility of daytime napping. In fact, our diary and actigraphy data did not allow reliable assessments of daytime sleep. Also, we lack information on whether the children woke up spontaneously in the morning, or if they were awakened by other family members. Yet, nothing suggests that there was a difference between children in the index and children in the control group in this respect. Moreover, another limitation of our study could be the relatively small sample size (n=32 matched pairs). However, power calculations (not shown) demonstrate that it is possible to detect clinically significant differences with a reasonably high power in our study.

To summarize, parents reported more difficulties falling asleep in children with AS/HFA. Diary and actigraphy data confirmed that children in the AS/HFA group had difficulties in falling asleep, possibly related to earlier bedtimes. The groups did not differ with respect to timing of sleep on school days, and the children in the AS/HFA group fell asleep earlier on weekends than children in the control group. Sleep duration and number of parent-recorded nighttime awakenings, actigraphic nighttime wakings (≥5 min), and duration of actigraphic wakings did not differ between the groups. However, the AS/HFA group had lower actigraphic sleep efficiency and parent-rated sleep quality on school days. No differences were found between the children with AS and HFA with respect to sleep patterns. Moreover, children with AS/HFA and parent-reported sleep problems displayed longer and more

Appendix A1 Description of cases according to ICD-10 research criteria for childhood autism and Asperger syndrome

Symptoms	AS (n=19)	HFA (n=13)
1. ICD-10 research criteria for childhood autism		
A. Abnormal or impaired development before the age of three years (in at least one area)		
1. Receptive/expressive language	0/19	13/13
2. Selective social attachment or reciprocal social interaction	0/19	11/13
3. Functional or symbolic play	0/19	6/13
B. (1) Qualitative abnormalities in reciprocal social interaction (in at least two areas)		
1. Failure adequately to use eye-to-eye gaze, facial expression, body posture, and gesture to regulate social interaction	13/19	12/13
2. Failure to develop peer relationships	16/19	11/13
3. Lack of socio-emotional reciprocity	14/19	11/13
4. Lack of spontaneous seeking to share enjoyment, interests, or achievements	4/19	4/13
B. (2) Qualitative abnormalities in communication (in at least one of the following areas)		
1. A delay in, or total lack of, development of spoken language that is not accompanied by an attempt to compensate through the use of gesture or mime	0/19	13/13
2. Relative failure to initiate or sustain conversational interchange in which there is reciprocal responsiveness to the communications of the other person	12/19	11/13
3. Stereotyped and repetitive use of language or idiosyncratic use of words or phrases	17/19	11/13
4. Lack of varied spontaneous make-believe or (when young) social imitative play	3/19	3/13
C. Restricted, repetitive, and stereotyped patterns of behavior, interests, and activities (at least one)		
1. An encompassing preoccupation with one or more stereotyped patterns of interest, abnormal in content, focus, or intensity	17/19	9/13
2. Apparently compulsive adherence to specific, non-functional routines or rituals	15/19	11/13
3. Stereotyped and repetitive motor mannerisms	4/19	3/13
4. Preoccupations with parts of objects or nonfunctional elements of play materials	3/19	6/13
2. ICD-10 research criteria for AS		
A. No clinically significant general delay in spoken or receptive language or cognitive development	19/19	0/13
B. Qualitative abnormalities in reciprocal social interaction (criteria as for autism)		
C. Unusually intense, circumscribed interest or restricted, repetitive, and stereotyped patterns of behavior, interests, and activities (criteria as for autism)		

variable sleep latency. A 3-year follow-up study of our sample will be performed with the goal of assessing the stability of our findings. Assessment of the underlying mechanisms of prolonged sleep latency in AS/HFA groups, such as anxiety, more problematic daytime behavior, and fear is an important topic for future research.

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