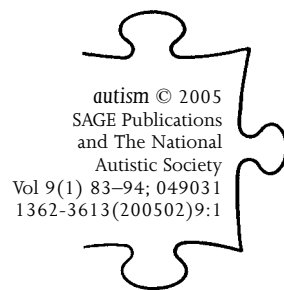


Sleep disturbances in adolescents and young adults with autism and Asperger syndrome



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ABSTRACT Sleep problems are commonly reported in children with autistic disorders. Most studies are based on sleep questionnaires and sleep diaries, but polysomnographic and actigraphic data have also been used. In this study we investigated sleep in older individuals (aged 15–25 years) with autism and Asperger syndrome, using sleep questionnaires, sleep diaries and actigraphy. Although the sleep questionnaires completed by parents and caretakers revealed only a moderate degree of sleep problems, greater sleep disturbance was recorded with actigraphy. Using the latter method, low sleep efficiency (below 85 percent) or long sleep latency (more than 30 minutes) were found in 80 percent of the individuals. There was no early morning awakening, contrary to some earlier reports. This study suggests that even though subjective complaints of sleep disturbances are less common in adolescents and young adults with autism, this may be due to an adaptation process rather than an actual reduction in sleep disturbances.

KEYWORDS

actigraphy;
Asperger
syndrome;
autism;
sleep diary;
sleep
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Introduction

Previous studies have reported sleep disturbances in 44–83 percent of children (aged 3–15 years) with autism (Hering et al., 1999; Richdale and Prior, 1995; Taira et al., 1998). Several studies have investigated the nature of these problems, but the goal of identifying specific sleep disturbances in individuals with autism has not yet been achieved.

Although a certain degree of sleep disturbance is relatively common in healthy young children (Nelson, 2001), problems with sleep onset and maintenance are particularly marked in preschool-aged children with autism (Richdale and Prior, 1995). In a retrospective study of 88 children with

autism in Tokyo, sleep disturbances were reported in 56 percent of the individuals (Taira et al., 1998). Ninety percent of these problems started in infancy, and the most frequent problems were difficulty in falling asleep, awakening during sleep time and early morning awakening. The age when sleep disturbances stopped typically coincided with the time of entrance into kindergarten or elementary school (Taira et al., 1998).

It has been questioned whether total sleep time is abnormally low in individuals with autistic disorder. Elia et al. (2000) completed a polysomnographic study which showed a significant reduction in total sleep time (7 h 30 min) in individuals with autism (aged 5 to 16 years) compared with a control group (8 h 43 min). In a further study of individuals with autism aged 12–24 years (Diomedei et al., 1999), sleep efficiency (sleep as a percentage of time in bed) was reported to be 81 percent, compared with 92 percent for controls. The number of nocturnal awakenings per night was also higher: 11.4 among the autism group, compared with 4.2 among the controls. The individuals with autism in this study all had an IQ level below 30 (Diomedei et al., 1999). In a study based on the use of a sleep diary, Patzold et al. (1998) reported both a significant reduction in total sleep time and a significant increase in sleep latency in individuals (mean age 7.8 years) with autistic disorder and Asperger syndrome compared with controls. Total sleep time was 9 h 50 min in the autism group compared with 10 h 14 min among controls, while sleep latencies for the two groups were 32 minutes and 19 minutes, respectively. Furthermore, children with autism also seemed less ready for sleep at bedtime than children in the control group (Patzold et al., 1998). In contrast, two recent publications have failed to show any significant reduction in total sleep time in individuals with autism (Hering et al., 1999; Schreck and Mulick, 2000). In the latter study, eight children with autism (aged 3–12 years) were registered with a 72 hour actigraphy and only sleep offset time was significantly delayed from the control group (Hering et al., 1999).

Parental perception of their children's sleep disturbances and sleep quality is different for children with autism compared with other children. In the study by Schreck and Mulick (2000), breath cessations, bruxism and problems tending to disrupt parental sleep were more frequently reported by parents of children with autism (aged 5 to 12 years). There was no correlation between age group and sleep quality variables (Schreck and Mulick, 2000).

It is important to distinguish between sleep disturbances specific to autistic subjects, and those disturbances that may merely be explained by intellectual impairment. Conclusive data are missing on this subject at present. Richdale and Prior (1995) compared two groups of individuals with autism, those with an IQ below 55 and those having an IQ above 55.

The latter group slept less than the former, and the younger individuals with higher IQ woke earlier than the other children. The less mentally impaired group also had longer sleep latencies and spent longer periods awake at night (Richdale and Prior, 1995). Elia et al. (2000) compared autistic individuals with mentally impaired individuals with fragile X syndrome in a polysomnography study. Their results suggest a difference in the sleep pattern between these two groups. Patzold et al. (1998) found no notable significant correlations between IQ and sleep problems.

Most of the above research has been done on children with autism aged 3–15 years, apart from the study by Diomedes et al. (1999), where the mean age was 18 years. Sleep difficulties are relatively common in all young children. This tends to normalize with increasing age, but little is known about this normalization in individuals with autistic spectrum disorders. Studies directed at older age groups can provide more information about the persistence of sleep abnormalities.

In the present study, we investigated sleep in adolescents and young adults, aged 15 to 25 years, with autistic disorder and Asperger syndrome. Although autistic disorder and Asperger syndrome are recognized as distinct diagnoses in the ICD-10 and DSM-IV classifications, Asperger syndrome is widely accepted as a continuation of the spectrum of autistic disorders (Klin et al., 1995; Patzold et al., 1998). We gathered both subjective and objective data concerning the sleep of our individuals, using retrospective sleep questionnaires, prospective sleep diaries and objective actigraphy. Actigraphy has been described as a valid cost-effective method for assessing specific sleep problems (Sadeh et al., 1991; 1995). The present study addresses the following questions:

- 1 Are sleep difficulties still a common complaint among older individuals with autism?
- 2 Does objective investigation of sleep indicate sleep disturbances?
- 3 How does the subjective impression of sleep correlate with objective findings?

Method

Participants

Adolescents and young adults, aged 15–25 years, were recruited through the Norwegian Autism Organization (Autismeforeningen), Department of Hordaland. Using the organization's member list, we selected all individuals meeting two criteria: first they had to have a diagnosis of either autistic disorder or Asperger syndrome, and second they had to be 15–25 years of age. There were no further inclusion or exclusion criteria. Twenty-seven

members of the association matched our criteria, and invitations to participate in the study were sent to all of them. Fifteen individuals (14 male, 1 female) agreed to participate in the study.

Six individuals had been diagnosed with Asperger syndrome and nine with autistic disorder. The diagnoses were made by psychiatrists of the Children's Medical Health program in Bergen, Norway. The mean age was 19.6 years (range 15–25). The mean age when the diagnosis was made was 13.7 years for Asperger syndrome and 7.7 years for autistic disorder. Eight individuals lived at home with their parents, most of these being among the youngest participants. One of the individuals with Asperger syndrome lived independently. The remaining participants lived at institutions for individuals with developmental disorders. One of the boys with autistic disorder had a diagnosis of epilepsy; however, no epileptic seizures were registered during the study period. None of the individuals in this study used any form of sleep medication, although the individual with epilepsy was treated with lamotrigine and valproate – medications where sleepiness and sleep disturbances are reported as side effects.

Apparatus and materials

Sleep questionnaire and Epworth Sleepiness Scale The retrospective part of this study included the use of a sleep questionnaire and the Epworth Sleepiness Scale (Johns, 1991). The sleep questionnaire consisted of 29 questions concerning sleep and sleep behavior during the last 3 months. The first part of the sleep questionnaire was a listing of 12 different disturbances with regard to sleep, and answers were given on a five-point scale: 1 (never), 2 (more than once per year), 3 (more than once per month), 4 (more than once per week) and 5 (every day). We also included questions concerning bedtime, wake-up time, assumed sleep need and daytime naps and some questions concerning sleep quality. In addition, the following two questions were asked: 'Do you think your son/daughter has a sleep problem?' and 'Has the person had any problems with daily activities due to poor sleep?' The Epworth Sleepiness Scale gives a score between 0 and 24, with increasing value indicating increasing daytime sleepiness. A score above 10 points is considered to be pathological sleepiness, as previously validated (see Johns, 1991).

Sleep diaries Sleep diaries were completed for a 2 week period. The diaries consisted of 10 questions concerning the following: how the individual functioned during the day (1 very good to 5 very bad), number and length of daytime naps, sleep medicine used, bedtime, lights off, sleep latency, number and length of nightly awakenings and get-up time.

Actigraphy Objective sleep data were obtained using an Actiwatch (Cambridge Neurotechnology Ltd, England) during the same 2 weeks as the sleep diaries were completed. The Actiwatch records intensity and frequency of movement using a piezoelectric linear accelerometer (for validation data see Kushida et al., 2001). The Actiwatch continually registers wrist movements, and the sum of all wrist movements during one minute is saved as an activity score. An activity score above a certain level indicates that the individual is awake, while a score below this level indicates a sleeping state. Data from the Actiwatch, collected in 1 minute epochs, were transferred via an interface to a computer and then analyzed using computer software from the same manufacturer (Actiwatch Sleep Analysis 98, version 4.13). We inserted the lights-off time and get-up time from each respective day based on the sleep diary, and the software then calculated values for sleep latency (time interval between lights off and sleep onset), sleep efficiency (percentage of time in bed where the individual is actually sleeping), total sleep time (time actually sleeping during the night) and early morning awakening (time between wake-up time and get-up time). In a recent review of actigraphy by Ancoli-Israel et al. (2003) this method was considered very effective for identifying sleep-wake rhythms, especially in individuals less likely to tolerate polysomnography.

The caretakers and parents of three individuals suggested that actigraphy should not be attempted, since the individuals most probably would not accept wearing the Actiwatch device. Two further individuals refused to wear the Actiwatch when it was presented to them. The remaining 10 participants completed 2 weeks of actigraphic recording without any signs of difficulty with Actiwatch. This recording was performed from mid February through April in the year 2001. Approval by both the regional committee of ethics in medical research and Norsk Samfunnsvitenskapelig Datateneste (NSD) were obtained before any data were collected.

Procedure

Two of the individuals with Asperger syndrome completed the sleep questionnaires and the Epworth Sleepiness Scale themselves, as they were able to read and understand the questions. In the remaining cases the individual's parents or caretakers answered the questions. For two consecutive weeks, a sleep diary was filled in by the individuals ($n = 3$), their parents ($n = 6$) or their caretakers ($n = 6$). Actigraphy was performed during the same 2 week period by the individuals who cooperated with this. From each returned sleep diary we selected the first complete week of data and used the actigraphy data from the same period. An earlier study has concluded that five or more nights of usable recordings are required to obtain reliable actigraph measures of sleep for children and adolescents (Acebo et al., 1999).

Results

Sleep questionnaire

Based on the question 'Do you think your son/daughter has a sleep problem?', five individuals were reported to have a sleep problem. In four of these individuals the sleep problems occurred during certain periods but were not constantly present. Both individuals who completed their own sleep questionnaires reported a sleep problem, while three parents or care-takers reported sleep problems. Two individuals were rated positively on the question, 'Has the person had any problems with daily activities due to poor sleep?'

Examining the different types of sleep disturbances (see Table 1), too little sleep, difficulties with falling asleep, and early morning awakening were also frequently reported. Two individuals were reported to have too little sleep; two were also reported to have early morning awakening every day. Daytime napping and sleepiness during daily activities were less frequently reported, while unwanted sleep attacks, cataplexy, snoring and breathing pauses during asleep were seldom noted.

On a five-point scale, five individuals were reported to be 'neither morning nor evening' persons, one individual was 'more morning than evening', five individuals were 'more evening than morning', and four individuals were rated as 'extremely evening' persons. Nine individuals were reported to have absolutely or more or less enough sleep, five individuals had slightly less than enough sleep, and one individual was reported to have definitely less than enough sleep. Concerning the overall impression of

Table 1 Reported sleep in 15 individuals with autistic disorder or Asperger syndrome based on sleep questionnaires (number of individuals in each category)

Sleep difficulty	Answer category			
	Once per month or less	More than once per month	More than once per week	Every day
Difficulties with falling asleep	7	3	4	0
Early morning awakening	9	2	1	2
Too little sleep	6	5	1	2
Snoring	10	1	1	0
Breathing pauses during sleep	8	1	1	0
Sleepiness during daily activities	6	6	1	0
Unwanted sleep attacks at work/school	13	2	0	0
Unwanted sleep attacks at home	11	2	2	0
Cataplexy	11	1	2	1
Daytime napping	11	2	1	1

quality of sleep, four individuals were reported to have very good sleep; in nine cases sleep was 'good' or 'satisfactory', and only one individual was reported as sleeping badly. The average expected sleep need reported was 8 hours and 30 minutes (SD = 1:23).

According to the Epworth Sleepiness Scale, there was no excessive daytime sleepiness. The mean value for the individuals was 3 points, which is well below the limit for pathological sleepiness. One individual scored 10 points (which is on the borderline of excessive sleepiness).

Sleep diary

Mean bedtime was 22:29 for weekdays and 23:01 for weekends (see Table 2). The get-up time averaged 07:50 for weekdays and 09:40 for weekends. The time in bed differed between weekdays and weekends, being 09:11 hours and 10:30 hours, respectively. Little or no daytime napping was reported among the individuals, with an average of only 0.2 naps per day.

Actigraphy

Overall results (rating) Sleep efficiency averaged 76 percent and sleep latency averaged 41 minutes. Wake after sleep onset averaged 1 hour 29

Table 2 Sleep diary data from 15 individuals with autistic disorder or Asperger syndrome

Parameter		Mean \pm SD (range)
Daytime napping	Naps per day	0.2 \pm 0.3 (0.0–1.0)
	Mean length (hh:mm)	00:35 \pm 00:34 (00:14–01:35)
Bedtime	Weekdays (hh:mm)	22:29 \pm 01:02 (20:30–00:04)
	Weekends (hh:mm)	23:01 \pm 01:11 (20:45–00:42)
Lights off	Weekdays (hh:mm)	22:35 \pm 01:07 (20:30–00:36)
	Weekends (hh:mm)	23:10 \pm 01:17 (20:45–00:52)
Time to fall asleep	1 (< 30 min)	1.7 \pm 0.7 (1.0–3.0)
	2 (30–60 min)	
	3 (60–120 min)	
	4 (> 120 min)	
Nightly awakenings	Awakenings per night	0.2 \pm 0.4 (0.0–1.1)
	Mean length	1.7 \pm 3.6 (1.0–2.7)
	1 (< 30 min)	
	2 (30–60 min)	
	3 (60–120 min)	
Get-up time	Weekdays (hh:mm)	07:50 \pm 01:11 (06:36–10:39)
	Weekends (hh:mm)	09:40 \pm 00:56 (07:17–11:00)
Time in bed	Weekdays (hh:mm)	09:11 \pm 00:48 (08:02–10:40)
	Weekends (hh:mm)	10:30 \pm 01:05 (08:15–12:37)

minutes. Early morning awakening averaged 8 minutes. The average total sleep time in this group was 07:06 per night (see Table 3).

Individual results We did not find normative actigraphy data that could be compared with our group of individuals with autism. However, a sleep efficiency below 85 percent or a sleep latency of more than 30 minutes are commonly used as indicators of sleep disturbance (Lacks and Morin, 1992). Based on actigraphy, 80 percent of the individuals in our study thus satisfied the criteria for a sleep disturbance. Seven of the 10 individuals in the actigraphy group had a mean sleep efficiency of less than 85 percent, and four of these additionally showed a sleep onset latency greater than 30 minutes. One of the individuals with a mean sleep efficiency greater than 85 percent also had a sleep onset latency greater than 30 minutes, so in total five individuals showed a sleep latency greater than 30 minutes. Only two individuals had neither a low sleep efficiency nor a long sleep latency, based on actigraphy. None of the individuals suffered from early morning awakening. The actigraphy estimated an average early morning awakening in one of the individuals of 29 minutes. The remaining individuals all had an average early morning awakening of less than 15 minutes.

When comparing actigraphy results with the retrospective sleep questionnaire, only two of the seven individuals with a low actigraphy-scored sleep efficiency were reported to have a sleep problem based on the question, 'Do you think your son/daughter has a sleep problem?' Only one of the five individuals with high actigraphy-scored sleep latency was reported to have a sleep problem. None of the individuals with combined low sleep efficiency and high sleep onset latency were reported to have a sleep problem on the retrospective sleep questionnaire.

Discussion

The objective sleep data suggest a high prevalence (80 percent) of sleep problems in adolescents and young adults with autism and Asperger syndrome. The actigraphic findings of a low sleep efficiency, a short total sleep time and a long sleep onset latency are consistent with previous studies (Diomedì et al., 1999; Elia et al., 2000; Patzold et al., 1998; Richdale and Prior, 1995), although these mostly involved younger individuals with autism. We did not find any early morning awakening, contrary to some earlier reports (Elia et al., 2000; Schreck and Mulick, 2000).

Although actigraphy is a non-invasive technique which has advantages over other established methods, it also has some disadvantages. It is, for example, impossible to investigate the individual's sleep architecture (Dagan et al., 1997). In a recent study on a population with various sleep disorders,

Table 3 The overall results of the actigraphy in 10 individuals with autistic disorder or Asperger syndrome

<i>Sleep parameter</i>	<i>Mean ± SD</i>	<i>Median value</i>
Sleep efficiency (%)	76 ± 10	75
Sleep onset latency (hh:mm)	00:41 ± 00:39	00:31
Wake after sleep onset (hh:mm)	01:29 ± 01:05	01:08
Early morning awakening (hh:mm)	00:08 ± 00:08	00:05
Total wake time (hh:mm)	02:19 ± 01:04	01:04
Total sleep time (hh:mm)	07:06 ± 00:45	07:02

sleep parameters derived by actigraphy and subjective sleep diaries were compared with those derived from polysomnography (Kushida et al., 2001). The actigraph had an excellent sensitivity for detecting sleep (92 percent), but the ability to detect wakefulness was much lower (48 percent). The latter was especially true for subjects with disturbed sleep lying quietly in bed for long periods of time. Actigraphy significantly overestimated total sleep time and sleep efficiency (Kushida et al., 2001). These findings may indicate that our study actually gives an overestimation of sleep efficiency, and that sleep latency and early morning awakening may be underestimated. Still, in individuals where polysomnography is less likely to be tolerated, actigraphy is considered the method of choice for objective recording of sleep (Anconi-Israel et al., 2003).

There is an unclear relationship between daytime behavior and sleep disturbances in children with autism, and it is possible that sleep problems can be both induced by and responsible for daytime behavior problems (Patzold et al., 1998). This may be explained by the importance of social cues in the regulation of diurnal rhythm (Aschoff et al., 1971; Ehlers et al., 1988) or by the fact that individuals with autism have a higher sensitivity to photoperiodic changes (Hayashi, 2001). Sleep disturbances may also be related to an increased incidence of anxiety and fear in individuals with autism (Gilman and Tuchman, 1995; Nelson, 2001). Regular and predictable daytime activities like school or kindergarten may significantly improve sleep quality (Taira et al., 1998).

Surprisingly, compared with the high amount of sleep disturbances recorded using actigraphy, parents and caretakers reported minor sleep problems in the retrospective sleep questionnaire and sleep diaries. The subjective findings were also low compared with other studies (Richdale and Prior, 1995; Taira et al., 1998). There may be different explanations for the relatively low amount of reported sleep problems, one of them being an adaptation process to sleep difficulties. For example, some of the parents denying a current sleep problem in their son/daughter noted that there had

been such problems in earlier childhood. Furthermore, most of the subjective information was provided by parents or caretakers, and we do not know whether the individuals themselves experienced more sleep problems than was reported. Parameters such as time taken to fall asleep and nightly awakenings may be difficult to estimate by anyone other than the individuals themselves, as they were not directly observed during the night. For instance, nightly awakenings may be underestimated if the individual does not get out of bed and wake the parents. For these reasons, it may also be difficult to estimate whether an individual has a sleep problem and how long it may have lasted. Taking into account the low reported daytime sleepiness, low amount of daytime napping and few reported sleep attacks, it seems reasonable to assume that the sleep need is met. However, apart from a single question in the sleep diary ('How did the individual function during the day?') we did not investigate daytime behavior, which could possibly be influenced by poor sleep.

Physicians have used pharmacological, behavioral and other interventions targeted at sleep problems in autism (Buitelaar and Willemsen-Swinkels, 2000; Gilman and Tuchman, 1995; Patzold et al., 1998). Some improvement of sleep has recently been reported with behavioral therapy and massage therapy (Escalona et al., 2001; Weiskop et al., 2001). Many of the studies that are carried out in this field are based on sleep questionnaires and sleep diaries, while strictly objective research using polysomnography and actigraphy is sparse. The latter might be able to give a more precise classification of sleep disorders in children with autism (Abril et al., 2001), and would make it easier to choose a more appropriate and effective treatment for autistic individuals with sleep problems. Nevertheless, it should be noted that the difference in both the type and extent of sleep problems seems to vary greatly between individuals and different studies, and at this time there is no specific treatment. Therefore, people with autism who are treated for sleep disturbances need to have the same individual examination and follow-up as other patients with disordered sleep.

A further important issue is whether individuals with autism should be treated for sleep disturbances if there are no complaints or daytime consequences. When considering the complex symptomatology often present in pervasive developmental disorders, specific daytime symptoms caused by sleep problems may be difficult to uncover. The beneficial effects of treating sleep problems on daytime behavior are still questionable and, as mentioned earlier, daytime behavior difficulties may be a cause of sleep disturbances, not necessarily vice versa. Larger intervention studies comparing sleep disturbances and daytime behavior in individuals can give us more information.

In conclusion, our study indicates that objective sleep disturbances are still present in adolescents and young adults with autistic disorder or Asperger syndrome, although sleep problems are less frequently reported by parents or caretakers after childhood. The latter finding may reflect an acceptance of sleep disturbances rather than a normalization of the sleep pattern. Some of the sleep disturbances typical in autistic disorder and Asperger syndrome can possibly be explained by a higher prevalence of anxiety, fear or social behavior problems. Larger studies with actigraphy in adolescents with autistic spectrum disorders, including intervention studies, could provide more accurate data on the persistence of sleep disturbances.

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References

- ABRIL, V.B., MENDEZ, G.M., SANS, C.O. & VALDIZAN, U.J.R. (2001) 'Sleep in Infantile Autism', *Revista de Neurología* 32: 641–4.
- ACEBO, C., SADEH, A., SEIFER, R., TZISCHINSKY, O., WOLFSON, A.R., HAFER, A. & CARSKADON, M.A. (1999) 'Estimating Sleep Patterns with Activity Monitoring in Children and Adolescents: How Many Nights Are Necessary for Reliable Measures?', *Sleep* 22 (1): 95–103.
- ANCOLI-ISRAEL, S., COLE, R., ALESSI, C., CHAMBERS, M., MOORCROFT, W. & POLLAK, C.P. (2003) 'The Role of Actigraphy in the Study of Sleep and Circadian Rhythms', *Sleep* 26 (3): 342–92.
- ASCHOFF, J., FATRANSKA, M., GIEDKE, H., DOERR, P., STAMM, D. & WISSER, H. (1971) 'Human Circadian Rhythms in Continuous Darkness: Entrainment by Social Cues', *Science* 171: 213–15.
- BUITELAAR, J.K. & WILLEMSSEN-SWINKELS, S.H.N. (2000) 'Medication Treatment in Subjects with Autistic Spectrum Disorders', *European Child and Adolescent Psychiatry* 9: 976–85.
- DAGAN, Y., ZEEVI-LURIA, S., SEVER, Y., HALLIS, D., YOVEL, I., SADEH, A. & DOLEV, E. (1997) 'Sleep Quality in Children with Attention Deficit Hyperactivity Disorder: An Actigraphic Study', *Psychiatry and Clinical Neurosciences* 51: 383–6.
- DIOMEDI, M., PAOLO, C., ANNA, S., FABIO, P., FLAVIA, C. & GIAN, L.G. (1999) 'Sleep Abnormalities in Mentally Retarded Autistic Subjects: Down's Syndrome with Mental Retardation and Normal Subjects', *Brain and Development* 21: 548–53.
- EHLERS, C.L., FRANK, E. & KUPFER, D.J. (1988) 'Social Zeitgebers and Biological Rhythms', *Archive of Genetic Psychiatry* 45: 948–52.
- ELIA, M., FERRI, R., MUSUMECI, S.A., BRACCO, S.D., BOTTITTA, M., SCUDERI, C., MIANO, B., PANERAI, S., BERTRAND, T. & BRUBAR, J. (2000) 'Sleep in Subjects with Autistic Disorder: A Neurophysiological and Psychological Study', *Brain and Development* 22: 88–92.

- ESCALONA, A., FIELD, T., SINGER-STRUNCK, R., CULLEN, C. & HARTSHORN, K. (2001) 'Brief Report: Improvements in the Behavior of Children with Autism Following Massage Therapy', *Journal of Autism and Developmental Disorders* 31: 513–16.
- GILMAN, J. & TUCHMAN, R. (1995) 'Autism and Associated Behavioral Disorders: Pharmacotherapeutic Intervention', *The Annals of Pharmacotherapy* 29: 47–56.
- HAYASHI, E. (2001) 'Seasonal Changes in Sleep and Behavioral Problems in a Pubescent Case with Autism', *Psychiatry and Clinical Neuroscience* 55: 223–4.
- HERING, E., EPSTEIN, R., ELVOY, S., IANCU, D.R. & ZELNIK, N. (1999) 'Sleep Patterns in Autistic Children', *Journal of Autism and Developmental Disorders* 29: 143–7.
- JOHNS, M.W. (1991) 'A New Method for Measuring Daytime Sleepiness: The Epworth Sleepiness Scale', *Sleep* 14: 540–5.
- KLIN, A., VOLKMAR, F.R., SPARROW, S.S., CICCHETTI, D.V. & ROURKE, B.P. (1995) 'Validity and Neuropsychological Characterization of Asperger Syndrome: Convergence with Nonverbal Learning-Disability Syndrome', *Journal of Child Psychology and Psychiatry and Allied Disciplines* 36: 1127–40.
- KUSHIDA, C.A., CHANG, A., GADKARY, C., GUILLEMINAULT, C., CARILLO, O. & CEMENT, W.C. (2001) 'Comparison of Actigraphic, Polysomnographic, and Subjective Assessment of Sleep Parameters in Sleep-Disordered Patients', *Sleep Medicine* 2: 389–96.
- LACKS, P. & MORIN, C.M. (1992) 'Recent Advances in the Assessment and Treatment of Insomnia', *Journal of Consulting Clinical Psychology* 60: 586–94.
- MAYES, S.D., CALHOUN, S.L. & CRITES, D.L. (2001) 'Does DSM-IV Asperger's Disorder Exist?', *Journal of Abnormal Child Psychology* 29: 271–93.
- NELSON, K. (2001) 'Toward a Biology of Autism: Possible Role of Certain Neuropeptides and Neurotrophins', *Clinical Neuroscience Research* 1: 300–6.
- PATZOLD, L.M., RICHDAL, A.L. & TONGE, B.J. (1998) 'An Investigation into Sleep Characteristics of Children with Autism and Asperger's Syndrome', *Journal of Paediatrics and Children's Health* 34: 528–33.
- RICHDAL, A.L. & PRIOR, M.R. (1995) 'The Sleep/Wake Rhythm in Children with Autism', *European Child and Adolescent Psychiatry* 4: 1–11.
- SADEH, A., LAVIE, P., SCHER, A., TIROSH, E. & EPSTEIN, R. (1991) 'Actigraphic Home-Monitoring Sleep-Disturbed and Control Infants and Young Children: A New Method for Pediatric Assessment of Sleep-Wake Patterns', *Pediatrics* 87: 494–9.
- SADEH, A., HAURI, P.J., KRIPKE, D.F. & LAVIE, P. (1995) 'The Role of Actigraphy in the Evaluation of Sleep Disorders', *Sleep* 18: 288–302.
- SCHRECK, K.A. & MULICK, J.A. (2000) 'Parental Report of Sleep Problems in Children with Autism', *Journal of Autism and Developmental Disorders* 30: 127–35.
- TAIRA, M., TAKASE, M. & SASAKI H. (1998) 'Development and Sleep: Sleep Disorder in Children with Autism', *Psychiatry and Clinical Neurosciences* 52: 182–3.
- WEISKOP, S., MATTHEWS, J. & RICHDAL, A. (2001) 'Treatment of Sleep Problems in a 5-Year-Old Boy with Autism Using Behavioural Principles', *Autism* 5 (2): 209–21.