OPEN ACCESS
Freely Available Online

JOURNAL OF SLEEP AND SLEEP DISORDER RESEARCH

ISSN NO: 2574-4518

Research Article

DOI: 10.14302/issn.2574-4518.jsdr-19-2950

The Effect of Weekends and Clock Changes on the Sleep Patterns of Children with Autism: A Study of Historical Records

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Abstract

Background: Children with autism spectrum disorders (ASD) often have difficulties settling to sleep and maintaining asleep through the night. Sleep difficulties are linked to challenging behaviour so understanding the causes of these difficulties is vital. Possible–explanations are: (1) that irregular innate cycles lead to difficulties maintaining/initiating sleep at the appropriate times; (2) that children with ASD fail to learn from the contingencies that teach neurotypical children to initiate and maintain sleep. If the cycles are innate then small externally imposed changes in routine will not affect the sleep cycle.

Methods: The sleep records of 46 children with autism and moderate to profound intellectual impairments attending a residential school were examined to identify the effects of spring time change and weekend leave on 1) the times children went to sleep, 2) the length of their sleep and 3) the number of sleep disruptions. Manual staff recordings of the children's sleep were conducted and data for these variables were analysed using repeated measures analysis of variance.

Results: A later sleep time was found in children regarding their sleep onset on Sunday after the time change (average onset was 9:57 p.m. ((s.e. = 8.49 minutes) versus 10:17 p.m. (s.e. = 8.19 minutes), with analysis of variance of sleep onset time showing a significant effect (F (3,41) = 5.02, p = 0.005). However, only two out of three comparison groups showed statistically significant effects (March 23rd versus March 30th mean difference = 0.39, p = 0.003; March 30th April 13th mean difference = 0.36, p = 0.03). No statistical difference was found between March 30th versus April 6th or other sleep parameters in any groups (i.e., sleep duration or night time awakenings). Similarly, no change in any sleep parameters (i.e., sleep onset or awakenings) were found when Sundays sleep parameters were compared to Mondays and/or Tuesdays.

Conclusions: In this small pilot study, small changes of day/night cycles appear to have few effects on the sleep patterns of children with ASD attending a residential school. While no significant sleep pattern change was found in this population due to change of clock times or weekend visits, larger epidemiological studies addressing other unexamined variables to better delineate changes in ASD are needed.

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Keywords: autism spectrum disorders, autism, sleep

Running title: Sleep patterns in Children diagnosed with Autism (ASD) following sleep routine perturbations

Received: June 20, 2019 **Accepted:** Aug 29, 2019 **Published:** Sep 06, 2019

Editor: Karim Sedky, Sleep Disorders Attention Deficit Hyperactivity Disorders (ADHD) Childhood Disorders Addiction Medicine Psychopharmacology ECT

Introduction

Systematic reviews [1, 2] and epidemiological studies [3] have shown that sleep of young people with autism spectrum disorders (ASD) is problematic, with more than half of the group complaining of difficulties falling asleep, and one third waking frequently at night [4, 5, 6]. Automated data acquisition confirms the extent of sleep problems [1,7]. One estimate put the incidence of sleep problems of all types at 73% in children with ASD and 50% of children with no known developmental disorder [5]. For people with learning disabilities and those with ASD, there is an association between sleep problems and challenging behaviour during the day [8,9,10]. It is thus important to understand factors affecting sleep and address them in this population to improve their behaviours and even possibly improve academic progress.

In general, human sleep is controlled by both external cues (i.e., the time shown on the clock, ambient light, exercise etc) and internal cues (i.e., circadian rhythm, melatonin levels etc) [11]. For young children, sleep patterns can be modified by altering external cues such as the behaviour of the caregivers [12,13], in particular by removing the contingency between wakefulness and caregiver attention to the child (extinction). Some authors have suggested that behavioural methods to manage the sleep of children with autism are unlikely to be effective due to internal factors specific to autism (e.g. an altered biological clock) [14,15]. Although evidence for altered biological control of sleep has included studies of melatonin production, these have demonstrated inconsistent results [16,17,18]. For example, Carmassi et al. found in their systematic review that melatonin peak delay, amplitude reduction and alteration in melatonin gene expression all predispose to circadian rhythm misalignment [2]. They speculate that this may be related to unusual CLOCK gene polymorphisms and genetic differences leading to abnormalities in melatonin production pathways. Thus, it is unsurprising that there is some evidence of the benefits of melatonin administration for lengthening sleep duration and shorter sleep latency (but not fewer night awakenings) [19]. Simultaneously authors have acknowledged that the relative insensitivity of children with autism to social cues could result in a failure to learn suitable rules for going to and remaining asleep and result in insensitivity to behavioural programmes for improving sleep.

Small perturbations in sleep cycle are often considered to have minimal consequences [20]; however, reviews suggest that the effects on sleep are significant and may relate to increased accidents and hence preventable injuries [20, 21]. In addition to studies of shift workers and transcontinental travelers who have to adjust their sleep by several hours at a time, there are two types of smaller changes that have been investigated: clock time changes (spring and fall/ autumn); weekends sleep pattern that might differ than weekdays. Both types of perturbation cause changes in sleep rhythms [20, 22, 23]. While the changes over weekends compared with weekdays are not so well understood, the clock time changes require shifting the sleep wake cycle by one hour, which in neurotypical populations takes several days [23, 24]. Our searches of the literature found no published studies that reported data for populations with ASD. Given the uncertainty about the effects of weekends, we also predicted that there should be an effect of weekends on the sleep pattern of children with autism shown by repeated patterns of longer sleep onset latency on Sunday nights compared with subsequent nights.

In summary, we have argued that changes in environmental cues would have little effect on the sleep patterns of children with ASD since their internal clocks (represented by melatonin production cycles) are disrupted. The occurrence of variation in environmental cues for sleep such as weekend changes in routine and clock time changes in spring and fall (autumn) offers the opportunity to study how environment may be important. In particular, we hypothesize that:

The change in clock time and hence shift in bedtime produces a shifted sleep pattern with loss of sleep in the springtime change.

Weekends should affect sleep latency, sleep duration or night awakenings.

Methods

Setting and Sleep Logging

This study was conducted in a residential school enrolling children with ASD, with a maximum capacity of 46 individuals. The staff at this residential school keep records of sleep at night. Every half hour from nine o'clock in the evening to half past six in the morning, each child is checked to see whether they are asleep. The information gleaned from the records were summarized as: (1) time at which the child fell asleep; (2) number of times the child woke in the night; and (3) the number of hours during which the child was recorded as asleep.

Study Description

The study was conducted during the period from 18th March 2003 to 15th April 2003. Many of the children returned to their guardians on the weekends (Friday and Saturday night) so the number of children resident varies from night to night. In addition, the routines followed by the staff change are different on Saturday morning and Sunday morning because they do not wake the children at 7am. In order to simplify the analyses and avoid using imputation for missing data we have excluded Friday and Saturday nights from analysis, but we can assume that all children have a different routine on those nights. All the children had received diagnoses of autism according to Diagnostic and Statistical Manual for Mental Illness-Fourth Edition (DSM-IV) criteria, checked by a clinical psychologist with more than twenty years' experience of diagnosis of autism (not including children with a diagnosis of Asperger's Syndrome). All the children also had moderate to profound intellectual impairments (IQ estimates in their records indicated a range up to IQ=50).

Variables and Sleep

For the summer time, sleep records were available for these children when the change from Greenwich Mean Time to British Summer Time (i.e., 1 a.m. became 2 a.m.) on the morning of Sunday 30th March 2003 . The dates of interest are the 1st April onwards.

The Information Recorded by the Waking Night Staff has Been Summarized as Follows:

The first time that the child is recorded as asleep is considered to be the time at which the child fell asleep;

The number of discreet occasions on which the child was recorded as being awake after this is recorded as a night time awakening. If consecutive half hour checks reveal the child to be awake, we considered that the child was awake throughout the period;

The number of half hour checks on which the child was recorded as being asleep were noted and recorded as the child's sleep duration.

Statistical Methods

Means and standard error (s.e.) values of sleep parameters (sleep onset, sleep disruptions and sleep duration) were reported. The data was analysed by repeated measures analysis of variance, which compares the means, taking account of the variability due to individuals and random factors. The ɑ value was set a priori at 0.05 (i.e. in order for a difference to reach significance it would have to occur less than one in 20 times in a random sample). The minimal clinical significance of a change was set at a change greater than 0.5 of one standard deviation (s.d.).

Result

Included Population

In order to simplify the analysis, all nights with missing data (March 21, 22, 28, 29, April 4, 5, 11, 12) children were with their parents [Fridays and Saturdays and holidays] were eliminated from the analysis. Thus, a complete set of data for the 46 children was available for 21 nights out of the possible 29 nights between 18th March and 15th April 2003 inclusive. The remaining eight nights for which most data was missing were nights when the children were at home. Of these four, were Sunday nights (23rd and 30th of March; 6th and 13th of April) of which one (30th March) was the night after the change to daylight savings time.

Demographics and Comorbidities

The children (39 boys, 6 girls) were aged between 5 years 5 months and 16 years 11 months, with a mean age of 11 years 8 months (s.e. = 2 years 8 months). Eight participants had diagnoses of epilepsy and were being successfully treated at the time with medication. One boy had Fragile X and one girl had Hypomelanosis of Ito.

I – The effect of time changes on sleep parameters

Sleep Onset Following Change to Summer Time

On Sunday nights, the children went to sleep on average at 9:57 p.m. (s.e. = 8.49 minutes). On the night after the change to daylight saving time (i.e., on 30th March) the children went to sleep at 10.17 (s.e. =

8.19 minutes). A repeated measures analysis of variance of sleep onset time on Sundays (March 23rd, 30th, April 6th, 13th) showed a statistically significant effect ($F(3,41) = 5.02$, $p = 0.005$). Post hoc tests (with Sidak correction for multiple comparisons) showed that sleep onset was statistically significantly different on March 30th from two out of three of the Sundays tested (March 23rd versus March 30th mean difference = 0.39, $p = 0.003$; March 30th April 13th mean difference = 0.36, $p = 0.03$). However, no statistical difference was found between March 30th versus April 6th (mean difference = 0.24, $p = 0.22$). Inspection of figure-1 shows that this is because the sleep onset time was later on March 30th than on other Sundays. However it should be noted that none of the statistically significant differences meet the criterion of a clinically significant change of more than 0.5 s.d.

Sleep Disruptions Following Change to Summer Time

The average number of sleep disruptions per night was 0.07 or about one awakening every fourteen nights. On the night following the time change, 4 night awakenings were recorded for the 46 children. This was due to only three of the children waking during the night, one of whom woke up twice. This does not differ from the number of night awakenings observed on other Sunday nights in the period (Friedman's analysis of variance by ranks $p = 0.34$).

Sleep Duration

On average, the 46 children slept for 8 hours 16 minutes. A repeated measures analysis of variance shows significant heterogeneity of variance (Mauchly's W = 0.002; chi square = 212.5; $p = 0.001$). There were no statistically significant differences between nights in duration of sleep recorded by the night staff according to the corrected F value (Greenhouse Geisser F = 0.971; d.f.= 10.3, 411.4; $p = 0.469$).

The effect of Weekend family visits on sleep parameters during the week

Comparison of Sunday nights to other days of the week in regards to sleep parameters

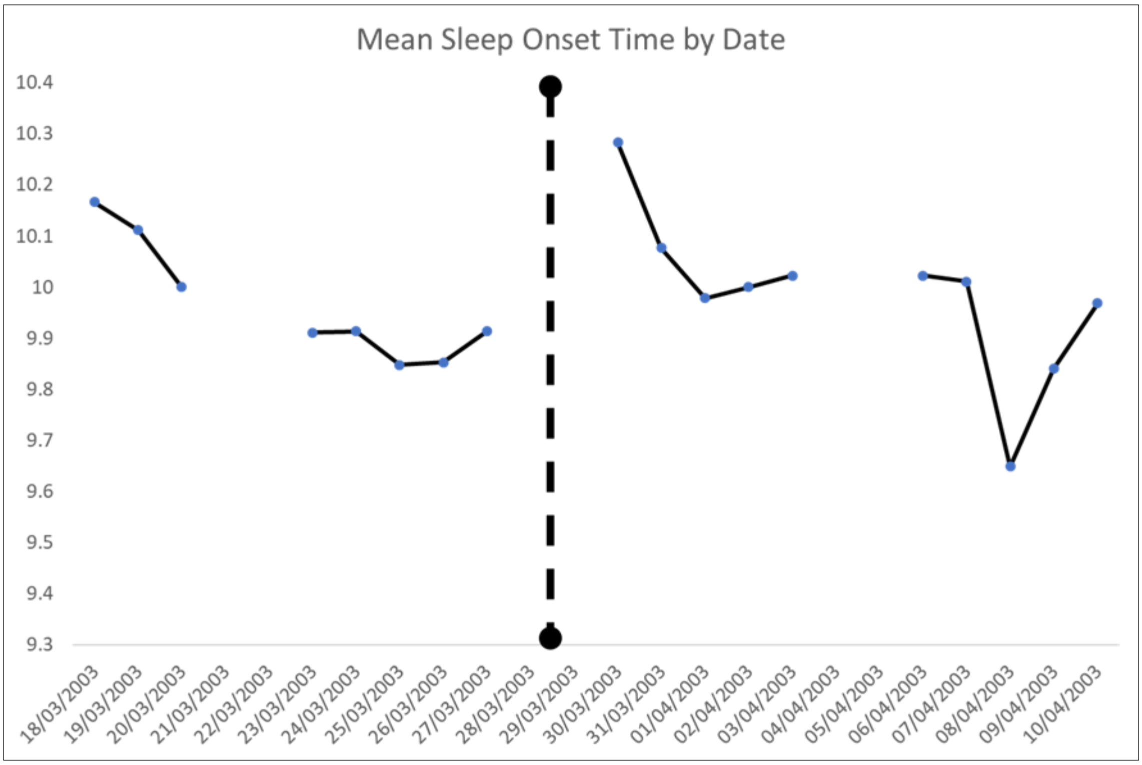

Figure 1. shows the mean sleep onset times of the children in this study. The bold vertical dashed line represents the night when the clock time changed. 18/03/2003 was a Tuesday. The data is recorded as missing for Fridays and Saturdays because most of the children were at home for those nights.

To examine the effect of weekend changes in awakenings and bedtime onset (the night following the return to school), we compared sleep onset time, sleep disruptions and sleep durations for Sunday nights with the following Monday and Tuesday nights for each of the four weeks. Analysis of the average time to sleep onset, sleep duration, sleep awakenings were conducted.

Sleep Onset Time

Using data from all four weeks, statistical analysis shows that the children went to sleep later on Sunday nights than on Monday and Tuesday nights (mean sleep onset time on Sundays = 22:01 s.e. = 7.2 min, Mondays = 21:59, s.e. = 6.6 min), Tuesdays = 21:50 s. e = 7.4 min). The weeks also demonstrated some variability (mean sleep onset time Week 1 = 9:50 s. e = 7.3 min, week 2 = 10:05 s. e = 6.7 min, week 3 = 9:52 s. e 8.2 min, week 4 = 9:58 s. e = 7.3 min. Mauchly's test for sphericity was significant for the interaction term (W (20) = 0.31, p = 0.001). A repeated measures of analysis of variance for the 4 weeks and 3 days showed that there were significant effects of weeks (Greenhouse Geisser corrected F (2.44, 105.04) = 3.32, p = 0.031), and days of the week (Greenhouse Geisser corrected F (1.85, 79.62) = 3.45, p = 0.04) but not their interaction (Greenhouse Geisser corrected F (4.31, 185.37) = 1.46, p = 0.21). Pairwise post hoc comparisons for weeks revealed only a significant difference between week one and week two (mean difference 0.25, p = 0.001). Post hoc analyses did not elucidate the source of the differences between days (Sundays vs Mondays mean difference = 0.04, p = 1.00; Sundays vs Tuesdays mean difference = 0.19, p = 0.08; Mondays vs Tuesdays mean difference = 0.15, p = 0.20).

Sleep Disruptions

The number of sleep disruptions was small as noted previously, therefore a Friedman's test was undertaken, which showed no difference between nights (χ^2= 17.04, p = 0.11).

Sleep Duration

Using the data only from Sunday, Monday and Tuesday nights the statistical analysis shows that the children slept for a mean of 8 hours 19 minutes over the three nights on all four weeks examined. There was no significant variability between nights: on Sundays, mean sleep duration was = 8:19 (s.e. 7.6 mins), Mondays = 8:18 (s.e. 5.9 mins), and Tuesdays = 8:17 (s.e. 7.9 mins). Similarly, there was no significant different between weeks: week 1, the mean sleep duration week 1 = 8:12 (s.e. 7.4 mins), week 2 = 8:12 (s.e. 7.4 mins), week 3 = 8:27 (s.e. 7.4 mins), week 4 = 8:22 (s.e. 7.4 mins)). The repeated measures analysis of variance (4 weeks, 3 days –Sunday, Monday, Tuesday) showed that sphericity could not be assumed (Mauchly's W for the interaction = 0.847, p = 0.02). The Greenhouse Geisser corrected F values showed no significant effect of weeks, days or their interaction on sleep duration (Weeks = F (2.74, 117.83) = 2.61, p = 0.06; Days = F (1.84, 79.05) = 0.058, p = 0.93; Days*Weeks = F (4.68, 201.07) = 1.05, p = 0.39).

Discussion

The children with autism in a residential school showed relatively few sleep disruptions, did not seem to have unusual difficulties falling asleep and slept for about eight hours per night on average. The children went to sleep 20 minutes later in response to a one hour time change. Although such a change is statistically significant it does not reach the minimum test of 0.5 standard deviation change. There was no effect of the time change on the duration of sleep or on sleep disruptions. Analysis of sleep parameters comparing Sundays versus Mondays and Tuesdays showed there were statistically significant variations between weeks and nights on sleep onset, but post hoc tests did not clarify which days or weeks were significantly different. Neither weeks nor days had a statistically significant relationship with sleep disruptions or sleep duration. The effect of weekends on sleep patterns were minor (less than ten minutes) and not clinically relevant. One might therefore conclude that the children with autism studied here were more resilient to changes in sleep cues than other populations.

The study of minor sleep perturbations can reveal useful information about the control mechanisms in sleep. Given that the sleep of children with autism is problematic, this study provides new information about the sleep of that group of children attending a residential school who are subject to time changes and weekly schedule changes. The use of sleep diaries to record sleep is often criticised as not being representative of actigraphic sleep recording. However, in this study the sleep diaries are completed by walking night staff who repeatedly check on the children and respond to unusual noises with additional checks. Actigraphy would undoubtedly have produced a more objective result, however like sleep diaries actigraphy is not a direct measure of sleep.

The use of a naturalistic observational design does not allow one to control for staff expectancies around the time change. It is possible that the night staff may have been expecting difficulties so that they provided stronger cues for the children to fall asleep at the correct time. However, this would suggest that the evidence for social environmental cuing of sleep is stronger than we propose.

Finally, the day on which times change might have an effect which mitigates the disruption caused by the change of hour is not examined in this study. Because the clocks are always changed on a Saturday to Sunday night, the children are usually at home. It is therefore impossible to measure the additional sleep that may be allowed at home to counteract the effects of the time change. However, previous studies of the time change and sleep have shown that the effects last several days [20]. In support of our conclusions are the results of the effects of weekends which shows that their effect is minor (2 minutes later to fall asleep on Sunday night). In addition, we did not separate children who stayed over the weekend at the residential facility versus those who went home. This could have potentially biased the data given the fixed sleep pattern expected at the facility by staff versus those staying with parents.

Research on the effects of daylight savings time [20, 21] suggests that there are robust and important effects on both sleep (time to settle, disruptions) and both preceding and subsequent daytime behaviour (accident data). Our study uses data gathered by walking night adults and is therefore more robust than those reviewed by Harrison [20] in which researchers had largely used self-completed sleep diaries. Our conclusions do not reveal changes in sleep pattern that would be considered clinically significant, but cannot answer the question about daytime behaviour. There were was no sleeping medication in use during this period.

The children in this study were going to sleep at about the same time as the children with autism spectrum disorders reported in Wiggs & Stores (14). (W&S sleepless group. 22:27, ok group 21:46, this study 22:00). The number of sleep disruptions reported was small (this study 0.07 per night, compared to cf. Wiggs & Stores [14] who found about 25% waking in the night 3 or more time per week). Although this may be an artefact of the method of recording sleep in that small disruptions during which the child did not leave their bed would not be detected by the school night staff but might be responded to by parents at home. The sleep duration of the children in this study is also similar to that seen in Wiggs and Stores (14), but rather less than that seen in the Polimeni, Richdale and Francis study (5). This could be due to the younger age of the children in that study (Mean age in this study 11.7 years compared to the mean age in Polimeni study of 6.5 years [5]).

Minor perturbations of routine do not seem to affect the sleep patterns of children with autism who are in a residential environment as much as they affect the sleep of neurotypical populations (cf. Lahti et al. [24]; Kantermann, et al. [25]). It therefore seems unlikely that the sleep patterns of children with autism are under the control of an internal zeitgeber alone; rather, the results suggest that the children's sleep was also affected by environmental stimuli. It may be that one of the advantages of a residential environment for children with autism is that their behaviour is managed more consistently at school than at home. As a result, the children's settling behaviour becomes associated with particular stimuli provided by the school and its staff. In its turn this behaviour is governed by the clock rather than by internal cues so that staff ensure that children settle at the same clock time each night. In the population studied here, the information about expected behaviour is presented to the children as visual schedules. In contrast, typically developing individuals are more likely to use verbal cues which last only as long as the sounds. The implication is that using clear visual information is likely to improve sleep difficulties in ASD.

A study using actigraphy like Wiggs and Stores [8] is needed to determine the accuracy of the night staff's records. This might also answer questions about how much about sleep in ASD is determined by a biological zeitgeber, rather than by environmental cues. However, the results of this study suggest that the children at the school not only went to bed at the times prescribed by the school routine but also shifted their sleep patterns to the new clock time very rapidly. It may be that sleep is controlled rather more tightly by environmental factors in children with ASD than in neurotypical populations.

Glossary

Actigraphy – the measurement of activity using electronic methods often considered to provide a more objective measure of sleep than diary records.

ASD – Autism spectrum disorder is a group of neurodevelopmental disorders used in DSM-5 and includes autism, Asperger syndrome, pervasive developmental disorder not otherwise specified (PDD-NOS) and childhood disintegrative disorder. However, in this study we used DSM-4 which only includes autism (without the inclusion of other subtypes such as Asperger or PPD-NOS.

Daylight Saving Time - refers to the practice of advancing the clocks by one hour during the summer months so that the evenings are longer.

Neurotypical- used to describe people with no known neurological abnormalities which might affect thinking, learning or behaviour. It is usually contrasted with one or more populations known to have abnormalities affecting one or more of thinking, learning or behaviour.

Zeitgeber – (from German) a notional biological clock which determines sleep wake cycles or shorter duration rhythms. Often considered to be relatively independent of the environment.

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