Falling asleep: the determinants of sleep latency

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ABSTRACT

Background: Difficulty falling asleep (prolonged sleep latency) is a frequently reported problem in school-aged children.
Aims: This study aimed to describe the distribution of sleep latency and factors that influence its duration.
Methods: 871 children of European mothers were recruited at birth. 591 (67.9%) children took part in the follow-up at 7 years of age. Sleep and daytime activity were measured objectively by an actigraph worn for 24 h.
Results: Complete sleep data were available for 519 children (87.8%) with a mean age of 7.3 years (SD 0.2). Median sleep latency was 26 minutes (interquartile range 13–42). Higher mean daytime activity counts were associated with a decrease in sleep latency (−1.2 minutes per 10^2 movement count per minute, $p = 0.05$). Time spent in sedentary activity was associated with an increase in sleep latency (3.1 minutes per hour of sedentary activity, $p = 0.01$).
Conclusions: These findings emphasise the importance of physical activity for children, not only for fitness, cardiovascular health and weight control, but also for promoting good sleep.

What is already known on this topic

- Up to 16% of parents of school-aged children report that their child has difficulty falling asleep.
- In an experimental situation, acute exercise reduces sleep latency (the time taken to fall asleep).

What this study adds

- In a community sample, higher daytime activity is associated with shorter sleep latency.
- Longer sleep latency is related to shorter total sleep duration, which has important implications for child health.

Up to 16% of parents of school-aged children report that their child has difficulty falling asleep.[1] This difficulty may promote poor sleep habits such as watching TV in bed or later bedtimes. Late bedtime is a key factor in reduced sleep duration in childhood, a factor that has been associated with being overweight or obese[2] and lower cognitive performance.[3]

In children the duration of sleep latency, the period from "lights out" or bedtime to the onset of sleep, is poorly described and relies on parental reports or polysomnography carried out in a laboratory. In general, parental report overestimates sleep time,[2 4] and is likely to be particularly inaccurate in older children who fall asleep independently in their own room.

Prolonged sleep latency may therefore have important implications for the overall sleep habits of children and may not be well described by parental report. The aim of this study was to quantify sleep latency objectively in a large community population of children and to examine factors that might influence it, especially daytime activity.

METHODS

This study formed part of a larger longitudinal study, the Auckland Birthweight Collaborative (ABC) Study.[2] Between 16 October 1995 and 12 August 1996 babies born at term (⩾37 completed weeks of gestation) and resident in the Waitemata Health or Auckland Healthcare regions were eligible for inclusion, and from 12 August 1996 to 30 November 1997 babies born in the Auckland Healthcare region were eligible to participate. All small for gestational age (SGA) infants (n = 844) and a random sample of appropriate for gestational age infants (n = 870) were selected. Of these 1714 infants, 871 were born to mothers of European ethnicity. Because of subsequent poor follow-up rates, children of non-European mothers were not assessed for the current study.

This study was carried out as part of the follow-up at 7 years of age. Parents/guardians of all children included in the study gave consent to participate, both at recruitment at birth and at the 7-year follow-up. The study received approval from the Auckland Ethics Committee.

The presence of sleep problems was evaluated using the child's sleep habits questionnaire.[5] Children's behaviour was assessed with the Strengths and Difficulties Questionnaire and Conner's Teacher and Parent Rating Scales, as previously reported.[2] In addition, children wore an actigraph around their waist for 24-h (model 7164; Manufacturing Technologies Inc Health Systems, Shalimar, Florida, USA).[2] Through the analysis of movement, actigraphy allows investigators to quantify daytime physical activity and determine the amount of sleep. The activity variables estimated were total physical activity counts, mean activity counts and minutes of sedentary, moderate and vigorous activity. The intensity of activity was defined by metabolic equivalent tasks (MET), where one MET is the energy expenditure and caloric requirement at rest and the MET for a given activity represent a ratio of the metabolic rate while seated and resting to the metabolic rate while performing that activity.[6] Sedentary activity corresponds to less than 3 MET, moderate activity to 3–5.9 MET (walking) and vigorous activity to 6+ MET (running).

Sleep was also quantified by actigraphy.[2] Sleep onset time was defined as the start time of the first of three consecutive minutes of sleep by actigraphy after the reported bedtime.[4] Sleep latency was the time from reported bedtime to sleep onset time.

Statistical methods

Sleep latency was analysed using regression models that included weighting for each subject based on the disproportionate sampling of SGA infants at birth. The analysis was carried out using the surveyreg procedure in SAS version 9.1. This procedure carries out linear regression allowing for weighting of complex samples, in this case to allow for the disproportionate sampling of the SGA infants. Results are reported as the estimated difference in sleep latency in minutes between categories for categorical variables or the estimated per unit change for continuous variables (as defined in table 1). A multivariable model was fitted including variables in the model that were significant at the univariable level. Because of multi co-linearity between the mean daytime activity counts and minutes in the various levels of activity, only the mean daytime activity counts were included in the model. The multivariable model thus included summer, mean daytime activity counts and sleep duration.

RESULTS

Parents of 591 (67.9% of the original birth cohort) children consented to take part in the follow-up at 7 years of age. Complete sleep data were available for analysis for 519 children (87.8%). The mean age was 7.3 years (SD 0.2); 262 were girls (50.5%) and 212 (40.8%) were born SGA. There were no differences in terms of gender, birth weight, gestation and sociodemographic factors in those with sleep data and those without.

Median sleep latency was 26 minutes (interquartile range 13–42 minutes; fig 1). Children whose parents reported that they rarely fell asleep within 20 minutes of going to bed (10.5%) had a sleep latency 15.5 minutes longer than the other children ($t = 2.94$, $p<0.01$).

Determinants of sleep latency are presented in table 1. Sleep latency was longest in summer compared with the other seasons (+7.8 minutes, $p = 0.05$); however, this became non-significant in multivariable analysis. Mean activity counts on the day of the sleep recording were inversely associated with sleep latency ($p = 0.05$); that is, more physical activity was associated with a shorter sleep latency. Vigorous activity was associated with a decrease in sleep latency ($p = 0.07$). Conversely, time spent in sedentary activity was associated with an increase in sleep latency ($p = 0.01$). In multivariable analysis mean activity counts continued to show a significant inverse relationship with sleep latency ($p = 0.04$).

Going to bed after 21:00 hours was not significantly associated with sleep latency. Mean sleep duration was 10.1 h (SD 0.8).[2] Sleep duration was inversely associated with sleep latency ($p<0.001$), and this remained highly significant in the multivariable model. However, this was not simply that those who fell asleep more quickly spent more time asleep, as the two were not related one to one (sleep latency fell by 11.3 minutes per additional hour of sleep duration). Duration of television watching per day did not affect sleep latency. No associations were found between sleep latency and behaviour as measured by the Strengths and Difficulties Questionnaire and Conner's Parent and Teacher Rating Scales (table 2).

DISCUSSION

This study is the first large community-based study to study sleep latency using an objective measure of sleep onset as well as daytime activity. It provides evidence to support a long-held parental belief that physical activity promotes sleep in children. A higher mean activity count during the day was associated with shorter sleep latency. This finding was supported by rather weaker evidence of the association of vigorous activity with shorter sleep latency. Conversely, for every hour during the day spent in sedentary activity, sleep latency increased by 3 minutes.

Evidence of the acute effects of exercise on sleep latency in experimental conditions is complicated by confounders of timing, intensity and duration of exercise as well as fitness, age and usual sleep habits of participants. A meta-analysis of studies of adult "good sleepers" found no consistent effect of exercise on sleep latency, with a median difference between the

Table 1 Determinants of sleep latency

Variable	Univariable analysis (95% CI)	p Value	Multivariable analysis (95% CI)	p Value
Season				
Winter, autumn or spring (n = 421)	Ref	0.046	Ref	0.48
Summer (n = 98)	7.8 (0.1 to 15.5)		2.9 (−5.1 to 10.8)	
Total daytime movement counts (change in sleep latency per 10^6 counts)*	−9.1 (−23.6 to 5.4)	0.22		
Mean daytime movement counts/minute (change in sleep latency per 10^2count)†	−1.2 (−2.4 to 0.00)	0.054	−1.0 (−2.0 to −0.0)	0.043
Sedentary activity (change in sleep latency per hour of sedentary activity)	3.1 (0.61 to 5.55)	0.01		
Moderate activity (change in sleep latency per hour of moderate activity)	1.3 (−2.2 to 4.8)	0.46		
Vigorous activity (change in sleep latency per hour of vigorous activity)	−5.7 (−12.0 to 0.6)	0.07		
Bedtime after 21:00 hours (n = 105)	−6.0 (−13.4 to 1.4)	0.11		
Sleep duration (change in sleep latency per hour of sleep)	−11.3 (−15.1 to −7.6)	<0.0001	−11.1 (−14.9 to −7.3)	<0.0001
Television watching, h				
<1 (n = 113)	Ref	0.63		
1–3 (n = 332)	2.4 (−3.6 to 8.3)			
>3 (n = 54)	−1.6 (12.9 to 9.7)			

Results are expressed as change (95% CI) in minutes per unit of the variable as defined, with positive results representing a longer sleep latency and negative results a shorter sleep latency. *Median total daytime counts 607 222 (interquartile range (IQR) 493 366–762 117). †Median mean daytime counts 768 (IQR 610–956). Sleep duration: median 10.1 h (IQR 9.5–10.6).

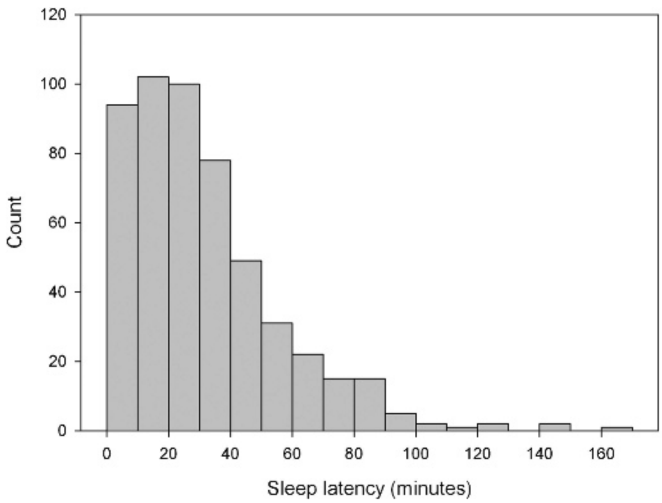

Figure 1 The distribution of sleep latency.

exercise condition and control of −1.0 minutes, although experimental studies of exercise performed 4–8 h before bedtime did show a significant reduction in sleep latency.[7] An experimental study of children (mean age 12.6 years, SD 0.8) found that high intensity exercise 3–4 h before bedtime was associated with reduced sleep latency compared with baseline (22.3 minutes vs 6.6 minutes, $p<0.05$).[8] Our study contributes to the knowledge of this area by reporting data of "real world" activity in a community sample.

This study showed that the median sleep latency was 26 minutes, but with wide variation. This is similar to that reported in children of a similar age using polysomnography in a sleep laboratory,[9 10] but longer than that measured using polysomnography at home (median 10 minutes for children aged 6–8 years).[11] Parents can use this information to know what is normal for this age group. Children whose parents reported that they had difficulty falling asleep took on average 15 minutes more to go to sleep than those children whose parents did not report this problem, which confirms that

Table 2 Sleep latency and health at 7 years of age

	Effect size in minutes (95% CI)	p Value
Strengths and Difficulties Questionnaire		
Total difficulties (abnormal/borderline vs normal)	2.5 (−7.0 to 11.0)	0.60
Emotion (abnormal/borderline vs normal)	0.3 (−8.0 to 8.6)	0.95
Conduct (abnormal/borderline vs normal)	3.2 (−4.5 to 11.0)	0.41
Hyperactivity (abnormal/borderline vs normal)	1.0 (−7.4 to 9.3)	0.82
Peer (abnormal/borderline vs normal)	4.7 (−3.8 to 13.3)	0.28
Pro-social (abnormal/borderline vs normal)	0.1 (−11.1 to 11.2)	0.99
Conner's Parent Rating Scale		
Oppositional	−1.1 (−7.9 to 5.8)	0.76
Cognitive problems	−2.3 (−10.2 to 5.7)	0.58
Hyperactivity	−3.5 (−10.7 to 3.8)	0.35
Anxious—shy	1.6 (−5.4 to 8.7)	0.65
Perfectionism	4.9 (−1.9 to 11.7)	0.16
Social problems	−1.9 (−11.2 to 7.4)	0.68
Psychosomatic	4.3 (−1.6 to 10.2)	0.15
Conner's ADHD index	−5.1 (−13.6 to 3.4)	0.24
CGI restless—impulsive	−4.5 (−11.2 to 2.3)	0.19
CGI emotional lability	−4.4 (−12.9 to 4.1)	0.31
CGI total	−3.9 (−11.1 to 3.3)	0.29
DSM-IV inattentive	−1.5 (−9.7 to 6.7)	0.72
DSM-IV hyperactive—impulsive	−4.7 (−11.8 to 2.3)	0.19
DSM-IV total	−5.9 (−13.3 to 1.6)	0.13
Conner's Teacher Rating Scale		
Oppositional	−6.8 (−15.4 to 1.8)	0.12
Cognitive problems	1.9 (−5.9 to 9.7)	0.63
Hyperactivity	−7.1 (−17.4 to 3.3)	0.18
Anxious—shy	3.3 (−2.0 to 8.6)	0.22
Perfectionism	0.9 (−7.0 to 8.7)	0.83
Social problems	1.4 (−5.3 to 8.1)	0.68
Conner's ADHD index	0.1 (−7.2 to 7.4)	0.98
CGI restless—impulsive	0.3 (−6.6 to 7.3)	0.92
CGI emotional lability	−2.3 (−10.4 to 5.9)	0.59
CGI total	−0.5 (−6.7 to 7.6)	0.89
DSM-IV inattentive	0.0 (−7.1 to 7.2)	0.99
DSM-IV hyperactive—impulsive	−1.6 (−9.5 to 6.2)	0.68
DSM-IV total	1.6 (−5.7 to 8.9)	0.66
Intelligence (WISC-III)		
IQ (change in sleep latency per IQ point)	−0.12 (−0.31 to 0.08)	0.23

ADHD, attention deficit hyperactivity disorder; CGI, Clinical Global Impression; DSM, Diagnostic and Statistical Manual of Mental Disorders; WISC, Wechsler Intelligence Scale for Children.

parental impression of sleep onset difficulties is valid in this age group. One previous study showed that polysomnographically measured sleep latency was significantly shorter than parental report, although the difference was not marked (mean parental reported sleep latency 15 minutes and polysomnography 11 minutes).[11] In addition, we showed that children took longer to go to sleep in the light summer evenings than during the rest of the year, which also supports this parent-held view.

The strengths of this study were that it was a large community group of children, who had been recruited at birth, and was representative of normal children and their exercise and sleep habits. Furthermore, it used an objective method to assess sleep onset and physical activity. We were able to demonstrate a reasonably sizeable effect of daytime activity levels on sleep onset. In addition, longer sleep duration was associated with shorter sleep latency, raising the possibility of short sleep latency as a marker for ''good sleepers''. As short sleep duration is associated with obesity[2] and lower cognitive performance,[3] community emphasis on the importance of promoting healthy sleep in children is vitally important. This study emphasises the importance of physical activity for children, not only for fitness, cardiovascular health and weight control, but also for sleep.

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Patient consent: Obtained.

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