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Original Article

Predictors of shorter sleep in early childhood

Laura McDonald, Jane Wardle, Clare H. Llewellyn, Cornelia H.M. van Jaarsveld, Abigail Fisher *

Health Behaviour Research Centre, Department of Epidemiology and Public Health, University College London, Gower Street, London WC1E 6BT, UK

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ABSTRACT

Objective: The aim of this study was to identify socio-demographic and home environmental predictors of shorter sleep in early childhood, and to examine whether effects were mediated by the timing of bedtime or wake time.

Methods: Participants were from Gemini, a British birth cohort of twins, and included 1702 children; one randomly selected from each twin pair. Parents reported night-time sleep duration at an average age of 15.8 months (range 14–27 months) using a modified version of the Brief Infant Sleep Questionnaire. Multiple logistic regression models were used to identify predictors of shorter sleep for this study.

Results: Using a cut-off of <11 h a night, shorter sleep was reported in 14.1% of children. Lower maternal education, non-white ethnic background, being male, low birth weight, living in a home with >1 older child and watching >1 h of TV in the evening were independently associated with shorter sleep. Mediation analyses showed that associations between education, ethnicity, evening TV viewing and sleep were driven predominantly by later bedtimes, while sex differences were driven predominantly by earlier wake times in boys.

Conclusion: In this sample, multiple environmental factors were associated with shorter sleep in young children, with several operating predominantly through later bedtime. An emphasis on the importance of an early and consistent bedtime could help promote healthy sleep and reduce inequalities in child health.

1. Introduction

In early childhood, insufficient sleep at night can impair learning and memory [1] and disrupt emotional regulation [2]. It is increasingly being shown to be associated with adverse health outcomes, notably an increased risk of obesity [3]. The health implications of short sleep make it important to understand its determinants, particularly in early life when patterns of sleep behaviour may be being established [4].

There are currently no clinical recommendations to define optimal sleep in early childhood [5], but sleeping <11 h per night substantially increases the risk of obesity in children under 5 years of age [3,6]. Between 18 and 24 months of age, children sleep on average 11.3 h a night and 1.5 h during the daytime [7]. However, daytime and night-time sleep may serve different functions; daytime sleep is not associated with obesity risk in children for example [6,8]; and they have different predictors [9].

Twin studies suggest that night-time sleep duration in early childhood is largely determined by the shared environment [10,11]. Multiple factors within the home have been shown to influence sleep. In an sample of over 5000 children aged from birth to 36 months, a regular bedtime routine and limited TV exposure were among the strongest predictors of longer sleep at night [9]. There are also marked ethnic and socio-economic differences in the sleep duration of young children [12], probably because these factors affect attitudes and practices surrounding sleep behaviours [13]. In a sample of over 10,000 children aged 18 months from the Avon Longitudinal Study of Parents and Children (ALSPAC), those from non-white ethnic backgrounds slept significantly less than other children in the cohort [7]. Other studies have also shown that children from non-white families, or those where the mother has less education, report shorter sleep at night [14,15], with some evidence that differences persist through the lifecourse [16]. Although multiple features within a child's physical and social environment have been associated with night-time sleep duration, it is not known whether these effects are mediated by the timing of bedtime or wake time. This information could help to understand the mechanisms of shorter sleep and inform strategies to improve sleep in early life.

Abbreviations: CI, confidence interval; OR, odds ratio; SD, standard deviation; m, minutes.

* Corresponding author. Tel.: +44 (0)20 7679 1722; fax: +44 (0)20 7679 8354.
E-mail address: Abigail.fisher@ucl.ac.uk (A. Fisher).

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This study therefore aimed to test whether predictors of shorter sleep at night operated primarily through sleep initiation (bedtime) or sleep termination (wake time).

2. Participants and methods

The Gemini study, described in full elsewhere [17], is a British twin birth cohort established to investigate genetic and environmental determinants of health in early life. The baseline sample includes 2402 families with twins born in the UK between March and December 2007 (36% of all live twin births). The proportion of male, female and opposite sex twin pairs in this sample is comparable to UK twin statistics. The geographic distribution of Gemini families reflects the UK population density, although white-British families from higher socio-economic backgrounds are over-represented [17]. The second wave of data collection, which included assessments of sleep, was completed by 1931 families (80% of baseline sample). For the present analyses, one child from each family was randomly selected to avoid non-independence of data. Written informed consent was provided by all parents. Ethical approval was granted by the University College London Committee of non-National Health Service Human Research.

2.1. Sleep behaviour

Sleep was assessed with a modified version of the Brief Infant Sleep Questionnaire [18] when the children were on average 15.8 months old. The primary caregiver reported on several aspects of sleep behaviour including daytime sleep, whether their child regularly woke up at night (yes/no), bedtime and wake time. Night-time sleep duration was calculated from parent-reported bedtime and wake time; a method that has been validated against objective measures [18]. In a subsample of 40 families, 1 week test–retest reliability of the sleep questionnaire was high (e.g., intraclass correlation 0.89; 95% confidence interval (CI) 0.76–0.95 for night-time sleep duration).

There are currently no clinical recommendations to define short sleep in early childhood, but population data can provide an indication of basic sleep requirements [19]. At around 18 months of age, age-specific reference values suggest children sleep on average 11.3 (standard deviation (SD) 1.3) h per night [7], although individual variability exists. Sleeping <11 h per night at this age is also associated with an increased risk of obesity [3,6], therefore reflecting a level of sleep that is not sufficient to support optimal functioning or health. Therefore, shorter sleep in this study was defined as sleep <11 h per night [3]. We also conducted a sensitivity analysis using a cut point at the 10th percentile of sleep duration (<10.5 h per night) and patterns of results were the same, so data are presented using <11 h as the demarcation for short sleep.

2.2. Socio-demographic and environmental characteristics

Socio-demographic risk factors were reported by the primary caregiver in baseline questionnaires. These included maternal education (up to secondary school, college and beyond), maternal ethnicity (white and non-white) and child sex (male and female). Birth weight was recorded by asking parents to photocopy or transcribe health records and was categorised as low ($\leqslant$2500 g) or normal weight (>2500 g) [20]. Environmental factors reported at the second wave of data collection when the children were 15.8 months old included the number of older children living in the home (0, 1 and >1), and hours of TV viewing in the morning and after 6:30 in the evening ($\leqslant$1 and >1 h).

2.3. Statistical analyses

Logistic regression models were used to identify significant predictors of shorter sleep. Models were first run separately for each factor, followed by a multiple logistic regression model. All models were adjusted for age because the range in the sample (14–27 months) was too narrow to study age effects, and for daytime sleep; because at this age daytime sleep still represents a large proportion of total sleep duration that a child receives [19], and shows considerable ethnic variation [21]. All models were also adjusted for regular night waking, as this may disrupt the normal sleep–wake cycle.

To test whether the predictors of shorter night-time sleep operated primarily through wake time or bedtime, a standard, four-step mediation approach was used [22]. Mediation is considered to take place when (1) the mediator (wake time or bedtime) significantly predicts the dependent variable (shorter sleep), (2) the independent variable significantly predicts the dependent variable, (3) the independent variable significantly predicts the mediator and (4) the association between the independent variable and the dependent variable is substantially reduced when the mediator is included in the model. Criteria 1 and 2 were assessed with the logistic regression and multiple logistic regression models used to identify predictors of shorter sleep. Criterion 3 was assessed using two separate multiple linear regression models predicting wake time and bedtime. Criterion 4 was assessed using two separate multiple logistic regression models including all determinants and either wake time or bedtime. Where the results satisfied criteria for mediation, the Sobel test was used as the test of significance [23].

3. Results

Complete data were available for 1702 children (71.0% of baseline sample). The average night-time sleep duration in the sample was 11.6 h per night (SD 52 min) and the average daytime sleep was 1.9 h (SD 41 min). Shorter sleep (<11 h per night) was reported in 14.1% of the sample. There was no significant association between daytime and night-time sleep duration, indicating that shorter night-time sleepers are not compensating during the day. Table 1 shows the percentage of children experiencing shorter night-time sleep by family characteristics. Shorter night-time sleep was more common in children from ethnic minority families and families where the mother had less education. Shorter sleep was also more common in boys, and children who watch more than 1 h of TV in the morning or evening.

The average bedtime of the shorter-sleeping group was 8:05 pm (SD 61 min) compared with 7:04 pm (SD 33 min) in those with $\geqslant$11 h of sleep. The average wake time of the shorter-sleeping group was 6:14 am (SD 54 min) compared with 6:56 am (SD 39 min) in those with $\geqslant$11 h of sleep. There was a positive correlation between bedtime and wake time ($r = 0.29$, $p < 0.001$).

3.1. Predictors of shorter sleep

Table 1 presents the logistic regression models predicting shorter sleep. Lower maternal education (odds ratio (OR) = 1.64, 95% CI 1.23–2.17), coming from a minority ethnic background (OR = 5.10, 95% CI 3.16–8.24), being male (OR = 1.45, 95% CI 1.08–1.92) and having been born at a low birth weight (OR = 1.43, 95% CI 1.07–1.90) significantly increased the odds of shorter sleep. Having more than one older child in the home (OR = 1.70, 95% CI 1.17–2.47) and watching more than an hour of TV in the morning (OR = 1.47, 95% CI 1.10–1.96) or evening (OR = 2.22, 95% CI 1.55–3.18) were also associated with shorter sleep. In the multiple