Short Sleep Duration in the First Years of Life and Obesity/Overweight at Age 4 Years: A Birth Cohort Study

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Objective To investigate whether short sleep duration from the first year of life influenced weight at an early age.
Study design During 2004, children born in Pelotas, Brazil, were enrolled in a cohort study. Sleeping habits during the previous 2 weeks were assessed, and the children were weighed and measured at 1-, 2-, and 4-year follow-ups. Overweight and obesity at 4 years were defined according to World Health Organization z-scores for body mass index for age. Short sleep duration was defined as fewer than 10 hours of sleep per night at any follow-up.
Results Out of the 4263 live births, 4231 were recruited. The prevalence of short sleep duration at any follow-up from 1-4 years of age was 10.1%. At 4 years of age, 201 children were obese (5.3%), and 302 (8%) were overweight. Among short sleepers, the prevalence ratio for overweight/obesity after adjusting for maternal and children's characteristics was 1.32 (1.03; 1.70).
Conclusions Children who slept for fewer than 10 hours per night at any follow-up from 1-4 years of age were more likely to be overweight or obese at 4 years of age, despite their sociodemographic and sleep characteristics. *(J Pediatr 2016;168:99-103)*.

Experimental studies conducted mainly among adults have suggested that curtailment of sleep may be linked to weight gain, possibly through elevation of cortisol and ghrelin levels, along with reduction of leptin levels, thereby leading to increased hunger and reduced energy expenditure.[1-4] Although individual variability in sleep need is considered to be a major determinant of the number of hours slept per day, the amount of sleep considered to be physiological is around 12-15 hours for infants and 11-14 hours for toddlers.[5] Regarding nighttime sleep, the average amount expected is approximately 12 hours at 1 year of age and 11 hours at 4 years of age.[6] Studies have indicated that children currently have at least 30 fewer minutes of sleep per day than the recommended amount.[7] This seems to be due to later onset times for sleeping, while the time schedule for waking up in the morning is maintained.[6] This finding has been observed from an early age and may also play an important role in weight gain.[8,9]

There is divergent evidence regarding the relationship between short sleep duration and weight status in childhood,[10-14] and a lack of evidence linking very early exposure to short sleep duration and weight changes before school age.[2,15] The present study aimed to investigate the association between short sleep duration at any time between 1 and 4 years of age and overweight or obesity at 4 years of age.

Methods

This study was developed in Pelotas, a city in southern Brazil with a population of around 328 000 inhabitants,[16] of whom approximately 95% live in the urban area. Over 99% of deliveries take place in 1 of the 5 city hospitals.

The 2004 Pelotas Birth Cohort, conducted through the Postgraduate Epidemiology Program at the Federal University of Pelotas, was designed to collect information from all children born from January 1, 2004, to December 31, 2004, to mothers living in the urban area of the municipality. More information on the study design and results can be found elsewhere.[17-19] Briefly, mothers were recruited in the hospital within 24 hours of delivery by trained fieldworkers and were interviewed using a structured questionnaire that asked for information on demographic, socioeconomic, and behavioral characteristics, along with reproductive history, antenatal care, and illnesses.

BMI	Body mass index
PR	Prevalence ratio

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Children were evaluated at birth and subsequently at follow-up home visits at 1, 2, and 4 years of age. Data on growth, development, morbidity, and feeding habits were collected, as well as social and demographic information.

The information collected at the perinatal interview included maternal age in complete years (<20, 20-29, 30-39, ≥40); skin color (based on interviewer observation, and classified as white/black/other); mother's schooling level in complete years of formal education (0, 1-4, 5-7, 8-10, ≥11); living with a partner; number of antenatal care appointments (1-4, 5-8, ≥9); parity (1, ≥2); mother's body mass index (BMI) at the beginning of pregnancy with weight from prenatal records or reported by the mother; and height measured by the interviewer (<18.5, 18.5-24.9, 25-29.9, ≥30 kg/m^2). Smoking, alcohol consumption, high blood pressure, and diabetes during gestation were reported by the mother. Socioeconomic status was categorized according to the Brazilian criteria of economic classification, which take into account household assets and the education level of the family head and are divided in 5 groups (A-E), such that A is the wealthiest.

Type of delivery was obtained from hospital records. Gestational age (<37, ≥37 weeks) was estimated according to the last menstrual period if it was consistent with birth weight, length, and head circumference (based on curves for gestational age)[20]; if inconsistent or unknown, newborn maturity was estimated using the Dubowitz method.[21]

Newborns were measured in length by the interviewers using an infantometer with 1 mm precision. Birth weight in g (≥4000, 2501-3999, 1500-2500, <1500) was collected from hospital records, which had been derived from electronic pediatric scales with 10 g precision that had been checked weekly by the study staff using standard weights. Breastfeeding practices were assessed at 1 year of age.

Data on sleep characteristics were collected at 1, 2, and 4 years of age, regarding the child's usual bedtime and wake up time during the 2 weeks preceding the interview. Total nighttime sleep duration was based on the parents' responses to questioning on what time the child was put to bed, how long it took the child to fall asleep (sleep latency), and what time the child usually woke up the following morning. Because sleep latency was on average 20 minutes at every follow-up, long sleep latency time was operationally defined by the authors as more than 50% longer than the mean (>30 minutes). Children who slept for fewer than 10 hours per night were considered to be short sleepers.[22] Because only 9 children (0.25%) slept less than 10 hours at all visits, the variable "short sleep duration between 12 and 48 months" was built such that it included children who slept for fewer than 10 hours in at least 1 of the follow-ups.

The parents were asked by whom the child was put to bed (mother, father, mother and father, other, nobody) and about the presence of night waking, number of nights with awakenings (0, 1, ≥2/wk), number of awakenings per night (0, 1, ≥2), use of a pacifier throughout the night, room or bed sharing, and number (0, 1, ≥2) and duration (<1, ≥1 hour) of daytime naps. The respondents were asked to judge the quality of their child's sleep (excellent, very good, good, fair, poor). Information on nightmares or night terrors was sought at the 2- and 4-year follow-ups, and on television viewing at nighttime at the 4-year visit (<1, ≥1 hour).

At the 1-year visit, children were weighed on their mother's lap using an electronic scale with 100 g precision, after their mother had been weighed while wearing light clothing. At the 2 and 4-year follow-ups, they were weighed on the same scale, standing on their own. Length was assessed in the recumbent position at 1 and 2 years, by means of an infantometer with 1 mm precision. At the 4-year visit, height was measured using a portable stadiometer with 1 mm precision, which was developed for this study.

BMI was calculated, and BMI z-scores determined. Children were classified as overweight or obese in accordance with World Health Organization z-score BMI-for-age metrics.[23] Children with a BMI z-score between 2 and 2.99 SDs above the World Health Organization cut-point were considered overweight, and those with a z-score of 3 SDs or more were considered obese.

The variables explored as being potential confounders of the association between short sleep duration and overweight/obesity were the antenatal maternal characteristics, those of the child at birth, and at 1 year of age. Other sleep variables measured at age 1 year (start of the exposure period) like night waking, sleep latency, sleep quality, and daytime naps were explored as potential confounders and mediators (**Figure**; available at www.jpeds.com).

This decision was based on a conceptual framework describing the postulated hierarchical relationships between exposures.[24] To be included in the model, variables had to be associated with fewer than 10 hours of sleep per night between the ages of 1 and 4 years and with overweight, obesity, or both at 4 years of age, with a P value of <.20, but without being in the causal pathway between shorter sleep duration and overweight/obesity.[25]

For multivariable analyses, Poisson regression with robust variance was used. The results were expressed as prevalence ratios (PRs) and their respective 95% CIs. Three analysis models were used: crude analysis (model 1); model 1 + mother's skin color and education level (model 2); and model 2 + sleep latency, number of night waking, and duration of day naps at 1 year of age (model 3).

In addition to using "any sleep duration between ages 1 and 4" as our main exposure, we also wished to assess the time-varying nature of the associations as a way of checking for reverse causality. We, therefore, assessed the association of: (1) short sleep duration at 1 year of age and overweight/obesity at 2 years of age, with adjustment for overweight/obesity at 1 year of age, mother's skin color, and schooling; and (2) short sleep duration at 2 years of age and overweight/obesity at 4 years of age, with adjustment for overweight/obesity at 1 and 2 years of age, short sleep duration at 1 year of age, mother's skin color, and schooling.

All of the analyses were made using the Stata statistical software, v 12.1 (StataCorp LP, College Station, Texas).