Short Sleep Duration and Later Overweight in Infants

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Objective To provide further knowledge about the longitudinal association between sleep duration and overweight in infants.

Study design The data for this study are from the CHILD-SLEEP birth cohort (n = 1679). The sleep data are based on parent-reported total sleep duration collected at 3, 8, 18, and 24 months. For a subgroup of 8-month old participants (n = 350), an actigraph recording was also made. Growth data were derived from the child health clinic records. A logistic regression model was used to study the association between sleep duration and later weight development.

Results Shorter sleep duration in 3-month-old infants was cross-sectionally associated with lower weight-for-length/height (all *P* values ≤ .026) and body mass index (all *P* values ≤ .038). Moreover, short sleep duration at the age of 3 months was associated with greater weight-for-length/height z score at the age of 24 months (aOR 1.56; 95% CI 1.02-2.38) as well as with a predisposition to gain excess weight between 3 and 24 months of age (aOR 2.61; 95% CI 1.75-3.91). No significant associations were found between sleep duration at 8, 18, or 24 months and concurrent or later weight status. Actigraph-measured short night-time sleep duration at the age of 8 months was associated with greater weight-for-length at the age of 24 months (aOR 1.51; 95% CI 1.02-2.23).

Conclusions Short total sleep duration at the age of 3 months and short night-time sleep duration at the age of 8 months are associated with the risk of gaining excess weight at 24 months of age. *(J Pediatr 2019;212:13-9)*.

Multiple factors have been considered to underlie the obesity epidemic in children and adults, such as increased consumption of high caloric food and soft drinks, decreased physical activity, and an altered intestinal microbiota.[1] In addition, increased TV watching, use of electronic devices, and overall sedentary behavior have been thought to contribute to obesity.[1] However, less is known about excess weight gain in infants. Some proposed mechanisms for infant weight gain include parental obesity, feeding practices, genetics, and epigenetics.[2-4] Although the prevalence of childhood obesity has increased, sleep duration among children has decreased. For instance, between the 1970s and 1990s, the total sleep duration in 2-year-old children decreased from 14.2 hours to 13.5 hours.[5] This issue has raised questions about the relationship between weight development and sleep in children.

There is a paucity of research on the relationship between sleep duration and the development of overweight in infants, and the existing results are somewhat controversial. Most of the studies concerning infants support the idea that an inverse connection exists between sleep duration and overweight,[4,6-16] but contrary findings also have been reported.[17,18]

By using data from the CHILD-SLEEP birth cohort, the aim of this study was to evaluate the longitudinal association between sleep duration and overweight in infants aged 3-24 months. In addition, we examined whether an association exists between short sleep duration and excess weight gain. Our hypothesis was that those infants with shorter sleep duration would have greater body weight in the later stages of their development. We also studied whether there is a curvilinear relationship between sleep and weight gain; 1 previous study reported such an association between sleep duration and weight among 3- to 5- year-old children.[15]

Methods

The CHILD-SLEEP birth cohort was a population-based prospective longitudinal study conducted in Finland from April 2011 to December 2017.

BMI	Body mass index

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The cohort has been described elsewhere.[19] Altogether, 1679 families from Tampere, Finland, entered the study during 2011-2012. The families were recruited to the study during their regular prenatal visits to the maternity clinics. The target population was composed of all Finnish-speaking, pregnant women who belonged to the Tampere University Hospital district. The study protocol was approved by the Pirkanmaa Hospital District Ethical Committee (9/3/2011, Ethical Research Permission Code R11032), and permission for the recruitment procedure was received from the physicians at the target health centers. The parents gave written informed consent at the beginning of the study.

The parents were asked to complete a questionnaire prenatally and when the child was 3, 8, 18, and 24 months old. The prenatal questionnaire contained questions about the demographic and socioeconomic characteristics of the family, as well as questions about parents' health and lifestyle. The questionnaires regarding the children included general health, neurologic and physiological development, and sleep. Children with a congenital structural (n = 9), developmental (n = 7), or metabolic disorder (n = 5) or other condition affecting growth or sleep (n = 9) were excluded from the study.

In follow-up, 1397 (97.2%) children were included in the analyses at the 3-month time point, 1277 (88.9%) at the 8-month time point, 1088 (75.7%) at the 18-month time point, and 889 (61.9%) at the 24-month time point. In addition, a subgroup of 350 (24.3%) children participated in actigraph measurements at the age of 8 months.

Information concerning the children's sleep characteristics was collected when the children were 3, 8, 18, and 24 months old from questionnaires sent to the parents. The questionnaire about sleep was based on the Brief Infant Sleep Questionnaire,[20] which included questions about the duration and quality of the child's sleep. For each time point, the total sleep duration was calculated based on the parents' estimation of the hours and minutes the child usually slept in a day between 7 a.m. and 7 p.m. and between 7 p.m. and 7 a.m.

Because general definitions for normal sleep duration for children of different ages do not exist and no reference data for sleep duration exist for the Finnish population, we used an internal cut-off point at the lowest quartile to differentiate short sleepers from normal/long sleepers. The cut-off point for short sleep at the 3-month time point was 13.0 hours (short sleepers, n = 342, 25.7%; mean 11.85 hours, SD 1.48 hours vs comparison group mean 15.17 hours, SD 1.17 hours), at the 8-month time point 12.5 hours (short sleepers, n = 345, 27.6%; mean 11.91 hours, SD 0.72 hours vs comparison group mean 13.85 hours, SD 0.84 hours), at the 18-month time point 11.8 hours (short sleepers, n = 283, 26.0%; mean 11.23 hours, SD 0.54 hours; vs comparison group mean 12.70 hours, SD 0.67 hours), and at the 24-month time point 11.4 hours per day (short sleepers, n = 219, 24.8%; mean 10.77 hours, SD 0.46 hours vs comparison group mean 12.22 hours, SD 0.65 hours).

Actigraph recordings were conducted to obtain an objective sleep measure. For this study, an Actiwatch 7 was used (CamNtech Ltd, Cambridge, United Kingdom). Parents were asked to place the actigraph on the thigh of their infant for 3 consecutive days and to carefully keep the sleep-log for their infant. Activity counts were summed over 1-minute intervals. The nighttime activity data were scored using the sleep analysis program provided by the manufacturer. This device uses the Oakley algorithm,[21] in which activity counts recorded during the measured epoch are modified by the level of activity in the surrounding 2-minute time period (ie, ± 2 minutes) to yield the final activity count for each epoch.[22] Furthermore, this algorithm has been validated previously in infants.[23] Finally, all cases with <2 wear days (n = 10) were excluded from the final analyses. Our sleep variable of interest was night-time sleep duration representing the average values of the measured nights. Actigraph-measured night-time sleep duration significantly correlated with parent-reported night-time sleep duration at 8 months ($r = 0.362$, $P < .001$).

The growth data, collected from the child health clinics' records, were obtained for 92.3% (n = 1545) of the 1673 records collected. The body mass index (BMI) was computed from the weight and height values, and the age- and sex-specific weight-for-length/height values were calculated using Finnish national reference data.[24] All growth measurements were carried out by professionals in the child health clinics. Birth weight and length were extracted from hospital registers.

The number of growth measurement points per subject ranged from 5 to 34 (mean 13.7, SD 2.7) during the first 2 years of age. Due to the varying number of measurement points, which also varied by age for each child, the age- and sex-specific weight-for-length/height values were generated for 3-, 8-, 18-, and 24-month time points to align these data with the sleep measurements. This was done by interpolating (or if not available, by extrapolating) the anthropometric measurements for the 4 fixed time points using the 2 nearest available measurements and assuming linear growth based on these values. These interpolated/extrapolated age- and sex-specific weight-for-length/height values were then used in the analyses.

The age- and sex-specific weight-for-length/height z-score values correspond to the ratio of weight to expected weight. These values were dichotomized using the internal 90th percentile as the cut-off point. The cut-off point for the greater weight at the 3-month time point was 1.5 (n = 135, 10.0%), at the 8-month time point 1.4 (n = 132, 10.0%), at the 18-month time point 1.3 (n = 124, 9.7%), and at the 24-month time point 1.3 (n = 125, 9.8%).

In the analyses, the following confounding factors were considered: age (days), birth weight (kilograms), sex, maternal early pregnancy BMI (kg/m^2), parental education level, maternal smoking during pregnancy, and breastfeeding at the age of 3 months.

Due to a significantly smaller amount of reported maternal prepregnancy weight values than the early pregnancy weight

values (n = 286 vs n = 1385), the early pregnancy weight was used in the analyses, even though the stage of the pregnancy at the time of filling out the questionnaire varied between mothers (mean 34.8 weeks, SD 2.5). The maternal early pregnancy BMI was then calculated as weight in kilograms divided by the square of the height in meters.

Maternal and paternal education levels were combined and dichotomized to create the variable named "parental education level," where "higher education level" indicates maternal or paternal polytechnic or university education and "lower education level" indicates both parents having vocational school or lower education.

Maternal smoking during pregnancy was dichotomized based on 4 initial options provided in the questionnaire. The answers indicating nonsmoking or smoking the last time more than 6 months ago, were recoded as "not smoking during the pregnancy" ("no"), and answers indicating smoking during the last 6 months as "smoking during the pregnancy" ("yes"). Mothers who did not respond (n = 41, 2.86%) were considered as nonsmokers during the pregnancy ("no"). The information on smoking inside the home during pregnancy or postnatally was not available.

Finally, breastfeeding at the age of 3 months also was dichotomized: "yes" was defined as a child being breastfed or breastfed and given formula and "no" defined as child given only formula. Those who did not answer the question (n = 48, 3.34%) were considered as having breastfed ("yes").

All statistical analyses were carried out using the IBM SPSS Statistics 24 software (IBM Corp, Armonk, New York). *T*-tests and multivariate ANCOVA were conducted to study cross-sectional associations between sleep and weight variables at each time point. Second, a logistic regression model was used to examine the longitudinal association between the total sleep duration at 3, 8, 18, and 24 months and the later weight status (weight-for-length/height z score at the age of 24 months and change in weight-for-length/height z score).

We used 2 different dependent variables to represent weight status in the logistic regression models. Weight-for-length/height z score dichotomized at the 90th percentiles, indicating severe overweight/obesity, was used as one dependent variable. In addition, to represent the change in growth, we calculated the change in weight-for-length/height z score between the time points (change between 3 and 24 months, 8 and 24 months, and 18 and 24 months) and used it as another dependent variable. The weight change variables also were dichotomized at the 90th percentiles to differentiate those individuals who gained the most weight during the time periods mentioned previously. The cut-off point used for high weight gain between 3 and 24 months was 1.30 (n = 127, 10.0%); between 8 and 24 months it was 1.01 (n = 127, 10.0%); and between 18 and 24 months it was 0.65 (n = 129, 10.1%).

Finally, we also computed linear regression models to explore potential curvilinear relationships between sleep duration and weight. These models were performed at all time points and first-, second-, and third-order terms were included in these models.

Logistic regression models, cross-sectional ANCOVA models, and linear regression models were adjusted for age, birth weight, and sex, and additionally for maternal early pregnancy BMI, parental education level, maternal smoking during pregnancy, and breastfeeding at the age of 3 months. The logistic regression models were further adjusted for paternal BMI, maternal age at delivery, family income, TV watching, day care status at the age of 18 months, amount of outdoor activities, and vegetable/fruit/berry consumption at the age of 24 months.

Results

The main birth and demographic characteristics of the participants are summarized in **Table I**, which describes all participants whose prenatal questionnaires were returned and whose sleep duration was reported at the 3-month time point. Of all participants, 52.6% (n = 756) were boys and 47.4% (n = 680) were girls. Altogether, 73.6% of the mothers and 61.3% of the fathers had polytechnic or university education. Families were on average well doing, as in 66.7% of the families, either one or both of the parents earned more than over 2000 euros per month. Furthermore, the mean maternal age at delivery was 31 years.

Table II presents the results of cross-sectional comparisons between sleep duration and weight variables with and without adjustments. No significant cross-sectional associations between sleep duration and weight variables were found in other time points than in 3 months. We found that 3-month-old infants sleeping less had lower weight-for-length/height (all P values $\leq .026$) and BMI (all P values $\leq .038$) than infants sleeping longer. No significant differences appeared between the unadjusted and adjusted models.

The longitudinal results from the logistic regression analyses predicting subsequent weight development by sleep duration at each time point are shown in **Table III**. Parent-reported short sleep duration at the age of 3 months was associated with greater risk for excess weight-for-length/height at the age of 24 months (aOR 1.56; 95% CI 1.02-2.38) as well as with the predisposition to gain excess weight between 3 and 24 months of age (aOR 2.61; 95% CI 1.75-3.91). No significant associations were found between the parent-reported total sleep duration at 8, 18, or 24 months and later weight status.

Actigraph-measured short night-time sleep duration at the age of 8 months was associated with greater weight-for-length/height at the age of 24 months (aOR 1.51; 95% CI 1.02-2.23).

In all models reported in **Table III**, female sex (all P values $< .001$), greater birth weight (all P values $< .014$), greater maternal early pregnancy BMI (all P values $< .015$), and maternal smoking during pregnancy (all P values $< .047$) were associated with greater weight-for-length/height status at the age of 24 months, whereas

Table I. Demographic characteristics of the children at 3, 8, 18, and 24 months

Demographic variables	n (%)/ mean (SD)	Min-max
Sex		
Female	633 (47.5)	
Male	699 (52.5)	
Birth weight, kg	3.5 (0.5)	2.0-5.8
Gestational age, wk	40.0 (1.3)	33.0-42.6
Premature babies		
<37 wk	29 (2.2)	
≥37 wk	1304 (97.8)	
Small birth weight		
<2500 g	11 (0.8)	
≥2500 g	1289 (99.2)	
Maternal age at delivery, y	31 (5)	18-48
Maternal early pregnancy BMI, kg/m^2	28.2 (4.3)	20.0-52.2
Paternal BMI, kg/m^2	26.4 (3.7)	16.7-49.7
Paternal education level		
Vocational school or lower education	484 (38.7)	
Polytechnic or university education	767 (61.3)	
Maternal education level		
Vocational school or lower education	344 (26.4)	
Polytechnic or university education	959 (73.6)	
Parental education level		
Both parents have vocational school or lower education	258 (19.4)	
Maternal or paternal polytechnic or university education	1071 (80.6)	
Maternal income		
<2000 euros per month	965 (74.0)	
≥2000 euros per month	339 (26.0)	
Paternal income		
<2000 euros per month	478 (37.9)	
≥2000 euros per month	784 (62.1)	
Maternal smoking during the pregnancy		
No	1257 (94.7)	
Yes	71 (5.3)	
Breastfeeding at the age of 3 mo		
No	170 (12.8)	
Yes	1163 (87.2)	
Day care at the age of 18 mo		
Not at all or part-time	797 (76.2)	
Full time	249 (23.8)	
TV watching at the age of 18 mo, h/d	0.6 (0.6)	0.0-4.2
<1 h	715 (73.0)	
≥1 h	265 (27.0)	
Outdoor activities at the age of 24 mo		
<1 h/d	276 (32.5)	
≥1-2 h/d	574 (67.5)	
Vegetable consumption at the age of 24 mo		
Once a day or less	115 (13.6)	
Twice a day or more	732 (86.4)	
Fruit and berry consumption at the age of 24 mo		
Once a day or less	191 (22.7)	
Twice a day or more	650 (77.3)	

breastfeeding at the age of 3 months and parental education were insignificant.

Finally, further adjusting for paternal BMI, maternal age at delivery, family income, TV watching, day care status at the age of 18 months, amount of outdoor activities, and vegetable/fruit/berry consumption at the age of 24 months revealed that the relationship between short sleep and greater weight-for-length/height remained. Accordingly, the association between short sleep duration at the age of 3 months and excess weight-for-length/height at the age of 24 months and the predisposition to gain excess weight between 3 and 24 months of age after these further adjustments remained similar (aOR 1.56; 95% CI 1.00-2.44, aOR 2.88; 95% CI 1.90-4.38, respectively). Finally, the association between actigraph-measured short night-time sleep duration at the age of 8 months and excess weight-for-length/height at the age of 24 months remained significant after these further adjustments (aOR 1.49; 95% CI 1.00-2.27).

In all the linear regression models, the quadratic terms were insignificant, suggesting that the association between sleep duration and weight gain does not follow a U-shaped curve in infancy.

Discussion

In previous studies, 6 months has usually been the youngest age at which sleep duration has been assessed. Therefore, the effect of sleep duration in early stages of life on later weight development is unknown. However, 1 study included sleep duration measurements in early infancy and examined the association between sleep and weight in infants younger than 1 year of age by using a panel data model.[14] With the follow-up time points of 1, 3, 6, 8, and 12 months, partly corresponding to the measurement points in our study, the authors found that parent-reported short sleep in these time points was associated with heavier weight status. However, in contrast to our study, the weight-for-age z-score growth curves were used in the analyses and they did not specify at which ages short sleep actually was associated with later overweight.[14]

Most of the other studies concerning infancy have included sleep measurements only from 6 months of age onwards. Parent-reported sleep duration of <12 hours a day from 6 months of age to 24 months of age was associated with a greater BMI z score, the sum of subscapular and triceps skinfold thicknesses, and risk for overweight at the age of 3 years.[9] In comparison with our study, this study used a weighted average of sleep duration at 6, 12, and 24 months, dichotomized at 12 hours, as a main explanatory factor.[9] Moreover, in this study, overweight was defined differently than in our study, because they used an age- and sex-specific BMI ≥95th percentile as the main outcome variable.[9]

In contrast, another study found that parent-reported total sleep duration at the ages of 9 and 18 months did not predict adiposity at the age of 3 years.[18] This finding is consistent with our findings regarding the association between parent reported sleep duration at 8, 18, and 24 months and weight status at 24 months of age. In addition to the BMI z score, this study used objective measurements to assess adiposity, which included triceps and subscapular skin-fold thicknesses and dual-energy X-ray absorptiometry. Finally, a large study of Australian children also showed no associations between sleep duration at 0-1 years of age and BMI at 2-3 years of age, or between sleep duration at 4-5 years of age and BMI at 6-7 years of age.[17] In their study, sleep duration was measured by parent-recorded 24-hour time-use diaries.

Table II. Cross-sectional comparisons (*t* tests and ANCOVA) between short and normal sleepers (dichotomized at 25th percentile) for weight parameters (weight, height, BMI, weight-for-length/height) at 3, 8, 18, and 24 months of age without adjustments (*P*) and with adjustments (P^1 and P^2)

	Normal/long sleepers		Short sleepers				
Growth variable	Mean (SD)	n	Mean (SD)	n	*P*	P^1	P^2
3 mo	Sleep duration >13.25 h/d		Sleep duration ≤13.25 h/d				
Weight	6.34 (0.71)	913	6.26 (0.74)	323	.071	.167	.185
Height	61.50 (2.10)	913	61.45 (2.11)	322	.748	.558	.583
BMI	16.74 (1.40)	913	16.53 (1.36)	322	.019	.033	.038
Weight-for-length/height	0.16 (1.06)	925	−0.01 (1.00)	324	.012	.020	.026
8 mo	Sleep duration >12.50 h/d		Sleep duration ≤12.50 h/d				
Weight	8.84 (1.02)	808	8.82 (1.07)	308	.786	.766	.974
Height	71.22 (2.46)	807	71.30 (2.32)	307	.608	.158	.252
BMI	17.40 (1.44)	807	17.31 (1.55)	307	.401	.474	.390
Weight-for-length/height	0.10 (1.02)	832	0.05 (1.09)	319	.466	.521	.462
18 mo	Sleep duration >11.83 h/d		Sleep duration ≤11.83 h/d				
Weight	11.40 (1.32)	514	11.27 (1.28)	177	.272	.498	.578
Height	83.00 (3.01)	514	82.60 (2.86)	177	.127	.200	.243
BMI	16.51 (1.33)	513	16.49 (1.32)	177	.847	.853	.805
Weight-for-length/height	−0.01 (1.02)	718	−0.07 (1.02)	258	.365	.486	.464
24 mo	Sleep duration >11.35 h/d		Sleep duration ≤11.35 h/d				
Weight	12.78 (1.41)	496	12.63 (1.35)	168	.222	.569	.445
Height	88.17 (3.00)	496	88.05 (3.04)	168	.648	.777	.672
BMI	16.41 (1.30)	496	16.26 (1.21)	168	.189	.325	.174
Weight-for-length/height	−0.01 (1.05)	594	−0.03 (1.05)	200	.851	.882	.691

P^1 ANCOVA adjusted for age, birth weight, and sex.
P^2 ANCOVA adjusted for age, birth weight, sex, maternal early pregnancy BMI, parental education level, maternal smoking during pregnancy, and breastfeeding at the age of 3 months.

We also found significant associations between objective actual sleep time during night at the age of 8 months and heavier weight status at 24 months. However, this relation was not confirmed with parent-reported sleep questionnaire. This disagreement might be due to the fact that parent-reported sleep duration was based on total sleep duration, and objective sleep duration was restricted to night time in this study. Moreover, actigraphy-based and parent-reported estimates on sleep duration can be slightly different, as they are based on different approaches to evaluate sleep. More studies are needed to confirm whether sleep duration at the age of 8 months is related to excessive weight gain at the age of 24 months.

In our study, the only significant cross-sectional association between sleep duration and weight was found in 3-month-old infants. In contrast to previous cross-sectional findings, we found short sleep to be associated with lower weight-for-length/height and BMI at 3 months. Most of the existing cross-sectional studies have associated short sleep with a heavier weight profile in older children and adults,[25] although negative results also have been reported.[17,18]

There is some evidence supporting that sleeping long hours could be also related to overweight. A study with a significant number of participants (n = 48 922) found a U-shaped, longitudinal connection between parent-reported sleep duration and BMI in 3- to 5-year-old children.[15] We did not find any significant curvilinear associations between sleep duration and weight gain.

Our study has some limitations. To assess sleep duration, we used parent-reported questionnaires, which may overestimate the duration of an infant's sleep.[26,27] The duration of sleep in small children varies widely across individuals and over time, and therefore the reference values for normal sleep duration have not been defined. According to a recent meta-analysis, the mean sleep duration (per 24 hours) for 3-month-old infants is 13.6 hours, for 9-month-old infants 12.6 hours, for 1- to 2-year-old children

Table III. Logistic regression models for short sleep duration (25th percentile at each age) and the risk for subsequent weight development

	High weight-for-length/height z score at 24 mo				High increase in weight-for-length/height z score between 3 and 24 mo, 8 and 24 mo, and 18 and 24 mo			
Explanatory variable	aOR* (95% CI)	*P**	aOR† (95% CI)	*P*†	aOR* (95% CI)	*P**	aOR† (95% CI)	*P*†
Short sleep duration at 3 mo	1.54 (1.01-2.33)	.044	1.56 (1.02-2.38)	.042	2.52 (1.70-3.75)	<.001	2.61 (1.75-3.91)	<.001
Short sleep duration at 8 mo	0.79 (0.49-1.26)	.323	0.78 (0.49-1.27)	.318	1.41 (0.92-2.16)	.118	1.32 (0.85-2.05)	.212
Short sleep duration at 18 mo	0.90 (0.55-1.47)	.665	0.87 (0.52-1.46)	.599	0.97 (0.60-1.57)	.902	1.08 (0.66 1.76)	.758
Short sleep duration at 24 mo	0.78 (0.45-1.38)	.397	0.70 (0.40-1.26)	.235	–	–	–	–

*Adjusted for age, birth weight, and sex.
†Adjusted for age, birth weight, sex, maternal early pregnancy BMI, parental education level, maternal smoking during pregnancy, and breastfeeding at the age of 3 months.

is 12.6 hours, and for 2- to 3-year-old children is 12.0 hours.[28] This is in line with our data, where the mean sleep durations were 14.3, 13.3, 12.3, and 11.9 hours for 3-, 8-, 18-, and 24-month-old infants, respectively.

Another limitation of this study includes using only weight- and height-based definitions to estimate overweight in children. We used weight-for-length/height z scores to assess overweight, as no Finnish reference data for BMI z scores are available for children younger than 2 years old.

The follow-up time in this study was relatively short. In our analyses, only 3- and 8-month sleep durations were associated with overweight at the age of 24 months, which could indicate that the effects of sleep deprivation on weight develops over a longer time span. If the follow-up time was longer, differences in the future weight status between short and normal/long sleepers might become clearer.

Finally, the study population in our study consisted mostly of well educated, middle-class families. Mothers were in general more highly educated than Finnish pregnant woman in general.[29] Families were, on average, doing well, and mothers' income was similar compared with the average income of Finnish pregnant women.[30] Thus, it is difficult to evaluate whether the results are generalizable to other populations.

The importance of sleep in relation to development and growth should be further emphasized, and parents should be encouraged to be aware of their child's circadian rhythm, bedtime routines, and sleep hygiene. However, previous interventions aiming to increase sleep duration to prevent obesity in children have not been successful.[31-33] Hence, novel ways of preventing overweight and further studies on sleep duration in early childhood and later weight status are needed. ■

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50 Years Ago in *The Journal of Pediatrics*

Proteolytic and Lipolytic Deficiency of the Exocrine Pancreas

Towne PJ. Pediatrics 1969;75:221-8.

In 1969, Dr Townes described a 4-year-old developmentally delayed girl who had generalized edema and was failing to thrive since birth. Throughout many hospitalizations, diagnostic evaluations, and interventions, the child continued to demonstrate suboptimal weight gain. After referral to Rochester's Strong Memorial Hospital, duodenal intubation was performed and duodenal fluid was collected to assess the activity of pancreatic enzymes. The test revealed normal amylase activity, however, there was no trypsin, chymotrypsin, carboxypeptidase, or lipase activity despite attempts to activate the enzymes with exogenous trypsin. The patient was then prescribed a hydrolyzed formula with the addition of pancreatin (pancreatic enzymes). With this intervention, the patient began to gain weight and progress developmentally at a rapid rate.

When addressing failure to thrive in childhood today, the differential diagnosis remains as broad as it did 50 years ago. Insufficient caloric intake, maldigestion, malabsorption, and increased energy expenditure are still considered the main processes that lead to failure to thrive. What has progressed over the past 50 years is the availability of noninvasive testing to diagnose conditions associated with failure to thrive. Exocrine pancreatic insufficiency can now be suspected and/or confirmed through various noninvasive tests.[1] Tests that raise the suspicion of pancreatic insufficiency include low levels of fat-soluble vitamins in the serum (particularly in the context of hypoalbuminemia and failure to thrive), increased alpha-1 antitrypsin clearance in the stool, or increased fecal fat excretion. Direct, but noninvasive, testing of pancreatic function includes the measurement of pancreatic enzymes or their byproducts in stool (eg, fecal elastase) or serum (eg, serum trypsinogen). With endoscopic advancements, a direct assessment of pancreatic function can be performed by measuring pancreatic enzyme activity following pancreatic stimulation with secretin and cholecystokinin. Lastly, innovations in genetic testing have allowed the ability to test for genetic conditions associated with exocrine pancreatic insufficiency (eg, Shwachman-Diamond syndrome). Thus, although the disease process has remained the same, owing to advances in diagnostic testing, exocrine pancreatic insufficiency can be detected early in life, allowing for early intervention that prevents the development of poor long-term outcomes, such as poor growth, blindness because of vitamin A deficiency, and neuropathy because of vitamin E deficiency, to name a few.

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