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Original Article

Sleep habits and weight status in Brazilian children aged 4–6 years of age: the PREDI study

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ABSTRACT

Objectives: To evaluate the association of sleep habits with the weight status of children aged 4–6 years.
Methods: Data were obtained from the PREDI Study, a Brazilian birth cohort study. The current study was carried out in the homes of the participants during two follow-ups: 2016/17 and 2018. The participants were submitted to anthropometric assessment and demographic, socioeconomic and sleep data were obtained. The child's sleep habits were self-reported by the mother or caregiver on the day of the visit and included information on the following sleep habits during the past week: bedtime routine, rhythmicity, and separation affect determined with the Sleep Habits Inventory for Preschool Children and the Sleep Habits Inventory. Logistic regression and gamma-log regression analyses were used to examine the association of sleep habits with excess body weight of children in the two follow-ups according to sex.
Results: Of the 217 and 185 children included in 2016/17 and 2018, respectively, 66 (30.6%) and 48 (25.9%) had a BMI >85th percentile at 4–6 years, respectively. The median rhythmicity score was higher in children with excess body weight ($p = 0.05$). Adjusted analysis showed that rhythmicity was associated with excess body weight of girls at ages 4–5 years (OR = 1.42, 95% CI: 1.09–1.86, $p = 0.009$) and 6 years (OR = 1.32, 95% CI: 1.06–1.65, $p = 0.015$), even after adjustment for other important covariates. Additionally, the sleep habit “separation affect” was inversely associated with the child's BMI in boys ($\beta = -0.005$, 95% CI: −0.010–0.000, $p = 0.037$).
Conclusions: In the present study, rhythmicity problems were associated with increased odds of girls aged 4–6 years having excess body weight. These results are important from a public health perspective since strategies aimed at preventing excess body weight in children need to consider the child's sleep quality as a potential risk factor, especially rhythmicity.

1. Introduction

The rising prevalence of overweight and childhood obesity in recent decades has become a global public health problem [1]. Excessive body weight in childhood threatens health and adequate growth and development, as well as quality of life, increasing disabilities in adulthood and reducing longevity [2]. Globally, over 38 million children under 5 years of age were overweight in 2019 [3]. Overweight and obesity have multiple causes and sleep problems are associated factors [4].

Sleep is part of human existence and has multiple benefits such as the maintenance of physical and mental health, balance and proper functioning of the organism, and cell recovery [5–7]. Adequate sleep is associated with healthy growth, cognitive and behavioral development, learning, memory consolidation, central nervous system maturation, willingness to participate in physical activities, adequate food choices (quantity and quality), and maintenance of energy balance [4,8–12].

Sleep habits are defined as culturally learned behaviors that are repeated and adopted by children or their family member/caregiver before bedtime and that favor sleep onset and the maintenance of an adequate quality of sleep [13]. Inadequate sleep habits in

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children are associated with mood swings, tiredness, lower school performance, anxiety and depression disorders [14–16], and body weight gain [17]. The maintenance of a sleep routine provides the child with a sense of predictability and security [6,7]. Establishing regular sleeping hours, stimulating naps after lunch, and encouraging children to sleep in their own bed are measures that contribute to the establishment of rhythmicity and good quality sleep [5,6] and prevent other behavioral and sleep disorders [18], including excess body weight [4].

Cohort studies investigating sleep habits in children are still scarce. Until the publication of this study, we did not find any cohort study involving children under 6 years of age that has estimated the association of sleep habits with weight status. Therefore, the objective of this study was to evaluate the association of sleep quality with the weight status of Brazilian children aged 4–6 years. Our hypothesis is that children with altered sleep habits are more likely to have excess body weight in the early years of school.

2. Methods

2.1. Study design, settings and participants

The presented data were extracted from the Predictors of Maternal and Infant Excess Body Weight - PREDI Study, a birth cohort study conducted in Joinville, the largest city of Santa Catarina State, Brazil. The PREDI study was designed to examine the determinants and consequences of maternal and child excess body weight in a cohort of mothers and their children.

This is a birth cohort study that used data collected from adult women and their children after 4–5 years and 6 years of follow-up (2016/2017; 2018). Details of the recruitment process have been described previously [19,20]. The sample size of the PREDI study was calculated based on a prevalence of macrosomic infants of 6%, considering a 95% confidence interval, an absolute precision of 2.5%, and a population of 7200 newborns. The estimated sample size was 331 individuals. Assuming a 20% loss, at least 397 participants were required [21]. Briefly, women older than 18 years giving birth to a full-term singleton (37–42 weeks of gestation) were invited to participate in the study with their newborns in January–February 2012 (baseline). The baseline exclusion criteria were pre-eclampsia, presence of an infectious contagious disease (AIDS, hepatitis, syphilis, and toxoplasmosis), birth defects, and plans for adoption immediately after delivery.

The study was approved by the Research Ethics Committee of the University of Joinville Region (Protocol No. 107/2011), and all persons gave their informed consent prior to inclusion in the study.

2.2. Data collection

Anthropometric measurements and clinical, biological, demographic, socioeconomic and sleep data were collected in the family's home by a group of trained health professionals at two time points using a structured questionnaire: 2016/17 (second follow-up, 4–5 years old) and 2018 (third follow-up, 6 years old). A total of 435 mother–child pairs were enrolled in the study at baseline (2012). After exclusions and losses, 217 pairs continued to participate in the second follow-up and 185 in the third follow-up (Fig. 1).

All women who had participated in the previous follow-up were contacted by phone 10–15 days before data collection and were invited to participate in the new follow-up of the study. If there was no response by phone, a team of researchers went to the participant's home and invited the woman personally. If the participant was not located even after visiting the residence, new attempts were made such as contacting neighbors and nearby commercial establishments and through social media.

The maternal demographic and socioeconomic variables included age, marital status, education, working (if the woman has a job and is not at home), and monthly household income. For children, sex and sleep habits were obtained. The data were collected individually in a room of the family's home using a previously tested structured questionnaire.

Anthropometric measurements were obtained from both the mother and her child in duplicate and the mean values were used for analysis. Weight was measured with a digital scale (G-Tech®, Glass 7 Model, Zhongshan, China) with a capacity of 180 kg to the nearest 0.1 kg. Height was measured to the nearest 0.1 cm using a portable stadiometer (WCS®, Compact Model, Curitiba, Brazil). Both measurements were performed using the method of Gordon et al. [22]. The women's weight status was evaluated based on the World Health Organization (WHO) body mass index (BMI) cut-offs [23]. A BMI $\geq$25.0 kg/m^2 was classified as excess body weight. The children's weight status was based on the 2006 WHO [24] and 2007 WHO [25] growth standards for BMI-for-age for children and adolescents aged 0–5 and 5–19 years, respectively. We defined a BMI >85th percentile as excess body weight in children.

2.3. Sleep habits

None of the mothers or caregivers refused to provide the child's sleep information. The characteristics of the child's sleep habits were investigated based on the mother's (or caregiver's) daily sleep inventory reported on the day of the visit. The inventory included information about three sleep habits during the past week: bedtime routine, rhythmicity, and separation affect according to the Sleep Habits Inventory for Preschool Children [26] and the Sleep Habits Inventory [5]. The Sleep Habits Inventory for Preschool Children was developed to assess bedtime parenting practices and the presence or absence of consistent sleep hygiene [27]. The instrument was translated into Brazilian Portuguese and the results showed reliability and validity [26]. The organization into subscales has been reported previously [5,18,26,28].

The inventory consists of 17 questions, five for bedtime routine, six for rhythmicity, and six for separation affect as follows:

2.3.1. Bedtime routine

This subscale is composed of items related to parenting behavior at bedtime and the child's independence when falling asleep. High scores in this subscale indicate the child's dependence at bedtime and inadequate habits that compromise the process of falling asleep [5,26,27]. Positive habits: 1) follows a bedtime routine; 2) falls asleep alone, and 3) falls asleep in own bed. Negative habits: 4) falls asleep before being put to bed. Neutral habits: 5) put to bed by one/both parents.

2.3.2. Rhythmicity

This subscale consists of items that address the regularity of the pre-sleep routine, bedtime and wake time, and sleep problems such as taking more than 30 min to fall asleep and nighttime awakenings [5,26,27]. High scores in this scale indicate the lack of a regular routine, bedtime problems, and nighttime waking [5,27]. Positive habits: 1) keeps a regular bedtime; 2) wakes up at a regular hour in the morning, and 3) sleeps in own bed all night. Negative habits: 4) wakes up during the night and 5) takes more than 30 min to fall asleep. Neutral habits: 6) has an afternoon nap.

2.3.3. Separation affect

The separation affect subscale comprises items related to the child's nighttime fear, parent-seeking behaviors, and the need for

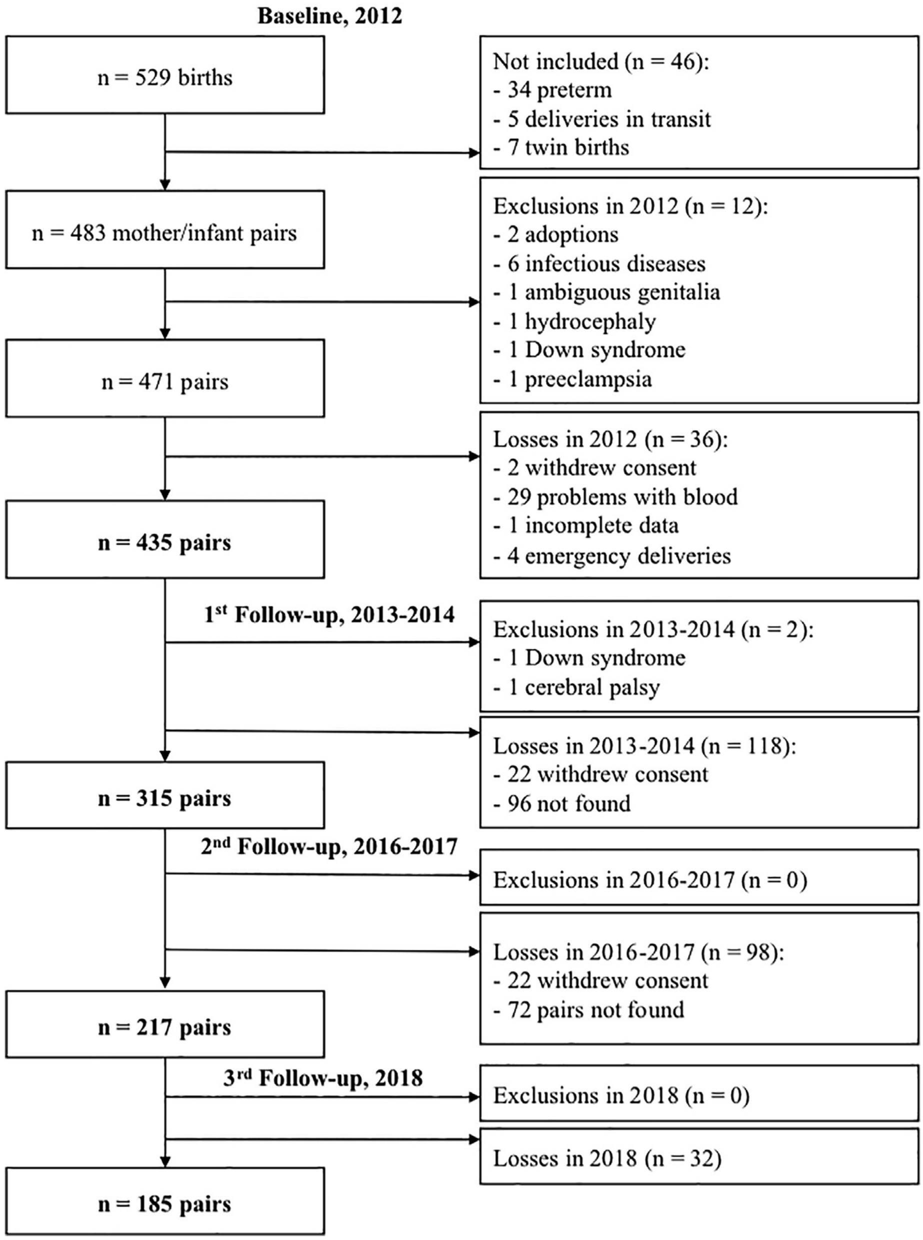

Fig. 1. Flow chart of participants through the PREDI cohort study, Joinville, Brazil, 2012–2018.

comfort/safety during nighttime separation [5]. High scores in this scale indicate nighttime fear, stress, and difficulties separating from the parents at night [5,27]. Negative habits: 1) expresses fear of darkness after being put to bed for the night; 2) wakes up in distress from dream/worry; 3) has a night light on while sleeping; 4) calls for parent/relatives during the night, and 5) comes to the parents' bed in the night. Neutral habit: 6) brings a security object to bed.

The questions of each sleep habit were scored on a Likert-type scale from 1 to 4 (1 = not this week, 2 = 1 to 2 times this week, 3 = 3 to 5 times this week, and 4 = 6 or more times this week). The higher the final score for each sleep habit, the larger the number of sleep problems and consequently the worse the sleep quality [5]. The scores for answers related to positive and negative habits were recoded as follows: positive habits: 4 = 0, 3 = 1, 2 = 2 and 1 = 3; negative habits: 1 = 0, 2 = 1, 3 = 2 and 4 = 3. Answers related to neutral habits were not included in the calculation since they could not be clearly classified as a positive or negative habit. The maximum and minimum scores possible were 12 and 0 for bedtime routine, 15 and 0 for rhythmicity, and 15 and 0 for separation affect, respectively. The maximum total score of the instrument was 42.

2.4. Statistical analysis

The IBM® Statistical Package for the Social Sciences 27.0 (SPSS®) was used for statistical analysis. The $\chi 2$ test was applied to compare the prevalence of categorical variables according to the child's weight status (≤85th and >85th percentile) (Table 1). Maternal age (<30, 30–40, and ≥40 years) and monthly household income (<3, 3–5, and ≥5 minimum wages) were classified according to the criteria of the Brazilian Institute of Geography and Statistics [29]: 1 minimum wage = US$ 291.00 in 2016 and US$ 246.00 in 2018. Maternal education (<9 years for women who completed primary school; 9–12 years for those who completed high school; ≥ 12 years for those who started/finished undergraduate courses) was

Table 1
Characteristics of the study participants according to the child's nutritional status at 4–6 years of age. PREDI Study, Brazil, 2016–2018.

Characteristic	Phase 1, 4–5 years old (n = 217)			*p* value	Phase 2, 6 years old (n = 185)			*p* value
	≤85th	>85th	Total		≤85th	>85th	Total	
	n (%)	n (%)	n (%)		n (%)	n (%)	n (%)	
Mothers								
Age (years)				0.750[a]				0.652[a]
<30	72 (69.2)	32 (30.8)	104 (47.9)		44 (78.6)	12 (21.4)	56 (30.3)	
30–40	60 (68.2)	28 (31.8)	88 (40.6)		59 (72.0)	23 (28.0)	82 (44.3)	
≥40	19 (76.0)	6 (24.0)	25 (11.5)		34 (72.3)	13 (27.7)	47 (25.4)	
Marital status				0.962[a]				0.065[a]
Married/Consensual union	128 (69.2)	56 (30.4)	184 (85.9)		115 (77.2)	34 (22.8)	149 (82.7)	
Other	21 (70.0)	9 (30.0)	30 (14.1)		19 (61.3)	12 (38.7)	31 (17.3)	
Education (years of schooling)				0.190[a]				0.407[a]
≥12	68 (73.9)	24 (26.1)	92 (43.0)		54 (70.1)	23 (30.3)	77 (42.8)	
9–12	43 (61.4)	27 (38.6)	70 (32.7)		49 (75.4)	16 (24.6)	65 (36.1)	
<9	38 (73.1)	14 (26.9)	52 (24.3)		31 (81.6)	7 (18.4)	38 (21.1)	
Working				0.301[a]				0.564[a]
Yes	78 (66.7)	39 (33.3)	117 (54.7)		78 (72.9)	29 (27.1)	107 (59.4)	
No	71 (73.2)	26 (26.8)	97 (45.3)		56 (76.7)	17 (23.3)	73 (40.6)	
Monthly household income (MW)				0.222[a]				0.456[a]
≥5	17 (63.0)	10 (37.0)	27 (12.6)		39 (81.3)	9 (18.8)	48 (27.0)	
3–5	46 (78.0)	13 (22.0)	59 (27.4)		60 (73.2)	22 (26.8)	82 (46.0)	
<3	86 (66.7)	43 (33.3)	129 (60.0)		34 (70.8)	14 (29.2)	48 (27.0)	
BMI (kg/m^2)				0.088[a]				0.070[a]
<25	61 (77.2)	18 (22.8)	79 (39.5)		53 (84.1)	10 (15.9)	63 (35.8)	
25–30	41 (67.2)	20 (32.8)	61 (30.5)		43 (71.7)	17 (28.3)	60 (34.1)	
≥30	36 (60.0)	24 (40.0)	60 (30.0)		35 (66.0)	18 (34.0)	53 (30.1)	
Gestational weight gain (kg)[d]	13.3 (7.0)	13.9 (9.3)	13.8 (7.6)	0.239[b]	14.0 (6.3)	13.2 (8.5)	13.8 (7.0)	0.422[b]
Children								
Gender				0.223[a]				0.304[a]
Boys	78 (66.1)	40 (33.9)	118 (54.4)		71 (70.0)	29 (29.0)	100 (54.0)	
Girls	73 (73.7)	26 (26.3)	99 (45.6)		66 (77.6)	19 (22.4)	85 (46.0)	
Birth weight (g)[e]	3.4 (0.4)	3.6 (0.5)	3.4 (0.5)	0.001[c]	3.4 (0.4)	3.6 (0.4)	3.4 (0.4)	0.003[c]
Sleep habits[d]								
Bedtime routine	3.0 (4.0)	3.0 (4.0)	3.0 (5.0)	0.121[b]	3.0 (4.0)	3.0 (5.0)	3.0 (4.0)	0.682[b]
Rhythmicity	3.0 (3.0)	3.0 (2.0)	3.0 (3.0)	0.244[b]	1.0 (3.0)	3.0 (5.0)	2.0 (4.0)	0.050[b]
Separation affect	3.0 (6.0)	3.0 (6.0)	3.0 (6.0)	0.632[b]	3.0 (6.0)	3.0 (6.0)	3.0 (6.0)	0.615[b]

MW, monthly minimum wage (1 MW = US$ 291.00 in 2016, and US$ 246.00 in 2018); BMI, body mass index.
[a] X^2 test.
[b] Mann-Whitney U test.
[c] t-test.
[d] Data are reported as median (interquartile range).
[e] Data are reported as mean (standard deviation).

classified according to the 1996 Education Law (Lei das Diretrizes e Bases da Educação Nacional) [30]. The Mann–Whitney U test was used to compare the median and interquartile range of the sleep habit scores (bedtime routine, rhythmicity, and separation affect) according to the child's weight status.

To examine differences between the mother–child pairs enrolled at baseline and those not enrolled in the third (n = 185) follow-up, maternal education years, monthly household income, marital status, birth weight and child's sex were compared using the Student t-test and the chi-square test. Odds ratios (OR) and 95% confidence intervals (CI) were calculated using logistic regression analysis to investigate the association of the child's weight status with the sleep habit scores and other covariates. In addition, we used a generalized linear model to analyze the effect of sleep habits on the child's BMI as a continuous variable. Gamma-log regression analyses were performed due to the asymmetric distribution of the outcome.

Covariates with $p < 0.10$ in at least one of the follow-ups (phase 1 or 2; Table 1) were selected (birth weight, mother's BMI, monthly household income, and marital status) for inclusion in the adjusted regression analyses (Tables 2 and 3) according to sex. To control for maternal age, this covariate was also included in the adjusted models. The analyses corresponding to each follow-up were performed considering the variables from the same follow-up.

The goodness-of-fit of the models was assessed using Akaike's information criterion, with lower values indicating better fits. The variance inflation factor (VIF) revealed little collinearity among the independent variables (highest VIF = 1.052) A p value < 0.05 was considered statistically significant in all analyses.

3. Results

3.1. Demographic characteristics

Of the 217 and 185 children included in the study in phase 1 and phase 2, respectively, 66 (30.6%) and 48 (25.9%) had a BMI >85th percentile at 4–5 and 6 years, respectively. There was no significant ($p < 0.05$) difference in maternal education years, monthly household income, marital status, birth weight or child's sex between mothers/children enrolled at baseline and those considered losses in the third follow-up (phase 2).

The mean birth weight was higher in children with excess body weight in both phases when compared to normal weight children (3.6 *vs* 3.4 kg; $p < 0.05$). The median rhythmicity score was also higher in children with excess body weight (3.0 vs. 1.0, respectively; $p = 0.05$) (Table 1).

3.2. Logistic regression models

Unadjusted logistic regression analysis showed that only rhythmicity was significantly associated with the child's excess

Table 2
Logistic regression models for excess body weight of children according to age and sex. PREDI Study, Brazil, 2016–2018.

Characteristic	Phase 1, 4–5 years old				Phase 2, 6 years old			
	Model 1 OR (95% CI)	*p* value	Model 2 OR (95% CI)	*p* value	Model 3 OR (95% CI)	*p* value	Model 4 OR (95% CI)	*p* value
Boys only								
Bedtime routine	0.93 (0.81–1.08)	0.351	0.96 (0.82–1.12)	0.631	0.93 (0.77–1.13)	0.481	0.95 (0.77–1.18)	0.658
Rhythmicity	0.94 (0.79–1.13)	0.520	0.93 (0.77–1.14)	0.496	1.16 (0.95–1.42)	0.155	1.16 (0.92–1.46)	0.219
Separation affect	0.93 (0.83–1.04)	0.185	0.96 (0.85–1.09)	0.584	0.99 (0.88–1.13)	0.923	0.96 (0.82–1.13)	0.658
Girls only								
Bedtime routine	0.89 (0.74–1.07)	0.209	0.91 (0.74–1.12)	0.395	1.09 (0.90–1.32)	0.357	1.19 (0.94–1.50)	0.160
Rhythmicity	1.25 (1.00–1.55)	**0.045**	1.42 (1.09–1.86)	**0.009**	1.32 (1.06–1.65)	**0.015**	1.47 (1.09–1.98)	**0.010**
Separation affect	1.06 (0.94–1.19)	0.387	1.05 (0.92–1.20)	0.460	0.97 (0.83–1.14)	0.723	0.99 (0.83–1.21)	0.980
Boys and girls								
Bedtime routine	0.92 (0.82–1.03)	0.149	0.94 (0.83–1.06)	0.329	1.00 (0.88–1.15)	0.916	1.06 (0.91–1.23)	0.497
Rhythmicity	1.06 (0.93–1.21)	0.355	1.09 (0.94–1.25)	0.257	1.22 (1.05–1.42)	**0.008**	1.27 (1.07–1.51)	**0.007**
Separation affect	0.98 (0.90–1.06)	0.577	0.99 (0.91–1.08)	0.803	0.99 (0.89–1.09)	0.775	0.99 (0.89–1.12)	0.973

OR, odds ratio; CI, confidence interval; BMI, body mass index.
Models 1, 3: unadjusted models.
Models 2, 4: models adjusted for birth weight, mother's age, mother's BMI and monthly household income as continuous variables, and for marital status as categorical variable.
Bold values denote statistical significance at the p < 0.05 level.

Table 3
Gamma-log regression models for body mass index of children according to age and gender. PREDI Study, Brazil, 2016–2018.

Characteristic	Phase 1, 4–5 years old				Phase 2, 6 years old			
	Model 1 β (95% CI)	*p* value	Model 2 β (95% CI)	*p* value	Model 3 β (95% CI)	*p* value	Model 4 β (95% CI)	*p* value
Boys only								
Bedtime routine	−0.005 (−0.012; 0.002)	0.147	−0.004 (−0.011; 0.002)	0.209	−0.001 (−0.014; 0.011)	0.839	0.000 (−0.013; 0.012)	0.980
Rhythmicity	−0.005 (−0.014; 0.004)	0.275	−0.006 (−0.014; 0.003)	0.198	0.011 (−0.001; 0.024)	0.072	0.010 (−0.003; 0.023)	0.124
Separation affect	−0.005 (−0.010; 0.000)	**0.037**	−0.003 (−0.008; 0.001)	0.152	0.005 (−0.004; 0.013)	0.273	0.005 (−0.004; 0.013)	0.312
Girls only								
Bedtime routine	−0.007 (−0.16; 0.003)	0.189	−0.003 (−0.014; 0.007)	0.522	0.012 (−0.004; 0.027)	0.137	0.016 (−0.001; 0.031)	0.051
Rhythmicity	0.007 (−0.004; 0.018)	0.205	0.009 (−0.002; 0.020)	0.116	0.022 (0.007; 0.037)	**0.004**	0.026 (0.009; 0.043)	**0.002**
Separation affect	0.001 (−0.004; 0.007)	0.691	0.001 (−0.004; 0.007)	0.594	−0.001 (−0.012; 0.010)	0.818	0.000 (−0.010; 0.010)	0.974
Boys and girls								
Bedtime routine	−0.006 (−0.012; 0.000)	0.054	−0.005 (−0.011; 0.001)	0.119	0.006 (−0.005; 0.016)	0.283	0.008 (−0.002; 0.019)	0.130
Rhythmicity	0.000 (−0.007; 0.007)	0.911	−0.005 (−0.007; 0.007)	0.990	0.017 (0.007; 0.027)	**<0.001**	0.019 (0.008; 0.030)	**0.001**
Separation affect	−0.002 (−0.006; 0.002)	0.245	−0.001 (−0.005; 0.002)	0.433	0.002 (−0.005; 0.009)	0.547	0.003 (−0.004; 0.010)	0.386

β, beta-coefficient (slope coefficient of the regression line); CI, confidence interval.
Models 1, 3: unadjusted models.
Models 2, 4: models adjusted for birth weight, mother's age, mother's BMI and monthly household income as continuous variables, and for marital status as categorical variable.
Bold values denote statistical significance at the p < 0.05 level.

body weight in girls in phases 1 and 2 (Table 2, Models 1 and 3). For each unit increase in the rhythmicity score, the odds of girls aged 4–5 years having excess body weight increased by 25% (Table 2, Model 1, OR = 1.25, 95% CI: 1.00–1.55, $p = 0.045$) compared to underweight/normal weight children in phase 1, and by 32% (Table 2, Model 3, OR = 1.32, 95% CI: 1.06–1.65, $p = 0.015$) in phase 2. This result continued to be significant and increased by about 12% after the inclusion of the covariates birth weight, mother's age, mother's BMI, monthly household income, and marital status in the models (Table 2, Model 2, OR = 1.42, 95% CI: 1.09–1.86, $p = 0.009$; Model 4, OR = 1.47, 95% CI: 1.09–1.98, $p = 0.01$).

Analysis of the “boys and girls” group in phase 2 also showed that only rhythmicity was significantly associated with child excess body weight in the unadjusted analysis (Table 2, Model 3; OR = 1.22, 95% CI: 1.05–1.42, $p = 0.008$), even after adjustment for the same covariates (Table 2, Model 4; OR = 1.27, 95% CI: 1.07–1.51, $p = 0.007$).

3.3. Gamma-log regression models

The results did not change substantially even when the child's BMI was included as a continuous variable (Table 3). Children with rhythmic problems at the age of six were more likely to have an increased mean BMI, especially in the “girls only” and “boys and girls” groups (Table 3, Models 3 and 4). For each unit increase in the rhythmicity score, the BMI of girls aged 6 years increased, on average, by 26.34% (95% CI: 0.009–0.043, $p = 0.002$) in the “girls only” group and by 19.18% (95% CI: 0.008–0.030, $p = 0.001$) in the “boys and girls” group, even after adjustment for the same covariates as in the logistic regression (birth weight, mother's age, mother's BMI, monthly household income, and marital status) (Table 3, Model 4). Additionally, the sleep habit “separation affect” was significantly and inversely associated with the child's BMI only in boys (Table 3, Model 1, β = −0.005, 95% CI: −0.010–0.000, $p = 0.037$). However, this association was no longer significant after adjustment (Table 3, Model 2, β = −0.003, 95% CI: −0.008–0.001, $p = 0.152$).

4. Discussion

In the present study, rhythmicity problems were associated with an increased odds of children aged 4–5 and 6 years having excess body weight even after adjustment for other maternal and child covariates. The higher the rhythmicity scores, the greater the child's BMI, especially in girls. The sleep habit “separation affect” was also associated with the child's BMI, but only in boys.

Sleep quality in children is a combination of many factors and has implications for physical and emotional health [31]. Previous studies have established the relationship between sleep habits and excess body weight in children [4,32,33]. A lack of bedtime routines, inadequate rhythmicity, separation problems, and not staying in bed throughout the period of sleep are determinants of poor sleep habits [34–37]. Additionally, some authors found that sleep deprivation caused by waking up at night, taking more than 30 min to sleep, lack of a bedtime routine and consequently sleeping later are associated with an inadequate diet, low fruit/vegetable intake, and high consumption of soft drinks and sugar in children [33,38,39].

A study conducted in Canada on 5560 children showed that half of the participants did not sleep properly at night [40]. The authors concluded that a longer sleep duration was associated with a lower risk of overweight and obesity, irrespective of other sleep characteristics, and with better diet quality and higher levels of physical activity [40], in agreement with our results. Another study involving about 70,000 Greek children revealed an association of insufficient sleep duration with unhealthy dietary habits such as skipping breakfast, fast-food consumption, regular consumption of sweets, and being overweight/obese [41]. An Italian study involving 71 adults and 128 children showed that adults and children who sleep less have an increased risk of obesity and overweight accompanied by dysfunctional eating behaviors, insufficient physical activity, and metabolic changes [42].

Some researchers have also investigated the relationship between sleep and obesity-associated hormones. Boeke et al. [43] reported a shorter sleep duration to be associated with lower leptin concentration in males. The same study found a modest positive association between sleep duration and leptin concentration in some subgroups of children and adolescents. The associations differed according to sex and age and, possibly, according to level of adiposity [43]. Changes in leptin concentration can alter satiety and have been associated with increased food consumption, especially high-calorie and high-carbohydrate foods [44]. This finding appears to be consistent with our results showing that inadequate rhythmicity possibly increased food consumption and the choice for high-calorie foods with added sugars, causing weight gain [33]. Indeed, maintaining adequate rhythmicity has become a common problem in different age groups in recent years [34].

The rhythmicity subscale addresses the continuity in habits and may indicate pre-sleep routine problems, irregular bedtimes and wake times, and insomnia complaints. Rhythmicity problems are indicators of inconsistent sleep routines and insomnia. We believe that children with altered rhythmicity are more likely to wake up at night, consequently feeling hungry and being unable to get back to sleep. This fact is probably interconnected with circadian rhythms. Sleep and circadian rhythm disorders in children and young adults are risk factors for the development of obesity [45]. Indeed, circadian misalignment has an adverse influence on energy balance and increases the risk of weight gain. Within this context, disturbances in the circadian variation of the gut microbiome composition may be associated with an increased risk of obesity related to insufficient sleep and circadian misalignment [45].

Regarding age (phase 1 and phase 2), despite an age difference of approximately 1 year between the groups studied, rhythmicity was significantly associated with weight status in both phases. However, girls aged 6 years were about 12% less likely to have problems with rhythmicity than girls aged 4–5 years (OR = 1.32, phase 2 vs. OR = 1.47, phase 1). Bedtime problems and childhood insomnia can be the result of inappropriate sleep onset associations such as parental presence and lack of encouragement for independence at bedtime. Indeed, some authors recommend encouraging independence at bedtime in order to avoid negative associations with early sleep onset [46]. We believe that, at 6 years of age, children are less dependent on their parents for both daytime and pre-sleep routines, a fact that contributes to sleep rhythmicity.

The habit of nighttime eating in order to get back to sleep is not new and has already been reported in adults [47], adolescents [48], and children [37]. Changing awake times or routine/rhythmicity during the week and especially on weekends contributes to the development of sleep disorders, as well as to changes in social and eating behaviors and in circadian rhythm [49], which are associated with excess body weight [45,50]. The altered rhythmicity can also be influenced by sex [48], in agreement with our results which showed that girls with rhythmicity problems were more prone to excess body weight. In adults, women reporting shorter or slightly less efficient sleeping hours than men are more likely to experience poor sleep [51]. Swedish adult women who reported not getting enough sleep, sleeping poorly, having difficulty falling asleep, feeling somnolent at work, and having disturbed sleep were more likely to report binge eating throughout life [52]. On the other hand, some studies found no differences in sleep habits according to sex in either children or adults [53,54].

Another interesting find of this study is the inverse association of the sleep habit separation affect and the child's BMI in boys. Although this result was not significant after adjustment for important covariates, the increase in the separation affect score seems to influence the child's dependence on parents at bedtime, as reported by other authors [55]. Children who rarely joined their parent's bed during night were more likely to be overweight than those who frequently joined [55]. However, we found no other studies that revealed similar results only for boys. Taken together, these findings highlight the need for new studies, especially longitudinal studies, to better understand the causal relationship between sleep habits and weight status.

Our study has several strengths. The data came from a longitudinal study that involved mother–child pairs and are primary data, a fact providing opportunities for future research in this field. Another important strength of the study is the possibility to adjust for important covariates.

5. Limitations

Some limitations of this study must be mentioned. First, variables such as sleep data, education years and household income were self-reported and are therefore vulnerable to reporting bias. Future studies should also use objective measures of sleep such as actigraphy which, together with self-report instruments, would permit more detailed analysis of the sleep characteristics of this population. Second, the different types of study designs for the evaluation of sleep habits impaired comparison of the data. Third, the fact that the children attended school at different times, morning or afternoon, may have influenced their sleep habits. In general, children who study in the afternoon sleep later and are less active in the morning. Lastly, the cross-sectional design of the study does not allow to draw causal conclusions.

6. Conclusions

In summary, the present study provides evidence that the child's weight status is influenced by sleep rhythmicity problems in children aged 4–6 years. Although more studies investigating children's sleep habits are needed to better understand their causal relationship with weight status, these results are important to encourage parents to help their children develop and maintain proper daily sleep habits in order to prevent excess body weight.

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Credit author statement

All authors participated in the study conception, data collection, data analysis, and manuscript writing.

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Conflict of interest

The authors declare no conflict of interests.

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