

Sleep duration and overweight: is there a relationship in adolescence?

Duração do sono e excesso de peso: existe relação na adolescência?

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ABSTRACT: *Objective:* This study aimed to investigate the association between sleep duration and excess weight in Brazilian adolescents. *Methods:* This is a cross-sectional study conducted with 65,837 adolescents, aged 12 to 17 years, enrolled in the Study of Cardiovascular Risks in Adolescents (ERICA). Sleep duration was assessed by means of a questionnaire focusing on weekday and weekend hours of sleep. Nutritional status was assessed based on body mass index, and participants were classified according to age and gender. The statistical analysis was performed with the Stata 13 software, using the survey command. Poisson regression was used to determine the association of excess weight with sleep duration categories. *Results:* A decline in sleep duration was associated with advancing age. The prevalence of short and long-term sleep among adolescents was 17.9 and 3.6%, respectively, while overweight was diagnosed in 25.5% of the sample. Adolescents who reported having short sleep had 10% (PR = 1.10; 95%CI 1.06 – 1.15) more overweight, while those who reported sleeping more than 11 hours had approximately 12% (PR = 0.88; 95%CI 0.78 – 0.99) less excess weight. *Conclusion:* Our findings reinforce the assumption that insufficient sleep poses health risks, and encouraging regular and sufficient sleep may be a cost-effective intervention for the prevention of overweight in adolescence.

Keywords: Sleep. Overweight. Obesity. Adolescent. Body mass index.

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RESUMO: *Objetivo:* Investigar a associação entre a duração do sono e o excesso de peso em adolescentes brasileiros. *Métodos:* Estudo de corte transversal, em amostra composta por 65.837 escolares, de 12 a 17 anos, participantes do Estudo de Riscos Cardiovasculares em Adolescentes (ERICA). A duração do sono foi avaliada por meio de questões sobre o horário em que os adolescentes costumavam dormir e acordar em dias da semana e final de semana. A avaliação do estado nutricional foi realizada pelo índice de massa corporal, sendo a classificação obtida segundo idade e sexo. As análises estatísticas foram realizadas no programa Stata 13, mediante o uso do comando *survey*, sendo a regressão de Poisson utilizada para verificar a associação entre o excesso de peso e as categorias de duração do sono. *Resultados:* Houve declínio na duração do sono com o avanço da idade. As prevalências de curta e longa duração do sono entre os adolescentes foram, respectivamente, de 17,9 e 3,6%, enquanto o excesso de peso foi diagnosticado em 25,5% da amostra. Adolescentes que relataram ter sono curto apresentaram 10% (RP = 1,10; IC95% 1,06 – 1,15) mais excesso de peso, enquanto os que referiram dormir mais de 11 horas apresentaram aproximadamente 12% (RP = 0,88; IC95% 0,78 – 0,99) menos excesso de peso. *Conclusão:* Os resultados reforçam o pressuposto de que o sono insuficiente acarreta consequências para a saúde e que incentivar o sono regular e suficiente pode representar uma intervenção com boa relação custo-benefício na prevenção do excesso de peso na adolescência.

Palavras-chave: Sono. Sobrepeso. Obesidade. Adolescente. Índice de massa corporal.

INTRODUCTION

Overweight in childhood and adolescence has recently reached alarming proportions¹ and became a major public health challenge worldwide². High prevalences have been confirmed in international³ and national⁴ studies, which demonstrates the need for action by several protagonists to expand programs that encourage the prevention of the problem as well as interventions.

Known as a nutritional disorder of multifactorial origin⁵, whose interactions between potential determining factors — with emphasis on social, environmental and behavioral domains — impact health directly, leading to relevant increases in chronic non-transmissible diseases, especially in adulthood⁶.

Short sleep duration — a modifiable risk factor — has been identified as one of these factors proven to have an association with the increased prevalence of overweight in adolescence⁷.

This can be explained by the change in the production and release of several hormones such as leptin, insulin, cortisol, ghrelin and growth hormones, which play an important role in signaling the hypothalamic centers that regulate food intake and energy balance^{8,9}. In addition, daytime sleepiness and fatigue as a result of short sleep duration can alter eating behaviors and physical activity, potentially leading to weight gain⁸. It could also lead to weight gain simply because people who stay awake longer would have more opportunities to eat, which makes the maintenance of a healthy lifestyle more difficult^{8,10}.

A recent meta-analysis on data from more than 56 thousand children and adolescents up to 16 years of age pointed out that participants who had shorter sleep time were 76% more

likely to be diagnosed with overweight compared to those with longer sleep time, in addition to showing greater gain body mass index (BMI). However, an increase of one hour in daily sleep was capable of reducing the risk of overweight and obesity by 21%⁷.

A longitudinal Brazilian study conducted by Halal et al.¹¹ showed that the prevalence of short sleep duration in any follow-up from the first to the fourth year of age was 10.1% and, at 4 years of age, 5.3% of children were diagnosed with obesity and 8% were overweight among those who slept little, with a prevalence ratio for overweight after adjustment for maternal and infant characteristics was 1.32.

The association between short sleep duration and weight gain has been the subject of several studies, initially with the adult population, but nowadays it was also extended to younger age groups. However, in Brazil, a population-based study that would investigate sleep duration as a health risk condition was not conducted yet.

Given the above, this study aimed to investigate the association between short sleep duration and excess weight in a representative portion of Brazilian adolescents enrolled in schools.

METHODS

This study used data from the nationwide epidemiological survey with cross-sectional design entitled “Study of Cardiovascular Risks in Adolescents” (ERICA, in the Portuguese acronym), conducted in 2013 and 2014. The sample was composed of adolescents aged 12 to 17 years enrolled in public and private schools in Brazilian municipalities with more than 100 thousand inhabitants.

Schools were selected with probability directly proportional to their size and inversely proportional to the distance from the capital. In each school previously drawn, the groups were selected based on a combination of period (morning and afternoon) and eligible years (seventh, eighth and ninth years of elementary school and first, second and third years of high school), with one class from each combination of period and year selected with equiprobability¹².

Of the selected classes, all students aged 12 to 17 years old were invited to participate, except adolescents with any physical disability that would prevent anthropometric assessment, mental disability and pregnant girls.

Data collection was conducted using standardized techniques by a previously trained team of evaluators, in which anthropometric measurements, blood pressure, 24-hour food recall and laboratory blood tests were performed. The other information was collected by means of a questionnaire, applied to students in the classroom, by means of an electronic collector named personal digital assistant (PDA). The complete study protocol is described by Bloch et al.¹³.

The outcome of overweight was assessed by calculating BMI (weight/height²) and the classification of nutritional status was established according to recommendations by the World Health Organization (WHO)¹⁴, with cut-off points specific to sex and age. The adolescents classified as very low weight and low weight were put in the group

“Low Weight”, and those diagnosed with overweight and obesity, were allocated in the group “Excess Weight”.

Sociodemographic and school-related variables were used to adjust the analyses: sex (girls and boys), age group (12–14; 15–17 years), self-reported race/color (white, black and mixed race/yellow/indigenous), mother’s educational level in years of study (<8 or ³8), type of school (public and private), study period (morning and afternoon) and school region (urban and rural).

The level of physical activity was determined using a questionnaire in a validated version for Brazilian adolescents¹⁵. The instrument consists of a list of 24 types of activities, in which the adolescents should choose the frequency in days and the time in hours and minutes that they had practiced that activity in the last week. Adolescents who did not accumulate at least 300 min/week of physical activity were considered inactive, as indicated by WHO¹⁶.

According to the criteria proposed by Marshall and Tanner^{17,18}, the stage of sexual maturation was self-assessed through visualization and selection of illustrative figures arranged in the PDA, according to the sex of the adolescent. The stages were classified into: stage 1 for pre-pubertal development; stages 2, 3 and 4, which correspond to the progression of puberty; and stage 5, complete maturation.

Sleep duration was investigated by four questions about the time the teenager used to go to sleep and wake up on a typical weekday and during weekends, with 24 response options. The inconsistencies in the response patterns were analyzed and corrected based on the most frequent times and the student’s study period, as described in a previous publication¹⁹. The variable sleep duration (hours) was obtained by the difference between usual bedtime and wake-up time, considering common weekdays and weekends. A weighted average of the duration of sleep per week was calculated using the formula: (sleep during the week × 5 + sleep at the weekend × 2)/720. As recommended by the National Sleep Foundation²¹, a short sleep duration was considered <7 hours and long sleep duration >11 hours. Therefore, the duration of inconsistent sleep was disregarded from the analysis when, during the week and the weekend, the adolescents reported sleeping <4 hours and >14 hours, maximum limits of what is considered appropriate for the age group¹⁹.

The data were analyzed in the statistical package Stata, version 13.0, whose survey mode was applied due to the complex design of the sample. The prevalence estimates were presented in proportions (%), with respective 95% confidence intervals (95%CI). The χ^2 test was used to assess the difference between the prevalence of sleep duration accordingly and the other variables in overweight adolescents.

The association between excess weight and sleep duration was analyzed using regression models in two stages: first, bivariate regressions of the independent variables in relation to the outcome, with results $p < 0,20$ in the χ^2 test being selected for the multivariate model. Then, models were used to obtain the prevalence rates of excess weight for each category of sleep duration, using the group of adolescents from 7 to 11 hours of sleep as a reference. The Poisson regression was used to calculate crude and adjusted prevalence ratios (PR) and respective 95%CI. The adjusted analyses verified the association between excess weight and

the categories of sleep duration, with control of the confounding variables, and the Wald test was used to assess the significance of the variable in the model. In all statistical analyses, the level of significance probability was set at 5%.

ERICA was approved by the Research Ethics Committee (REC) of each of the 27 participating institutions, one in each unit of the Brazilian federation, and of the institutions that participated in the pilot study. The adolescents signed an informed consent form and, when required by the local REC, brought the free and informed consent form signed by their parents/guardians.

RESULTS

In this study, 65,837 adolescents from the ERICA study population were considered to have complete data on the variables relating to nutritional status (BMI) and hours of sleep. Short sleep duration had a prevalence of 17.9% (95%CI 17 – 18.8) among adolescents, while long duration was observed in 3.6% (95%CI 3 – 4.3) of the sample, with no gender differences ($p = 0.146$).

The descriptive analyses showed that most of the adolescents who composed the sample were females (56.6%) and aged 15 to 17 years (54.9%). There was also a higher proportion of participants with sedentary behavior when characterized in the final stages of sexual maturation, race/skin color as brown, yellow and indigenous, who were students from public schools in urban areas, who studied in the morning period and whose mothers had more than 8 years of study (Table 1).

The prevalence of overweight in adolescents who reported short sleep duration was 32% of adolescents aged 12 to 14 years, being significantly higher among adolescents in the stage of complete sexual maturation (31.2%), among students from private schools (34.5%) and whose mothers' education was over 8 years of study (31.3%). Lower prevalence of overweight was reported in adolescents whose sleep duration was greater than 11 hours, for all variables being studied, except stage 5, of sexual maturation (Table 1).

A downwards trend in sleep duration as age advances was observed among the adolescents (Figure 1). The average hours of sleep for the 12-year-old age group was 8.66 ± 1.35 hours for girls and 8.73 ± 1.38 hours for boys. However, at 17 years of age, these averages are 7.81 ± 1.30 and 7.67 ± 1.31 for girls and boys, respectively, with a reduction of almost one hour of sleep per day. Until the age of 14, boys had a longer average sleep duration than girls; however, from the age of 15 on, they begin to show a more pronounced decline.

The most prevalent nutritional disorder among ERICA adolescents was overweight, found in more than 1/4 of the population (25.5%). The prevalence of overweight among adolescents with short sleep duration was significantly higher than among adolescents with long sleep duration, with values of 26.9 (95%CI 25.3 – 28.7) and 20.5% (95CI % 16.9 – 24.7), respectively (Table 2).

Table 1. Prevalence of overweight according to biological, sociodemographic and behavioral characteristics of adolescents with inadequate sleep duration. ERICA, Brazil, 2013–2014.

Variables	n (%)	Excess weight		
		Sleep duration		p-value
		< 7 hours % (95%CI)	> 11 hours % (95%CI)	
Sex				
Female	37,263 (56.6)	27.2 (25 – 29.5)	23.6 (18.1 – 30.1)	0.451
Male	28,574 (43.4)	26.7 (24 – 29.7)	17.8 (13.3 – 23.3)	
Age (years)				
12–14	29,726 (45.1)	32.0 (29 – 35.1)	21.1 (16.8 – 26.2)	0.010
15–17	36,111 (54.9)	24.5 (22.5 – 26.5)	18.3 (13.6 – 24.3)	
Sexual maturation stage				
1	287 (0.4)	18.2 (7 – 39.6)	10.2 (2.1 – 37.9)	< 0.001
2	3,321 (5.1)	27.3 (17.4 – 40.1)	14.8 (6.8 – 29.3)	
3	11,602 (17.6)	22.0 (17.8 – 26.7)	17.7 (12.1 – 25.2)	
4	26,284 (40.0)	23.9 (21.5 – 26.5)	16.2 (12.1 – 21.3)	
5	24,274 (30.9)	31.2 (28.8 – 33.9)	34.7 (26.3 – 44.2)	
Race/skin color				
White	23,779 (36.4)	28.1 (25.2 – 31.1)	26.0 (19.1 – 34.5)	0.107
Black	4,711 (7.8)	23.5 (18.9 – 28.9)	17.2 (9.4 – 29.1)	
Others	39,984 (55.8)	26.5 (24 – 29.1)	18.1 (14.5 – 22.3)	
Mothers' schooling (Years of study)				
< 8	35,092 (68.9)	25.6 (23.6 – 27.7)	20.9 (16.2 – 26.6)	0.011
≥ 8	15,817 (31.1)	31.3 (27.8 – 35.1)	22.6 (15.5 – 31.6)	
Physical activity				
Active	30,606 (49.9)	27.5 (25.3 – 29.7)	21.7 (17.1 – 27.1)	0.333
Not active	30,612 (50.1)	26.2 (23.5 – 28.9)	20.4 (14.5 – 27.1)	
School network				
Public	51,194 (77.8)	25.1 (23.3 – 26.9)	20.3 (16.5 – 24.5)	< 0.001
Private	14,643 (22.2)	34.5 (31 – 38.2)	28.6 (19.3 – 40.2)	
Study period				
Morning	45,972 (69.8)	27.0 (25.3 – 28.9)	10.4 (3.8 – 25.1)	0.034
Afternoon	19,865 (30.2)	25.8 (20.7 – 31.6)	20.8 (17 – 25.1)	
School region				
Urban	64,684 (98.2)	27.1 (25.5 – 28.8)	20.9 (17.2 – 25.2)	0.013
Rural	1,153 (1.8)	9.8 (2.6 – 31.2)	9.6 (2.6 – 30.3)	

95%CI: 95% confidence interval; for: χ^2 test.

We found a higher prevalence ratio for excess weight in the category of short sleep duration when compared with long sleep duration, both in crude and adjusted analyses, as observed in Table 3. When adjusted for potential confounding factors such as age, sexual maturation stage, race/skin color, type and region of the school, both short

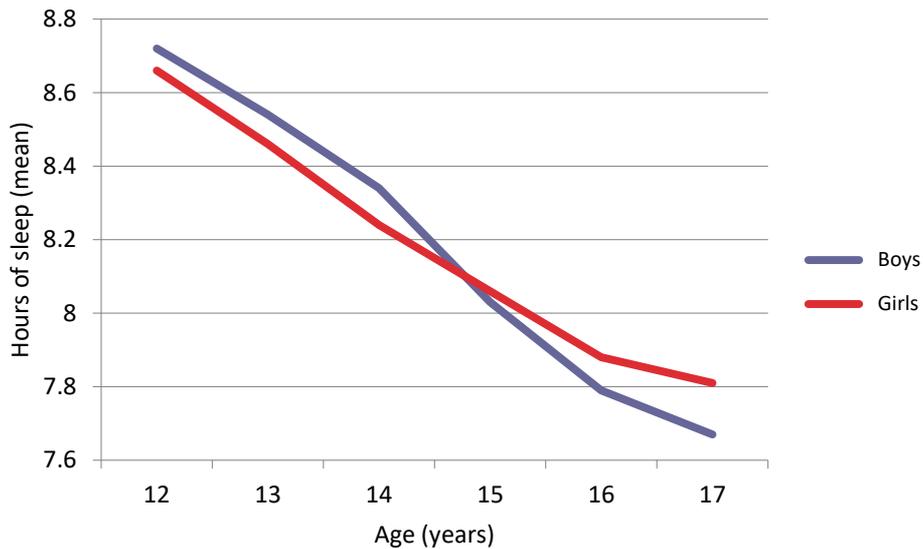


Figure 1. Average hours of sleep by age among Brazilian boys and girls. ERICA, Brazil, 2013–2014.

Table 2. Prevalence of the nutritional status of adolescents according to categories of sleep duration. ERICA, Brazil, 2013–2014.

Sleep duration (Hours)	Nutritional status		
	Low weight % (95%CI)	Adequate weight % (95%CI)	Excess weight % (95%CI)
< 7	2.2 (1.7 – 2.9)	70.8 (69.1 – 72.5)	26.9 (25.3 – 28.7)
7–11	3 (2.7 – 3.3)	71.6 (70.3 – 72.9)	25.4 (24.2 – 26.7)
> 11	3.6 (2.4 – 5.2)	75.9 (71.4 – 79.8)	20.5 (16.9 – 24.7)
Total	2.9 (2.6 – 3.1)	71.6 (70.4 – 72.8)	25.5 (24.4 – 26.6)

95%CI: 95% confidence interval.

Table 3. Crude and adjusted prevalence ratios for excess weight according to sleep duration in adolescents. ERICA, Brazil, 2013–2014.

Sleep duration	Excess weight			
	Crude PR	95%CI	Adjusted PR*	95%CI
Adequate sleep	1	-	1	-
Short duration (< 7 hours)	1.07	1.03 – 1.10	1.10	1.06 – 1.15
long duration (> 11 hours)	0.83	0.75 – 0.91	0.88	0.78 – 0.99

PR: prevalence ratio; 95%CI: 95% confidence interval; *variables age, sexual maturity stage, race/skin color, school network and region.

and long sleep durations remained associated with overweight. Using the sleep duration of 7 to 11 hours a day as a reference for the analyses, we found that adolescents who reported sleeping less than 7 hours have about 10% (PR = 1.10; 95%CI 1.06 – 1.15) more overweight than adolescents with adequate sleep time; however, adolescents who reported sleeping more than 11 hours had about 12% (PR = 0.88; 95%CI 0.78 – 0.99) less excess weight when compared with those who reported adequate sleep time, which suggests that sleep duration in adolescence is an important component in the prevalence of this nutritional disorder.

DISCUSSION

Studies on the association between sleep duration and excess weight in a representative sample of Brazilian children and adolescents are still scarce^{11,22}. In this sense, the results presented here are of great relevance and will contribute substantially to epidemiological research and to preventive and intervention measures, as being overweight is a relevant health problem that generates physical, emotional and social damage²³, often irreparable, with a consequent reduction in the quality of life of a large portion of the affected population^{24,25}.

Our results show a higher prevalence of overweight among adolescents with short sleep duration. This association remained independent even after adjusting the analyses, thus confirming the hypothesis that Brazilian students who maintain a sleep habit of less than 7 hours on a daily basis are more likely to gain weight. Adolescents who reported having short sleep had 10% (PR = 1.10; 95%CI 1.06 – 1.15) more overweight, while those who reported sleeping more than 11 hours had approximately 12% (PR = 0.88; 95%CI 0.78 – 0.99) less excess weight, corroborating other studies of great epidemiological relevance that also pointed the relationship between sleep duration and weight gain in the most diverse ages and in different countries^{11,22, 26}.

The prevalence of short sleep duration among adolescents was higher (17.9% 95%CI 17 – 18.8), when compared to the habit of sleeping approximately 11 hours daily (3.6% 95%CI 3 – 4.3). A representative study with 11,830 Chinese children ratifies the prevalence found here, using as a cut-off point for short sleep duration less than 7 hours per day²⁷. Sleep duration among Australian, European, American and Asian adolescents was studied by Olds et al.²⁸, who reported a significant difference in sleep duration between cultures. Young Asians sleep less, and their prevalence for short sleep duration is similar to those found here²⁸.

Lund et al. state that short sleep duration in adolescence is associated with numerous unfavorable health outcomes, including metabolic and cognitive problems²⁹.

According to recommendations, it is possible that young people need to sleep, on average, 8 hours a night²⁶; however, there is no consensus in the literature regarding the ideal amount of sleep for adolescence, which makes it difficult to compare studies.

Our demonstrate that adolescents sleep, on average, 8 hours or more until they are 15 years old. However, as age advance, the averages drop considerably in older students and in the final stages of sexual maturation.

Similar results can be observed in national^{22,30} and international^{27,28} studies that report a downwards trend in sleep duration in the course of adolescence explained by maturation factors, in which slower melatonin secretion, especially in the late stages of puberty, leads to a delay in the sleep phase, characterized by later bedtime and waking up³¹. The increase of work activities among older adolescents and the greater availability of computers, televisions and video games in their bedrooms contribute to exacerbating this trend³².

A study suggested that girls sleep more than boys²⁸, but our results show no significant difference between genders ($p = 0.146$), despite the tendency for boys to sleep less after the age of 15. This difference may be associated with the phase change induced by testosterone in boys³¹, whose hormonal environment would be leading them to stay awake until later. However, the reasons for general sexual differences in sleep time are not yet clear²⁸.

Morning shift students had a higher prevalence of short sleep duration (23.5% 95%CI 21.9 – 25.2), compared to afternoon shift students (6.3% 95%CI 5.6 – 7.1), confirming previous findings that state that the time to start classes contributes to short sleep^{28,30}. The delay in sleep onset, added to the commitment to wake up early, conflicts with the biological needs of adolescents, further reducing sleep time³²; for this reason, the American Academy of Pediatrics, in view of the potential benefits for students with regard to physical and mental health, safety and academic performance, recommends that the start time of classes be late³³.

In this study, a higher prevalence of short and long-term sleep among black adolescents can be observed, an end-to-end variation in the usual sleep time. A study with adolescents, in a birth cohort representing racial minorities, evaluated the duration of sleep using actigraphy and observed a shorter sleep duration among African-American participants³⁴. Although this relationship is not yet well understood, it is believed to be linked to genetic, biological and psychosocial factors³⁵, but there is little evidence about this relationship among adolescents.

Our study consolidates the high prevalence of overweight and obesity in Brazilian adolescents, as recent research accounts for more than ¼ of this population diagnosed with overweight^{4,36}. From the perspective of sleep duration, more than 26% of the population affected by a deficit in sleep duration has this nutritional disorder and a drop of around 6% in the prevalence of excess weight is seen when adolescents have a longer sleep duration, confirming previously published findings^{11,22}.

The average sleep time duration was associated with changes in the distribution of BMI in a representative sample of adolescents in eight study waves, in which the authors reported little sleep as associated with a higher BMI from 14 to 18 years old. These data support the recommendation that adolescents should sleep between 8.5 and 10.5 hours a day, as it would have a significant impact on preventing overweight²⁶.

Among the limitations of this study, the study design should be considered, since ERICA is a cross-sectional study and it prevents analysis of causal relationship. In addition, it should be noted that the sleep duration and physical activity assessments were self-reported by adolescents, which may result in error; however, the self-reported sleep duration is widely and worldwide used and indicated for measuring sleep hours of teenagers³⁷. Another important limitation is related to the loss of data due to inconsistencies in responses of the sleep variable, although a careful analysis of the distribution of responses in ERICA has allowed an important percentage to be corrected and used (reduction from 18.67 to 10.64% losses), the final sample remaining representative¹⁹. In addition, the sleep duration reported after corrections is similar to that found in another study³⁰. Finally, the duration of sleep can influence not only the health of individuals, but also the quality of sleep³⁸, data that were not assessed in the ERICA study.

Based on the results presented here, we conclude that short sleep duration is associated with an increase in the prevalence of overweight among adolescents, adding to the growing body of evidence that supports this relationship. Encouraging children and adolescents to sleep regularly and sufficiently can be a cost-effective intervention for the prevention of excess weight in this age group. Public health policies, with regard to adequate hours of sleep, can be significant for the promotion of health and the prevention of this problem of great relevance to health. Therefore, we encourage the inclusion of the variable sleep duration in the routine of services and in the planning of health actions as a measure to prevent diseases and non-communicable comorbidities.

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