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Original Article

Correlates of self-reported weekday sleep duration in adolescents: the 18-year follow-up of the 1993 Pelotas (Brazil) Birth Cohort Study

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ABSTRACT

Objective: To investigate factors associated with sleep duration in adolescence.
Methods: Data are from the 1993 Pelotas Birth Cohort Study of 5249 live births. Of these individuals, 4563 were located for follow-up at 18 years of age, and 4106 agreed to be interviewed (follow-up rate 81.3%). Sleep duration was continuously assessed by survey as hours per weekday. Additional covariates were collected during the perinatal period and at the 11- and 18-year follow-ups. Linear regression models were used to estimate associations between sleep duration and its hypothesized influences. All analyses were sex-stratified.
Results: The average sleep duration among participants was 8.4 hours (standard deviation 1.9). Longer sleep duration at 18 years of age was associated with the following perinatal factors: low maternal schooling, low family income, maternal black skin color, and low birth weight; and with the following factors measured at 18 years of age: being out of school, low achieved schooling, low family income, absence of depressive symptoms, and high screen time.
Conclusion: Social and demographic variables may play an important role in determining adolescents' sleep duration, but the nature of these relationships in Brazil may differ from those observed in higher-income contexts.

1. Introduction

Sleep is a crucial determinant of psychological, emotional, and physical health, and evidence suggests that reduced sleep duration may be associated with poorer diet quality, obesity, hypertension, type 2 diabetes, and cardiovascular disease [1–7]. Sleep has also been associated with non-medical outcomes such as poor judgment, lack of motivation, inattention [8], motor vehicle crashes [9], and lower academic achievement [10]. Reduced sleep duration is now common in modern society. Data from the United States show that adults now sleep between one and two hours less than they did four decades ago, and twice as many adolescents now sleep fewer than seven hours per night [11]. A recent systematic review of sleep in children and adolescents from 20 countries (data from 1905 to 2008) found rapid declines in sleep duration of investigated samples [12]. In Brazil, a study showed that 39% of the teenagers slept eight hours or less on school days [13].

The mechanisms of sleep duration are complex. Inadequate sleep in adolescence is due to a combination of biological processes, modern lifestyles, and obligations [14]. Longitudinal predictors of sleep duration among adolescents are not well understood. Some studies have found that socioeconomic status and schooling are positively associated with sleep duration [15–17]. Furthermore, social pressures and poor environmental conditions may negatively affect sleep duration in lower socioeconomic groups [18]. Also, studies of maternal alcohol consumption during pregnancy, exposure to cigarette smoke, low birth weight, and short length at birth have shown associations with short infant sleep duration [19,20]. Each of these factors may cause or reflect altered fetal development in utero, resulting in alterations in the hypothalamic–pituitary–adrenocortical axis and sympathetic nervous system activity later in life [21]. These alterations may affect the sleep infrastructure [22].

Across the adolescence years, changes in the circadian system lead to a delay in sleep schedule [23]. Body mass index (BMI) has

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also been associated with sleep problems, with overweight and obese individuals sleeping less than their counterparts [24,25]. Obesity leads to increased intra-abdominal pressure, and this mechanism has been implicated in sleep disorders [26]. Moreover, according to the National Sleep Foundation, 75% of children and adolescents in the United States have at least one electronic device in their bedrooms [27]. The use of electronic media has been associated with delayed bedtime and shorter total sleep time [28]. A number of other factors have been related to reduced sleep durations during adolescence, such as ethnic minority, bed/room sharing, mental health issues, low physical activity, and early school starting time [17,25,29]. Individuals with depression exhibit alterations in sleep architecture, including reduced sleep efficiency and reduced slow-wave sleep [18]. The relationship between physical activity and sleep is supported by theories about the function of sleep, such as the thermoregulatory, body restoration, and energy conservation hypotheses [30]. Also, during adolescence there is the delayed timing of nocturnal melatonin secretion, which consequently results in difficulty falling asleep at an earlier bedtime [31]. As a result, most teenagers stay up late on school nights and get less sleep during school days. A previous study has also suggested that alcohol use and smoking are positively associated with sleep disorder [32]. Smoking may affect sleep architecture [33] and cause problems initiating sleep [34]. Similarly, alcohol use may cause adolescents to stay awake late [32].

A recent review of risk factors for adolescent sleep showed that decreased sleep duration was related to tobacco use, computer use, evening light, negative family environment, and caffeine use, whereas longer sleep length was associated with good sleep hygiene and parent-set bedtimes [35]. However, most studies have focused on higher-income countries and have used cross-sectional approaches, and none of the studies in lower and middle income countries have considered potential determinants of sleep measured at multiple periods of the life course. To help fill these gaps in knowledge, we aimed to investigate perinatal, childhood, and adolescent factors associated with sleep duration in adolescents, using data from the 1993 Birth Cohort of Pelotas.

2. Methods

2.1. Study design and sample

Data are from a population-based birth cohort study located in Pelotas, Brazil. Between January 1 and December 30, 1993, all maternity hospitals in the city were visited daily, and 5265 births from women living in the city were recorded. Of these individuals, 5249 agreed to take part in the longitudinal study.

In 2004–2005 (at the participant age of 11 years), a follow-up visit to all cohort members was carried out. Those who completed the interviews (along with those known to have died) represented 87.5% (n = 4452) of the original cohort. Adolescents and their mothers were interviewed during home visits.

At the age of 18 years, 4563 adolescents were located, of whom 4106 were interviewed, representing 81.3% of the original cohort (when added to those known to have died). All measurements were taken by trained interviewers. More detailed information about the study can be found in specific methodological publications [36,37].

2.2. Baseline measurements

The variables included in the analyses were family income (minimum wage, in fifths), maternal schooling in completed years (0; 1–4; 5–8; 9–11; ≥12), maternal skin color (white/black/other), maternal age at birth in years (<20; 20–29; 30–34; ≥35), gestational weight gain (adequate/inadequate), pregnancy smoking (no/yes), pregnancy alcohol consumption (no/yes), birth order (first-born/second-born/third-born/fourth-born or later), type of delivery (normal/cesarean), and low birth weight (no/yes).

Adequate gestational weight gain was evaluated according to nutritional status: underweight (12.5–18.0 kg), normal (11.5–16.0 kg), overweight (7.0 to <11.5 kg), and obese (<7.0 kg) [38]. Low birth weight was defined as weight at birth less than 2500 g.

2.3. Follow-up measurements

2.3.1. Follow-up at 11 years

The variables included the number of persons who slept within the same room with the adolescent (0; 1; ≥2), mental health (normal–borderline/abnormal), BMI (normal/overweight/obese), physical activity in minutes per week (<300; ≥300), and screen time in hours per day (<2; 2–4; ≥4).

In relation to adolescents' mental health, mothers and guardians were interviewed using the Strengths and Difficulties Questionnaire (SDQ) [39]. The total difficulties score was categorized in normal–borderline (0–16) and abnormal (17–40). Weight was measured using an electronic scale (SECA, Australia), which was accurate to 100 g. Height was measured using a portable stadiometer, accurate to 1 mm. Adolescents' BMI was classified according to World Health Organization (WHO) reference [40]. Physical activity was evaluated using a questionnaire to measure commuting to and from school, and leisure-time activities [41]. The questionnaire also included information on both weekday and weekend screen times separately for television (TV), video games, and computer use. An average number of minutes per day of combined screen time was calculated as a weighted (by weekday = 5, or weekend = 2) average of these.

2.3.2. Follow-up at 18 years

Unlike the previous follow-up visits, the follow-up at 18 years of age took place entirely at the university facilities. In the present analysis we used the following variables: family income (fifths), currently enrolled in school (no/yes), adolescent schooling in years completed to date (≤4; 5–8; ≥9), number of persons sleeping per room at home (1; 2; ≥3), current smoking (no/yes), alcohol consumption (never/once a month or less/two to four times a month/two to three times a week/≥4 times a week), depression (no/yes), BMI (normal/overweight/obese), physical activity in minutes per week (<300; ≥300), and screen time in hours per day (<2; 2–4; ≥4).

Depression was assessed by the Mini International Neuropsychiatric Interview (MINI) [42]. Height was measured using an aluminum stadiometer with a capacity of 2 m and precision of 1 mm; and weight was measured with an electronic scale connected to air displacement plethysmography (BOD POD®). Adolescents' BMI was classified according to the WHO reference [40]. Physical activity was evaluated using a questionnaire to measure commuting to and from school, and leisure-time activities [43]. The questionnaire also included information on screen time. The instrument included questions on whether the adolescent watched TV, played video games, and used the computer. The questions were: (1) "How much time do you watch TV?" (2) "How much time do you play video games?" and (3) "How much time do you use the computer?" The mean time using each of these electronic media (in a typical week) was reported separately for weekdays and weekends. An average number of minutes per day of combined screen time was calculated as a weighted (by weekday = 5, or weekend = 2) average of these.

During the 18-year follow-up, the data collection on outcome (sleep duration) was performed by asking the adolescents two questions: "What time do you usually fall asleep on weekdays?" and, "What time do you usually wake up on weekdays?" Typical daily weekday sleep duration was calculated as the time difference between the two answers.

2.4. Analytical methods

Sleep duration was assessed continuously in hours per weekday. Descriptive analyses of the independent variables and sleep duration were performed, presenting the absolute and relative frequencies.

Variables were included in linear regression in accordance with a conceptual framework defined a priori [44]. This model incorporated all perinatal characteristics in the first (family income, maternal schooling, maternal skin color, maternal age at birth, gestational weight gain, pregnancy smoking, and pregnancy alcohol consumption), second (birth order), third (type of delivery), and fourth (low birth weight) hierarchical levels of determination. Variables collected at 11 years in the fifth level (number of persons who sleep with the adolescent) and sixth level (mental health, BMI, physical activity, and screen time), and the variables from the 18-year follow-up in the seventh level (current student, adolescent schooling, number of people per sleeping rooms, and family income) and eighth level (current smoking, alcohol consumption, depression, BMI, physical activity, and screen time). We adjusted the variables for other variables in the same and distal levels of determination; those that presented $p < 0.20$ remained in the model. Significance was set at 5%, and all reported p values were for two-sided tests. All of the analyses were performed with Stata, version 12.1 (Stata Corp., College Station, TX, USA).

2.5. Ethical considerations

On all phases of the study, ethical approval was obtained from the Medical School Ethics Committee of the Federal University of Pelotas, and full informed consent was provided by cohort members or by their parents if the subject was younger than 18 years.

3. Results

The characteristics of the sample studied are shown in Table 1. Most of the adolescents' mothers had 5–8 years of schooling (47.9%), were white (76.9%), and had inadequate gestational weight gain (66.1%). About one third of the mothers reported smoking during pregnancy. Regarding the individuals' characteristics at 11 years, almost half of them were physically active (48.4%), and 43.5% reported watching TV, playing video games, and/or using the computer for four hours or more per day. Finally, at 18 years of age, most of the adolescents was studying (54.4%) and had nine years or more of schooling (54.9%). About 7% of them reported depressive symptoms. The majority of the adolescents were physically active (61.0%), and almost 50% reported watching TV, playing videogames, and/or using the computer for four hours or more per day. In relation to sleep duration, the average was 8.4 hours (standard deviation 1.9).

Table 2 shows the crude and adjusted analyses of the association between sleep duration and independent variables according to sex. In relation to perinatal variables, maternal schooling remained associated with sleep duration in both genders after adjustment for other covariates, with an inverse linear trend in girls ($p < 0.001$). Girls whose mothers had no schooling showed an increase of 1.40 hours per day (95% confidence interval [CI], 0.77–2.04) in sleep duration compared to those whose mothers had 12 years or more of schooling. Maternal skin color also remained associated with sleep duration in both sexes in the adjusted analyses. Girls whose mothers were black had 0.37 hours more sleep per day (95% CI, 0.17–0.58) than those whose mothers were white. Family income and low birth weight were associated with sleep duration in girls. Those in the lowest fifth of income and those born with low birth weight had higher sleep duration compared to girls in the highest fifth and born with normal weight.

Regarding the independent variables from the 11-year follow-up, the only variable that remained directly associated with sleep duration in girls was the number of persons who slept in the same room as the adolescent ($p = 0.001$). In relation to the variables from 18 years, adolescents who were not currently studying, those with lower schooling, and in the lowest fifth of family income showed higher sleep duration. Moreover, boys and girls who were depressed slept less: –0.53 hours (95% CI, –0.96 to –0.11) and –0.30 hours (95% CI, –0.56 to –0.04), respectively. Finally, screen time showed a direct linear trend with sleep duration in both sexes.

4. Discussion

This is one of the first studies on the association between sleep duration and demographic, socioeconomic, biological, behavioral, and health characteristics in a sample of Brazilian adolescents. There are few studies that focus on early life factors and sleep duration, and most of them have been conducted in high-income countries [45–48].

We have found that social and demographic variables are more important than early biological or maternal behavioral characteristics in determining sleep duration in adolescence. Our analyses have shown an inverse relationship between maternal schooling and family income at birth, and sleep duration at 18 years. The same pattern was seen in the contemporaneous variables: adolescent schooling and family income at 18 years.

This result highlights an important difference between sleep patterns in low- and/or middle income countries (LMICs) compared to that typically observed in higher-income countries. Several studies from high-income countries have indicated that adolescents from families from racial minorities or with low income may have greater risk of insufficient or poor-quality sleep [15–17]. Some mechanisms linking low socioeconomic status to sleep deficiency are poor environmental conditions such as noise, light, and air pollution [18]. Although this scenario is evidenced in Brazil, we found the opposite result. This was also observed in a study from São Paulo, which found that upper-class adolescents compared to those of lower socioeconomic status had a higher prevalence of short sleep duration (prevalence ratio = 1.48; 95% CI, 1.20–1.83) [13]. One possible explanation for this association is analogous to the global nutrition transition that sees obesity disproportionately affecting affluent people in LMICs but poorer people in higher-income counties. In a LMIC, adolescents from higher socioeconomic status are more likely to have multiple electronic devices, Internet access, and television sets in the bedroom than their less wealthy peers, all factors that have been associated with short sleep duration and later bedtimes [28]. Perhaps as these devices become more common among persons of lower socioeconomic status (SES) (as they have in higher-income countries), the gradient that we observe might change to reflect the other, remaining inequalities, as they have for obesity risk.

Adolescents whose mothers were black had longer sleep duration. As described above, lower family income is associated with increased sleep duration. Ethnic differences in sleep duration are probably due to social factors and not related to physiological mechanisms, as black skin color is associated with lower SES in Brazil.

Low birth weight was associated with higher sleep duration at 18 years among girls only. This finding may be attributable to the association of low birthweight with poorer socio-economic status. Although we have found no studies evaluating birth weight and sleep duration in adolescence or adulthood, McDonald et al. [47] found the opposite: low birth weight was associated with shorter sleep duration in children aged 14–27 months (odds ratio, 1.43; 95% CI, 1.07–1.90).

Table 1
Characteristics of sample according to the variables studied: The 1993 Pelotas Birth Cohort, Brazil (N = 4085).

Variables	Total	Male	Female
	n (%)	n (%)	n (%)
Family income at birth (quintiles)			
1 (poorer)	774 (19.3)	379 (19.2)	395 (19.4)
2	938 (23.3)	484 (24.5)	454 (22.2)
3	698 (17.4)	340 (17.2)	358 (17.6)
4	809 (20.2)	391 (19.8)	418 (20.5)
5 (richer)	795 (19.8)	382 (19.3)	413 (20.3)
Maternal schooling at birth (years)			
0	89 (2.2)	41 (2.1)	48 (2.3)
1–4	994 (24.4)	479 (23.9)	515 (24.8)
5–8	1952 (47.8)	960 (47.9)	992 (47.8)
9–11	730 (17.9)	360 (18.0)	370 (17.8)
≥12	313 (7.7)	161 (8.1)	152 (7.3)
Maternal skin color			
White	3141 (76.9)	1553 (77.4)	1588 (76.4)
Black	758 (18.6)	358 (17.9)	400 (19.3)
Other	184 (4.5)	94 (4.7)	90 (4.3)
Maternal age at birth			
<20	699 (17.1)	361 (18.0)	338 (16.3)
20–29	2174 (53.2)	1047 (52.3)	1127 (54.1)
30–34	755 (18.5)	367 (18.3)	388 (18.7)
≥35	456 (11.2)	229 (11.4)	227 (10.9)
Gestational weight gain			
Adequate	1324 (33.9)	655 (34.3)	669 (33.5)
Inadequate	2582 (66.1)	1256 (65.7)	1326 (66.5)
Pregnancy smoking			
No	2745 (67.2)	1365 (68.1)	1380 (66.3)
Yes	1340 (32.8)	640 (31.9)	700 (33.7)
Pregnancy alcohol consumption			
No	3874 (94.8)	1914 (95.5)	1960 (94.2)
Yes	211 (5.2)	91 (4.5)	120 (5.8)
Birth order			
First-born	1626 (39.9)	788 (39.3)	838 (40.3)
Second-born	1218 (29.8)	598 (29.9)	620 (29.8)
Third-born	649 (15.9)	309 (15.4)	340 (16.4)
Fourth-born or later	589 (14.4)	308 (15.4)	281 (13.5)
Type of delivery			
Normal	2816 (68.9)	1381 (68.9)	1435 (69.0)
Cesarean	1269 (31.1)	624 (31.1)	645 (31.0)
Low birth weight			
No	3719 (91.0)	1857 (92.6)	1862 (89.5)
Yes	366 (9.0)	148 (7.4)	218 (10.5)
Number of persons who sleep with adolescent at 11 years			
0	1039 (26.4)	503 (26.4)	536 (26.4)
1	1486 (37.8)	722 (37.9)	764 (37.6)
≥2	1409 (35.8)	679 (35.7)	730 (36.0)
Mental health at 11 years			
Normal/borderline	2691 (68.4)	1244 (65.3)	1447 (71.3)
Abnormal	1244 (31.6)	661 (34.7)	583 (28.7)
Body mass index at 11 years (kg/m^2)			
Normal	3020 (76.6)	1418 (74.2)	1602 (78.8)
Overweight	461 (11.7)	194 (10.2)	267 (13.1)
Obese	462 (11.7)	297 (15.6)	165 (8.1)
Physical activity at 11 years (min/week)			
<300	1969 (51.6)	773 (41.6)	1196 (61.1)
≥300	1848 (48.4)	1086 (58.4)	762 (38.9)
Screen time at 11 years (h/day)			
<2	608 (15.5)	299 (15.7)	309 (15.2)
2–4	1615 (41.0)	724 (38.1)	891 (43.8)
≥4	1712 (43.5)	877 (46.2)	835 (41.0)
Student at 18 years			
No	1864 (45.6)	999 (49.8)	865 (41.6)
Yes	2221 (54.4)	1006 (50.2)	1215 (58.4)
Adolescent schooling (years) at 18 years			
≤4	188 (4.6)	130 (6.5)	58 (2.8)
5–8	1655 (40.5)	932 (46.5)	723 (34.8)
≥9	2240 (54.9)	941 (47.0)	1299 (62.4)
Number of persons per sleeping rooms at 18 years			
1	2437 (59.6)	1273 (63.5)	1164 (56.0)
2	1199 (29.4)	550 (27.4)	649 (31.2)
≥3	449 (11.0)	182 (9.1)	267 (12.8)

(*continued on next page*)

Table 1 (*continued*)

Variables	Total	Male	Female
	n (%)	n (%)	n (%)
Family income at 18 years			
1 (poorer)	830 (20.3)	373 (18.6)	457 (21.9)
2	802 (19.6)	356 (17.8)	446 (21.4)
3	817 (20.0)	366 (18.3)	451 (21.7)
4	824 (20.2)	459 (22.8)	365 (17.6)
5 (richer)	812 (19.9)	451 (22.5)	361 (17.4)
Current smoking at 18 years			
No	3508 (85.9)	1700 (84.8)	1808 (86.9)
Yes	577 (14.1)	305 (15.2)	272 (13.1)
Alcohol consumption at 18 years			
Never	1081 (26.9)	484 (24.6)	597 (29.1)
Once a month or less	960 (23.8)	417 (21.2)	543 (26.4)
2–4 times a month	605 (15.0)	277 (14.1)	328 (15.9)
2–3 times a week	895 (22.2)	489 (24.7)	406 (19.7)
≥4 times a week	487 (12.1)	303 (15.4)	184 (8.9)
Depression at 18 years			
No	3742 (93.1)	1894 (96.5)	1848 (90.0)
Yes	275 (6.9)	69 (3.5)	206 (10.0)
Body mass index (kg/m^2) at 18 years			
Normal	2867 (72.7)	1461 (74.6)	1406 (70.9)
Overweight	678 (17.2)	316 (16.2)	362 (18.2)
Obese	397 (10.1)	180 (9.2)	217 (10.9)
Physical activity (min/week) at 18 years			
<300	1591 (39.0)	513 (25.6)	1078 (51.9)
≥300	2486 (61.0)	1488 (74.4)	998 (48.1)
Screen time (h/day) at 18 years			
<2	571 (14.0)	269 (13.5)	302 (14.6)
2–4	1488 (36.6)	723 (36.2)	765 (36.9)
≥4	2012 (49.4)	1008 (50.3)	1004 (48.5)
Sleep duration at 18 years	4085	2005	2080
Mean (SD)	8.4 (1.9)	8.1 (1.8)	8.8 (1.9)

Abbreviations: SD, standard deviation.
Maximum percentage of unknown observations: n = 179; 4.4% for the gestational weight gain variable.

Our results showed that the number of persons who slept in the same room as the adolescent at 11 years was directly associated with sleep duration in girls at 18 years. In contrast, in previous studies with children and adolescents, bed/room sharing seemed to have an important negative impact on sleep duration [25,49].

Being enrolled in school at 18 years was associated with lower sleep duration. Although we do not have information about school start times, some studies have reported that delaying school start times is an effective strategy to achieve more total sleep on school nights, less daytime sleepiness, and better academic performance [50,51]. A study conducted with Brazilian adolescents assessed whether the shift from afternoon to morning classes reduced the duration of sleep. The authors found a reduction of time-in-bed during weekdays for those students who changed to the morning session ($p < 0.001$) [52]. Furthermore, this result can also represent the higher SES of students because those individuals are more likely to be studying at 18 years than the lower SES adolescents.

A number of psychosocial factors are associated with sleep, including stress and depression [53]. Patients with depression exhibit alterations in sleep architecture and commonly have insomnia [18]. Our results showed that depressed adolescents at 18 years slept less than their peers. Similar results were found in a study in China with adolescents, which showed that bedtime anxiety, excitement, and/or depression were some of the factors associated with sleep duration of less than eight hours [25].

Unexpectedly, we found a direct linear trend between screen-time and sleep duration at 18 years. A review study about electronic media use and sleep in school-aged children and adolescents has shown that the use of electronic media has a negative impact on their sleep. The possible mechanisms highlighted by the authors are that media use directly displaces sleep, increased mental, emotional, and physiological arousal, and the bright light exposure delays the circadian rhythm [28]. These factors may have a higher impact on sleep when electronic media are used in the evening or at night [54]. Unfortunately, we do not have information about the time of day that adolescents have used the electronic media, but we speculated that adolescents who have more screen time are more sedentary sleep more. It is also important to highlight that screen time included both periods (weekdays and weekends), whereas sleep duration included weekdays only.

Some limitations in the present study must be highlighted. First, sleep duration was self-reported. Studies comparing self-reported sleep duration with objective methods indicate that self-reports of sleep frequently overestimate the real sleep duration, which means that the problem of sleep loss during the adolescence may be greater than the data presented here [55]. Moreover, epidemiologic studies of adolescents' sleep duration typically use self- or parent-reported questionnaire data to assess adolescent sleep patterns and the factors affecting them. A recent meta-analysis evaluating the impact of sleep on overweight and obesity in children and adolescents from 22 longitudinal studies found that only three studies used objective methods [56]. Another limitation is that only weekday sleep was considered. Although weekday sleep may better reflect the usual sleep pattern in adolescents, they may extend sleep on weekend nights as a recovery process to compensate for an accumulated week sleep debt [57]. Also, the screen time was measured using a questionnaire that was not validated. Although we are aware of potential misclassification because of the instrument and the self-reported nature of data, sedentary behavior is frequently assessed using such methodology [58]. Besides, previous studies using data from the same cohort have been published [59,60]. Finally, as with any longitudinal study, the potential selection biases due to loss to follow-up must be considered. Comparing the sample participants with the original participants examined in 1993, we have seen that

Table 2
Crude and adjusted analyses of association between sleep duration (hours/day) at 18 years and independent variables stratified by sex: The 1993 Pelotas Birth Cohort, Brazil (N = 4085).

Variables	Crude analyses				Adjusted analyses				Level*
	Male		Female		Male		Female		
	β (95% CI)	*p*	β (95% CI)	*p*	β (95% CI)	*p*	β (95% CI)	*p*	
Family income at birth (quintiles)		0.148		<0.001		0.699		<0.001	1
1 (poorer)	0.32 (0.07, 0.57)		0.99 (0.74, 1.25)		0.10 (−0.19, 0.40)		0.58 (0.30, 0.87)		
2	0.14 (−0.09, 0.38)		0.46 (0.22, 0.71)		0.01 (−0.27, 0.28)		0.14 (−0.13, 0.41)		
3	0.08 (−0.18, 0.34)		0.68 (0.42, 0.94)		−0.10 (−0.38, 0.19)		0.42 (−0.14, 0.69)		
4	0.11 (−0.13, 0.36)		0.43 (0.18, 0.68)		0.03 (−0.23, 0.30)		0.21 (−0.05, 0.47)		
5 (richer)	Reference		Reference		Reference		Reference		
Maternal schooling at birth (years)		0.001		<0.001[a]		0.002		<0.001[a]	1
0	0.90 (0.29, 1.50)		1.86 (1.26, 2.46)		0.84 (0.23, 1.44)		1.40 (0.77, 2.04)		
1–4	0.32 (0.01, 0.64)		1.27 (0.94, 1.61)		0.27 (−0.04, 0.59)		0.93 (0.56, 1.31)		
5–8	0.19 (−0.10, 0.49)		0.95 (0.63, 1.26)		0.16 (−0.14, 0.45)		0.68 (0.33, 1.02)		
9–11	−0.08 (−0.41, 0.25)		0.63 (0.28, 0.97)		−0.10 (−0.43, 0.23)		0.45 (0.09, 0.81)		
≥12	Reference		Reference		Reference		Reference		
Maternal skin color		0.008		<0.001		0.032		<0.001	1
White	Reference		Reference		Reference		Reference		
Black	0.19 (−0.01, 0.40)		0.55 (0.35, 0.75)		0.14 (−0.06, 0.34)		0.37 (0.17, 0.58)		
Other	0.50 (0.13, 0.86)		−0.26 (−0.66, 0.13)		0.45 (0.08, 0.81)		−0.39 (−0.79, 0.003)		
Maternal age at birth		0.654		0.041[a]		0.828		0.787	1
<20	−0.03 (−0.24, 0.19)		0.10 (−0.12, 0.33)		−0.04 (−0.26, 0.18)		0.02 (−0.21, 0.25)		
20–29	Reference		Reference		Reference		Reference		
30–34	−0.07 (−0.28, 0.14)		−0.14 (−0.36, 0.07)		−0.03 (−0.25, 0.18)		−0.01 (−0.23, 0.20)		
≥35	−0.16 (−0.41, 0.10)		−0.26 (−0.53, 0.003)		−0.12 (−0.38, 0.14)		−0.13 (−0.40, 0.13)		
Gestational weight gain		0.848		0.271		0.692		0.837	1
Adequate	Reference		Reference		Reference		Reference		
Inadequate	−0.02 (−0.18, 0.15)		0.10 (−0.08, 0.27)		−0.03 (−0.20, 0.13)		0.02 (−0.15, 0.19)		
Pregnancy smoking		0.178		0.122		0.742		0.909	1
No	Reference		Reference		Reference		Reference		
Yes	0.11 (−0.05, 0.28)		0.13 (−0.04, 0.30)		0.03 (−0.14, 0.20)		−0.01 (−0.19, 0.16)		
Pregnancy alcohol consumption		0.648		0.281		0.259		0.688	1
No	Reference		Reference		Reference		Reference		
Yes	0.20 (−0.17, 0.57)		0.08 (−0.26, 0.43)		0.21 (−0.16, 0.58)		0.07 (−0.27, 0.41)		
Birth order		0.107		<0.001[a]		0.582		0.159	2
First-born	Reference		Reference		Reference		Reference		
Second-born	−0.04 (−0.22, 0.15)		0.08 (−0.11, 0.28)		−0.05 (−0.24, 0.13)		0.04 (−0.15, 0.23)		
Third-born	0.10 (−0.13, 0.33)		0.18 (−0.06, 0.41)		0.06 (−0.18, 0.29)		0.12 (−0.11, 0.36)		
Fourth-born or later	0.25 (0.01, 0.48)		0.59 (0.34, 0.84)		0.11 (−0.13, 0.35)		0.29 (0.03, 0.54)		
Type of delivery		0.845		0.019		0.589		0.901	3
Normal	Reference		Reference		Reference		Reference		
Cesarean	−0.02 (−0.18, 0.15)		−0.21 (−0.38, −0.03)		0.05 (−0.12, 0.22)		−0.01 (−0.19, 0.17)		
Low birth weight		0.001		0.372		0.445		0.002	4
No	Reference		Reference		Reference		Reference		
Yes	0.46 (0.20, 0.72)		0.13 (−0.16, 0.43)		0.11 (−0.18, 0.41)		0.41 (0.15, 0.67)		
Number of persons who sleep with adolescent at 11 years		0.001[a]		<0.001[a]		0.092		0.001[a]	5
0	Reference		Reference		Reference		Reference		
1	0.08 (−0.12, 0.28)		0.22 (0.02, 0.42)		0.03 (−0.17, 0.24)		0.10 (−0.11, 0.31)		
≥2	0.33 (0.13, 0.53)		0.67 (0.46, 0.87)		0.21 (−0.003, 0.42)		0.35 (0.13, 0.57)		
Mental health at 11 years		0.097		0.005		0.498		0.960	6
Normal/borderline	Reference		Reference		Reference		Reference		
Abnormal	0.14 (−0.03, 0.31)		0.26 (0.08, 0.44)		0.06 (−0.11, 0.23)		−0.005 (−0.19, 0.18)		
Body mass index at 11 years (kg/m^2)		0.022[a]		0.538		0.283		0.489	6
Normal	Reference		Reference		Reference		Reference		
Overweight	−0.12 (−0.39, 0.14)		−0.14 (−0.38, 0.10)		−0.03 (−0.30, 0.24)		−0.04 (−0.29, 0.20)		
Obese	−0.25 (−0.47, −0.03)		−0.01 (−0.31, 0.29)		−0.18 (−0.41, 0.04)		0.17 (−0.14, 0.47)		
Physical activity at 11 years (min/week)		0.938		0.807		0.931		0.344	6
<300	−0.01 (−0.18, 0.16)		−0.02 (−0.18, 0.14)		0.01 (−0.16, 0.17)		0.08 (−0.09, 0.25)		
≥300	Reference		Reference		Reference		Reference		
Screen time at 11 years (h/day)		0.012		0.925		0.063		0.853	6
<2	Reference		Reference		Reference		Reference		
2–4	−0.03 (−0.27, 0.21)		−0.04 (−0.28, −0.20)		−0.01 (−0.24, 0.23)		0.05 (−0.20, 0.29)		
≥4	−0.26 (−0.49, −0.03)		−0.05 (−0.29, 0.19)		−0.20 (−0.43, 0.04)		0.07 (−0.18, 0.32)		
Student at 18 years		<0.001		<0.001		<0.001		<0.001	7
No	Reference		Reference		Reference		Reference		
Yes	−0.99 (−1.15, −0.83)		−0.49 (−0.64, −0.33)		−0.34 (−0.51, −0.17)		−0.75 (−0.92, −0.59)		

(*continued on next page*)

Table 2 (*continued*)

Variables	Crude analyses				Adjusted analyses				Level*
	Male		Female		Male		Female		
	β (95% CI)	*p*	β (95% CI)	*p*	β (95% CI)	*p*	β (95% CI)	*p*	
Adolescent schooling (years) at 18 years		<0.001[a]		<0.001[a]		0.011[a]		<0.001	7
≤4	0.84 (0.52, 1.16)		1.18 (0.70, 1.66)		0.45 (0.09, 0.81)		0.40 (−0.10, 0.89)		
5–8	0.40 (0.24, 0.56)		0.94 (0.78, 1.11)		0.17 (−0.02, 0.36)		0.46 (0.27, 0.65)		
≥9	Reference		Reference		Reference		Reference		
Number of persons per sleeping rooms at 18 years		0.012[a]		<0.001[a]		0.658		0.506	7
1	Reference		Reference		Reference		Reference		
2	0.20 (0.03, 0.38)		0.30 (0.12, 0.48)		0.003 (−0.18, 0.19)		0.09 (−0.09, 0.27)		
≥3	0.25 (−0.03, 0.52)		0.72 (0.48, 0.97)		−0.13 (−0.42, 0.16)		−0.04 (−0.31, 0.22)		
Family income at 18 years		<0.001		<0.001[a]		<0.001		<0.001[a]	7
1 (poorer)	0.75 (0.51, 0.99)		1.11 (0.86, 1.36)		0.58 (0.33, 0.84)		0.69 (0.41, 0.96)		
2	0.21 (−0.03, 0.45)		0.85 (0.59, 1.10)		0.004 (−0.26, 0.27)		0.52 (0.25, 0.79)		
3	0.34 (0.10, 0.58)		0.62 (0.37, 0.88)		0.25 (−0.01, 0.50)		0.32 (0.06, 0.59)		
4	0.25 (0.03, 0.48)		0.33 (0.07, 0.60)		0.17 (−0.07, 0.41)		0.16 (−0.11, 0.43)		
5 (richer)	Reference		Reference		Reference		Reference		
Current smoking at 18 years		0.012		<0.001		0.527		0.633	8
No	Reference		Reference		Reference		Reference		
Yes	0.27 (0.06, 0.49)		0.54 (0.30, 0.78)		0.08 (−0.16, 0.31)		0.06 (−0.19, 0.31)		
Alcohol consumption at 18 years		0.496		0.003		0.730		0.114	8
Never	Reference		Reference		Reference		Reference		
Once a month or less	0.01 (−0.22, 0.24)		0.18 (−0.04, 0,39)		0.02 (−0.21, 0.26)		0.16 (−0.05, 0.36)		
2–4 times a month	−0.02 (−0.28, 0.24)		−0.18 (−0.43, 0.07)		0.07 (−0.20, 0.34)		−0.06 (−0.30, 0.18)		
2–3 times a week	−0.17 (−0.40, 0.05)		−0.27 (−0.50, −0.03)		−0.11 (−0.34, 0.13)		−0.14 (−0.36, 0.09)		
≥4 times a week	−0.03 (−0.28, 0.22)		0.08 (−0.22, 0.39)		−0.01 (−0.28, 0.25)		0.09 (−0.21, 0.39)		
Depression at 18 years		0.136		0.320		0.014		0.025	8
No	Reference		Reference		Reference		Reference		
Yes	−0.32 (−0.74, 0.10)		0.14 (−0.13, 0.41)		−0.53 (−0.96, −0.11)		−0.30 (−0.56, −0.04)		
Body mass index (kg/m^2) at 18 years		0.265		0.142		0.470		0.810	8
Normal	Reference		Reference		Reference		Reference		
Overweight	−0.14 (−0.35, 0.08)		0.19 (−0.03, 0.40)		−0.13 (−0.35, 0.08)		0.07 (−0.14, 0.27)		
Obese	−0.17 (−0.45, 0.10)		0.17 (−0.09, 0.44)		−0.06 (−0.33, 0.21)		0.04 (−0.22, 0.29)		
Physical activity (min/week) at 18 years		0.611		0.017		0.261		0.557	8
<300	−0.05 (−0.22, 0.13)		0.20 (0.04, 0.36)		−0.10 (−0.28, 0.08)		0.05 (−0.11, 0.20)		
≥300	Reference		Reference		Reference		Reference		
Screen time (h/day) at 18 years		0.316		0.040[a]		0.008[a]		<0.001[a]	8
<2	Reference		Reference		Reference		Reference		
2–4	0.11 (−0.13, 0.36)		0.17 (−0.08, 0.42)		0.19 (−0.06, 0.45)		0.28 (0.04, 0.52)		
≥4	0.18 (−0.06, 0.41)		0.26 (0.02, 0.50)		0.32 (0.08, 0.57)		0.46 (0.23, 0.69)		

Abbreviations: CI, confidence interval.
* Adjusted for variables in the same and distal levels of determination.
[a] Linear trend test.

adolescents with worse socioeconomic and nutritional profiles were slightly less likely to be followed up. Participants from the intermediate socioeconomic stratum were more likely to be located as compared with very poor or very rich adolescents (81.8% vs 75.6% and 76.1%, respectively). Furthermore, participants whose mothers had no schooling were less likely to be followed up compared to those whose mothers had nine or more years of schooling (69.4% vs 77.5%). However, the magnitude of such differences is modest, therefore minimizing the likelihood of bias [36].

Strengths of our study include the prospective design, the relatively large sample size, and the high follow-up rate at 18 years (81.3%), ensuring the representativeness of the sample despite some small differences between study participants and those lost to follow-up.

5. Conclusion

The present study provides information about influential factors on sleep duration in Brazilian adolescents. Our findings have relevant clinical significance because the results indicate that social and demographic variables play an important role on adolescents' sleep duration, thus highlighting the need for prevention of sleep loss in this population.

Conflict of interest

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: http://dx.doi.org/10.1016/j.sleep.2016.02.013.

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