Sleep Medicine 67 (2020) 83–90

Contents lists available at ScienceDirect

Sleep Medicine

journal homepage: www.elsevier.com/locate/sleep

Original Article

Sleep parameters measured by accelerometry: descriptive analyses from the 22-year follow-up of the Pelotas 1993 birth cohort

Andrea Wendt*, Inácio Crochemore Mohnsan da Silva, Helen Gonçalves, Maria Cecilia F. Assunção, Ana Maria B. Menezes, Fernando C. Wehrmeister

Federal University of Pelotas, Post-graduate Program in Epidemiology, Marechal Deodoro, 1160 – 3rd Floor, CEP 96020-220, Pelotas, RS, Brazil

ARTICLE INFO

Article history:
Received 25 July 2018
Received in revised form
10 April 2019
Accepted 17 October 2019
Available online 26 November 2019

Keywords:
Sleep
Population-based
Accelerometry
Cross-sectional

ABSTRACT

Objective: To describe the sleep time window (STW), total sleep time (TST), and sleep percent [SP = (TST/STW) × 100] by accelerometry in a population-based young adult cohort in Brazil.
Methods: Cross-sectional analysis with a 22-year sample (N = 2462). Sleep variables were measured using an accelerometer. The devices were worn on the non-dominant wrist for approximately seven days. A raw data analysis using the GGIR package was performed. The following sleep variables were extracted: TST, STW, and SP. Linear regression was used to adjust averages. All analyses were stratified according to sex. A comparison between weekday and weekend averages was also conducted.
Results: The means of TST, STW, and SP for men were 5.9 h, 7.1 h, and 83.1%, respectively. For women, the means of TST, STW, and SP were 6.4 h, 7.6 h, and 84.6%, respectively. Women presented a higher means of all outcomes compared to men ($p < 0.001$). After adjusting for both sexes, white skin color and not working or studying were associated with higher TST. Individuals not working or studying presented higher means of STW and lower sleep SP. Women with children who were less than two years of age presented lower values of three evaluated outcomes. Regarding behavior and health condition variables, obesity was associated with lower STW only for men. Physical activity was associated with higher SP and risk drinking with lower TST and STW only for women.
Conclusion: Differences between sexes were observed in TST, STW, and SP. In all outcomes women presented a higher means. Socioeconomic variables were associated with both sexes, but having children and behavior/health conditions differed between sexes.

1. Introduction

Sleep duration and quality have great relevance to the general health of individuals [1]. Inadequate sleep duration and poor sleep quality are associated with several adverse health-related outcomes, such as a higher risk of all-cause mortality [2], obesity [3,4] chronic diseases [3], and poor mental health [5].

The gold standard for sleep medicine research is polysomnography (PSG), a method that assesses many parameters during sleep but requires specialized professionals and equipment [6]. There are also subjective measures, such as clinical interviews, questionnaires, and sleep logs [7]. An accelerometer is an instrument with reasonable accuracy to classify sleep minutes [8]. This method has been used to evaluate sleep parameters when PSG is not feasible, as in the case of large population-based studies [8]. Also, a night of PSG, which requires a specialized laboratory and several types of monitors and sensors, is very different from a typical night of accelerometry, which uses only a device worn on the wrist [7]. The use of accelerometers has some limitations compared to PSG, but it is a good option compared to questionnaires and sleep logs when the studies aim to evaluate variables such as total sleep time (TST), sleep time window (STW), and sleep percent (SP), which do not require subjective perception [8]. Furthermore, this measure is not influenced by interviewers or the understanding capacity of the participants [7].

Abbreviations: BMI, Body Mass Index; TST, Total Sleep Time; STW, Sleep Time Window; SP, Sleep Percent.

* Corresponding author.
E-mail addresses: andreatwendt@gmail.com (A. Wendt), inacio_cms@yahoo.com.br (I.C.M. da Silva), hdgs.epi@gmail.com (H. Gonçalves), cecilia.epi@gmail.com (M.C.F. Assunção), anamene.epi@gmail.com (A.M.B. Menezes), fcwehrmeister@gmail.com (F.C. Wehrmeister).

https://doi.org/10.1016/j.sleep.2019.10.020
1389-9457/

The literature remains scarce regarding the description of sleep measures with accelerometry in large population-based studies, mostly due to the high cost of accelerometry compared to that of questionnaires [7]. Furthermore, most studies with accelerometry are conducted in high-income countries, where different patterns are expected compared with low- and middle-income settings. In general, subjective measures such as poor sleep quality or self-reported sleep disorders are highly prevalent in low- and middle-income countries [9], and information about objective sleep measures are scarce in this context. A description of sleep variables may help to find strategies and interventions planned to ensure sound sleep health for all. Thus, this study aims to describe STW, TST, and SP in a population-based birth cohort in Pelotas/Brazil with participants who were 22 years of age.

2. Methods

The present study was based on data from the most recent follow-up of the 1993 Birth Cohort, a population-based study in Pelotas, Brazil [10]. All maternity hospitals of the city were visited, and all live births in the 1993 calendar year, by mothers living in the urban area, were included in the cohort. From the perinatal study through the 15-year-old follow-up, information was collected by interviewers at the participants' home. During the 18-year and 22-year follow-up, individuals were invited to visit the research clinic, where they answered questionnaires, took psychological tests, and were submitted to some examinations and accelerometry for the assessment of sleep and physical activity in the subsequent week. The original cohort comprised 5249 children, and this study used data from accelerometry at the 22-year-old visit (follow-up rate of 76.3%, including those who are deceased) [10]. Additional information on the methodological aspects of the cohort is available elsewhere [10,11].

The Medical School Ethics Committee of the Federal University of Pelotas approved this study. Ethical approval was obtained, and full informed consent was provided by the cohort members or by their parents if the individuals were younger than 18 years.

2.1. Sleep parameters using accelerometry

Participants were asked to wear triaxial accelerometers (GT3x; Actigraph®) on their non-dominant wrist during a 24-h protocol lasting seven days. A member of the research clinic staff collected the device at the end of the period. The devices started collecting data at 00:00 h for a maximum of six cycles of 24 h for each participant. The data were collected in 5-s epochs with a 60 Hz-sampling frequency. The data were downloaded in Actilife 6.1 and processed in the R program with the GGIR package (version 1.5–21).

For sleep parameter detection, the algorithm proposed by Van Hess et al. [12], was used to look for time windows (eg, 5 min) and to search for changes in the wrist angle (z-axis) to classify sleep periods [12]. Five-minute windows and changes in the angle of three degrees were used in this study. The work published by Van Hess et al., found an accuracy of 83 ± 8 to TST versus PSG [12]. The detection of STW was performed with the HDCZA algorithm, the default of the GGIR package. Briefly, a sleep period is considered as the longest period of continuous sleep in 24 h. A wake period greater than 60 min during the sleep period is treated as two separate sleep periods.

The accelerometry measures included in this study were the following:

a. Sleep time window (STW): the difference between sleep onset and sleep end automatically detected by algorithm [12].
b. Total sleep time (TST): the total of time classified as sleep inside STW [12].
c. Sleep percent (SP): percentage of time classified as sleep compared to total STW [(TST/STW) $\times$ 100] [13].

SP was used as an alternative to sleep efficiency since the last considers sleep latency, and we were not able to obtain this information due to automatized detection. Weekly averages were calculated for all measures. To minimize measurement error, we excluded nights with TST or STW of less than 2 h and more than 15 h, avoiding potential bias in weekly averages. In a total of 13,516 nights, 488 were excluded due to these problems. Also, participants with less than four nights of data (N = 194) and who worked at night (N = 168) were excluded.

2.2. Independent variables

The independent variables were self-reported skin color (white/black/brown/other), work status (none, only study, only work, both), children less than two years old (no/yes), wealth index, body mass index (BMI), total screen time, physical activity, current smoking, perceived health (dissatisfied, regular, satisfied) common mental disorders, and risky drinking. Brazil is a mixed-race country; thus, we used categories of white, black, and brown skin color because these best represent the people in our country (individuals in the brown category self-reported their skin color as "*pardo*" in Portuguese). The wealth index was based on principal component analysis using several assets and then divided into quintiles. BMI was obtained from the ratio weight/height (kg/m^2). Weight was collected using a scale coupled to air displacement plethysmography equipment (BOD POD® Composition System; COSMED, Albano Laziale, Italy) with ten gram precision. Height was obtained using a 0.1-cm precision stadiometer. The final measure of BMI was categorized as normal (<25 kg/m^2), overweight (25–29.9 kg/m^2), and obese ($\geq$30 kg/m^2). Total screen time is the sum of time spent watching TV, using the computer, and playing videogames, later divided into terciles. Physical activity was obtained from a list of leisure-time activities [14]. A sum of minutes in each activity was calculated, and the total score was divided into terciles. Common mental health disorders were measured by self-reporting questionnaire (SRQ-20) [15] and defined with a cut-off of 8 or higher for women and six or higher for men, indicating symptoms of common mental disorders. Harmful alcohol intake was measured by Alcohol Use Disorder Identification (AUDIT) [16] and defined with a cut-off of 8 or higher as risk drinking. All analyses were performed using Stata 12.1 (StataCorp LP, College Station, United States).

2.3. Analysis

A descriptive analysis was performed comparing the total sample at 22 years and the analytical sample (with data for sleep by accelerometry). The frequency and 95% confidence intervals (95% CI) were presented. The means for TST, STW, and SP in weekdays and weekends were also compared. All analyses were stratified by sex, because of biological differences in sleep and interaction of sex with some variables.

To describe the outcomes according to independent variables, we used linear regression to present crude and adjusted means and 95% CIs using a hierarchical model with three levels. The socioeconomic variables were inserted in the first level. In the second level, we included behavioral variables; in the third level, we included health conditions. Only variables presenting an association with a p-value of 0.20 were maintained in the model. Finally, we considered variables with $p < 0.05$ statistically significant. When appropriate, the linear p trend is presented.

3. Results

The 22-year follow-up of the 1993 Birth Cohort comprised 3810 participants, from which data of sleep parameters using accelerometry were available for 2462 individuals. The analytical sample presented similar distributions in terms of independent variables compared to the followed cohort members (Table 1). Regarding sex differences, the means of TST and STW were higher in women on weekdays and weekends ($p < 0.001$).

Fig. 1 shows the distribution of TST and STW on weekdays and weekends for men. The means of TST in weekdays and weekends were 5.9 h (1.0) and 5.9 h (1.3), respectively. For STW, the means in weekdays and weekends were 7.2 h (1.2) and 7.2 h (1.6), respectively. No difference was found between weekdays and weekends for both TST ($p = 0.808$) and STW ($p = 0.924$).

The distribution of TST and STW on weekdays and weekends for women is shown in Fig. 2. The mean of TST on weekdays was 6.4 (1.1), and the mean of TST on weekends 6.4 (1.4), whereas the mean STWs on both weekends and weekdays were 7.6 h. Also, for women, no difference between weekdays and weekends was found for TST ($p = 0.869$) and STW ($p = 0.906$).

Although we found no differences in main sleep measures according to weekdays and weekends, the sleep onset and sleep end were delayed in weekends for both sexes ($p < 0,001$), but did not affect the total amount of sleep (Supplementary material).

Table 2 shows crude and adjusted means of TST, STW, and SP for men according to independent variables. The adjusted means of TST, STW, and SP were 5.9 h, 7.2 h, and 83.3%, respectively. After adjustments, white men presented a higher mean of TST ($p = 0.038$) and SP ($p = 0.036$) compared with those with brown and black skin color. Regarding work status, men not working or studying presented higher means of STW ($p < 0.001$) but lower means of SP ($p < 0.001$). Individuals identified as overweight and obesity presented lower means of STW ($p = 0.015$). Wealth index, physical activity, screen time, harmful alcohol intake, smoking, perceived health status, and common mental disorders were not associated with any sleep parameter for men.

Sleep outcomes for women according to independent variables, are presented in Table 3. The adjusted means of TST, STW, and SP were 6.4 h, 7.6 h, and 84.5%, respectively. White women presented a higher mean of TST ($p = 0.004$). Women not working or studying presented higher STW ($p = 0.002$) and lower sleep SP ($p = 0.001$). In the same direction, those in the poorest quintile of wealth index presented lower SP ($p < 0.001$). Women with children who were less than two years of age presented lower TST (6.1 h vs. 6.5 h; $p < 0.001$), STW (7.4 h vs. 7.7 h; $p < 0.001$), and SP (84.9 h vs. 82.8 h; $p < 0.001$). Regarding behavioral variables, those with more minutes of self-reported physical activity presented SP of 85.1%, whereas those with fewer minutes had an SP of 84.2% ($p = 0.001$). Those with harmful alcohol intake presented lower means of TST (6.5 h vs. 6.1 h; $p < 0.001$) and STW (7.7 h vs. 7.3 h; $p < 0.001$). For women, screen time, BMI, perceived health status, and common mental disorders were not associated with any sleep parameter.

Table 1
Distribution of the total sample and sleep accelerometry sample at 22 years of age in 1993 Birth Cohort, Pelotas/Brazil.

	1993 Birth Cohort 22 years' follow-up	Analytical sample (Accelerometry)	
	N (%)	N (%)	P-value
Sex			0.587*
Men	1783 (46.8)	1170 (47.5)	
Women	2027 (53.2)	1292 (52.5)	
Skin color			0.312
White	2262 (63.3)	1455 (61.7)	
Black	538 (15.1)	395 (16.7)	
Brown *(pardo)*	637 (17.8)	413 (17.5)	
Others	137 (3.8)	97 (4.1)	
Occupation			0.170
None	756 (21.2)	505 (22.1)	
Only study	409 (11.5)	295 (12.9)	
Only work	1624 (45.5)	1026 (44.9)	
Both	778 (21.8)	459 (20.1)	
Wealth index (quintiles)			0.963
1° (poorest)	761 (20.0)	490 (19.9)	
2°	761 (20.0)	481 (19.6)	
3°	761 (20.0)	507 (20.6)	
4°	761 (20.0)	483 (19.6)	
5° (richest)	761 (20.0)	499 (20.3)	
Children < 2 years old			0.872*
No	3214 (85.5)	2091 (85.6)	
Yes	546 (14.5)	351 (14.4)	
BMI			0.981
Normal	2023 (56.8)	1390 (56.9)	
Overweight	959 (27.0)	653 (26.7)	
Obese	577 (16.2)	399 (16.3)	
Screen time (terciles)			0.537
1° (lowest)	1518 (39.9)	955 (38.8)	
2°	1184 (31.1)	762 (31.0)	
3° (highest)	1103 (30.0)	744 (30.2)	
Physical activity (terciles)			0.677
1° (lowest)	1296 (34.3)	813 (33.3)	
2°	1226 (32.5)	810 (33.1)	
3° (highest)	1252 (33.2)	821 (33.6)	
Perceived health status			0.642
Dissatisfied	287 (7.6)	170 (6.9)	
Regular	938 (24.7)	614 (25.0)	
Satisfied	2577 (67.8)	1672 (68.1)	
Current smoking			0.890*
No	3167 (83.2)	2052 (83.4)	
Yes	638 (16.8)	409 (16.6)	
Common mental disorders			0.730*
No	2951 (78.0)	1918 (78.4)	
Yes	833 (22.0)	529 (21.6)	
Alcohol use disorders			0.729*
No	2981 (78.4)	1937 (78.7)	
Yes	823 (81.6)	523 (21.3)	
Total	**3810 (100%)**	**2462 (100%)**	

BMI: body mass index; *Fisher exact test; Total sample is related to all individuals evaluated at 22 years' follow-up, and the analytical sample is related to individuals with valid data on accelerometry.

4. Discussion

The parameters of sleep health measured by accelerometry were described according to demographic, socioeconomic, and behavioral aspects in a birth cohort at age 22 years. In general, women presented higher means of TST, STW, and SP compared to men, and the results presented very few changes after adjusting for potential confounders. Individuals who were not working or studying presented lower SP. Self-reported leisure-time physical activity was associated with higher SP, and risk drinking was associated with lower TST and STW only for women. Overweight and obesity were associated with lower SP only for men. No differences in weekdays and weekends were found for the sleep parameters.

This study evaluated the three most common measures of sleep accelerometry: TST, STW (Also referred to as time in bed in other studies), and SP. Although these measures are usually presented in the literature, one should reflect on their meanings. TST is frequently treated as sleep duration. On the other hand, STW may be a more appropriate measure. Briefly, TST is a sum of minutes or hours in which the accelerometer did not identify relevant changes in movement (by acceleration magnitude or changes in the angle of the wrist) [12], and it is very dependent on the classification algorithm for each minute. In accelerometry, STW may be defined by

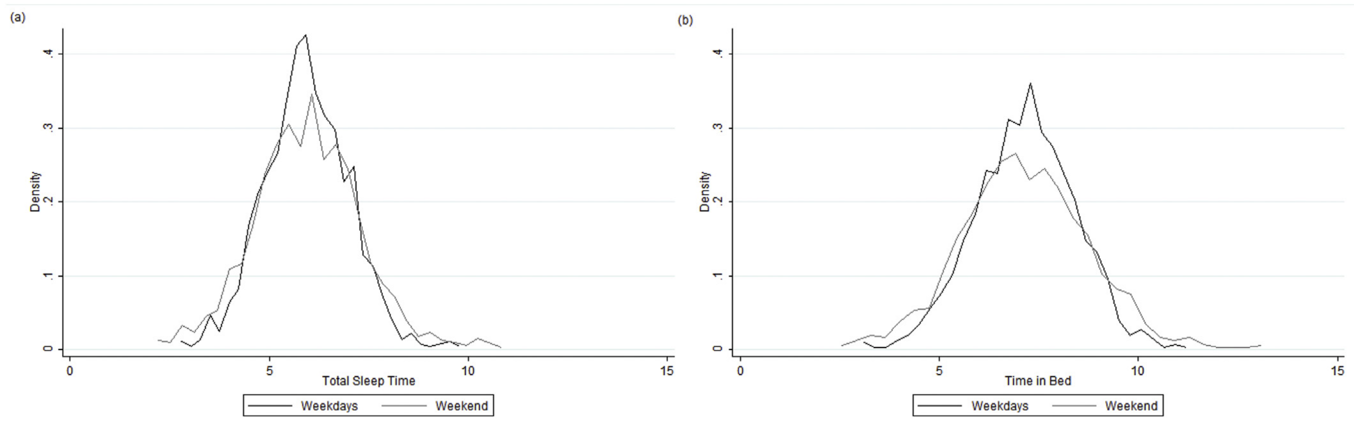

Fig. 1. Distribution of total sleep time and sleep time window according to weekdays and weekends for men. 1993 Birth Cohort, Pelotas/Brazil. (a) Distribution of total sleep time in weekdays and weekends ($p = 0.808$); (b) Distribution of sleep time window in weekdays and weekends ($p = 0.924$).

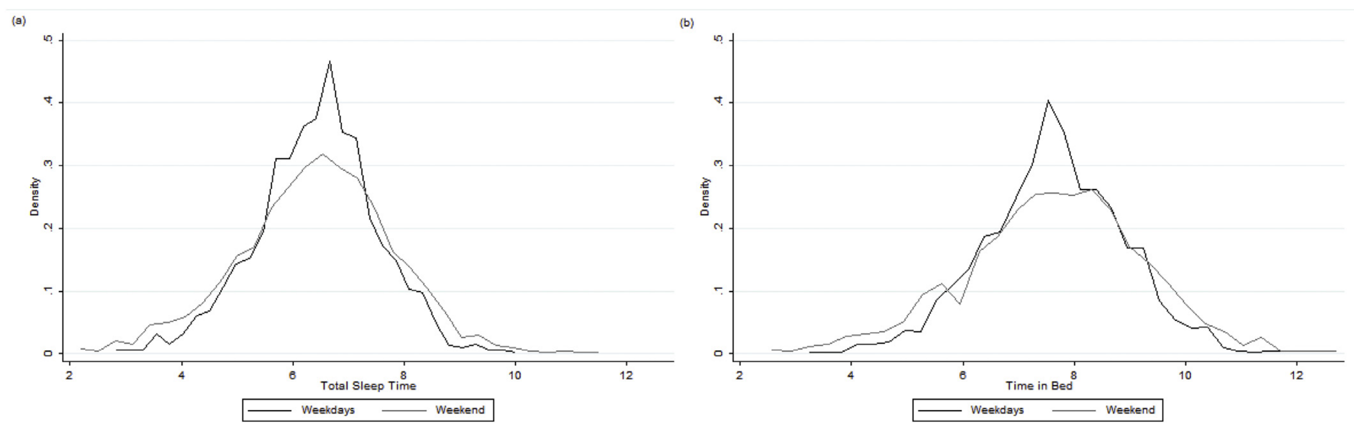

Fig. 2. Distribution of total sleep time and sleep time window according to weekdays and weekends for women. 1993 Birth Cohort, Pelotas/Brazil. (a) Distribution of total sleep time for women on weekdays and weekends ($p = 0.869$); (b) Distribution of sleep time window in weekdays and weekends ($p = 0.906$).

the time window, starting at sleep onset and finishing at sleep end [12]. The self-reported sleep duration is also the difference between sleep onset and sleep end and does not consider movement during the night or micro awakenings. In this regard, STW measured by accelerometry may be more similar to sleep duration measured in questionnaires. Considering SP, some associations were significant only for TST and STW and other ones only for SP. SP is a measure that takes into account both TST and STW and balances these two. Defined as a percentage of TST by STW, SP (or sleep efficiency when available) may be a measure more related to sleep quality or restoration; sometimes, it is the principal measure to evaluate sleep disorder treatments [17]. Work with a combined measure such as SP or sleep efficiency, instead of only STW and TST, is relevant. An increase in TST or STW reflects higher time sleeping but also may generate a greater possibility of interruptions/movement. Thus, while SP is more related to fewer interruptions/movement during sleep and may reflect higher quality, higher TST or STW (amount of time) may not necessarily mean good sleep. Thus, it is essential to measure and present the results from SP, not just TST, STW, or time in bed.

Regarding the finding of no difference between weekdays and weekends, population-based studies with adults and self-reported sleep duration show conflicting results [18,19]. A population-based study in Sweden with an 18 or more years' sample, showed that a mean of self-reported sleep duration on weekdays is almost 1 h less compared with weekends (7.0 h vs. 7.8 h). It was expected that some differences between weekdays and weekends would be found in this study. A possible explanation is that studies with self-reported information overestimate the differences between weekdays and weekends. A smaller study in Sweden using accelerometer data found an increment of TST on weekends compared with weekdays, but the sample included only workers with higher mean age than those in our study (45 y vs. 22 y) [13]. To explore this, we performed additional analyses to evaluate the sleep onset and sleep end during weekdays and weekends (Supplementary Tables). Although the time of sleep onset and sleep end is a little bit earlier on weekdays, TST and STW were not different. Thus, the difference between weekdays and weekends in our sample is related only to sleep onset and sleep end, but not to the total other evaluated parameters. This delay on weekends may occur because individuals usually do not have work/study activities on weekends.

The means of TST, STW, and SP were always higher for women compared with men. The literature shows that women present worse sleep quality, higher prevalence of sleep disorders, and shorter duration than men when subjective measures were available [20]. On the other hand, in studies using the objective measures of PSG and accelerometry, women present higher means of sleep duration and lower latency time to fall asleep (influencing SP) [20]. Although questionnaires and accelerometry measure the same parameters theoretically (eg, sleep duration), they do so in

Table 2
Distribution of Total Sleep Time, Sleep Time Window, and Sleep Percent according to independent variables for young adult men, Brazil.

	Total Sleep Time (hour)				Sleep Time Window (hour)				Sleep Percent (%)			
	Crude		Adjusted		Crude		Adjusted		Crude		Adjusted	
	Mean (95% CI)	P value	Mean (95% CI)	P value	Mean (95% CI)	P value	Mean (95% CI)	P value	Mean (95% CI)	P value	Mean (95% CI)	P value
Skin color		0.064		0.038		0.252		0.092		0.006		0.036
White	6.0 (5.9; 6.1)		6.0 (5.9; 6.1)		7.2 (7.1; 7.3)		7.2 (7.1; 7.3)		83.8 (83.4; 84.3)		83.6 (83.2; 84.1)	
Black	5.8 (5.7; 6.0)		5.8 (6.7; 6.0)		7.1 (6.9; 7.2)		7.0 (6.9; 7.2)		82.9 (82.0; 83.8)		83.1 (82.2; 84.0)	
Brown *(pardo)*	5.9 (5.8; 6.0)		5.9 (5.7; 6.0)		7.2 (7.1; 7.4)		7.2 (7.0; 7.3)		82.1 (81.2; 83.0)		82.2 (81.3; 83.1)	
Others	5.8 (5.5; 6.0)		5.8 (5.5; 6.0)		6.9 (6.6; 7.2)		6.9 (6.6; 7.2)		83.7 (81.9; 85.5)		84.0 (82.1; 85.8)	
Occupation		0.043		0.046		<0.001		<0.001		<0.001		<0.001
None	6.1 (5.9; 6.2)		6.1 (6.0; 6.2)		7.5 (7.3; 7.6)		7.5 (7.3; 7.6)		82.0 (81.1; 82.9)		82.0 (81.1; 82.9)	
Only study	6.0 (5.9; 6.2)		6.0 (5.8; 6.2)		7.2 (7.0; 7.4)		7.2 (7.0; 7.4)		84.3 (83.1; 85.4)		84.2 (83.0; 85.4)	
Only work	5.9 (5.8; 6.0)		5.9 (5.8; 6.0)		7.1 (7.0; 7.2)		7.1 (7.0; 7.2)		83.0 (82.5; 83.5)		83.0 (82.5; 83.5)	
Both	5.9 (5.8; 6.0)		5.9 (5.7; 6.0)		7.0 (6.8; 7.1)		7.0 (6.8; 7.1)		85.0 (84.1; 85.8)		84.8 (83.9; 85.7)	
Wealth index (quintiles)		0.510		0.404		0.752		0.730		0.098		0.369
1° (poorest)	5.9 (5.8; 6.1)		5.9 (5.7; 6.0)		7.2 (7.1; 7.4)		7.1 (6.9; 7.3)		82.8 (81.9; 83.7)		83.1 (82.2; 84.1)	
2°	5.9 (5.8; 6.1)		5.9 (5.8; 6.1)		7.2 (7.0; 7.3)		7.2 (7.1; 7.4)		82.9 (82.0; 83.7)		82.7 (81.8; 83.6)	
3°	5.9 (5.8; 6.0)		5.9 (5.8; 6.0)		7.1 (7.0; 7.2)		7.1 (7.0; 7.3)		83.2 (82.4; 84.0)		83.3 (82.5; 84.1)	
4°	6.0 (5.9; 6.1)		6.0 (5.9; 6.2)		7.2 (7.1; 7.3)		7.2 (7.1; 7.4)		84.1 (83.3; 84.8)		83.9 (83.1; 84.7)	
5° (richest)	5.9 (5.8; 6.1)		5.9 (5.8; 6.1)		7.1 (7.0; 7.2)		7.1 (7.0; 7.3)		83.9 (83.1; 84.6)		83.3 (82.5; 84.2)	
Children <2 years old		0.714		0.384		0.362		0.326		0.522		0.826
No	5.9 (5.9; 6.0)		5.9 (5.9; 6.0)		7.2 (7.1; 7.2)		7.1 (7.1; 7.2)		83.5 (83.1; 83.9)		83.4 (83.0; 83.8)	
Yes	5.9 (5.8; 6.1)		6.0 (5.8; 6.2)		7.2 (7.1; 7.4)		7.3 (7.1; 7.4)		83.1 (82.1; 84.2)		83.5 (82.3; 84.6)	
Physical activity (terciles)		0.378		0.089		0.301		0.177		0.885		0.611
1° (lowest)	5.9 (5.8; 6.0)		5.8 (5.7; 5.9)		7.1 (7.0; 7.2)		7.1 (6.9; 7.2)		83.4 (82.7; 84.1)		83.2 (82.5; 84.0)	
2°	6.0 (5.9; 6.0)		6.0 (5.9; 6.1)		7.2 (7.1; 7.3)		7.2 (7.1; 7.3)		83.6 (82.9; 84.2)		83.3 (82.6; 84.0)	
3° (highest)	6.0 (5.8; 6.0)		6.0 (5.9; 6.1)		7.2 (7.1; 7.3)		7.2 (7.1; 7.3)		83.4 (82.8; 83.9)		83.4 (82.9; 84.0)	
Screen time (terciles)		0.072		0.205		0.179		0.417		0.307		0.246
1° (lowest)	5.9 (5.8; 6.0)		5.9 (5.8; 6.0)		7.1 (7.0; 7.2)		7.1 (7.0; 7.2)		83.3 (82.7; 83.9)		83.1 (82.5; 83.8)	
2°	6.0 (5.9; 6.1)		6.0 (5.9; 6.1)		7.2 (7.1; 7.3)		7.2 (7.1; 7.3)		83.1 (82.5; 83.8)		83.0 (82.3; 83.7)	
3° (highest)	6.0 (5.9; 6.1)		6.0 (5.9; 6.1)		7.2 (7.1; 7.3)		7.2 (7.1; 7.3)		83.8 (83.2; 84.4)		83.8 (83.1; 84.4)	
Alcohol use disorders		0.092		0.185		0.272		0.246		0.152		0.597
No	6.0 (5.9; 6.0)		6.0 (5.9; 6.0)		7.2 (7.1; 7.3)		7.2 (7.1; 7.3)		83.6 (83.1; 84.0)		83.4 (82.9; 83.8)	
Yes	5.9 (5.8; 6.0)		5.9 (5.8; 6.0)		7.1 (7.0; 7.2)		7.1 (7.0; 7.2)		83.0 (82.3; 83.7)		83.1 (82.4; 83.9)	
Current smoking		0.382		0.867		0.494		0.772		0.006		0.169
No	6.0 (5.9; 6.0)		5.9 (5.9; 6.0)		7.2 (7.1; 7.2)		7.2 (7.1; 7.2)		83.7 (83.3; 84.1)		83.4 (83.0; 83.9)	
Yes	5.9 (5.8; 6.0)		5.9 (5.8; 6.1)		7.2 (7.1; 7.3)		7.2 (7.0; 7.3)		82.4 (81.6; 83.2)		82.8 (81.9; 83.6)	
BMI		0.482		0.146		0.035*		0.015*		0.075		0.065
Normal	6.0 (5.9; 6.0)		6.0 (5.9; 6.0)		7.2 (7.1; 7.3)		7.2 (7.1; 7.3)		83.1 (82.6; 83.5)		82.9 (82.4; 83.4)	
Overweight	6.0 (5.9; 6.1)		6.0 (5.9; 6.1)		7.1 (7.0; 7.2)		7.1 (7.0; 7.3)		84.0 (83.3; 84.6)		83.9 (83.2; 84.6)	
Obese	5.9 (5.7; 6.0)		5.8 (5.7; 5.9)		7.0 (6.9; 7.1)		7.0 (6.8; 7.1)		83.7 (82.8; 84.7)		83.6 (82.6; 84.6)	
Perceived health status		0.300		0.502		0.213		0.386		0.554		0.433
Dissatisfied	5.7 (5.6; 6.0)		5.8 (5.6; 6.0)		7.0 (6.7; 7.1)		7.2 (7.1; 7.3)		83.8 (82.4; 85.0)		83.3 (81.9; 84.8)	
Regular	5.9 (5.8; 6.1)		5.9 (5.8; 6.1)		7.2 (7.1; 7.3)		7.1 (7.0; 7.3)		83.0 (82.2; 83.8)		82.8 (82.0; 83.7)	
Satisfied	6.0 (5.9; 6.0)		5.9 (5.9; 6.0)		7.2 (7.1; 7.2)		7.0 (6.8; 7.1)		83.5 (83.0; 83.9)		83.5 (83.0; 83.9)	
Common mental disorders		0.634		0.446		0.295		0.117		0.232		0.106
No	5.9 (5.9; 6.0)		5.9 (5.9; 6.0)		7.1 (7.1; 7.2)		7.2 (7.1; 7.3)		83.3 (82.9; 83.7)		83.2 (82.7; 83.6)	
Yes	5.9 (5.8; 6.0)		5.9 (5.8; 6.0)		7.1 (7.0; 7.2)		7.1 (6.9; 7.2)		83.8 (83.0; 84.6)		83.9 (83.1; 84.8)	
Total	**5.9 (5.8; 5.9)**		**5.9 (5.9; 6.0)**		**7.1 (7.1; 7.2)**		**7.2 (7.1; 7.2)**		**83.2 (82.9; 83.6)**		**83.3 (82.9; 83.7)**	

BMI: body mass index.
Adjustment follows a hierarchical model first level: skin color, occupation, wealth index, have children <2 years old; second level: physical activity, screen time, alcohol use disorders, current smoking; third level: BMI, perceived health status, common mental disorders.
* p-value for trend.

different ways. Accelerometry works with movement, and questionnaires ask for the perceived time of sleep onset and sleep end. Thus, self-reported sleep duration, which was higher in women than in men, may be related to other factors such as hormonal changes faced by women throughout life (eg, menstrual cycle) [20,21]. Also, factors such as a higher prevalence of depression and anxiety in women may affect the subjective perception of sleep [20,22]. Furthermore, some authors suggest the difference in circadian rhythms as the potential reason for this divergence between studies with objective and subjective measures [20,21]. Some studies have shown that the secretion of melatonin happens earlier in women, but the hour of sleep onset and sleep end may not vary between the sexes [20,22].

Regarding socioeconomic variables, women in the higher quintile of wealth showed higher SP. Individuals with white skin color presented a higher means of TST. A review shows that few studies support the theory of biological ethnic differences in sleep [23]. However, as with other health outcomes, sleep seems to be associated with socioeconomic status, with lower educational and socioeconomic level groups presenting worse general health [23–25]. Another important socioeconomic variable is work status. In this study, individuals who were not studying or working

Table 3
Distribution of Total Sleep Time, Sleep Time Window, and Sleep Percent according to independent variables for young adult women, Brazil.

	Total Sleep Time (hour)				Sleep Time Window (hour)				Sleep Percent (%)			
	Crude		Adjusted		Crude		Adjusted		Crude		Adjusted	
	Mean (95% CI)	P value	Mean (95% CI)	P value	Mean (95% CI)	P value	Mean (95% CI)	P value	Mean (95% CI)	P value	Mean (95% CI)	P value
Skincolor		0.002		0.004		0.141		0.063		<0.001		0.048
White	6.5 (6.4; 6.5)		6.5 (6.4; 6.5)		7.7 (7.6; 7.7)		7.7 (7.6; 7.7)		84.9 (84.5; 85.3)		84.8 (84.4; 85.2)	
Black	6.2 (6.1; 6.3)		6.2 (6.1; 6.3)		7.5 (7.3; 7.6)		7.4 (7.3; 7.6)		83.2 (82.5; 83.9)		83.7 (83.0; 84.5)	
Brown *(pardo)*	6.5 (6.3; 6.6)		6.5 (6.4; 6.6)		7.7 (7.6; 7.8)		7.7 (7.6; 7.9)		84.2 (83.5; 84.9)		84.8 (84.1; 85.5)	
Others	6.3 (6.1; 6.6)		6.3 (6.1; 6.6)		7.6 (7.3; 7.9)		7.6 (7.3; 7.9)		83.4 (81.9; 84.9)		83.5 (82.1; 85.0)	
Occupation		0.603		0.208		0.036		0.002		<0.001		0.001
None	6.4 (6.3; 6.5)		6.5 (6.3; 6.6)		7.7 (7.6; 7.8)		7.8 (7.7; 7.9)		82.9 (82.3; 83.5)		83.6 (82.0; 84.3)	
Only study	6.4 (6.3; 6.6)		6.4 (6.3; 6.6)		7.6 (7.5; 7.8)		7.6 (7.5; 7.8)		84.8 (84.0; 85.5)		84.2 (83.4; 84.9)	
Only work	6.5 (6.4; 6.6)		6.5 (6.4; 6.6)		7.6 (7.5; 7.7)		7.7 (7.5; 7.7)		85.0 (84.5; 85.5)		85.1 (84.5; 85.6)	
Both	6.4 (6.3; 6.5)		6.3 (6.2; 6.4)		7.5 (7.3; 7.6)		7.4 (7.3; 7.5)		85.9 (85.2; 86.5)		85.1 (84.4; 85.8)	
Wealth index (quintiles)		0.153		0.296		0.378		0.222		<0.001		<0.001
1° (poorest)	6.4 (6.3; 6.5)		6.5 (6.3; 6.6)		7.7 (7.6; 7.8)		7.7 (7.6; 7.9)		82.9 (82.3; 83.5)		83.6 (82.9; 84.2)	
2°	6.3 (6.2; 6.5)		6.3 (6.2; 6.5)		7.6 (7.4; 7.7)		7.6 (7.4; 7.7)		84.1 (83.5; 84.8)		84.2 (83.6; 84.9)	
3°	6.4 (6.3; 6.5)		6.4 (6.3; 6.5)		7.6 (7.5; 7.7)		7.6 (7.5; 7.7)		84.4 (83.8; 85.1)		84.3 (83.6; 85.0)	
4°	6.5 (6.3; 6.6)		6.4 (6.3; 6.6)		7.5 (7.4; 7.7)		7.5 (7.4; 7.7)		85.7 (85.0; 86.4)		85.7 (84.9; 86.4)	
5° (richest)	6.5 (6.4; 6.7)		6.5 (6.4; 6.7)		7.7 (7.5; 7.8)		7.7 (7.5; 7.8)		85.7 (85.1; 86.4)		85.4 (84.6; 86.1)	
Children <2 years old		<0.001		<0.001		0.013		<0.001		<0.001		<0.001
No	6.5 (6.4; 6.5)		6.5 (6.4; 6.6)		7.7 (7.6; 7.7)		7.7 (7.6; 7.7)		85.1 (84.7; 85.4)		84.9 (84.6; 85.3)	
Yes	6.1 (5.9; 6.2)		6.1 (5.9; 6.2)		7.5 (7.3; 7.6)		7.4 (7.2; 7.5)		81.8 (81.1; 82.5)		82.8 (82.0; 83.6)	
Physical activity (terciles)		0.778		0.997		0.631		0.885		<0.001*		0.001*
1° (lowest)	6.4 (6.3; 6.5)		6.4 (6.3; 6.5)		7.7 (7.6; 7.8)		7.6 (7.5; 7.7)		83.9 (83.4; 84.4)		84.2 (83.7; 84.7)	
2°	6.4 (6.3; 6.5)		6.4 (6.3; 6.5)		7.6 (7.5; 7.7)		7.6 (7.5; 7.7)		84.5 (84.0; 85.0)		84.5 (83.9; 85.0)	
3° (highest)	6.4 (6.3; 6.6)		6.4 (6.3; 6.5)		7.6 (7.5; 7.7)		7.6 (7.5; 7.7)		85.3 (84.8; 85.9)		85.1 (84.5; 85.7)	
Screen time (terciles)		0.961		0.683		0.878		0.869		0.324*		0.627
1° (lowest)	6.4 (6.3; 6.5)		6.4 (6.3; 6.5)		7.6 (7.5; 7.7)		7.6 (7.5; 7.7)		84.6 (84.1; 85.1)		84.4 (83.9; 84.8)	
2°	6.4 (6.3; 6.5)		6.4 (6.3; 6.5)		7.6 (7.5; 7.7)		7.6 (7.5; 7.7)		84.5 (84.0; 85.1)		84.7 (84.2; 85.3)	
3° (highest)	6.4 (6.3; 6.5)		6.4 (6.3; 6.5)		7.7 (7.5; 7.8)		7.6 (7.5; 7.7)		84.2 (83.6; 84.8)		84.6 (84.0; 85.2)	
Alcohol use disorders		<0.001		<0.001		<0.001		<0.001		0.416		0.999
No	6.5 (6.4; 6.5)		6.5 (6.4; 6.5)		7.7 (7.6; 7.7)		7.7 (7.6; 7.7)		84.5 (84.3; 84.9)		84.6 (84.3; 85.0)	
Yes	6.1 (6.0; 6.2)		6.1 (5.9; 6.3)		7.3 (7.1; 7.5)		7.3 (7.1; 7.4)		84.2 (83.4; 85.0)		83.9 (83.1; 84.7)	
Current smoking		0.008		0.452		0.058		0.152		0.095		0.731
No	6.4 (6.4; 6.5)		6.4 (6.4; 6.5)		7.6 (7.6; 7.7)		7.6 (7.6; 7.7)		84.6 (84.3; 85.0)		84.5 (84.2; 84.8)	
Yes	6.2 (6.1; 6.4)		6.4 (6.2; 6.5)		7.5 (7.3; 7.6)		7.5 (7.3; 7.7)		83.8 (83.0; 84.6)		84.7 (83.8; 85.5)	
BMI		0.210		0.333		0.117*		0.140		0.854		0.212
Normal	6.4 (6.4; 6.5)		6.4 (6.4; 6.5)		7.7 (7.6; 7.7)		7.7 (7.6; 7.8)		84.5 (84.1; 84.9)		84.3 (83.9; 84.7)	
Overweight	6.4 (6.3; 6.5)		6.4 (6.3; 6.5)		7.6 (7.5; 7.7)		7.6 (7.5; 7.7)		84.5 (83.9; 85.1)		84.9 (84.3; 85.5)	
Obese	6.3 (6.2; 6.4)		6.3 (6.2; 6.5)		7.5 (7.4; 7.7)		7.5 (7.4; 7.6)		84.3 (83.6; 85.0)		84.8 (84.1; 85.5)	
Perceived health status		0.598		0.906		0.525		0.595		0.360		0.410
Dissatisfied	6.3 (6.1; 6.5)		6.4 (6.2; 6.6)		7.5 (7.3; 7.8)		7.5 (7.3; 7.8)		84.0 (82.9; 85.2)		84.4 (83.1; 85.6)	
Regular	6.4 (6.3; 6.5)		6.4 (6.3; 6.5)		7.6 (7.5; 7.7)		7.6 (7.5; 7.7)		84.8 (84.2; 85.4)		84.8 (84.3; 85.4)	
Satisfied	6.4 (6.4; 6.5)		6.4 (6.3; 6.5)		7.6 (7.6; 7.7)		7.6 (/7.6; 7.7)		84.5 (84.0; 84.8)		84.3 (84.0; 84.8)	
Common mental disorders		0.040		0.208		0.075		0.180		0.387		0.137
No	6.4 (6.4; 6.5)		6.4 (6.4; 6.5)		7.7 (7.6; 7.7)		7.6 (7.6; 7.7)		84.6 (84.2; 85.0)		84.7 (84.3; 85.0)	
Yes	6.3 (6.2; 6.4)		6.4 (6.3; 6.5)		7.5 (7.4; 7.6)		7.5 (7.4; 7.7)		84.2 (83.6; 84.9)		84.1 (83.5; 84.7)	
Total	**6.4 (6.4; 6.5)**		**6.4 (6.4; 6.5)**		**7.6 (7.6; 7.7)**		**7.6 (7.6; 7.7)**		**84.5 (84.3; 84.8)**		**84.5 (84.2; 84.8)**	

BMI: body mass index.
Adjustment follows a hierarchical model first level: skin color, occupation, wealth index, have children <2 years old; second level: physical activity, screen time, alcohol use disorders, current smoking; third level: BMI, perceived health status, common mental disorders.
* p-value for trend.

presented lower SP. For men not working or studying, TST and STW were higher compared with students and/or workers, but this result did not reflect higher SP. These findings suggest that SP may be a measure closely related to the general quality of sleep. Aspects such as sleep movement, sleep interruptions, or long latency may lead to lower SP [17].

Only for women, having children who were less than two years of age was associated with lower TST, STW, and SP. Studies with women in the postpartum period have shown that sleep behavior changes in this phase of life, and the chance for developing insomnia are higher [26,27]. One study comparing women in the postpartum period with other women showed that the secretion of melatonin in postpartum individuals presented a lower percent increase [28]. This biological change associated with sleep interruption by young children [27] may explain the association found in this work. Studies that include mothers of children up to two years are scarce. We believe that the routine of mothers with children at this age is different from mothers with older children when demands from the child seem to be lower compared with the postpartum period.

Although overweight and obesity are generally associated with a wide range of sleep outcomes, in this study the association was found only for STW among men. The problems of this association are related to sleep breathing disorders, mainly obstructive sleep apnea (OSA), and this study did not evaluate this outcome [29,30]. If the present study had evaluated more specific outcomes such as sleep disorders, the association with BMI would be more likely. Concerning sleep parameters such as TST, STW, and SP, the role of sex in association with BMI and sleep remains controversial. A US study with individuals 21–35 years of age also found an association of higher BMI and worse sleep indicators only for men [31]. Mezick et al., found an inverse association of BMI with TST and SP only for women [32]. The authors also discuss that possibly some studies found associations only for men and other ones only for women due to the discrepancy in instruments, constructs assessed, and population features in each study, making comparison difficult [31].

We found that physical activity was associated with better SP among women. The literature notes physical activity as a behavior with an essential role in sleep measures [33]. Most of the population-based studies about associated factors of sleep parameters used subjective measures of sleep (eg, questionnaires and sleep logs). The evidence of physical activity's effect on objective measures of sleep remains unclear. A study with a representative sample of 18- to 74-year-old Latinos in the US did not show any association of physical activity and sleep measures by accelerometry, even after adjusting for potential confounders [34]. Studies using samples from the general population with objective methods to assess sleep parameters, such as accelerometry, are necessary to establish this association.

Regarding harmful alcohol disorders, some authors note a reduction in TST and SP in individuals with alcohol problems [33,35]. The frequent use of alcohol can also lead to an increase in awakenings and nightmares. The authors suggest that ethanol has a sedative effect, but it decreases across the night [35]. Unfortunately, we only have information about alcohol intake frequency and dependence from our questionnaire, and data about alcohol during the night are not available. Disorders of alcohol use were associated with lower TST and STW only for women in this study. Few studies evaluated sex differences in association with alcohol and sleep, but some explanations may be discussed. In general, women present less body water and more body fat than men and tend to have higher blood alcohol levels after ingestion [36,37]. Furthermore, alcohol ingestion in women might be influenced by hormonal changes during the menstrual cycle [37]. This difference may result in an association of risk drinking with TST and STW only in women.

One study about sleep highlights a series of associated behavioral factors [33], but the majority of studies use subjective measures. In the present study, few associations remained significant after adjustments, and the majority of associations found are relatively small compared to studies with questionnaires. It is possible that behavioral and socioeconomic components played a more prominent role in subjective sleep outcomes such as daytime sleepiness and sleep quality or specific sleep disorders such as OSA than TST, STW, and SP. The age of participants in the present study is something to consider in the comparison of the findings. Our sample encompassed individuals without a significant variation in age (22 years old, ranging from 21 to 23 at the time of interview). Most populational studies about sleep have been conducted among children, middle-aged adults, and the elderly. Young adults may be the population less affected by sleep problems. Harmful behaviors such as physical inactivity, poor nutrition, and others may not affect sleep in this life phase but may impact sleep health as age increases.

For all results in the present study, the magnitude of findings is something to be highlighted. We found significant differences according to categories of exposure variables, but not more than 20 min for TST and STW and two percentage points for SP. Perhaps these changes in outcomes, according to exposure variables, are not clinically relevant.

This work has some limitations worth highlighting. First, sleep measures based on accelerometry should be interpreted with caution, since sleep is a state involving several conditions (eg, cerebral waves, breathing, horizontal position), and sustained inactivity is only one of them [8]. Self-reported measures require memory and perception and are highly dependent on how the question is asked and the recall period. Even so, accelerometry still brings valid information about sleep [7,8]. Second, an automatic method of sleep time window detection was employed. Automatic detection may be a good option, when using sleep logs is not possible, but the results could present possible errors of an automated algorithm. In our sample, the correlation between STW and self-report of sleep duration was 0.3 (data not presented), very similar to studies with physical activity comparing accelerometer measurement with a questionnaire. This finding reinforces the observation that mechanical and self-report measures are entirely different. However, mechanical measurement makes the process of obtaining objective sleep measures easier in population-based studies. Finally, it is essential to highlight that the present study aims only to find factors associated with TST, STW, and SP and not to establish a causal relationship. The cross-sectional design of our study does not allow causal inference.

Among the strengths of the present study, it was conducted on a birth cohort with high standards in data collection and a relatively small amount of follow-up loss. All independent variables were collected using standardized questionnaires and valid measures. Also, the study was conducted in a middle-income country, whereas the majority of studies with objective sleep measures were conducted in high-income countries. In general, individuals from high-income countries experience better life conditions due to higher income, as well as better health services, employment rates, and other features. These individuals tend to present better values of sleep parameters compared with individuals living in worse conditions. According to our knowledge, this is one of the first studies to describe TST, STW, and SP in a young adult population-based sample in a middle-income setting.

5. Conclusions

Differences were observed in TST, STW, and SP between sexes, with women presenting higher means of the sleep parameters measured. No difference was found between weekdays and weekends. Variables such as skin color, work status, risk drinking, physical activity, and BMI have shown weak associations with objectively measured sleep characteristics.

Acknowledgments

This article is based on data from the study: Pelotas Birth Cohort, 1993; conducted by the Postgraduate Program in Epidemiology at Universidade Federal de Pelotas with the collaboration of the Brazilian Public Health Association (ABRASCO). From 2004 to 2013, the Wellcome Trust supported the 1993 birth cohort study. The European Union, National Support Program for Centers of Excellence (PRONEX), the Brazilian National Research Council (CNPq), and the Brazilian Ministry of Health supported previous phases of the study. The 22-year follow-up was supported by the Science and Technology Department/Brazilian Ministry of Health, with resources transferred through the Brazilian National Council for Scientific and Technological Development (CNPq), grant 400943/2013-1.

Conflict of interest

None declared.

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: https://doi.org/10.1016/j.sleep.2019.10.020.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.sleep.2019.10.020.

References

[1] Buysse DJ. Sleep health: can we define it? Does it matter? Sleep 2014;37:9–17.
[2] Cappuccio FP, D'Elia L, Strazzullo P, et al. Sleep duration and all-cause mortality: a systematic review and meta-analysis of prospective studies. Sleep 2010;33:585–92.
[3] Foley D, Ancoli-Israel S, Britz P, et al. Sleep disturbances and chronic disease in older adults: results of the 2003 National Sleep Foundation Sleep in America Survey. J Psychosom Res 2004;56:497–502.
[4] Taheri S. The link between short sleep duration and obesity: we should recommend more sleep to prevent obesity. Arch Dis Child 2006;91:881–4.
[5] Luo J, Zhu G, Zhao Q, et al. Prevalence and risk factors of poor sleep quality among Chinese elderly in an urban community: results from the Shanghai aging study. PLoS One 2013;8:e81261.
[6] Hirshkowitz M. Polysomnography challenges. Spleep Med Clin 2016;11:403–11.
[7] Martin JL, Hakim AD. Wrist actigraphy. Chest 2011;139:1514–27.
[8] Sadeh A. The role and validity of actigraphy in sleep medicine: an update. Sleep Med Rev 2011;15:259–67.
[9] Stranges S, Tigbe W, Gomez-Olive FX, et al. Sleep problems: an emerging global epidemic? Findings from the INDEPTH WHO-SAGE study among more than 40,000 older adults from 8 countries across Africa and Asia. Sleep 2012;35:1173–81.
[10] Gonçalves H, Wehrmeister FC, Assuncao MCF, et al. Cohort profile update: the 1993 Pelotas (Brazil) birth cohort follow-up at 22 years. Int J Epidemiol 2018 Oct 1;47(5). https://doi.org/10.1093/ije/dyx249. 1389–1390e.
[11] Victora CG, Hallal PC, Araujo CL, et al. Cohort profile: the 1993 Pelotas (Brazil) birth cohort study. Int J Epidemiol 2008;37:704–9.
[12] van Hees VT, Sabia S, Anderson KN, et al. A novel, open access method to assess sleep duration using a wrist-worn accelerometer. PLoS One 2015;10:e0142533.
[13] Aili K, Astrom-Paulsson S, Stoetzer U, et al. Reliability of actigraphy and subjective sleep measurements in adults: the design of sleep assessments. J Clin Sleep Med 2017;13:39–47.
[14] Bastos JP, Araujo CL, Hallal PC. Prevalence of insufficient physical activity and associated factors in Brazilian adolescents. J Phys Act Health 2008;5:777–94.
[15] Mari JJ, Williams P. A validity study of a psychiatric screening questionnaire (SRQ-20) in primary care in the city of Sao Paulo. Br J Psychiatry: J Ment Sci 1986;148:23–6.
[16] Fabor TF, Higgins-Biddle JC, Saunders JB, et al. The alcohol use disorders identification test (AUDIT) - guidelines for use in primary care. Geneva: WHO; 2001.
[17] Reed DL, Sacco WP. Measuring sleep efficiency: what should the denominator Be? J Clin Sleep Med: JCSM: official publication of the American Academy of Sleep Medicine 2016;12:263–6.
[18] Brockmann PE, Gozal D, Villarroel L, et al. Geographic latitude and sleep duration: a population-based survey from the Tropic of Capricorn to the Antarctic Circle. Chronobiol Int 2017;34:373–81.
[19] Mallon L, Broman JE, Akerstedt T, et al. Insomnia in Sweden: a population-based survey. Sleep Disord 2014;2014:843126.
[20] Mong JA, Cusmano DM. Sex differences in sleep: impact of biological sex and sex steroids. Philos Trans R Soc Lond B Biol Sci 2016 19;371(1688):20150110.
[21] Mallampalli MP, Carter CL. Exploring sex and gender differences in sleep health: a Society for Women's Health Research Report. J Women's Health 2014;23:553–62.
[22] Cain SW, Dennison CF, Zeitzer JM, et al. Sex differences in phase angle of entrainment and melatonin amplitude in humans. J Biol Rhythms 2010;25:288–96.
[23] Adenekan B, Pandey A, McKenzie S, et al. Sleep in America: role of racial/ethnic differences. Sleep Med Rev 2013;17:255–62.
[24] Cunningham TJ, Wheaton AG, Ford ES, et al. Racial/ethnic disparities in self-reported short sleep duration among US-born and foreign-born adults. Ethn Health 2016;21:628–38.
[25] Grandner MA, Patel NP, Gehrman PR, et al. Who gets the best sleep? Ethnic and socioeconomic factors related to sleep complaints. Sleep Med 2010;11:470–8.
[26] McBean AL, Montgomery-Downs HE. Diurnal fatigue patterns, sleep timing, and mental health outcomes among healthy postpartum women. Biol Res Nurs 2015;17:29–39.
[27] Parker White C, White MB. Sleep problems and fatigue in chronically ill women. Behav Sleep Med 2011;9:144–61.
[28] Thomas KA, Burr RL. Melatonin level and pattern in postpartum versus nonpregnant nulliparous women. J Obstet Gynecol Neonatal Nurs: J Obstet Gynecol Neonatal Nurs 2006;35:608–15.
[29] Romero-Corral A, Caples SM, Lopez-Jimenez F, et al. Interactions between obesity and obstructive sleep apnea: implications for treatment. Chest 2010;137:711–9.
[30] Zammit C, Liddicoat H, Moonsie I, et al. Obesity and respiratory diseases. Int J Gen Med 2010;3:335–43.
[31] Wirth MD, Hebert JR, Hand GA, et al. Association between actigraphic sleep metrics and body composition. Ann Epidemiol 2015;25:773–8.
[32] Mezick EJ, Wing RR, McCaffery JM. Associations of self-reported and actigraphy-assessed sleep characteristics with body mass index and waist circumference in adults: moderation by gender. Sleep Med 2014;15:64–70.
[33] Irish LA, Kline CE, Gunn HE, et al. The role of sleep hygiene in promoting public health: a review of empirical evidence. Sleep Med Rev 2015;22:23–36.
[34] Cespedes EM, Hu FB, Redline S, et al. Comparison of self-reported sleep duration with actigraphy: results from the hispanic community health study/study of Latinos sueno ancillary study. Am J Epidemiol 2016;183:561–73.
[35] Garcia AN, Salloum IM. Polysomnographic sleep disturbances in nicotine, caffeine, alcohol, cocaine, opioid, and cannabis use: a focused review. Am J Addict 2015;24:590–8.
[36] Ely M, Hardy R, Longford NT, et al. Gender differences in the relationship between alcohol consumption and drink problems are largely accounted for by body water. Alcohol Alcohol 1999;34:894–902.
[37] Colrain IM, Nicholas CL, Baker FC. Alcohol and the sleeping brain. Handb Clin Neurol 2014;125:415–31.