Sleep Medicine: X 6 (2023) 100079

Contents lists available at ScienceDirect

Sleep Medicine: X

journal homepage: www.sciencedirect.com/journal/sleep-medicine-x

Relationship between sleep problems and headaches among adolescents: Pelotas 2004 Birth cohort

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ARTICLE INFO

Article history:
Received 5 May 2023
Received in revised form
26 June 2023
Accepted 29 June 2023
Available online 8 July 2023

Keywords:
Headache
Sleep
Sleep problems
Adolescents

ABSTRACT

Objective: To investigate the cross-sectional association between sleep problems (the exposure) and headaches (the outcome) among 15-year-olds from the Pelotas 2004 Birth Cohort, a population-based study in the south of Brazil.
Method: The occurrence of headaches was obtained through the question: "Do you usually suffer headaches?" and the ICHD-3 criteria were used to classify as: tension-type headache, headache with characteristics of migraine with or without aura, or other. Regarding sleep, the weekly frequency in the last month of insomnia and bad dreams/nightmares, and self-reported sleep quality were investigated. Unadjusted and adjusted prevalence ratios (PR) with 95% confidence intervals were calculated using Poisson regression with robust variance.
Results: A total of 1916 adolescents were analyzed. The prevalence of headaches was 51.6% (69.0% in females and 34.8% in males): 31.8% (39.7% vs. 24.1%) reported tension-type headache; 14.7% (21.9% vs. 7.8%), headaches with characteristics of migraines without aura; 3.6%, headaches with characteristics of migraines with aura; and 1.5% (5.1% vs. 2.3%), other types. Adolescents with insomnia ≥3 times/week presented higher probability of headaches (PR = 1.54; 95%CI 1.23−1.93), compared with those with no problems falling asleep or maintaining sleep. Among those who classified their sleep as poor/very poor, the probability of headaches was 33% higher (PR = 1.33; 95%CI 1.13−1.57) than among those who classified their sleep as very good.
Conclusions: Headaches were highly prevalent among the adolescents and were related to sleep problems even after allowing for several confounders.

1. Introduction

Adolescence is a stage of development marked by physical and psychosocial changes, involving genetic and environmental determinants, as well as complex neuro-hormonal mechanisms [1,2]. It is a critical period of neurodevelopment, with intense structural and functional adaptation of the brain, in response to the demands of the moment, which prepare the individual for the adult phase [3,4]. Physical or psychological disorders that may occur in this age group can have a negative impact on quality of life, school performance, and social functioning, as well as on long-term health [3,5].

Among the common clinical conditions, headaches are the most frequent neurological complaint in adolescence [6], with prevalence ranging between 30 and 80% [6–9]. Many factors are associated with the occurrence of headaches in adolescence, such as

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https://doi.org/10.1016/j.sleepx.2023.100079

Abbreviations

95% CI	95% confidence interval
CAAE	Presentation Certificate for Ethical Appreciation
IHS	International Headache Society
NCS-A	National Comorbidity Survey - Adolescent Supplement
PR	prevalence ratio

hormonal changes (which means female are the most affected group) and behavioral factors (physical inactivity, alcohol consumption, caffeine and other stimulants, and the excessive use of electronic devices) [7,10,11]. Alongside, comorbidities such as mood depression, anxiety, attention deficit hyperactivity disorders, epilepsy, and sleep disturbances may play a role in the origin of headaches during infancy and adolescence [12].

There is evidence that sleep problems and headaches are often comorbid and their association derive from a common underlying pathophysiology, from both an anatomical and a neurochemical viewpoint [13,14]. Headaches may be triggered by sleep disorders, sleep may be used to stifle headaches, and headaches may also be a risk factor for the development of sleep problems [13,15,16]. Youth experiencing general aches/pains, like headaches, tend to have greater difficulty waking in the morning, worse cognitive-emotional arousal around sleep, and worse sleep environments at the baseline [17]. In counterpoint, persistent sleep problems from preschool to school age predict a nine-fold increased risk of having clinically elevated somatic complaints during school age [18], and adolescents with diagnosed insomnia were at increased risk for experiencing somatic distress (poorer perceived physical health), having frequent school absences, and experiencing negative impacts on their personal and family lives [19].

The interaction between sleep and headaches is linked in terms of anatomical location such as the hypothalamus and the brainstem, as well as in terms of signaling pathways including neurotransmitters like serotonin and dopamine [15,20]. Despite the biological plausibility for this association, the particularities of sleep physiology and brain maturation in adolescence demand great research effort and the number of studies addressing this relationship in this population is still small [12,13,21,22].

Thus, the aim of this study was to assess the prevalence of headaches and investigate the strength of the association between sleep problems (the exposure of interest) and headaches (the outcome), among 15-year-old adolescents of the Pelotas 2004 Birth Cohort.

2. Materials and methods

2.1. Sample

The Pelotas 2004 Birth Cohort is a longitudinal population-based study, initiated with newborns from hospital births of mothers residing in the urban area of the city of Pelotas, south of Brazil. From January 1 to December 31 of 2004, all the five hospitals with maternity wards were visited daily, and all mothers living in the urban area of Pelotas and giving birth to alive newborns (N = 4263) were eligible for the study. The mothers of 4231 newborns agreed to take part in the study and they were examined by the research team in the hospital at postpartum. The members of this cohort were followed-up on various occasions: at 3, 12, 24, and 48 months, and at 6, 11, and 15 years of age. More details about the methodology are available [23,24]. The current study included adolescents with available information on the occurrence of headaches and sleep problems at the age of 15.

2.2. Dependent variable

The occurrence of headaches was assessed based on questions extracted from the Cleveland Clinic Headache Intake Questionnaire (Toronto Health and Wellness Centre) applied to the adolescents at the 15-year follow-up by trained lay interviewers through face-to-face interviews. The occurrence of headaches was ascertained through the question “Do you usually suffer from headaches?”. To characterize the headaches, the following were investigated: when the pain generally started (morning, afternoon, end of the day, or at night); intensity (weak, moderate, strong, incapacitating); location (left side, right side, as much on the left as on the right side, on both sides of the head, in the forehead, in the temple, at the back of the eyes, in the nape, in the neck, or other); type (pressure, penetrating like a knife, thumping, like a tight band around the head, burning, constant, or other); and frequency (daily, at least once a week, and at least once a month).

For the analysis, the variables “intensity”, “location” and “types of pain” were re-categorized. The strong and incapacitating intensities were placed in the same group, leaving the variable with three categories: weak, moderate, and strong/incapacitating. The locations were grouped into frontal (in the forehead); temporal (including the left side, right side, as much on the left as the on right side, temple); bilateral (on both sides of the head); occipital (in the nape); at the back of the eyes; and other. The types of pain were grouped into pulsatile (including pain referred to as thumping), pressure (including pressure and like a tight band around the head), penetrating, constant, and other.

Information about associated symptoms and aura (transitory focal neurological symptoms that generally precede but can also accompany the painful episode) was collected. Associated symptoms *(“Do you experience any of these symptoms during your headaches?”)* included: nausea/upset stomach, vomiting, bright lights/sun bothers you, loud sounds bother you, strong smells/odors bother you, dizziness/lightheadedness, vertigo, numbness or tingling, increased sensitivity of scalp/hair/ears, eye tears, runny or stuffy nose, difficulty concentrating, and mood changes/irritability.

The symptoms of aura *(“Do you experience any of the following before your headache begins?”)* included: visual (bright lights, flashes of light, zig-zag lines, multicolored lights, blurred vision), sensorial (numbness or tingling), speech and/or language (aphasia), motor (muscle weakness, paresis), brainstem (buzzing, vertigo, dysarthria, diplopia, hypacusis), and retinal (partial loss of vision).

According to the availability of collected information, the headaches were classified into four types, using the third edition of The International Classification of Headache Disorders (ICHD-3) [44] criteria:

- Headaches with characteristics of migraines without aura:

Headaches that presented at least two of the following characteristics: unilateral location, pulsatile, moderate or strong intensity; and at least one of the following symptoms during the headaches: nausea and/or vomiting and photophobia with phonophobia.

- Headaches with characteristics of migraines with aura:

Headaches that presented at least two of the following characteristics: unilateral location, pulsatile, moderate or strong intensity; and the report of one or more symptoms of aura which were completely reversible.

- Tension-type headaches:

Headaches that presented at least two of the following characteristics: bilateral location, tightness or pressure (non-pulsatile), mild to moderate intensity, without nausea or vomiting.

- Other types:

All the other types that did not fit the previous classifications.

2.3. Independent variables

The questions employed to assess sleep disorders and subjective sleep quality applied at the 15-year follow-up were extracted from the Pittsburgh Sleep Quality Index [26,27]. The frequency of sleep disorders (i.e., insomnia and history of bad dreams/nightmares) in the month prior to the interview included none, <1, 1–2 or ≥3 times/week as answer options. Insomnia was considered when the participant answered a frequency ≥3 times/week to the question about sleep initiation or sleep maintenance problem: *"During the last month, how often did you have difficulty sleeping, because you couldn't get to sleep in the first 30 min?"* and *"During the last month, how often did you have difficulty sleeping, because you woke up in the middle of the night or very early in the morning?"*. History of bad dreams/nightmares was obtained using the question *"During the last month, how often did you have difficulty sleeping because you had bad dreams or nightmares?"*. Self-reported quality of sleep was obtained using the question *"Considering the last month, how would you classify your quality of sleep?"*, with the following answer options: very good, good, poor, very poor. For the analysis, the "poor" and "very poor" categories were combined into one.

A severity score of sleeping problems was created based on reports of insomnia and occurrence of bad dreams/nightmares ≥3 times/week, together with poor/very poor-quality sleep. The score ranged from 0 to 2+, with 0 indicating that the adolescent did not have insomnia or bad dreams/nightmares ≥3 times/week nor poor/very poor-quality sleep, while a score of 1 indicated that he/she had one of the three conditions, and a score of 2+ indicated the presence of at least two of the conditions.

2.4. Potential confounding factors

The selection of covariates as potential confounders was based on previous publications on factors associated with headache in adolescents [28,29]. The covariates obtained in the perinatal study included the family's socioeconomic status, calculated based on the National Association of Research Companies, considering assets, presence of domestic employees and the education level of the household head, which classify the families in five socio-economic levels: A (the wealthiest), B, C, D, and E (the poorest) (for the analysis, the categories were combined in A-B, C, and D-E); maternal depression/nervous problems during pregnancy (no/yes) investigated thorough the question: *"During pregnancy, did you have depression or nervous problems?"* (no/yes); gestational age (<34, 34–36, and ≥37 weeks); low birth weight (<2500 g; no/yes); and sex of the adolescent (male, female). The adolescent's skin color was reported by the mother, in the 6-year follow-up (white, brown, black, or other).

Contemporary variables of the adolescent collected at 15 years included: the family's current socio-economic status, obtained considering a list of household assets, educational level of the head of the family and access to public services, classified as A-B (wealthiest group), C, and D-E (poorest group) [30]; mental health measured through the Strengths and Difficulties Questionnaire with cutoff point ≥17 (no/yes) [31] weekly frequency of consumption of coffee and *chimarrão* (a caffeine-rich beverage highly consumed in South Brazil) (0, 1–3, 4–6, every day); cigarette smoking in the last month (1–5 days, 6–9 days, ≥10 days, every day of the month, I didn't smoke in the last 30 days, and I've never smoked cigarettes); and consumption of alcoholic beverages in the last month (1–5 days, 6–9 days, ≥10 days, every day of the month, I didn't drink alcoholic beverages in the last 30 days, and I've never drunk alcoholic beverages). For the analysis, the categories 1–5 days, 6–9 days, ≥10 days, and every day of the month for smoking and alcoholic beverages consumption were categorized as "yes", and the remaining, as "no". Wheezing in the chest was defined by the question: "Since < same month of the interview application> of last year, have you had wheezing? (no/yes). Physical inactivity was evaluated through the sum of the time from a list of activities performed in the adolescent's free time during the week before the interview, with a cut-off point for inactive of <300 min/week [45]. Screen time was evaluated by the standardized sum of the average time watching television, playing on the cell phone or tablet, playing video games, and using the computer for leisure activities (≤3 h, >3 h/day) [32].

2.5. Statistical analyses

The data from the 15-year follow-up were collected and directly inserted into the RedCap tool (Research Electronic Data Capture) [33]. The statistical analyses were conducted using the Stata statistical package (version 16.0) (College Station, TX: StataCorp LLC. StataCorp. 2017). The descriptive analysis was based on calculation of the absolute and relative frequencies of the covariates. The chi-square heterogeneity test was used to compare characteristics at birth of the participants included in the analyses with the entire cohort. The prevalence of headaches with 95% confidence interval (95% CI) was calculated for the whole sample and stratified by sex. The unadjusted and adjusted prevalence ratios (PR) were obtained by Poisson regression, with a robust adjustment for the variance. *P*-values for heterogeneity or p-values for linear trend for ordinal variables were calculated. All covariables were entered in the multivariable model. Through backward analyses, covariables associated with the outcome with the greatest p-values were removed one-by-one, and only those that were associated with the outcome at p-value ≤0.20 were kept in the final model. The significance level adopted for the two-tailed testing was $p < 0.05$.

2.6. Ethics approval

The study protocol and all follow-ups of the Pelotas 2004 Birth Cohort were approved by the Research Ethics Committee of the School of Medicine of the Federal University of Pelotas. The approval protocol number of the 15-year follow-up was 3.554.667 and that of the Presentation Certificate for Ethical Appreciation (CAAE) was 20183419.1.0000.5317. In all follow-ups informed consent was obtained in writing from the mothers or legal guardians. At 15 years old, the participants also signed a free and informed assent form.

3. Results

Due to the arrival of the COVID-19 pandemic in Brazil [46], the 15-year follow-up rate of the cohort was 50.4%, as follow-up was suspended in March 2020, ahead of schedule. A total of 1924 adolescents answered the instrument for headaches. Eight adolescents had no information on sleep variables and were excluded from the analysis. Thus, the final study sample was composed by 1916 participants. Table 1 compares the sample with the original cohort. Differences between the two samples were not observed.

The occurrence of headaches was reported by 51.6% (49.4–53.9%) of the adolescents (Fig. 1). Prevalence rate of tension-type headaches, headaches with characteristics of migraines without aura, and headaches with characteristics of migraines with aura were, respectively, 31.8% (29.7–33.9%), 14.7% (13.2–16.4%), and 3.6% (2.9–4.6%). Prevalence of headaches overall and subtypes, stratified by sex, can be seen in Table S1. In all cases, the prevalence was higher in females, with an overall prevalence of headache almost twice as high in female (69.0%; 66.0–71.9%) than in male adolescents (34.8%; 31.9–37.9%) ($p < 0.001$).

Table 2 describes the characteristics of pain. Regarding the time of start and intensity of pain, the highest frequencies were for at the end of the day (38.4%) and moderate intensity (45.7%), respectively. More than a third of the adolescents (39.0%) mentioned strong intensity/incapacitating pain. The location of pain more frequently reported was in the temporal area (35.1%) and the most reported type of pain was pulsatile (44.3%). Almost three in every five adolescents with headaches reported having pain at least once a week.

Around 34.0% of the adolescents reported insomnia at the last month and 10.5% reported the occurrence of bad dreams/nightmares ≥3 times/week in the last month (Table 3). Analysis by sex showed that prevalence was higher in females than in males, representing values of 42.9% vs. 25.0% for insomnia and 13.3% vs. 7.8% for bad dreams/nightmares, respectively (results not shown in Tables). The majority (65.2%) classified their own sleep as good. Table 3 also shows the prevalence and the crude and adjusted PR of headaches (all types) according to the frequency of sleep problems and self-reported quality of sleep. Almost two-thirds (65.8%) of the adolescents with insomnia ≥3 times/week and those who classified their sleep as poor/very poor (64.6%) reported headaches, compared with 34.0% and 38.4%, respectively, of those who did not present any sleep initiation or maintenance problem and who considered their own sleep as very good. Approximately 60.0% of the adolescents who reported occurrence of bad dreams/nightmares ≥3 times/week also reported headaches, compared with 45.8% of those who did not present bad dreams/nightmares in the last month.

After confounder adjustment, the probability of the adolescents with insomnia ≥3 times/week presenting headaches was 54% higher than among the adolescents without insomnia (PR = 1.54; 1.23–1.93). Among the adolescents who classified their own sleep as poor/very poor, the probability of presenting headaches was 33% higher (PR = 1.33; 1.13–1.57) as compared to those who classified their sleep as very good. In adjusted analyses, there was no association between bad dreams/nightmares and headaches. When stratified by type of headache, insomnia and bad dreams/nightmares were associated with migraine without aura, whereas poor/very poor sleep quality was associated with migraine without aura and tension-type headache (Table S2).

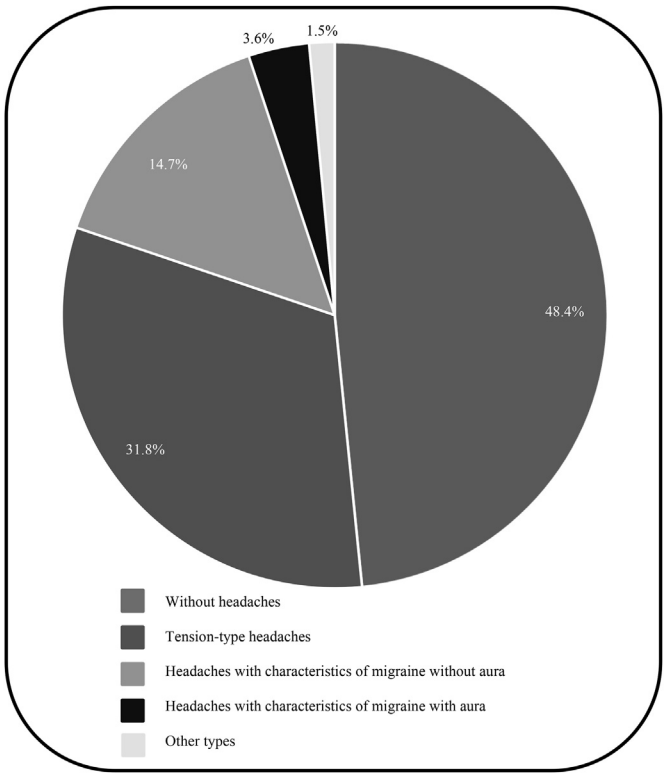

Fig. 1. Prevalence of types of headaches. (N = 1916).

The association between insomnia and headache remained significant when analyzed by sex: the probability was 74% higher in males with insomnia than in those without (PR = 1.74; 1.14–2.65) and 51% higher in females with insomnia than in those without (PR = 1.51; 1.14–2.02 (Table S3). The association with sleep quality remained significant only for females, with a probability 31% higher of headaches occurrence among those who reported poor/very poor sleep quality (PR = 1.31; 1.10–1.57) (Table S3).

Table 1
Sample description and comparison with the original cohort.

Characteristics	Original cohort (N = 4231) N (%)	Sample studied (N = 1916) N (%)	p
Family socio-economic status			0.205
A-B	1557 (47.7)	701 (45.0)	
C	1128 (34.5)	572 (36.8)	
D-E	580 (17.8)	284 (18.2)	
Maternal characteristics			
Depression/nervous problems during pregnancy (yes)	1059 (25.0)	473 (24.7)	0.799
Adolescent characteristics at birth			
Gestational age (weeks)			0.082
< 34	140 (3.3)	44 (2.3)	
34-36	472 (11.2)	208 (10.9)	
≥ 37	3603 (85.5)	1662 (86.8)	
Low birth weight (< 2.500 g) (yes)	423 (10.0)	168 (8.8)	0.135
Sex			0.457
Male	2195 (51.9)	974 (50.8)	
Female	2036 (48.1)	942 (49.2)	
Skin color			0.999
White	2726 (68.2)	1297 (68.2)	
Brown/Black/Other	1272 (31.8)	606 (31.8)	

Table 2
Characteristics of the headache. (N = 989).

Variables	N (%)
Time of start	
Morning	176 (17.9)
Afternoon	297 (30.2)
End of the day	378 (38.4)
At night	133 (13.5)
Intensity	
Weak	151 (15.3)
Moderate	452 (45.7)
Strong/incapacitating	386 (39.0)
Location	
Temporal	347 (35.1)
Frontal	270 (27.3)
Bilateral	125 (12.6)
Occipital	115 (11.6)
Back of the eyes	70 (7.1)
Other	62 (6.3)
Type of pain	
Pulsatile	438 (44.3)
Pressure	367 (37.1)
Constant	103 (10.4)
Penetrating	50 (5.1)
Other	31 (10.3)
Frequency of headache	
Daily	121 (12.2)
At least once a week	589 (59.7)
At least once a month	278 (28.1)

Table 4 presents the unadjusted and adjusted analysis for reports of headaches, according to the severity score. Around 44% of the adolescents reported the occurrence ≥3 times/week of at least one sleep problem or poor/very poor-quality sleep. About three of every four adolescents (73.8%) who scored 2+ reported suffering from headaches. The highest severity score indicated a probability 66% higher of suffering from headaches ($p < 0.001$). A dose-response gradient was observed, with an increase in the prevalence of headaches as the sleep got worse. After the adjustment, the adolescents with a score of 2+ presented a 35% higher probability of suffering from headaches, compared with those with a zero-score (PR = 1.35; 1.22–1.49). Female adolescents with a score of 2+ also presented a 35% higher probability of headaches occurrence when compared to the reference category (PR = 1.35; 1.23; 1.48) (Table S4). Among male adolescents the association lost statistical significance after allowing for confounders.

4. Discussion

This study identified a 51.6% (49.4–53.9%) prevalence rate of headaches, most frequently occurring at the end of the day, with moderate intensity, most often located in the temporal region, and mostly of the pulsatile type. Tension-type headaches represented 31.8% of the headaches. Insomnia ≥3 times/week and poor/very poor sleep were positively associated with the occurrence of headaches. Approximately 44% of the sample reported the occurrence of at least one of the sleep problems evaluated, and there was an increase in the prevalence of headaches as the sleep got worse. The adolescents who accumulated more sleep problems presented a 35% higher probability of having headaches than those who did not report such problems.

In a literature review, including 50 population-based studies with children and adolescents conducted between 1990 and 2007, the prevalence of headaches and/or migraines in any time period, such as in the month prior to the interview or during their lifetime, was 58.4% (58.1–58.8%) [28]. Another review of 64 studies conducted with children and adolescents between 1988 and 2013 found a mean prevalence of headaches of 54.4% (43.1–65.8%) [29]. A recent systematic review of 48 studies published between January 1988 and June 2022, which sought to identify the prevalence of headaches in individuals aged 8–18 years, found a prevalence of 62.0% (53.0–70.0%) [9]. As for the overlapping of the 95%CI, the prevalence of headaches in our study is similar to those reported in the two most recent literature reviews.

The prevalence of headaches including migraines, in most recent studies, varies considerably depending on the instruments, diagnostic criteria, and the length of the recall period. A school-based Austrian study with 3386 participants aged 10–18 years, the prevalence of headaches in a year was 75.7% (74.3–77.1%) [34]. In a Brazilian population-based study with 539 adolescents of both sexes aged 15–19 years, whose instrument for evaluating headaches was similar to the one used in the present study, the prevalence was 38.2% (33.8–42.7%) [35].

In relation to the classification of headaches, the prevalence of headaches with characteristics of migraines and of tension-type

Table 3
Unadjusted and adjusted prevalence ratios (PR) for headaches with 95% confidence interval (95% CI), according to sleep problems and self-reported sleep quality. (N = 1916).

Sleep characteristics	N (%)	Headache prevalence	Unadjusted analysis		Adjusted analysis	
		% (95% CI)	PR (95% CI)	p	PR (95% CI)	p
Insomnia at the last month[a]				<0.001[t]		<0.001[t]
None	162 (8.5)	34.0 (27.1; 41.6)	1.00		1.00	
< 1 time/week	443 (23.1)	40.4 (35.9; 45.0)	1.19 (0,93; 1.52)		1.10 (0,86; 1.40)	
1–2 times/week	664 (34.6)	49.6 (45.8; 53.3)	1.46 (1.16; 1.83)		1.25 (1.00; 1.58)	
≥ 3 times/week	647 (33.8)	65.8 (62.1; 69.4)	1.94 (1.55; 2.42)		1.54 (1.23; 1.93)	
Bad dreams/nightmares at the last month[b]				<0.001		0.205
None	917 (47.9)	45.8 (42.6; 49,0)	1.00		1.00	
< 1 time/week	450 (23.5)	53.8 (49.1; 58.3)	1.17 (1.05; 1.31)		1.12 (1.00; 1.25)	
1–2 times/week	348 (18.2)	58.9 (53.7; 64.0)	1.29 (1.15; 1.44)		1.10 (0.97; 1.23)	
≥ 3 times/week	201 (10.5)	60.7 (53.8; 67.2)	1.33 (1.16; 1.51)		1.09 (0.95; 1.24)	
Self-reported sleep quality[b]				<0.001[t]		<0.001[t]
Very good	333 (17.4)	38.4 (33.4; 43.8)	1.00		1.00	
Good	1250 (65.2)	51.7 (48.9; 54.4)	1.34 (1.16; 1.56)		1.20 (1.04; 1.40)	
Poor/very poor	333 (17.4)	64.6 (59.3; 69.5)	1.68 (1.43; 1.97)		1.33 (1.13; 1.57)	

[a] Adjusted for depression/nervous problems during maternal pregnancy, sex, mental health of the adolescent, weekly *chimarrão* consumption, weekly coffee consumption, and screen time.
[b] Adjusted for depression/nervous problems during maternal pregnancy, sex, mental health of the adolescent, weekly *chimarrão* consumption, weekly coffee consumption, wheezing in the chest in the last year, and screen time.
[t] p for trend.

Table 4
Unadjusted and adjusted prevalence ratios (PR) for headaches with 95% confidence interval (95% CI), according to the severity score of sleep problems and poor-quality sleep. (N = 1916).

Score level	N (%)	Headache prevalence	Unadjusted analysis		Adjusted analysis	
		% (95% CI)	PR (95% CI)	p	PR (95% CI)	p
				<0.001[t]		<0.001[t]
0	1078 (56.3)	44.5 (41.6; 47.5)	1.00		1.00	
1	556 (29.0)	54.1 (50.0; 58.2)	1.22 (1.10; 1.35)		1.10 (0.99; 1.22)	
2+	282 (14.7)	73.8 (68.3; 78.6)	1.66 (1.50; 1.82)		1.35 (1.22; 1.49)	

[1] Adjusted for depression/nervous problems during maternal pregnancy, sex, mental health of the adolescent, weekly *chimarrão* consumption, and screen time.
[t] p for trend.

headaches were quite varied in the different studies, partly due to the employment of the criteria used among adults. Studies suggest that children and adolescents usually have bilateral migraines, contradicting the unilaterality criterion [36,37]. Among children and adolescents, review studies found prevalence of migraines varying between 7.7 and 9.1% [9,28,29]. In studies conducted exclusively with older adolescents aged 14–18 years, this prevalence was higher than 20% [38,39], indicating that the age group may imply variations in the findings of the studies. For tension-type headaches, in turn, independently of the age group, the prevalence fluctuates considerably between the samples and can reach up to 58% [40].

In our study, insomnia and poor quality of sleep were associated with the occurrence of headaches. A study with 1073 children and adolescents aged 8–15 years in Italy [41] showed that the main triggering factor for headaches was poor-quality sleep (32.2%), both for cases of migraines and for cases of tension-type headaches. Moreover, a case-control study with 283 participants aged 5–14 years was one of the first to demonstrate that both migraines and tension-type headaches were associated with different sleep problems [42]. Both studies, however, included a diverse sample, covering children and adolescents, the latter being younger, up to 15 years old, thus making it difficult to provide evidence specifically for the adolescent population.

In our study, the three exposures of sleep were associated with migraine without aura, and those who reported their sleep as poor/very poor were also more likely to present tension-type headache. According to the National Comorbidity Survey – Adolescent Supplement (NCS-A), conducted in the United States, adolescents with some type of headache, particularly migraines, presented more sleep problems (including maintenance insomnia and early waking) than those with no headaches [43]. Similarly, The TEENs Study, conducted with schoolchildren aged 12–18 years in Spain, identified that those with headaches had a shorter duration and lower efficacy of sleep, a lower prevalence of regular sleeping habits, as well as a higher prevalence of insomnia and daytime sleepiness, when compared to adolescents without headaches [7]. Voci et al. found that 72.9% of the 140 patients with migraine experienced sleep problems [16].

This study has limitations. First, although it is longitudinal study, the exposure and the outcome of interest were analyzed cross-sectionally, and so the association was subject to reverse causality bias. However, the aim of the study was not to establish causality, but rather to explore the association between sleep disorders and headaches in adolescents. Associated with this, the bidirectional nature of the association can also be a limitation, making it difficult to define if sleep problems tend to precede headaches or headaches perpetuate sleep problems. Second, it was not possible to use all the criteria for classifying headaches defined by the ICHD-3, as information such as frequency and duration of painful episodes, duration of symptoms of aura, role of routine physical activity in pain aggravation, and time between aura and the start of pain was not available. Additionally, given that migraine in children may be characterized by non-pulsating, bilateral pain, most young migraineurs can easily meet the criteria of tension-type headache [37]. Also, the best diagnostic clinical characteristics of migraine in children and adolescents are pain of moderate or severe intensity, pain aggravated by physical activity, and pulsating quality [37], it is possible that the lack of information on the role of routine physical activity in pain aggravation may have led to underdiagnosis of migraine, in favor of tension-type headache. The third limitation was the difficulty to apply all the criteria for insomnia definition from the International Classification of Sleep Disorders and the Diagnostic and Statistical Manual of Mental Disorders (DSM-5). Finally, although a commonly used instrument to assess headaches characteristics, the Cleveland Clinic Headache Intake Questionnaire (Toronto Health and Wellness Centre) was not tested for validity in Brazil.

Despite these limitations, the sample studied included a large number of adolescents of both sexes, who did not differ in relation to the original cohort. The percentage of adolescents with no information about headaches and sleep was lower than 2%, which prevents selection bias; and the data collection was carried out in a standardized way by trained personnel, with the aim of preventing information bias. Additionally, our study expands upon previous research in the field by adding evidence on the association between sleep and headache among adolescents living in an upper-middle-income country.

5. Conclusions

Prevalence of headaches was high among the adolescents, and was related to insomnia and self-reported poor-quality sleep. The consistency of results, the dose-response gradient, and the biological plausibility supports the hypothesis of association between sleep problems and poor-quality sleep with headaches, although due to the cross-sectional nature of our study we cannot define the temporality between the conditions. Nonetheless, our findings reinforce the importance of investigating the occurrence of both conditions (headaches and sleep disorders or quality), when assessing adolescents complaining of any of these conditions.

CRediT authorship contribution statement

Isabel Oliveira Bierhals: Conceptualization, Methodology, Formal analysis, Writing – original draft, Visualization. **Gabriel Santana Pereira de Oliveira:** Conceptualization, Writing – original draft. **Iná S. Santos:** Conceptualization, Methodology, Writing – original draft, Project administration, Visualization. **Camila S. Halal:** Writing – review & editing, Supervision. **Luciana Tovo-Rodrigues:** Writing – review & editing, Supervision. **Alicia Matijasevich:** Writing – review & editing, Supervision. **Fernando C. Barros:** Writing – review & editing, Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

This article is based on data from the study "Pelotas Birth Cohort, 2004″ conducted by Postgraduate Program in Epidemiology at Universidade Federal de Pelotas, with the collaboration of the Brazilian Public Health Association (ABRASCO). The World Health Organization, National Support Program for Centers of Excellence (PRONEX), Brazilian National Research Council (CNPq) (grant 476727/2003−0), Brazilian Ministry of Health (grants FNS-2799-03 and FNS-4589-04), and Children's Pastorate supported the perinatal phase of the study. The Brazilian Ministry of Health supported the 15-year follow-up. GS, ISS, LTR, AM, and FCB are supported by CNPq.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.sleepx.2023.100079.

References

[1] Chulani VL, Gordon LP. Adolescent growth and development. Prim Care Clin Off Pract 2014;41(3):465−87.
[2] Christie D, Viner R. Adolescent development. BMJ 2005;330(7486):301−4.
[3] Fuhrmann D, Knoll LJ, Blakemore SJ. Adolescence as a sensitive period of brain development. Trends Cognit Sci 2015;19(10):558−66.
[4] Vijayakumar N, Op de Macks Z, Shirtcliff EA, Pfeifer JH. Puberty and the human brain: insights into adolescent development. Neurosci Biobehav Rev 2018;92:417−36.
[5] Steiner TJ, Gururaj G, Andrée C, Katsarava Z, Ayzenberg I, Yu SY, Al Jumah M, Tekle-Haimanot R, Birbeck GL, Herekar A, Linde M, Mbewe E, Manandhar K, Risal A, Jensen R, Queiroz LP, Scher AI, Wang S, Stovner LJ. Diagnosis, prevalence estimation and burden measurement in population surveys of headache: presenting the HARDSHIP questionnaire. J Headache Pain 2014;15(1):3.
[6] Cvetković VV, Plavec D, Lovrenčić-Huzjan A, Strineka M, Ažman D, Bene R. Prevalence and clinical characteristics of headache in adolescents: a Croatian epidemiological study. Cephalalgia 2014;34(4):289−97.
[7] Torres-Ferrus M, Vila-Sala C, Quintana M, Ajanovic S, Gallardo VJ, Gomez JB, Alvarez-Sabin J, Macaya A, Pozo-Rosich P. Headache, comorbidities and lifestyle in an adolescent population (The teens study). Cephalalgia 2019;39(1):91−9.
[8] Xavier MKA, Pitangui ACR, Silva GRR, Oliveira VMA, Beltrão NB, Araújo RC. Prevalência de cefaleia em adolescentes e associação com uso de computador e jogos eletrônicos. Ciência Saúde Coletiva 2015;20(11):3477−86.
[9] Onofri A, Pensato U, Rosignoli C, Wells-Gatnik W, Stanyer E, Ornello R, Chen HZ, De Santis F, Torrente A, Mikulenka P, Monte G, Marschollek K, Waliszewska-Prosół M, Wiels W, Boucherie DM, Onan D, Farham F, Al-Hassany L, Sacco S, European Headache Federation School of Advanced Studies (EHF-SAS). Primary headache epidemiology in children and adolescents: a systematic review and meta-analysis. J Headache Pain 2023;24(8):1−16.
[10] Robberstad L, Dyb G, Hagen K, Stovner LJ, Holmen TL, Zwart JA. An unfavorable lifestyle and recurrent headaches among adolescents: the HUNT Study. Neurology 2010;75(8):712−7.
[11] Moschiano F, D'Amico D, Ramusino MC, Micieli G. The role of diet and lifestyle in adolescents with headache: a review. Neurol Sci 2013;34(S1):187−90.
[12] Bellini B, Arruda M, Cescut A, Saulle C, Persico A, Carotenuto M, Gatta M, Nacinovich R, Piazza FP, Termine C, Tozzi E, Lucchese F, Guidetti V. Headache and comorbidity in children and adolescents. J Headache Pain 2013;14(1):79.
[13] Dosi C, Figura M, Ferri R, Bruni O. Sleep and headache. Semin Pediatr Neurol 2015;22(2):105−12.
[14] Alberti A. Headache and sleep. Sleep Med Rev 2006;10(6):431−7.
[15] Vgontzas A, Pavlović JM. Sleep disorders and migraine: review of literature and potential pathophysiology mechanisms. Headache J Head Face Pain 2018;58(7):1030−9.
[16] Voci A, Bruni O, Ferilli MAN, Papetti L, Tarantino S, Ursitti F, Sforza G, Vigevano F, Mazzone L, Valeriani M, Moavero R. Sleep disorders in pediatric migraine: a questionnaire-based study. J Clin Med 2021;10(16):3575.
[17] Van Dyk TR, Krietsch KN, King CD, Byars KC. Prevalence of somatic and pain complaints and associations with sleep disturbance in adolescents with insomnia presenting to a behavioral sleep medicine clinic. J Clin Sleep Med 2022;18(1):151−60.
[18] Simola P, Liukkonen K, Pitkäranta A, Pirinen T, Aronen ET. Psychosocial and somatic outcomes of sleep problems in children: a 4-year follow-up study. Child Care Health Dev 2012;40(1):60−7.
[19] Roberts RE, Roberts CR, Chen IG. Impact of insomnia on future functioning of adolescents. J Psychosom Res 2002;53(1):561−9.
[20] Tiseo C, Vacca A, Felbush A, Filimonova T, Gai A, Glazyrina T, Hubalek IA, Marchenko Y, Overeem LH, Piroso S, Tkachev A, Martelletti P, Sacco S. Migraine and sleep disorders: a systematic review. J Headache Pain 2020;21(1):126.
[21] Bellini B, Panunzi S, Bruni O, Guidetti V. Headache and sleep in children. Curr Pain Headache Rep 2013;17(6):335.
[22] Tarokh L, Saletin JM, Carskadon MA. Sleep in adolescence: physiology, cognition and mental health. Neurosci Biobehav Ver 2016;70:182−8.
[23] Santos IS, Barros AJD, Matijasevich A, Domingues MR, Barros FC, Victora CG. Cohort profile: the 2004 Pelotas (Brazil) birth cohort study. Int J Epidemiol 2011;40:1461−8.
[24] Santos IS, Barros AJD, Matijasevich A, Zanini R, Cesar MAC, Camargo-Figuera FA, Oliveira IO, Barros FC, Victora CG. Cohort profile update: 2004 Pelotas (Brazil) birth cohort study. Body composition, mental health and genetic assessment at the 6 Years follow-up. Int J Epidemiol 2014;43(5):1337−437.
[26] Buysse DJ, Reynolds CF, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. Psychiatr Res 1989;28:193−213.
[27] Bertolazi NA, Fagondes SC, Hoff LS, Dartora EG, Miozzo ICS, Barba MEF, Menna Barreto SS. Validation of the Brazilian Portuguese version of the Pittsburgh sleep quality Index. Sleep Med 2011;12:7075.
[28] Abu-Arafeh I, Razak S, Sivaraman B, Graham C. Prevalence of headache and migraine in children and adolescents: a systematic review of population-based studies: review. Dev Med Child Neurol 2010;52(12):1088−97.
[29] Wöber-Bingöl Ç. Epidemiology of migraine and headache in children and adolescents. Curr Pain Headache Rep 2013;17(6):341.
[30] Associação Brasileira de Empresas de Pesquisa (ABEP). Critério de classificação econômica Brasil. Alterações na aplicação do Critério Brasil. 2019. válidas a partir de 01/09/2020.
[31] Fleitlich B, Cortázar PG, Goodman R. Questionário de capacidades e dificuldades (SDQ). Infanto Rev Neuropsiquiatr Infanc Adolesc 2000;8(1):44−50.
[32] Sociedade Brasileira de Pediatria (SBP). Recomendações sobre o uso saudável das telas digitais em tempo de pandemia da COVID-18. #MENOS TELAS #MAIS SAÚDE. Manual de orientações; 2020.
[33] Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (Redcap)-A metadata-driven methodology and workflow process for providing translational research informatics support. J Biomed Inf 2009;42(2):377−81.
[34] Philipp J, Zeiler M, Wöber C, Wagner G, Karwautz AFK, Steiner TJ, Wöber-Bongöl Ç. Prevalence and burden of headache in children and adolescents in Austria - a nationwide study in a representative sample of pupils aged 10-18 years. J Headache Pain 2019;20(1):101.
[35] Okamura MN, Goldbaum M, Madeira W, Cesar CLG. Prevalência e fatores associados de cefaleia entre adolescentes: resultados de um estudo de base populacional. Rev Bras Epidemiol 2020;23:e200067.
[36] McAbee GN, Morse AM, Assadi M. Pediatric aspects of headache classification in the international classification of headache disorders-3(ICHD-3 beta version). Curr Pain Headache Rep 2016;20(1):7.
[37] Özge A, Noemi Faedda N, Abu-Arafeh I, Gelfand AA, Goadsby PJ, Cuvellier JC, Valeriani M, Sergeev A, Barlow K, Uludüz D, Yalın OÖ, Lipton RB, Rapoport A, Guidetti V. Experts' opinion about the primary headache diagnostic criteria of the ICHD-3rd edition beta in children and adolescents. J Headache Pain 2017;18(1):109.
[38] Unalp A, Dirik E, Kurul S. Prevalence and clinical findings of migraine and tension-type headache in adolescents. Pediatr Int 2007;49(6):943−9.
[39] Nieswand V, Richter M, Gossrau G. Epidemiology of headache in children and adolescents-another type of pandemia. Curr Pain Headache Rep 2020;24(10):62.
[40] Krogh AB, Larsson B, Linde M. Prevalence and disability of headache among Norwegian adolescents: a cross-sectional school-based study. Cephalalgia 2015;35(13):1181−91.
[41] Bruni O, Russo PM, Ferri R, Novelli L, Galli F, Guidetti V. Relationships between headache and sleep in a non-clinical population of children and adolescents. Sleep Med Rev 2008;9(5):542−8.
[42] Bruni O, Fabrizi P, Ottaviano S, Cortesi F, Giannotti F, Guidetti V. Prevalence of sleep disorders in childhood and adolescence with headache: a case-control study. Cephalalgia 1997;17(4):492−8.
[43] Lateef T, Witonsky K, He J, Ries Merikangas K. Headaches and sleep problems

in US adolescents: findings from the national comorbidity survey - adolescent supplement (NCS-A). Cephalalgia 2019;39(10):1226–35.
[44] Headache Classification Committee of The International Headache Society (IHS). The international classification of headache disorders. third ed., vol. 38. Cephalalgia; 2018. p. 1–211. 1.
[45] World Health Organization (WHO). WHO guidelines on physical activity and sedentary behaviour: at a glance. Genebra: World Health Organization; 2020.
[46] World Health Organization (WHO). Coronavirus disease (COVID-19): situation report –124. 2020. https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200523-covid-19-sitrep-124.pdf?sfvrsn¼9626d639_2.