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Epidemiology of sleep patterns and circadian typology in uruguayan children: The contribution of school shifts

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A R T I C L E I N F O

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A B S T R A C T

Healthy sleep is defined by the combination of adequate duration, good quality, and regular timing. In children, sleep thus depends on the interplay of individual, parental, organizational, community, and social variables, but only a few studies have addressed this issue in a comprehensive way nationwide. Using the Uruguayan nationally representative survey (Nutrition, Child Development, and Health Survey, Encuesta de Nutrición, Desarrollo Infantil y Salud, ENDIS), we present the first epidemiological characterization of chronobiological and sleep parameters in Latin American children. On average, Uruguayan urban children (n = 2437; 5−10-years old) showed quite late chronotypes (MSFsc = 03:53 ± 1:07), moderate misalignment (SJL = 1.0 ± 0.9 h), and adequate sleep duration (SDweek = 9.9 ± 1.0 h). Further, we show the substantial influence of school shift schedules on children's circadian typology and sleep patterns. Our results show that children attending the morning school shift have a higher risk of sleep problems than afternoon-school shift ones. The chronotype and sleep were earlier in morning-school shift children than in children attending the afternoon school shift. However, morning-school shift children had stronger misalignment, shorter sleep on school days, and a higher risk of chronic sleep deficit and non-healthy circadian misalignment (even worse in late chronotypes) than afternoon-shift children. This evidence points to the need of evaluating policies to reorganize school start times to prevent the negative effects that early schooling seems to have on children's sleep health, which has been neglected so far.

1. Introduction

Healthy sleep is defined by the combination of adequate duration, good quality, and regular timing, and is associated with better quality of life, in particular with a lower risk of metabolic and cardiovascular disorders [1–3]. Despite the well-documented benefits of healthy sleep, there is an increasing prevalence of sleep disorders and sleep deficit in modern urban societies. This reality also includes childhood, as it has been reported that an increasing percentage of children do not achieve the minimum recommended sleep duration between 9 and 12 h per night [4–6]. In addition to individual traits such as chronotype, there are relevant factors at levels beyond that also contribute to the inadequate timing and duration of sleep in children [7–9].

The sleep-wake cycle is a circadian rhythm, and thus has an average intrinsic period of around 24 h and individual variations, chronotypes, that depend on both genetic and environmental factors [10–12].

Abbreviations: CCTQ, Children Chronotype Questionnaire; CI, Confidence Interval; ENDIS, Encuesta Nacional de Desarrollo Infantil y Salud (National Survey of Child Development and Health; MS, Mid-Sleep; MSFsc, Mid-Sleep on Free Days corrected by Sleep Debt; OR, Odds Ratio; SD, Sleep Duration; SDweek, Average weekly sleep duration; SES, Socioeconomic Status; SJL, Social Jetlag.

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Although most of the adult population has intermediate chronotypes, some people exhibit strong preferences for staying up late and doing their activities at night (late chronotypes or owls), and others prefer to get up early and schedule their most demanding activities in the morning (early chronotypes or larks). Children exhibit early circadian preferences on average [13,14], while adolescents shift to later circadian preferences associated with pubertal development [15,16]. Lateness itself, and more importantly, the misalignment between the late endogenous clock and early social pressures (social jet lag, SJL), are considered risk factors for various pathologies such as cardiovascular diseases, metabolic conditions, and addictions [3,17,18]. Indeed, recent studies in adolescents have shown that the misalignment, rather than the late chronotype, is the most important factor influencing sleep deficit and academic performance [19–22].

The Uruguayan youth population has proven to be an advantageous model for analyzing the interplay between sleep, chronotype, and circadian misalignment. On one hand, the first records of circadian preferences categorization in Uruguayan adolescents [20] and young adults [23,24] have identified extreme nocturnal preferences and strong misalignment. On the other hand, as in many other Latin American countries, elementary and secondary education is taught in several shifts to maximize school infrastructure usage [25]. Previous reports have shown that high school schedules contribute to differences in chronotypes, circadian misalignment, sleep patterns, and sleep deprivation, with 80 % of morning shift high school students sleeping less than 8 h per day on average [26,27]. Part of these differences stem from the moderating effect of shifts on the influence of chronotypes on social jet lag, sleep patterns, and academic performance [19,26]. It is thus crucial to determine the roots of these issues in Uruguayan childhood, in which there is no epidemiological evaluation of the duration and timing of sleep so far.

Although it is well documented that individual, parental, organizational, community, and social variables shape sleep in childhood and have an influence on the emergence of sleep problems [28], only a few studies have addressed this issue using big databases with national or community representation [7,29–31]. In these studies, characteristics beyond individual level such as socioeconomic status (SES), ethnicity, meal timing, school schedule, type of day, or parenting style, significantly shape children's sleep. Here, we used data from a nationally representative survey to carry out the first categorization of chronotype, circadian misalignment, and sleep patterns of Uruguayan children [32]. Furthermore, we evaluated the influence of school shifts, chronotypes, and other sociodemographic factors on children's circadian misalignment and sleep deficit.

2. Methods

2.1. Design

The present study, in which we carried out the first epidemiological characterization of chronobiological and sleep parameters among Uruguayan children 5−10-years of age, was part of a large-scale nationally representative survey (Nutrition, Child Development and Health Survey, Encuesta de Nutrición, Desarrollo Infantil y Salud, ENDIS, https://www.gub.uy/ministerio-desarrollo-social/endis). ENDIS is a longitudinal survey that follows urban households that were included in the official household survey (Encuesta Continua de Hogares) between February 2012 and December 2013 and had children from 0 to 3 years old [32], with the approval of the Ethical Committee of the Facultad de Medicina, Universidad de la República (March 18, 2013, #070153-000486-13).

2.2. Procedures and participants

This study is based on the third wave of ENDIS, applied in 2019 (June–October).The sample of the first wave corresponds to the Continuous Household Survey (Encuesta Continua de Hogares), in which the design is random and stratified. Then, all households that met the condition of having children under four years of age were selected (sufficient to obtain estimates with reasonable levels of precision and confidence). Between the successive waves, there was a loss of cases from the previous sample due to household moves, migration, death, and exhaustion of respondents. In the third wave, a total of 2474 children responded, 1615 of whom responded to all three waves. To compensate for this deficit in the third wave, the ENDIS sample was renewed by selecting new cases (refresh sample) from the last available Household Survey following the same sample design of the initial wave for the corresponding age period. The survey, answered by the child's primary caregiver, included eight questions related to sleep adapted from the Spanish version of the Children's Chronotype Questionnaire (CCTQ) [13,33] and reduced to a short version similar to the MCTQ validated by Ref. [34]. In addition, as shown in Table 1, we used child demographic information (gender, age, residence), school schedule, and household income, collected by ENDIS.

For our study, we restricted the sample to only children whose caregivers provided complete data on the sleep module questions (n = 2437, 98.5 % of the total sample). Thirty-seven subjects were excluded for having missing data for school hours and/or inconsistent data between sleep end time and school start time. The final sample considered belonged to 2183 households, as 10.0 % of the households had more than one child in the age range.

2.3. Data

Different parameters of sleep timing were used to characterize children's sleep patterns. Sleep onset and sleep end (coded to a resolution of 30 min) of both school days and weekends were directly provided by ENDIS survey and used to calculate sleep duration (SD) and the midpoint of sleep. We computed the chronotype (MSFsc) by the midpoint of sleep on free days corrected for sleep debt on school days, and average weekly sleep duration (SDweek) according to Refs. [16,35]. We calculated SJL as the absolute difference between the mid-sleep on school days and weekends [36]. Sleep duration was considered deficient when SDweek was <9 h (short SDweek), the lower limit for the recommended sleep duration for this age group [4]. The circadian misalignment was considered non-healthy when SJL was ≥ 2h (high SJL; [37–39]. All these chronobiological and sleep parameters were used as outcome variables to test the influence of school shifts. We also evaluated the influence of sociodemographic variables and school shifts on SDweek and SJL

Table 1
Sociodemographic characteristics of participants considered in the study.

	N = 2,437[a]
Age	
5	137 (5.6 %)
6	540 (22 %)
7	728 (30 %)
8	666 (27 %)
9	299 (12 %)
10	67 (2.7 %)
Sex	
Boy	1270 (52 %)
Girl	1167 (48 %)
Region	
Capital city	914 (38 %)
Rest of the country	1523 (62 %)
School shift	
Morning	1502 (62 %)
Afternoon	935 (38 %)
SES (Tertil)	
1	857 (35 %)
2	819 (34 %)
3	761 (31 %)

[a] n (%).

(outcome-dependent variables often used as indicators of children's health and wellness), and how school shifts moderated the associations MSFsc-SJL and MSFsc-SDweek.

As shown in Table 1, we analyzed the effect of the following variables provided by ENDIS on sleep deficit and misalignment: a) age in years; b) sex, it refers to the child's sex reported by the survey respondent and was categorized exclusively into "girls" and "boys"; c) region, it refers to the child's place of residence, which always corresponded to urban areas (that account for 85 % of the Uruguayan population) and categorized into "capital city" (Montevideo with approximately 1.5 M inhabitants) and "rest of the country" (including cities and towns from 5000 to 110,000 inhabitants countrywide); d) school shifts, this classification was established in two shifts depending on school start time: the "morning shift" corresponded to schools that started before 12:00 (mode = 08:00, range between 07:30 to 11:30) while the "afternoon shift" corresponded to the schools that started after 12:00 (mode = 13:00, range between 13:00 to 15:00); and e) socioeconomic status (SES), measured by family income level divided into tertiles.

2.4. Statistical analysis

Statistical analyses were conducted in R Statistical Software [40] using RStudio as an integrative development environment [41]. When characterizing the participants, the difference in discrete variables was assessed using the chi-squared test, the difference in continuous variables between groups was assessed using the *t*-test, and the association between continuous variables was studied using Pearson's correlation coefficients.

Throughout the text, values are presented as mean ± standard deviation in descriptive statistics or marginal mean ± standard error for estimates. Time is presented in military time and was converted to hours for statistical analysis. Values of $p < 0.05$ were considered statistically significant throughout. The data supporting this study's findings are open-access and available at https://www.ine.gub.uy/endis.

3. Results

The age of the participants of this study (n = 2437) was on average 7.3 ± 1.2 years old. As shown in Table 1, younger children (from 5 to 7 years old) and boys slightly prevailed with respect to older ones (from 8 to 10 years old) and girls, respectively. All participants lived in urban environments, and approximately one-third of them were from the capital city Montevideo, where almost half of the total Uruguayan population lives. One especially valuable feature collected by ENDIS was school start times, which extended from 08:00 to 13:30, with approximately one-third of the participants attending school only during the afternoon (Table 1).

3.1. Chronobiological characterization and sleep patterns

The average chronotype corresponded to an MSFsc of 03:53 ± 1:07 (ranging from 00:58 to 09:00). Average SJL was 1.0 ± 0.9 h ranging from 0 to 5.5 with 17.3 % of children suffering a strong circadian misalignment (high SJL ≥2 h). On a weekly average, children slept 9.9 ± 1.0 h ranging from 4.9 to 13.7 h with 14.5 % suffering sleep deficit (short SDweek <9 h). Sleep timing was significantly delayed on the weekends with respect to school days, when children fell asleep and woke up later, resulting in a longer SD (Table A1).

When considering school days and weekend days separately, as shown in Fig. 1, a positive association was observed between school days and weekends SD ($R^2 = 0.13$, B = 0.4 ± 0.1, $p < 0.001$). At the same time, a considerable percentage of children did not reach the recommended minimum of 9 h of sleep (SD < 9 h), either on school days (n = 407, 16.7 %), or on weekends (n = 195, 8.0 %), or both (n = 81, 3.3 %). It is also noticeable that the majority of sleep-deprived children belonged to the morning shift (yellow dots in Fig. 1). Interestingly, children with shorter SD on school days were found to sleep more on weekends on average (fit line above the diagonal dotted line indicating the equivalence of school days and weekends SD in Fig. 1), while children with longer SD on school days tended to sleep less in weekends (fit line below the diagonal dotted line in Fig. 1).

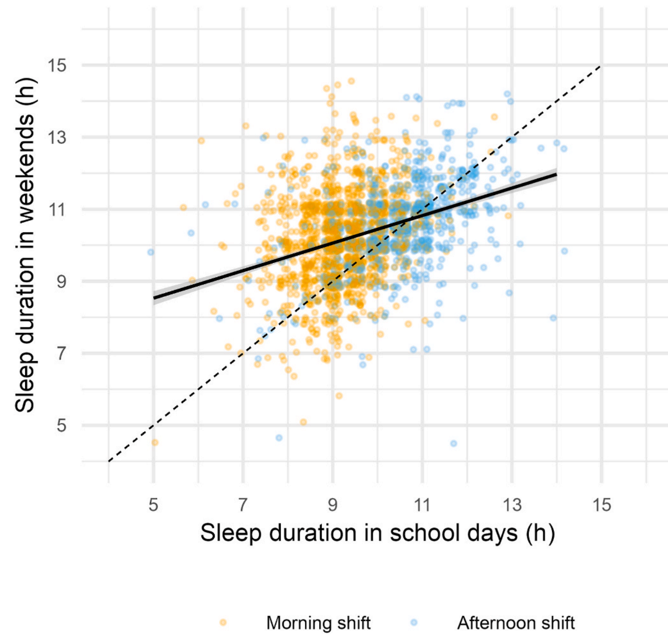

Fig. 1. Scatterplot of reported sleep durations in school vs weekend days (N = 2437). Reported sleep duration in school vs weekend nights of participants attending either the morning (yellow dots, n = 1502) or the afternoon school shift (blue dots, n = 935). The continuous line indicates the estimated association between both sleep durations, while the gray ribbon indicates its 95 % Confidence Interval. The dashed line indicates the 1:1 association between sleep durations.

We found striking differences in chronobiological and sleep parameters between children attending the morning school shift and the afternoon school shift. MSFsc resulted significantly earlier in morning-shift children (03:29 ± 00:56) with respect to afternoon-shift ones (04:31 ± 01:05 h; t = 25.4, $p < 0.001$). As shown in Fig. 2 and Table A2, there were also remarkable differences between shifts in children's sleep patterns between school days and weekends. Children attending the morning shift showed a more pronounced earlier and shorter sleep on school days as compared to weekends than children on the afternoon shift. It is interesting to note that the main difference between shifts was observed in the sleep end of school days (2 h earlier in morning-shift children than in afternoon-shift ones). Early sleep end in morning-shift children, likely forced by early school start times, resulted in a significantly shorter SD with respect to afternoon-shift children in school days, which was not observed on weekends.

3.2. Determinants of sleep deficit and circadian misalignment

We focused on SJL and SDweek as two relevant outcome-dependent variables of circadian misalignment and sleep health, respectively. First, we ran multiple univariate regression models to test the influence of the independent variables presented in Table 1 (age, sex, region, school shift, and socioeconomic status) on SJL. As shown in Fig. 3A and Table A3, age, region, and school shift had predictive power on the dependent variable SJL, while sex and socioeconomic status did not. Each one-year increment in age was associated with a SJL 4.8 min longer (t = 5.1, $p < 0.001$), while children residing in the capital city had a SJL 13 min longer than children residing in the rest of the country (t = −5.8, $p < 0.001$). School shift had a higher predictive power on SJL than the

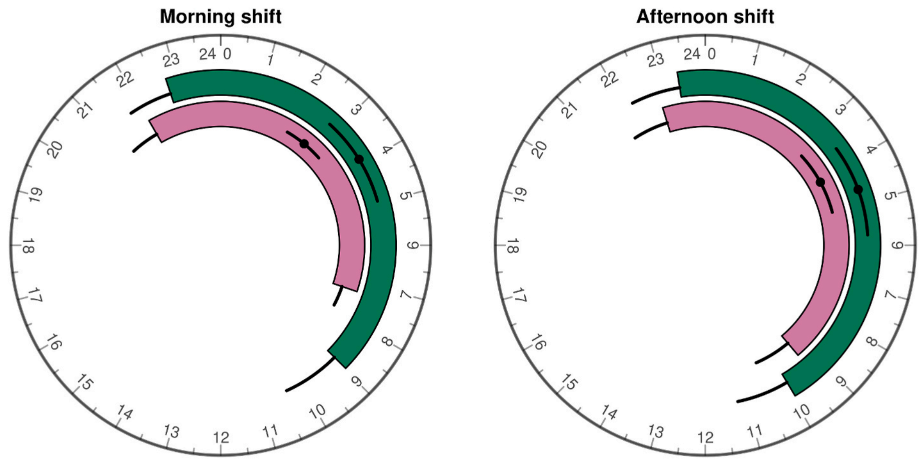

Fig. 2. Sleep pattern of urban Uruguayan children (N = 2437). Each rectangle represents the average night sleep episode on weekends (outer track, green rectangle) and on school days (inner track, pink rectangle) for children attending either the morning school shift (left circle, n = 1502) or the afternoon school shift (right circle, n = 935). Each rectangle extends from the mean sleep onset to the mean sleep end. Dots represent mean mid-sleeps. Lines represent standard deviations.

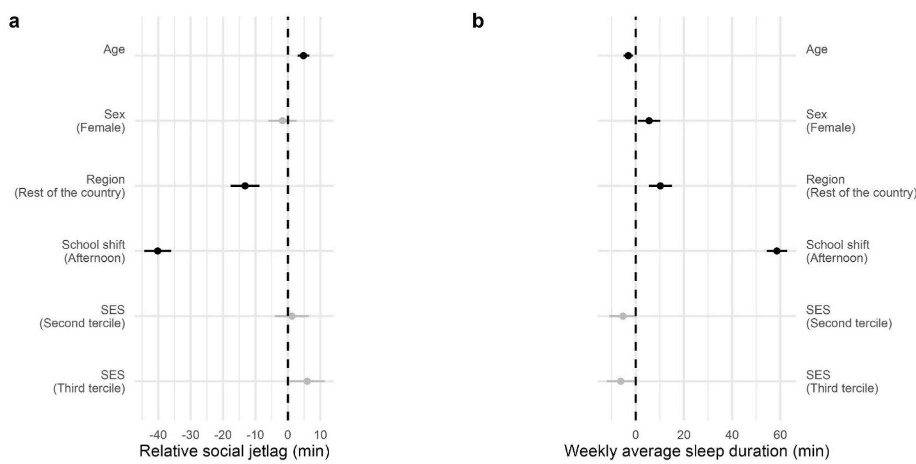

Fig. 3. Coefficient plot for SJL and SDweek univariate regressions (N = 2437). Coefficients for factors predicting a) SJL (min), and b) SDweek (min) are considered in univariate regressions. Dots indicate beta values and lines indicate their 95 % Confidence Intervals and represent the estimated change in minutes in the output variable generated by the change from reference level to the level indicated in parentheses (categorical predictors) or a change in one unit (age, that was mean centered). Positive values indicate increases, while negative values indicate reductions from the reference level. Significant predictors are colored in black while non-significant ones are colored in gray (Table A3).

other independent values; children attending the morning shift had a SJL 38 min longer than afternoon-shift children ($t = -18.9$, $p < 0.001$). As a consequence, 24.2 % of morning-shift children but only 6.2 % of afternoon-shift children had SJL ≥2 h ($z = -10.3$, $p < 0.001$ for the difference in high SJL frequency between shifts; Table A4).

Secondly, we ran multiple univariate regression models to test the influence of the independent variables presented in Table 1 (age, sex, region, school shift, and socioeconomic status) on SDweek. As shown in Fig. 3B and Table A3, age, sex, region, and school shift had predictive power on the dependent variable SDweek, while socioeconomic status did not. Each one-year increment in age was associated with a 3 min shorter SDweek ($t = -3.0$, $p = 0.002$), girls slept 6 min more than boys ($t = 2.3$, $p = 0.021$), and children residing in the capital city had 10 min shorter SDweek than children residing in the rest of the country ($t = 4.1$, $p < 0.001$). The influence of school shift on SDweek was one order of magnitude higher than the other independent values; children attending the afternoon shift slept 58 min more than morning-shift children ($t = 27.1$, $p < 0.001$). As a consequence, 20.9 % of morning-shift children but only 4.3 % of afternoon-shift children had SDweek <9 h ($z = -10.3$, $p < 0.001$ for the difference in short SDweek frequency between shifts; Table A4).

Overall, we have shown that school shifts had a strong influence on MSFsc, SJL (Fig. 3A; Table A3), and SDweek (Fig. 3B; Table A3). Therefore, the question we aimed to address to round up this study was how school shifts moderated the associations MSFsc-high SJL and MSFsc-short SDweek. As shown in Fig. 4A, the probability of having high SJL increased in children with later MSFsc of both school shifts (pseudo-$R^2 = 0.47$), but this association was steeper in children of the morning shift ($\log OR = 2.3 \pm 0.1$, $z = 17.5$, $p < 0.001$) with respect to children of the afternoon shift ($\log OR = 0.8 \pm 0.1$, $z = 6.3$, $p < 0.001$). In children attending the morning shift the probability of high SJL approached 1 when MSFsc values approached the average MSFsc of afternoon-shift children, while in the afternoon shift the most extreme MSFsc values were associated with a high SJL probability slightly above 0.6. On the other hand, as shown in Fig. 4B, the probability of having an insufficient SDweek increased in children with later MSFsc (pseudo-$R^2 = 0.12$) only in the morning shift ($\log OR = 0.3 \pm 0.1$, $z = 4.5$, $p < 0.001$), while this association was not significant in the afternoon shift ($\log OR = -0.1 \pm 0.2$, $z = -0.4$, $p = 0.7$).

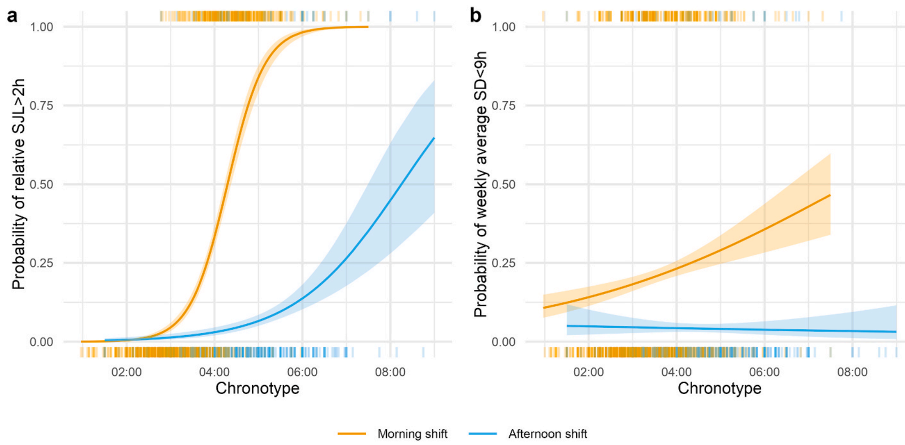

Fig. 4. Estimated association between chronotype (MSFsc) and excessive social jetlag (SJL) and insufficient weekly averaged sleep duration (SDweek) by school shift (N = 2437). Association between MSFsc and a) excessive relative SJL (≥2h), and b) insufficient SDweek (<9h) was studied using generalized linear regressions including the interaction of MSFsc with school shift (yellow: morning shift attendants, blue: afternoon shift attendants). Lines indicate the estimated probability while ribbons indicate its 95 % Confidence Interval. Rugs indicate participants with (above) or without (below) the considered outcome.

4. Discussion

This study contributes the first childhood categorization of chronotype, circadian misalignment, and sleep patterns from nationally representative data in a Latin American country. On average, Uruguayan urban children showed a quite late chronotype (MSFsc around 04:00), a moderate misalignment (SJL around 1 h), and adequate sleep (SDweek around 10 h). This is also the first nationwide study to highlight the paramount influence of school shift schedules on children's circadian typology and sleep patterns: a) children attending the morning school shift had earlier chronotypes, stronger misalignment, and shorter sleep than children attending the afternoon school shift; b) morning-shift children showed earlier and shorter sleep than afternoon-shift ones on school days but not on weekends; c) morning-shift children showed a higher percentage of chronic sleep deficit and non-healthy circadian misalignment than afternoon-shift students; and d) late chronotype children attending the morning school shift, but not the afternoon shift, had an increased risk of both chronic sleep deficit and non-healthy circadian misalignment.

At first glance, the average value (and range) of MSFsc as a proxy of Uruguayan children's chronotype presented in this study does not deviate too much from what was previously reported in related populations of similar age. In other words, Uruguayan children are more late-oriented than Japanese [14] and Swiss children [13], but not later than Portuguese [30] or Spanish ones [38]. In line with this, the average values of circadian misalignment and sleep duration are also comparable to other cultural-related populations [30,33,38,42,43]. This first chronobiological characterization of childhood in a Latin American country is already an important contribution of this study. However, more interesting insights emerge from simply analyzing some of the raw data collected by ENDIS as shown in Fig. 1. For example, Uruguayan children tend to have consistent profiles of sleep duration, i.e., short-sleepers in school days are found to sleep less on weekends as well, and vice versa (long-sleepers in school days also sleep longer on weekends). Maintaining individual sleep styles from school days to weekends has already been suggested in childhood [7]. It is also interesting to note that while most short-sleepers sleep longer on weekends than on school days; most long-sleepers do the opposite. In short, sleep on weekends was delayed in children of both shifts but was longer only among morning shift children. The lack of weekend extended sleep among afternoon attendees has also been reported in adolescents [26,33,44]. A previous meta-analysis using actimetric data found significant differences between sleep on morning school days and sleep on free days in adolescents but not in children [45]. These raw sleep data indicate that school shifts (morning and afternoon shifts displayed in yellow and blue dots, respectively in Fig. 1, Tables A1 and A2) have a strong influence on children's sleep patterns and offer a unique perspective of analysis.

Understanding the social determinants of sleep is key and challenging, especially among children. On one hand, several traits (such as school start times, dinner times, and screen exposure times) impact early-life circadian preferences and sleep health [13,28,38,46]. On the other hand, these traits (and others) are tightly linked to specific socio-cultural contexts with predictable differential influence on sleep patterns across the world. School start times have been recognized as a relevant determinant of chronotype and sleep in children from different continents in previous epidemiological representative studies [29–31]. However, these previous studies did not have the chance to evaluate school start time in a wide range, i.e., school was always in the morning and the reported variation in school start times was never above 2 h. Therefore, this first South American database provides an excellent opportunity to evaluate the real influence of school start times as an exaggerated trait provided by school shifts. The relevant influence of shifts on chronotype and sleep patterns was previously anticipated in volunteered invited populations of adolescents [19,25,26,33] and children [33,44,47], but never evaluated in non-biased nationally representative databases. In line with these previous reports, this study shows that children attending school in the afternoon had later chronotypes, but lower circadian misalignment, and later and longer sleep during school days than children attending school in the morning around the world [7,29,30]. Interestingly, although the duration of sleep on weekends was not different between children of the morning and afternoon school shifts, the huge imposition of early awakening suffered by morning shift children during school days was enough to lead to a significantly shorter SDweek in morning school shift children with respect to afternoon shift ones. School shifts are not only a paramount social pressure for the biological clock and sleep, but also a valuable chronobiological tool to reinforce the general understanding that early school start times are detrimental to sleep health since early childhood.

In addition to the well-known association of late chronotypes with health problems, both sleep deprivation and circadian misalignment stand out as proxies of impaired physical and mental health [48–50]. In line with this, we found that later chronotypes were associated with non-healthy circadian misalignment and sleep deficit, particularly (or exclusively), in children attending the morning shift. On one hand, the later the chronotype the higher the probability of having strong circadian misalignment, but this association was stronger and steeper among children attending the morning shift than in afternoon shift children. On the other hand, the probability of having insufficient SD was positively associated with later chronotypes only in the morning shift children. Previous reports in Latin American children showed associations between evening chronotypes and both misalignment and sleep deficit [33, 44], although differences in these associations between shifts were not evaluated. Previous work on European children attending school in the morning also showed a higher prevalence of high circadian misalignment and sleep deficit in evening chronotypes [13,38,51,52]. In addition, high school students attending school in shifts in Uruguay [26] and in the neighboring country Argentina [21], showed a similar influence of the interaction between chronotype and school shift on circadian misalignment and sleep deficit. Overall, the interplay between chronotypes and social pressures, particularly school start times, emerges as the main influence on sleep timing and duration on weekdays by constraining the sleep opportunity, generating stronger circadian misalignment, and also sleep deprivation.

5. Strengths and limitations

Only a few previous studies, none of them from Latin America, have addressed the epidemiology of childhood sleep and chronobiological parameters using big databases with national or community representation [7,29–31]. Although there is no precedent for an epidemiological evaluation of the duration and timing of sleep in Uruguayan childhood, sleep disorders among Uruguayan children [53] have been shown to have a similar prevalence than in other South American [54,55], North American [56] and European [57] populations. Interestingly, we found a higher proportion of sleep deficit in Uruguayan children with respect to previous reports on children from Spain [38] or from the United States [58].

Data presented in this study collected by ENDIS [32] from 2437 urban children represent the actual population of around 200,000 Uruguayan children within a total population of 3.46 million people. Beyond the high quality and diversity of the ENDIS database, there are some advantageous characteristics of the represented population worth noting for this study. Uruguay is a small country with a homogeneous population, similar cultural customs, and universal coverage of elementary education (around 99.5 %) [59], being these traits helpful in finding trends and associations that can be unnoticed in larger and more heterogeneous populations. On the other hand, this study had the operational advantage that we designed the specific sleep questions included in the ENDIS ourselves (adapted from the validated short Spanish version of the CCTQ) [13,33,34], and monitored the training of the interviewers and of the data processing as well.

Our study also has the expected weaknesses of a huge database obtained by a survey. First, the reported times had a resolution of 30 min. Second, chronotype calculation by the MSFsc requires that participants do not use/need an alarm clock on the "off work" day, but ENDIS used this reduced version of the CCTQ that assumed by default that the alarm clock is not used on weekends. Third, there are several ENDIS parameters about the time spent in different activities (exposure to screens, meal times, physical activity) that do not report their timing or duration, which leads to misuse or underutilization of the database. In particular, ENDIS only reports school start times but does not have data on the total time each child spends in scheduled activities. Fourth, the categorization of morning shift and afternoon shift children was based only on school start times, while some of the morning shift children may also attend school in the afternoon (double shift) and some of the afternoon shift children may also have scheduled activities early in the morning. Interestingly, the lack of this information did not prevent us from observing the clear effect of school shifts on the circadian system and sleep patterns. Fifth, subjectivity is another limitation to take into account as in any survey answered by parents, which always entails personal bias and unintentional errors. Despite these limitations, the rigorous longitudinal design of ENDIS [32] represents the best way to determine community trends from information collected from large cohorts of children. The incorporation of objective measures of activity-rest patterns to ENDIS, as planned to do in future ENDIS cohorts, will certainly reduce some of the limitations of this study and validate its results as well.

6. Conclusions

The results presented in this study point to the potential health risk, especially for late-oriented children, of attending school in the morning, which is the globally widespread primary school schedule. Therefore, our results call for prioritizing sleep health policies in childhood [60,61] and for the development of interventions tailored to the cultural and socioecological factors influencing sleep health, with the child at the center, surrounded by the parents, community, social, and environmental context. In line with what other studies have shown and several public and mental health groups advocate [62–64] regarding the relationship between the delay in school start time and sleep health among adolescents, our research confirms the relevance of considering delaying school start time also for children, as well as of rescheduling children's everyday activities.

Future longitudinal or retrospective studies using the extensive presence of shifts in Latin American educational systems constitute an excellent setup to disentangle whether it is eveningness or its interplay with the social pressures -that generate SJL and sleep deficit-that lead to the observed negative consequences. This near-future perspective implies at least two challenges for Latin America studies to contribute to global epidemiological chronobiology, which are in current progress: a) extend to childhood the studies carried out in adolescents to evaluate the influence of environmental (light exposure) and social (highschool shifts) factors on circadian rhythms and sleep patterns; and b) incorporate objective measurements (actigraphy, hormones) to Latin American epidemiological databases to enhance the statistical validity of potential associations that will become useful inputs for the design of worldwide health and educational policies.

Statement from authors

All authors have seen and approved the manuscript.

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CRediT authorship contribution statement

Andrés Olivera: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Ignacio Estevan:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Conceptualization. **Bettina Tassino:** Writing – review & editing, Writing – original draft, Project administration, Investigation, Funding acquisition, Conceptualization. **Cecilia Rossel:** Writing – review & editing, Writing – original draft, Supervision, Funding acquisition, Data curation, Conceptualization. **Ana Silva:** Writing – review & editing, Writing – original draft, Supervision, Project administration, Investigation, Funding acquisition, Conceptualization.

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.

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Appendix A. Supplementary data

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