

# The sleep of school children

O sono de crianças em período escolar

El sueño de los niños durante el periodo escolar

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## Abstract

**Objective:** To describe and relate individual, family and environmental characteristics, sleep time and 6-sulfatoxymelatonin levels in schoolchildren.

**Methods:** This is a cross-sectional and prospective study, carried out in a private educational institution, with children  $\geq 6$  years old, after ethical approval. An actigraph and sleep diary were used to assess sleep for 15 days. On the last night, urine was collected to measure 6-sulfatoxymelatonin levels. Descriptive analysis and non-parametric tests were carried out on correlations, considering  $p < 0.05$  for significance.

**Results:** The sample consisted of 12 children with a mean age of 7.6 ( $\pm 1.1$ ) years. The mean total sleep time was 7.9 ( $\pm 0.8$ ) hours with an efficiency of 89.9% ( $\pm 2.67$ ). The 6-sulfatoxymelatonin level was 14.4 ( $\pm 8.9$ )  $\mu\text{g}/\text{dL}$ , and the mean daily use of electronic devices was 2.8 ( $\pm 1.8$ ) hours. There was a significant difference in total sleep time between children who studied full or late.

**Conclusion:** Family habits influenced children's sleeping habits, and prolonged use of electronic devices is a concerning factor. Children who study full time had less total sleep time than recommended for their age.

## Resumo

**Objetivo:** Descrever e relacionar as características individuais, dos familiares e ambientais, o tempo de sono e níveis de 6-sulfatoximelatonina em crianças na fase escolar.

**Métodos:** Estudo transversal e prospectivo, realizado em instituição privada de educação, em crianças  $\geq 6$  anos, após aprovação ética. Utilizaram-se actígrafo e diário de sono para avaliação do sono durante 15 dias. Na última noite, foi coletada urina para mensurar o nível da 6-sulfatoximelatonina. Realizaram-se análise descritiva e testes não paramétricos nas correlações, considerando  $p < 0,05$  para significância.

**Resultados:** Amostra foi composta por 12 crianças com idade média de 7,6 ( $\pm 1,1$ ) anos. A média de tempo total de sono foi de 7,9 ( $\pm 0,8$ ) horas com eficiência de 89,9% ( $\pm 2,67$ ). O nível de 6-sulfatoximelatonina foi de 14,4 ( $\pm 8,9$ )  $\mu\text{g}/\text{dL}$ , e média diária de uso de eletrônico foi de 2,8 ( $\pm 1,8$ ) horas. Houve diferença significativa no tempo total de sono entre as crianças que estudavam integral ou tarde.

**Conclusão:** Os hábitos familiares dos responsáveis influenciaram os hábitos de sono das crianças, e o uso prolongado de eletrônicos é um fator preocupante. Crianças que estudam em período integral apresentaram tempo total de sono inferior ao recomendado para a idade.

## Resumen

**Objetivo:** Comprender y relacionar características individuales, familiares y ambientales, tiempo de sonido y niveles de 6-sulfatoximelatonina en niños en edad escolar.

**Métodos:** Estudio transversal y prospectivo, realizado en una institución educativa privada, con niños  $\geq 6$  años, previa aprobación ética. Se utilizó un actígrafo y un diario de sueño para evaluar el sueño durante 15 días. La última noche, se recogió orina para medir el nivel de 6-sulfatoximelatonina. Se realizaron análisis descriptivos y pruebas no paramétricas de correlaciones, considerando para significancia  $p < 0,05$ .

**Resultados:** La muestra estuvo compuesta por 12 niños con una edad media de 7,6 ( $\pm 1,1$ ) años. El tiempo total promedio de sueño fue de 7,9 ( $\pm 0,8$ ) horas con una eficiencia del 89,9% ( $\pm 2,67$ ). El nivel de 6-sulfatoximelatonina fue de 14,4 ( $\pm 8,9$ )  $\mu\text{g}/\text{dL}$  y el uso diario promedio de dispositivos electrónicos fue de 2,8 ( $\pm 1,8$ ) horas. Hubo una diferencia significativa en el tiempo total de sueño entre los niños que estudiaron completo o tarde.

**Conclusión:** Los hábitos familiares de los responsables influyeron en los hábitos de sueño de los niños, siendo el uso prolongado de dispositivos electrónicos un factor preocupante. Los niños que estudian a tiempo completo tuvieron menos tiempo total de sueño del recomendado para su edad.

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Pediatric nursing; Sleep; Bed rest; Child; Child development; Child care

## Descritores

Enfermagem pediátrica; Sono; Repouso; Criança; Desenvolvimento infantil; Cuidado da criança

## Descriptores

Enfermería pediátrica; Sueño; Reposo; Niño; Desarrollo infantil; Cuidado del niño

## Introduction

Upon reaching the age of 6, children enter the middle childhood or school phase, a period of significant impact on their development and relationships, which ends around the age of 12, with the arrival of adolescence.<sup>(1)</sup> For Piaget, children are in the concrete operational period, a phase that presents the ability to reason about the world in a more logical and adult way, but they acquire the ability to carry out these operations only in the concrete.<sup>(2)</sup> For Vygotsky, typically human development occurs only if children are exposed to a culture, appropriating the beliefs, values, traditions and skills of the social group to which they belong.<sup>(3)</sup>

It is during the school phase that children acquire new experiences at school, a new environment that allows the extension of vocabulary and expansion of concepts in conjunction with the nervous system maturation and the formal learning provided by schools.<sup>(4,5)</sup> Thus, the cognitive process will be enhanced depending on previous and current conditions related to sleep, care and the environment.<sup>(6)</sup>

Sleep is essential for adequate neurodevelopment and important for the consolidation of memory and learning.<sup>(7-9)</sup> The lack of ideal conditions for children's sleep can lead to emotional and physical losses, which may reflect on school performance, with difficulties in learning, learning, relationships, among others.<sup>(8,9)</sup>

Sleep structure and duration evolve from the fetal period to adolescence, and encompass genetic, physiological, environmental and social factors that can influence its quantity and quality.<sup>(10-12)</sup> Among the physiological factors, melatonin production stands out, with secretion influenced by environmental luminosity, beginning and progressively increasing at dusk, inducing the tendency to begin sleep.<sup>(13)</sup> Thus, exposure to intense light at dusk causes a reduction or even postponement of its secretion, with repercussions on the sleep-wake cycle.<sup>(12-14)</sup>

For children, from a social point of view, the family environment and quality of life are the main organizers of sleep.<sup>(15,16)</sup> The family environment promotes sleep habits, cultural behaviors learned by children or their guardians, which help sleep onset or maintenance.<sup>(17)</sup> Thus, changes in daily lifestyle habits identified in recent decades, such as prolonged use of artificial lights, excessive use of electronic devices, early

start times for school activities and late start of sleep routine, have significantly influenced sleep time and quality in children.<sup>(16,18,19)</sup>

Sleep deprivation can trigger a decrease in growth hormone (GH) secretion, premature sexual development, a greater propensity to develop obesity and, consequently, greater tendency to diabetes and high blood pressure, increasing the chance of developing mental illness in adulthood, cortisol levels, emotional insecurity, fatigue, depression and learning difficulties.<sup>(10,20)</sup>

Knowing the importance of sleep for child development, the question arises whether schoolchildren are having enough sleep for their age group. Thus, this study aims to describe and relate individual, family and environmental characteristics, sleep time and 6-sulphatoxymelatonin levels in schoolchildren.

Based on the identification of sleep deprivation and non-adoption of healthy sleep practices in schoolchildren, we emphasized the importance of education in a school environment on sleep hygiene for children to acquire healthy habits that promote better sleep quality.

## Methods

This is a cross-sectional, prospective and association study guided by STrengthening the Reporting of OBservational studies in Epidemiology (STROBE) (<http://www.equator-network.org/>).

It was carried out in a private early childhood education institution, located in the municipality of Diadema, state of São Paulo, Brazil. The institution is recognized by the Brazilian Ministry of Education and Culture (MEC - *Ministério da Educação e Cultura*), which assists children who attend elementary school I and high school.

The sample was composed of children enrolled in elementary school I (first to fourth grade) and who were at least 6 years old, characterizing the beginning of school phase. The study excluded children who had a medical diagnosis of neurological and/or behavioral impairment that could interfere with sleep, children with hearing and/or visual deficits, who were using medication that acts on the central nervous system, who had chronic pain, who had some type of respi-

ratory condition, such as asthma, bronchitis, among others, gastroesophageal reflux, or who had an acute illness during the data collection period.

Study variables were composed of sample, environment and family characterization, obtained through a structured questionnaire and sleep characteristics and 6-sulfatoxymelatonin levels of the children studied.

Total sleep time (TST) was measured by actigraphy. It consists of a non-invasive method that uses an actigraph on the wrist, which records individuals' motor activity, obtaining rest and activity data that give an approximate idea of TST. The Condor<sup>®</sup> (Brazil) ActTrust actigraph recorded the light, the ambient temperature, the peripheral body temperature, and measured, through its accelerometer, children's activity depending on the movement of the arm.<sup>(21)</sup> Furthermore, children guardians were asked to fill out a sleep diary consisting of variables such as: time at which children slept and woke up; time and frequency of waking up at night; who they slept with and in which room in the house; presence of light and/or noise in the place where they slept; whether electronic devices were used on the day of data collection; and for what period.

In relation to 6-sulfatoxymelatonin levels, it is highlighted that, due to the possible difficulty of families in collecting and/or storing urine at home for 15 consecutive days and concomitantly with the use of the actigraph by children, we chose to collect urine only on the fifteenth day from 7:00 p.m. to 7:00 a.m. so that it would not coincide with weekend days. Children and their guardians were instructed to collect the entire urinary volume during the specified period and store it in a dark plastic vial provided by the researcher, which should be kept covered and stored in the refrigerator. Children guardians were instructed to fill out a form, indicating the start and end times of urine collection, and also inform the frequency of urination during this period. The data were stored in an electronic spreadsheet for later analysis.

In order to describe the reality of children's habits, no guidance was given regarding the need for the absence of light in the sleeping environment throughout the data collection period.

The research project was presented and explained to parents of elementary school I students by the re-

searcher in a previously scheduled meeting at the school. Subsequently, through children's school diary, an appointment was made with parents at the school with the aim of delivering the actigraph, the questionnaire, the sleep diary and the vial to collect urine. Data collection took place from August to November 2018, a period outside Brazilian summer time.

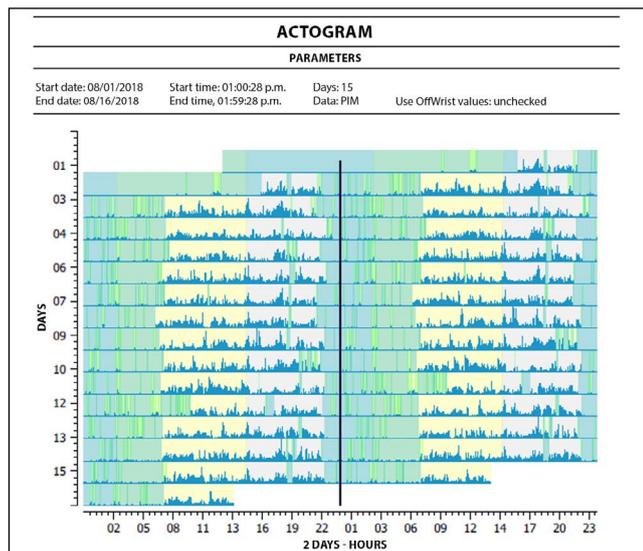
On the day scheduled with children's family members, the researcher positioned the actigraph on children's preferred upper limb, gave guidance regarding the need to keep it on their arm, guided them on how to fill out a sleep diary for 15 days and how to proceed with collecting and storing nighttime urine. After 15 days, the material was collected by the researcher at the school. The vial containing the urine sample was received and transported by the researcher to the laboratory for analysis in a reusable ice pack.

In the laboratory, urine was quantified and stored by the main researcher in two aliquots in a freezer at -80°C for later analysis. Urine colorimetric analysis using the ELISA method was performed by a biomedical doctor in a specialized laboratory at the *Universidade Federal de São Paulo*. Sample quantification was performed by interpolating values on a standard curve.

The data obtained by an actigraph were downloaded into the ActStudio<sup>®</sup> software. Raw activity scores were converted into sleep-wake scores based on computerized scoring algorithms<sup>(22)</sup> assessed by a professional trained to read and interpret them. For analysis, sleep indices were used, including TST and sleep efficiency. The data obtained from a sleep diary were used to support the interpretation of the data generated by the actigraph.

ActStudio<sup>®</sup> generates an actogram with the data recorded by an actigraph. The vertical axis represents the days of the week, and the horizontal axis represents the hours. The peaks of the blue horizontal waves indicate moments of activity, and their absence means rest. In the graph, gray shows the phase of exposure of children to the dark environment, and yellow, exposure to the bright environment (Figure 1).

After assessing the actigraphy, sleep diary and 6-sulfatoxymelatonin levels, data were stored in an Excel<sup>®</sup> spreadsheet. Descriptive analysis was carried out by calculating mean, standard deviation, median, minimum and maximum. To assess sample normality, the Shapiro-Wilk test was used, for equality



**Figure 1.** Actogram and actigraph parameters generated in ActStudio®

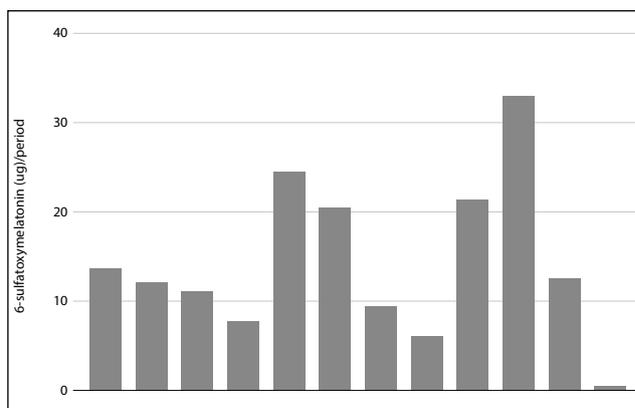
of variances, Levene’s test was used, for comparison, the Mann-Whitney test was used, and for independent samples, the Pearson correlation test was used. To associate variables, chi-square and Fisher’s exact tests were used, considering p-values <0.05 to be statistically significant.

The study was conducted in accordance with national and international ethics guidelines, and was approved by the *Universidade Federal de São Paulo* Research Ethics Committee (Opinion 2.633.064/CAAE (*Certificado de Apresentação para Apreciação Ética* - Certificate of Presentation for Ethical Consideration) 87111918.2.0000.5505). The written Informed Consent Form and the Assent Form (for children) were obtained from all individuals involved in the study.

## Results

The convenience sample consisted of 12 children, six boys and six girls, white (66.7%), with a mean age of 7.6 ( $\pm 1.1$ ), belonging to the 2<sup>nd</sup> grade (50%) of elementary school I, attending school for about 5.9 ( $\pm 1.8$ ) years, with five children studying full time (41.7%). Just over half of children were cared for after birth mainly by their parents or grandparents (58.4%); the majority of guardians work full time (63.6%); and half of guardians had completed high school. We identified a mean of 2.8 ( $\pm 1.9$ ) hours using electronic

devices per day, and it was found that only one child used it daily for six hours and half of children had a television in their room. Most children slept in a shared room (66.7%), in their own bed (66.7%), with the absence of artificial light (83.3%) and did not consume foods or drinks with caffeine at night (66.7%) during the data collection period. From the analysis of the data generated by the records made by an actigraph, it was identified that the mean time at which children went to sleep was 10:53 p.m. ( $\pm 1.5$ ) and that they woke up at 7:59 a.m. ( $\pm 1.6$ ), presenting a mean TST of 7.9 ( $\pm 0.8$ ) hours, with a mean sleep efficiency of 89.9% ( $\pm 2.7$ ). With urine collection at night, a mean excretion value of 14.4 ( $\pm 8.9$ ) ug of 6-sulfatoxymelatonin was obtained. Figure 2 shows 6-sulfatoxymelatonin levels per child.



**Figure 2.** 6-sulfatoxymelatonin level per child

In order to assess the impact of time spent at school on TST, the 12 children were divided into two groups based on the periods they studied at school: group I – full time (8 a.m. to 5 p.m.) and group II – afternoon (1 p.m. to 6 p.m.). Group I had a mean TST of 8.5 hours ( $\pm 0.4$ ), lower than group II, of 9.0 hours ( $\pm 0.3$ ), identifying statistical significance ( $p=0.038$ ). Children in group I woke up earlier than those in group II ( $p=0.005$ ). However, group I went to bed earlier, at 10:03 p.m. ( $\pm 0.8$ ), than children in group II, who went to bed at 11:13 p.m. ( $\pm 1.3$ ), with greater sleep efficiency, 90.4% (88.0-91.6) and 89.7 (84.2-93.4), respectively, with no statistical significance identified. Table 1 shows the distribution of children’s demographic characteristics, activity, rest and 6-sulfatoxymelatonin level.

**Table 1.** Demographic characteristics of children, sleep and 6-sulfatoxymelatonin levels according to GI and GII groups

Variables	GI (n=5)	GII (n=7)	p-value
Age in years (Q1-Q3)	7 (7-7)	8 (6-9)	1.000 <sup>a</sup>
Sex - f (%)			0.203 <sup>a</sup>
Female	3(57.1)	3(42.8)	
Male	2(42.8)	4(57.1)	
Total sleep time in hours during the week (SD)	8.5 (±0.4)	9.0 (±0.3)	0.038 <sup>d</sup>
Total sleep time in hours on weekends (SD)	10.2 (±0.8)	9.5 (±0.9)	0.213 <sup>d</sup>
Bedtime during the week (SD)	22h03 (±0.8)	23h13 (±1.3)	0.132 <sup>d</sup>
Bedtime on weekends (SD)	22h25 (±1.4)	23h54 (±1.9)	0.181 <sup>d</sup>
Wake up time during the week (SD)	06h36 (±0.48)	08h15 (±1.2)	0.005 <sup>a</sup>
Wake up time on weekends (SD)	08h39 (±1.8)	09h27 (±1.6)	0.467 <sup>d</sup>
Sleep efficiency, mean % (Q1-Q3)	90.4 (88.0-91.6)	89.7 (84.2-93.4)	0.755 <sup>a</sup>
Use of electronic devices h/day (SD)	1.6 (±1.5)	3.6 (±1.7)	0.515 <sup>a</sup>
Use of artificial light at night - f (%)			0.600 <sup>b</sup>
Yes	0(0)	2(28.6)	
No	5(100.0)	5(71.4)	
Ingestion of caffeinated food at night - f (%)			0.30 <sup>b</sup>
Yes	3(60.0)	1(14.3)	
No	2(40.0)	6(85.7)	
6-sulfatoxymelatonin in ug/period (SD)	17.1 (±8.5)	10.5(±8.9)	0.223 <sup>d</sup>

SD - standard deviation; f - frequency; Q1 - 1<sup>st</sup> quartile; Q3 - 3<sup>rd</sup> quartile; <sup>a</sup> - Mann-Whitney test; <sup>b</sup> - generalization of Fisher's exact test; <sup>d</sup> - t-test

## Discussion

It is possible to notice that children who study full time sleep less than what is recommended in the literature, which recommends that children aged 6 to 12 years sleep 9 to 12 hours per night.<sup>(23)</sup> The result of this study is similar to research that aimed to validate the use of an actigraph in children, which showed a mean of 8.4 hours of TST in children with an average of 9.3 years.<sup>(24)</sup> Children who study in the afternoon have a mean TST corresponding to the recommended minimum.

However, it is clear that sleep efficiency, the proportion of time an individual sleeps in relation to the total time spent sleeping in bed during the night, is adequate in both groups, supporting a review study that aimed to compare actigraphy and polysomnography, in which the sample of children who did not present any sleep disorder showed 80.5% efficiency.<sup>(24)</sup> Therefore, it is estimated that children who study full-time are sleeping less than recommended, but they have less fragmented sleep during this period, i.e., possibly quality sleep.

In the results, it can be seen that most guardians have full-time jobs and that many of the children possibly go with them, waking up early and arriving home late. Parental actions are extremely important for sleep quality and quantity in children, and they

can influence their children's sleeping habits, as their activity and sleep patterns affect their bedtime and wake-up routine.<sup>(25)</sup> Furthermore, parents are responsible for creating a physical environment conducive to optimal sleep for children, who have little control over their environment.<sup>(26)</sup>

An adequate sleep environment must be devoid of electronic devices and screens, which are responsible for insufficient sleep in 30% of young, preschool and schoolchildren in the United States, with 75% reporting the presence of at least one screen media device in their room, with around 60% reporting regular use of these devices for an hour before bed.<sup>(27)</sup> Evidence suggests that using electronic devices can negatively affect sleep.<sup>(17,28)</sup>

Thus, using electronic devices may be associated with lower TST. The children studied are using electronic devices for 2.8 hours on average per day. According to the American Academy of Pediatrics, for children aged 6 and older, limits should be imposed on the time spent using media of all types and ensure that it does not replace sleep, physical activity and other behaviors essential to health.<sup>(17)</sup>

In the present study, it is possible to observe that children who study in the afternoon make greater use of electronic equipment and sleep later than those who study full time. Research with children aged 3

to 6 years old, using actigraphy, demonstrated that sleep start time, duration and efficiency were associated with exposure to screens, indicating that children with later bedtimes, shorter sleep durations and poorer sleep efficiency tend to have longer screen exposure times.<sup>(29)</sup>

This exposure to electronic devices before bed, due to the light emitted, causes nocturnal suppression of melatonin, which in children is greater than in adults in identical light conditions, influencing the circadian timing system and causing phase delay.<sup>(30)</sup> Exposure to light - especially blue light - and use of screens before bed affect melatonin levels and can delay or interrupt sleep, impairing school performance.<sup>(31)</sup>

In this study, the mean value of 6-sulfatoxymelatonin secretion was 14.4 ( $\pm 9.0$ ) ug/period. Precursor research, with a sample of 99 children with a mean age of 8.4 years, which aimed to investigate the relationship between the urinary excretion rate of 6-sulfatoxymelatonin and children's age, identified a mean level of 10.1 ( $\pm 0.6$ ) ug/period of 6-sulfatoxymelatonin secreted at night.<sup>(32)</sup> Melatonin is extremely important for the normal neurodevelopment of children, as it has anti-inflammatory/antioxidant action and regulates their circadian cycle and, consequently, sleep, improving mood, intellectual development and health as a whole.<sup>(33,34)</sup>

The present study was carried out in a private educational institution, therefore, the data obtained do not portray the reality of all students. Children who attend public schools may be in a less favorable socioeconomic context that will interfere with sleep. A more polluted and noisy neighborhood around the home, in addition to having less security, can result in sleep deprivation.<sup>(35)</sup> Studies describe that living in poorer neighborhoods is associated with lower sleep quality and quantity.<sup>(36,37)</sup>

Limitations of this study include sample size and loss of urine samples from some children, making it impossible to perform a global analysis of all outcome variables, implying the impossibility of generalizing the results. Furthermore, as mentioned, an actigraph assesses activity and rest, estimating TST.

The fact that the research was carried out only in a private educational institution is also a limitation of this study.

## Conclusion

Family and/or guardian habits have influenced children's sleeping habits, and prolonged use of electronic devices is a concerning factor, as it exposes children to blue light, especially at night, which impairs melatonin secretion. However, melatonin values in this study were within those expected in the literature. Schoolchildren who study full-time had lower TST during the week than recommended in the literature, with a statistically significant difference between children who study full-time and those who attend school in the afternoon. Even though they slept less time than recommended in the literature, the full study group had normal sleep efficiency, possibly presenting quality sleep. More studies, with larger and varied samples from a socioeconomic point of view are necessary for conclusive results.

## Collaborations

Llaguno NS, Camargo VHG, Tsunemi MH, Pedrazzoli Neto M, Pinheiro EM and Avelar AFM declare to have contributed to study design, data collection, analysis and interpretation, manuscript writing, relevant critical review of intellectual content, and approval of the final version to be published.

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