Original Article

Salivary cortisol levels and biological rhythm in schoolchildren with sleep bruxism

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ABSTRACT

Objective: Salivary cortisol levels and biological rhythms could be hypothesized as part of the multi-factorial framework that explains bruxism etiology. The objective of this study was to examine salivary cortisol levels and biological rhythms in schoolchildren with sleep bruxism (SB).
Methods: This is a cross-sectional study with a school-based sample. The Biological Rhythms Interview for Assessment in Neuropsychiatry for Kids (BRIAN-K) was used to evaluate biological rhythms. Salivary samples were collected by the spitting method. The salivary cortisol level was measured by electro-chemiluminescence. The criteria proposed by the American Academy of Sleep Medicine (AASM) were used to evaluate SB.
Results: The SB prevalence was 16%. The SB presence was associated with belonging to families of lower economic status ($p = 0.003$). In addition, children with SB showed greater difficulty in maintaining biological rhythm ($p = 0.002$) and had higher levels of salivary cortisol ($p = 0.034$) compared with children without SB.
Conclusions: Higher levels of cortisol and disruption of biological rhythm was associated with SB in schoolchildren.

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1. Introduction

Bruxism is defined as a repetitive jaw–muscle activity characterized by clenching or grinding of the teeth and/or by thrusting of the mandible. It occurs in two circadian manifestations, namely, sleep and awake bruxism, and can lead to tooth damage, pain, and disturbed sleep [1]. Questionnaires (self-report and/or parent-reports) with or without physical examination are used in most studies to detect this condition, providing a possible or probable diagnosis of sleep bruxism (SB), respectively. However, a definite diagnosis can be achieved only by means of polysomnographic recordings [2]. The prevalence of SB in children ranges from 5.9% to 49.6%, depending on the method of diagnosis used and characteristics of the sample [3]. No gender difference has been reported in SB [4].

A possible association between SB and biological rhythms could be hypothesized as part of the multifactorial framework that explains bruxism etiology [5]. Biological rhythm is defined by biological changes repeated at regular intervals, such as secretion of hormones, sleep/wake cycle, and regular food intake [6]. Difficulties in maintaining the regulation of biological rhythm can be related to health outcomes. In this regard, some studies show the worst quality of sleep among children with SB, suggesting the presence of sleep disorders [7,8].

The ability of the circadian clock to adapt to environmental changes is critical for maintaining homeostasis. However, if the human body or cells experience significant stress, their ability to regulate internal systems (including circadian rhythms) may become impaired [9]. It has been reported that stress increases the activity of the hypothalamic–pituitary–adrenal (HPA) axis and alters the pattern of cortisol secretion, an important hormone used as a biomarker of psychological stress [10]. The determination of free cortisol can be measured in the saliva easily. This is a noninvasive method of collection and consists in an advantage of particular relevance for ambulatory assessments and for studies in children

[11]. Although the literature suggests that the role of cortisol in stress is very important, it is unclear whether those symptoms are consistently associated with larger or smaller awakening cortisol responses, including bruxism in children [12,13].

Stress sensitivity, evaluated by salivary cortisol, may be a psychological factor associated with bruxism. According to a case−control study, high levels of stress increase the chance of exhibiting the muscular activity of SB among children [14]. SB is subject to constant discussion in different health areas due to potential etiologic associations [3]. However, the knowledge about this condition is inconclusive, and studies with children are scarce. The objective of this study was to evaluate salivary cortisol levels and biological rhythms in schoolchildren with SB.

2. Methods

This was a cross-sectional study with a school-based sample. The sample consisted of seven- and eight-year-old schoolchildren enrolled in primary schools in the city of Pelotas, Rio Grande do Sul, Brazil. This study was part of a larger project entitled "Healthy childhood in context: a multidisciplinary research." The research protocol was approved by the Human Research Ethics Committee of the Universidade Católica de Pelotas (UCPel) under protocol number 843.526.

Twenty public schools were selected by systematic random sampling. All the children who fulfilled the inclusion criteria were invited to participate in the study. The inclusion criterion was regular attendance at the selected schools. The exclusion criterion was inability of the child or the parents or caregivers to understand or to answer to the questions on the instruments because of a medical condition or severe disability.

Data collection began after the parents or caregivers provided written informed consent. It was divided into two steps: (1) the assessment of children during classes in their school, and (2) the interview with parents or caregivers at their homes.

A socio-demographic questionnaire was used to obtain information about the child and the family. The National Economic Index measured the economic status. Its use enables the calculation of scores for households from information on the ownership of a set of assets, household characteristics, and the household head's education [15], referred to as income tertiles.

The Biological Rhythms Interview for Assessment in Neuropsychiatry for Kids (BRIAN-K) was used to evaluate the biological rhythms and had as informants parents or caregivers. The BRIAN-K assessed difficulties in maintaining the overall biological rhythm and in the four domains of biological rhythm: sleep, activity, social rhythms, and eating pattern. For all BRIAN-K domains, higher scores indicate greater difficulty in maintaining the biological rhythm. This scale was designed to measure biological rhythm disruptions in Brazilian children and adolescents. The internal consistency was considered acceptable with Cronbach's alpha of 0.871 [16].

Salivary samples of children were obtained at the schools by the spitting method [17]. The saliva collected was maintained at −20 °C until analysis. A commercial kit was used to evaluate the salivary cortisol levels according to the manufacturer's instructions (Roche Diagnostics, Mannheim, Germany), by the electrochemiluminescence technique with a COBAS 6000 analyzer (Roche). Salivary cortisol levels were expressed as nanograms per milliliter (ng/mL).

The criteria proposed by the American Academy of Sleep Medicine (AASM) in the International Classification of Sleep Disorders−3rd edition (ICSD-3) [1] was adopted in this study to diagnose SB. According to these criteria, SB is diagnosed when there is a report of tooth grinding sounds occurring during sleep, and the

presence of one or more of the following clinical signs and/or symptoms: presence of abnormal tooth wear, and/or reported fatigue, pain, or discomfort in the chewing muscles upon awakening.

To assess the presence of dental wear, physical examination of the children's oral cavity was performed through a visual examination performed by a single trained and calibrated postgraduate student in pediatric dentistry, with the assistance of one recorder (dentistry student) at the schools, under natural light, following World Health Organization (WHO) biosafety guidelines [18]. The child was accommodated sitting on an ordinary chair, with the head facing a source of natural light, the examiner sitting facing him or her, using gauze, a mirror examination probe (community periodontal index probe), and millimeter scale (flexible plastic ruler). The correct record of the data and the visualization of the examination were enabled by the position. To standardize the dental wear patterns, the following criteria were used: (0) absent; (1) dental wear of the enamel only; (2) dental wear of the enamel and dentin; (3) dental wear of up to one-third of the length of the crown; and (4) dental wear more than one-third of the length of the crown. Children who had grade 2 or higher in at least one tooth were considered to meet positive diagnostic criteria [19].

Statistical analysis was carried in SPSS, version 22 for Windows and GraphPad Prism 6.0. Categorical variables were shown by absolute and relative frequencies, and numerical variables were shown by mean and standard deviation or by median and quartile intervals, according the distribution of the variables. A χ^2 test was used to assess differences in variables between the groups with and without SB in the crude analysis. Moreover, a t test or Mann−Whitney test was used according the distribution of the variables. Spearman correlation was conducted to analyze salivary cortisol levels and BRIAN-K scores. Linear regression was performed to adjust for the variables with $p \leq 0.20$ in the crude analysis. The level of significance considered for all tests was 5%.

3. Results

In total, 551 schoolchildren were evaluated. Boys (52.8%) and girls (47.2%) were included in similar proportions. The mean number of hours of sleep was 10.07 (± 1.40).

Table 1 shows the sociodemographic and clinical characteristics regarding SB. The prevalence of SB in the sample was 16%. Having SB was associated with belonging to families of lower economic status ($p = 0.003$). Regarding clinical characteristics, children with SB showed greater difficulty in maintaining the overall biological rhythm than did children without SB ($p = 0.002$). The median of the salivary cortisol levels was higher for children with SB, as compared to children without SB ($p = 0.034$). There was no association between cortisol levels and difficulty in maintaining the biological rhythm ($r = 0.042$; $p = 0.324$).

According to the biological rhythm domains, children with SB showed higher difficulty in maintaining the sleep ($p = 0.009$), activity ($p = 0.038$), social rhythms ($p = 0.044$), and eating pattern ($p = 0.030$) than children without SB (Fig. 1).

Children from families of lower economic status had higher levels of salivary cortisol ($p < 0.001$). After adjusting analysis for economic status, the increase in cortisol salivary levels remained associated with SB ($\beta = 0.015$; 95% confidence interval = 0.001−0.0029; $p = 0.036$).

4. Discussion

In this school-based sample, the prevalence of SB using the ICSD-3 was 16%. The presence of SB was associated with belonging to families of lower economic status. In addition, children with SB showed greater difficulty in maintaining biological rhythms and

Table 1
Sample sociodemographic and clinical characteristics regarding sleep bruxism.

Variable	Total	Sleep bruxism		p
		Yes	No	
Gender[a]				0.160
Boys	291 (52.8)	53 (18.2)	238 (81.8)	
Girls	260 (47.2)	35 (13.5)	225 (86.5)	
Economic status[a]				0.003
Lower	184 (33.4)	39 (21.2)	145 (78.8)	
Intermediate	184 (33.4)	31 (16.8)	153 (83.2)	
Upper	183 (33.2)	18 (9.8)	165 (90.2)	
Hours of sleep[b]	10.07 (±1.40)	10.08 (±1.32)	10.07 (±1.41)	0.941
BRIAN-K overall[c]	9.00 (4.00–19.00)	12.00 (7.00–22.75)	8.00 (4.00–18.00)	0.002
Salivary cortisol[c]	0.091 (0.067–0.136)	0.097 (0.074–0.156)	0.089 (0.066–0.128)	0.034
Total	551 (100)	88 (16.0)	463 (84.0)	

BRIAN-K, Biological Rhythms Interview for Assessment in Neuropsychiatry for Kids. Sleep Bruxism was diagnosed according to Ekfeldt et al., 1990.
[a] Data are n (%), analysis by χ^2 test.
[b] Data are mean (±SD), analysis by t test.
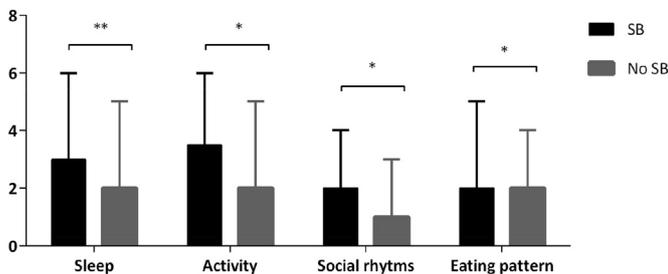[c] Data are median (25%–75%), analysis by Mann–Whitney test.

Fig. 1. Differences in biological rhythms domains across sleep bruxism. Legend: SB: sleep bruxism; *p < 0.050; **p < 0.010.

had higher levels of salivary cortisol as compared with children without SB. Current interpretations of bruxism in adults suggest that it may be considered as a behavior that can become a risk factor for possible clinical consequences [20]. During childhood, although the condition may be part of an ongoing physiological maturation of the central nervous system, another possible explanation has been emphasized in literature, which is line with the present findings. It states that a personality profile of the bruxing child has been developed featuring high levels of responsibility and of neuroticism in particular, as well as the presence of other psychological and social factors, mainly concerning peer relationships and behaviors [21,22]. Furthermore, when SB begins during childhood, there is a need for more attention, since this condition may persist over the years, remaining in the adult phase.

The prevalence of SB is quite discrepant in the literature, varying according to how it is evaluated and the characteristics of the sample studied [3]. The exact rate is hard to determine, given the absence of a validated and universal diagnostic criteria for SB in children. Moreover, most studies are usually based on self-report questionnaires due of the cost and infrastructure required for technical evaluation from a scientific point of view, such as polysomnography [23].

A 35.3% prevalence of bruxism was found among schoolchildren ranging from 7 to 11 years old [21]. In comparison, we found a lower SB prevalence in our sample; this difference can be explained by the absence of dental wear evaluation in the cited study, although other criteria from AASM were considered. Meanwhile, in a 7- to 17-year-old population in orthodontic treatment, 15% of the patients reported the condition, which was more prevalent among the youngest ones (≤12 years of age) [7]. In the study by Tachibana et al. [24], there was an association between SB and age, and the

prevalence was higher among the group aged five–seven years (21.0%). This may explain the prevalence of SB in our sample, since schoolchildren were between seven and eight years old, and it has been shown that SB decreases with age.

In the literature, little information was available on sociocultural issues. Of note, contrary to findings of previous investigations that did not identify an association with social vulnerability and SB, in our study there was association between SB and belonging to economically disadvantaged families [21,24,25]. However, it is known that a low socioeconomic status is associated with higher psychosocial stress [26], which may affect SB.

In our sample, children with SB had more difficulty in maintaining the biological rhythm in all domains (sleep, activities, social rhythm, and eating pattern). In regard to the domain of sleep maintenance, in a study with a clinical population, the SB group reported more sleep problems (daytime sleepiness, feeling unrefreshed in the morning, and difficulty waking up) and several behavioral complaints, as being easily distracted and interrupting or intruding on other peoples' conversations, than the control group [7]. Moreover, other studies show that sleep disturbances such as sound and light stimuli, as well as reduced sleep time (<8 h) presented strong associations with SB in schoolchildren [27,28]. These behavioral complaints, especially, can be related to the difficulties in the social domain evaluated by biological rhythm instrument used in our study, as well as low academic performance and health damage.

Emotional stress, sleep conditions, high media consumption, and adverse dietary habits have been identified as risks of bruxism in children and adolescent in a review of the literature from 2007 to 2016 [29]. In the Suwa et al., [30] study, SB in children was strongly related to the disturbance of sleep habits and lifestyle, such as poor eating habits and excessive use of media. Ribeiro et al., [31] reported that nocturnal agitation and nightmares were associated with SB in children, but the association between SB and chronotype profile was not found according to the applied scale. These findings appear to be in line with biological rhythm alterations, but not with chronotypes. Pain or tense feeling in the jaws upon awakening and the report of feeling stressed was also associated with a higher prevalence of SB among adolescents [32].

Children who sleep poorly present with greater fluctuations in neuroendocrine functioning, and this seems to be related to greater psychological stress [33]. Current studies suggest that investigations of the association between bruxism and different chronotype profiles need to continue to be conducted. These

investigations could performed by using specific instruments for assessing the circadian cycle and stress levels, such salivary cortisol, since both are related to the biological internal clock [5]. However, we did not find a correlation between cortisol levels and altered biological rhythm, suggesting that these alterations are independently associated; that is, that bruxism is associated with a higher level of stress, as demonstrated through the increase of salivary cortisol, as well as with biological rhythm alteration, independently.

In this regard, studies that demonstrate the association between SB and cortisol levels have contradictory results; the role and significance of these levels are not fully understood [34,35] and with populations of schoolchildren are still scarce. A study conducted by Castelo et al., [13] that evaluated children with a mean age of seven years showed that children with SB had lower concentrations of salivary cortisol on awakening, whereas a study with nine-year-old children did not find an association between salivary cortisol and SB [25]. Studies with eight- to nine-year-old children using actigraphic monitoring of sleep showed that short and poor sleep was related to increased cortisol levels [33—36], and children with insomnia symptoms also had increased cortisol levels [12]. Similarly, in our study, we found association between cortisol levels and SB, which means that children with bruxism had greater psychological stress than those without SB. Our results are consistent with the literature and suggest that, under conditions of psychological stress, there is an increase in cortisol levels due to overstimulation of the HPA axis [37].

Finally, bruxism could contribute to temporomandibular disorders (TMD) [38]. Kobayashi et al., [39] observed no significant differences in the salivary cortisol between children with and without TMD; however, case and control groups included children with bruxism. We believe that this methodological choice made it impossible to test the possible association between this stress biomarker and bruxism, since the latter is a condition for the TMD manifestation.

This study design does not allow us to draw conclusions as to cause-and-effect relations, and represents generalizable information for public school students. However, we have a probabilistic sampling. The methodology of our research was conducted with accuracy. Saliva collection used a standard protocol, and provided a biological measure of stress. Regarding the diagnosis of SB, the ASSM considers that although polysomnography is not required for the diagnosis, SB is ideally recorded with masseter muscle activity with audio-video sign to increase diagnostic reliability [1]. In a population of children, high economic costs, limited availability, technical requirements, and scarce evidence for its use in diagnosing SB limit the use of PSG [40]. Thus, similar to most studies, reports of sleep tooth grinding by parents have been adopted to detect SB. Despite the possible limitations, parent-reported SB is still viewed as an acceptable means of gathering data for studies involving large numbers of participants, such as the present one [20]. Moreover, a dentist performed clinical evaluation of tooth wear consistent with reports of tooth grinding during sleep.

5. Conclusion

In conclusion, a high prevalence of sleep bruxism was found among schoolchildren. The factors associated with the occurrence of the outcome were low socioeconomic level as well as difficulties in sleep maintenance, activity, social rhythm, and eating patterns. In addition, children with bruxism had higher levels of stress, which can impair childhood development. Thus, the present study adds to the comprehension of factors associated with SB in children. Future investigations of endogenous biological rhythm biomarkers could be useful.

Conflicts of interest

The authors declare that they have no conflict of interest in regard to this work.

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: https://doi.org/10.1016/j.sleep.2018.09.031.

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