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Original Article

Validity of the Brief Infant Sleep Questionnaire (BISQ) in Brazilian children

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ABSTRACT

Objective: To investigate the validity of the Brief Infant Sleep Questionnaire (BISQ), in assessing sleep quality in childhood.

Methods: This was a validation study with children from the Pelotas 2015 Birth Cohort. BISQ was applied to mothers when their children were 3, 6, 12, and 24 months of age. The poor sleep indicators analysed, as defined by BISQ, were >3 wakings per night, nocturnal wakefulness >1 h and total sleep duration <9/24 h, compared to number of wakings per night and nocturnal and total sleep duration defined by actigraphy taken as the gold standard. The Actiwatch wGT3X-BT device was used by the child consecutively during five days at three and six months and for three days at 12 and 24 months. At each age the prevalence, sensitivity, specificity, accuracy, and positive (PPV) and negative predictive values (NPV) of each sleep indicator was calculated.

Results: A total of 586 children were enrolled in the study. Nocturnal wakefulness >1 h was the most frequent indicator at all ages, with higher sensitivity (varying from 27.5% at six months to 54.8% at three) and lower specificity (53.4% at three months to 79.4% at six months), in comparison to the other sleep indicators. Specificity for >3 wakings and total sleep duration <9 h was greater than 85.0% at all the ages. Higher accuracies were observed for total sleep <9 h at 3 (85.6%), 6 (88.2%) and 12 months (73.6%) and for > 3 wakings at 24 months (84.5%). The sensitivity for the presence of at least one indicator decreased with age from 56.0% at three months to 35.8% at 24 months, whereas the specificity increased from 50.6% at three months to 63.8% at 24 months.

Conclusion: The high specificity of the BISQ sleep parameters supports the validity of parents' reports on sleep-related problems in childhood for use in epidemiological studies.

1. Introduction

Sleep problems are among the most prevalent complaints presented to paediatricians and other professionals involved in children's healthcare. With an estimated prevalence of about 25% [1,2], sleep problems are directly associated with the child's mental and physical health [3–5]. Nocturnal wakefulness is one of the principal sleep disorders and has been associated with behavioral problems in childhood [6,7]. The prevalence rate of sleep-related problems and their consequences for physical and mental health highlight the need for screening instruments able to identify children at increased risk of presenting sleep disturbances.

Sleep assessment in early childhood has been a challenge in epidemiological studies [8]. Polysomnography is considered the gold standard for assessing sleep problems however its use is still limited because it requires expensive equipment and complex evaluation. Actigraphy has being considered an alternative to polysomnography as it provides an objective estimate of sleep patterns based on the child's movements. The technique uses devices similar

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to a watch, placed preferably on the child's ankle or wrist [9]. In children up to three years of age, actigraphy showed good agreement with polysomnography [10] and direct observation [11,12]. Actigraphy has the advantage of allowing to assess sleep objectively and non-invasively, providing continuous information for long periods of time and under different environmental conditions [9,11].

Due to its practicality and lower cost, subjective tools such as sleep questionnaires and diaries are widely used in epidemiological studies [13–15]. An additional advantage of sleep questionnaires over other methods is that a second visit to recover the sleep measuring device is unnecessary. Although parents' observation can be less sensitive for assessing sleep quality variables (such as nocturnal wakings) than to assess other measures such as sleep duration [16], studies that compared parents' report with actigraphy measurements [17–22] found good agreement between the two methods, especially in regard to total sleep duration. None of these studies however were conducted in Brazil, where previous studies have reported different sleep habits in childhood compared to those seen in children in wealthy countries [23,24]. Thus, the current study was planned to assess the validity of the Brief Infant Sleep Questionnaire (BISQ) [22] when compared to actigraphy among Brazilian children aged 3, 6, 12 and 24 months.

2. Methodology

2.1. Participants

The study was conducted with the 586 participants of an educational intervention conducted with a subsample of children from the Pelotas 2015 Birth Cohort [25]. At the cohort's three-month follow-up, the eligibility criteria for the intervention were children born at term, from singleton pregnancies, with no history of admission to neonatal intensive care units, who slept on average less than 15 h in 24 h, and whose homes had at least one bedroom [26].

2.1.1. Brief Infantile Sleep Questionnaire (BISQ)

BISQ was developed and validated by Sadeh [22] with the purpose of screening sleep problems in children 0–3 years of age. The semi-structured questionnaire consists of 12 general questions on sleep, referring to the week prior to the interview, to be answered by the parents or caregivers. The questionnaire takes about 10 min to answer. The reliability, validity, and applicability of the BISQ for screening sleep problems was originally assessed in comparison with actigraphy and sleep diaries [22]. The instrument was translated to Brazilian Portuguese by Nunes et al., [27].

In the current study, BISQ was applied to mothers when the children were 3, 6, 12, and 24 months of age. BISQ defines poor quality of sleep when at least one of the following criteria is satisfied: > 3 wakings per night, nocturnal wakefulness >1 h and total sleep time <9 h in 24 h. The questions from BISQ used for this assessment were: *"On average, how many times a night does your child wake up?"* to assess the number of night wakings; *"How much time does your child spend in wakefulness during the night (from 10 at night to 6 in the morning)?"*, to assess nocturnal wakefulness; and the questions *"How much time does your child spend in sleep during the NIGHT (from 7 in the night to 7 in the morning)?"* and *"How much time does your child spend in sleep during the DAY (from 7 in the morning to 7 at night)?"*, to estimate total sleep duration.

2.2. Actigraphy

The actigraph device used in the study was Actiwatch wGT3X-BT, placed on the child's left ankle by field personnel specifically trained for this purpose. At three and six months of age, the infants used the device consecutively for five days (thus providing recordings for three full days), and at 12 and 24 months, for three days (thus providing information for one full day), due to the logistic planning of the main cohort. Then, to standardize the analyses we used records from one only full day at all follow-ups. The data recorded by the devices were downloaded to a computer and edited using the Actilife 6.1 software. Actigraphy data were collected in 5-s epochs and reintegrated in 60-s epochs for analysis. Epochs were classified as sleep or wakefulness using the classification algorithm proposed by Sadeh et al., [28]. Likely sleep periods were defined as beginning at the first of three consecutive 60-s epochs classified as sleep and as ending at the first of fifteen consecutive 60-s epochs classified as wakefulness after sleep onset [29]. Additionally, a third rule was applied: To define a sleep period, at least 15 60-s epochs classified as sleep between sleep onset and sleep end were required. Data obtained from the actigraphy device included nocturnal sleep duration, daytime sleep duration, total 24-h sleep duration, number of night wakings (lasting at least 5 min each), and nocturnal wakefulness. Nocturnal wakefulness was defined as the total time between 10:00 p.m. to 6:00 a.m. when the child was awaken.

2.3. Independent variables

The independent variables employed to the sample description were household assets index in quintiles, maternal age (categorized as < 20, 20–29, and ≥30 years), maternal education (categorized as 0–4, 5–8, 9–11, and ≥12 full years of school), maternal self-reported skin color (white, brown, black, or other), mother's marital status (with or without spouse/companion), and child's sex.

2.4. Analyses

We first conducted a descriptive analysis of the study's participants according to the child's sex and mother's sociodemographic characteristics. Next, for each age, we calculated the mean (standard deviation - SD), median (interquartile range - IQR) and minimum and maximum values for number of night wakings, duration of nocturnal wakefulness and total sleep duration in 24 h, according to the recording method (actigraphy or BISQ).

The validity of each of the BISQ indicators was assessed separately. We also assessed the validity when only one or when only two or when all three BISQ indicators were present. We calculated the prevalence, sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy of BISQ, with the respective 95% confidence interval (95% CI) of each indicator. Sensitivity was calculated as the proportion of children with actigraphy records indicating >3 night wakings, nocturnal wakefulness >1 h and total sleep duration <9 h that were identified as such by BISQ. Specificity was calculated as the proportion of children with actigraphy records indicating ≤3 night wakings, nocturnal wakefulness <1 h and total sleep duration ≥9 h that were identified as such by BISQ. Accuracy was the proportion of children with positive and negative results in agreement between the two methods. PPV was the proportion of children with the presence of the sleep indicator by BISQ that were confirmed by actigraphy (truly positive answers); and NPV was the proportion of children with truly negative answers among all those who reported absence of the indicator by BISQ. All the analyses were performed with Stata® (*Stata Corporation, College Station*, USA), version 14.0.

2.5. Ethical issues

The Pelotas 2015 Birth Cohort Study was approved by the Institutional Research Board of the School of Physical Education of the Federal University of Pelotas (protocol number 267446414.5.0000.5313), and the intervention study was registered in ClinicalTrial.gov under number NCT02788630. All the interviews were performed after the child's mother, father or legal guardian signed the free and informed consent form.

3. Results

The mothers of most of the 586 children included in the study were 20–29 years old (51.7%), had ≥ 9 years of schooling (65.6%), lived with a spouse or companion (84.3%), and reported white skin color (68.9%) (Table 1).

Table 2 provides a description of the means (SD) and minimum, maximum, and median values (IQR) of the sleep indicators obtained from actigraphy and BISQ. According to the two methods, total sleep duration decreased between six and 24 months of age. In addition, mean nocturnal sleep and total sleep durations at all ages were more similar between the two methods than were the mean and median numbers of night wakings and duration of nocturnal wakefulness.

Table 3 shows the prevalence rates for >3 night wakings, nocturnal wakefulness >1 h, and <9 h of total sleep duration in 24 h for each age, according to the gold standard (actigraphy) and BISQ. Of the three indicators of poor sleep, nocturnal wakefulness >1 h was the most prevalent at all ages according to the two methods. At three and twelve months, the prevalence of >3 night wakings according to BISQ was about six times lower than that recorded by actigraphy; and at six and 24 months the prevalence was twice as lower than that recorded by actigraphy. Prevalence of total sleep duration <9 h by BISQ was even lower than the prevalence recorded by actigraphy at all ages (Table 3).

At all ages, nocturnal wakefulness presented the highest sensitivity (54.8%, 27.5%, 33.0%, and 27.8% at 3, 6, 12, and 24 months, respectively). In terms of specificity, at three and six months, total sleep duration <9 h presented the highest specificity (98.3% and 94.5%, respectively), whereas at 12 and 24 months, > 3 night wakings had the highest specificity (96.6% and 95.1%, respectively).

Table 1
Description of the sample according to sociodemographic variables at perinatal follow-up.

Sample characteristics	N	%
Household assets index in quintiles		
1st (poorest)	107	18.7
2nd	131	22.9
3rd	112	19.5
4th	123	21.5
5th (richest)	100	17.4
Mother's age (years)		
<20	88	15.1
20-29	302	51.7
≥30	194	33.2
Mother's schooling (complete years)		
0-4	47	8.0
5-8	154	26.4
9-11	199	34.1
≥12	184	31.5
Mother's skin color		
White	395	68.9
Black	96	16.8
Brown	79	13.8
Other	3	0.5
Mother's marital status		
With spouse/companion	483	84.3
Without spouse/companion	90	15.7
Child's sex		
Male	318	55.5
Female	255	44.5

At three, six and 12 months, the most accurate indicator in comparison to the actigraphy records was sleep duration <9 h with 85.9%, 88.2% and 73.6% of truly results as recorded by actigraphy, while at 24 months > 3 night wakings presented the highest accuracy (84.5%).

Except at six months, when the prevalence of infants with poor sleep indicators was lower, at the remaining ages more than half of the sample presented at least one of the poor sleep indicators according to actigraphy. The sensitivity for the presence of at least one indicator decreased with age from 56.0% at three months to 35.8% at 24 months, whereas the specificity increased from 50.6% at three months to 63.8% at 24 months. The accuracy for presence of at least one indicator of poor sleep was 54.0%, 59.1%, 47.9%, and 48.6% at 3, 6, 12, and 24 months, respectively.

4. Discussion

In this study the specificity of the BISQ for most of the indicators was high, suggesting a high confirmatory power of BISQ when it is positive for poor sleep quality. Parents' reports on sleep-related problems showed to be reliable, thus strengthening the importance of subjective instruments in identifying sleep-related problems in childhood. We found no studies that have assessed the validity of BISQ by estimating its sensitivity and specificity to compare with our findings, but some evaluated correlation or agreement. A study with Israeli children aged 3–18 months aiming to compare three sleep assessment methods (actigraphy, sleep diaries and BISQ) found high correlation and low agreement between actigraphy and the subjective methods [30]. Nonetheless, a study conducted in Switzerland with 54 children aged 4–7 years, compared measures derived from questionnaire, diary and actigraphy and identified good agreement between actigraphy and the questionnaire for the beginning and end of sleep period and poor agreement for total sleep duration and waking time [18].

According to BISQ, the prevalence of poor sleep at three, six, twelve, and 24 moths was 53.6%, 31.8%, 31.6%, and 36.0%, respectively; whereas the prevalence according to actigraphy was 63.1%, 35.9%, 59.3% and 54.2%, respectively. Corroborating with our findings, a study conducted by Thomas et al. [31], with two-year-olds, assessed sleep quality through the BISQ and found a prevalence of poor sleep of 31.0%. In addition, another study using BISQ and conducted in Turkey with nine-month-old infants found a prevalence of poor sleep similar to ours of 32.0% [32].

Although the BISQ can be considered appropriate for correctly identifying children with sleep problems, we found low sensitivity of the instrument in identifying children that woke up more than three times a night or that slept less than 9 h in 24 h. Nocturnal wakefulness greater than 1 h was the indicator with the highest sensitivity. There are some possible explanations for such results. One is the fact that BISQ is dependent on the report by the parents or guardians. If the child does not cry nor demands the parents' attention, it is less likely that the parents will be aware that the child is awake, and they will thus not report these wakings [13,20,22]. In this sense, it is plausible to expect that the sensitivity will be even lower at more advanced ages, as the child begins to cope with sleep alone rather than demanding the parents' help, and thus the reported number of nocturnal wakings and duration of nocturnal wakefulness tend to be less accurate. A recent study noted low agreement between actigraphy and the parents' report of night wakings when the children were 18 months old, as compared to children with three and six months of age [30]. Another factor that may influence parents' perception is bed-sharing. If the child sleeps with their parents', they may be

Table 2
Description of sleep variables according to actigraphy and BISQ.

Variables	Actigraphy measures				BISQ measures			
	Mean (SD)	Minimum	Maximum	Median (IQR)	Mean (SD)	Minimum	Maximum	Median (IQR)
3 months								
Nocturnal sleep duration, h	8:12 (1:42)	4:12	13:00	8:06 (2:18)	8:00 (1:18)	4:00	12:00	8:00 (2:00)
Total sleep duration, h	11:24 (2:12)	5:42	20:06	11:06 (3:06)	12:12 (1:30)	6:00	14:48	12:30 (2:00)
Night wakings, number	3.3 (1.4)	0.0	7.0	3.0 (2.0)	1.5 (1.3)	0.0	8.0	1.0 (2.0)
Nocturnal wakefulness, h	1:18 (1:24)	0:00	5:54	1:00 (2:12)	1:30 (1:06)	0:00	6:00	1:30 (1:00)
6 months								
Nocturnal sleep duration, h	9:06 (1:54)	4:48	15:48	8:54 (2:24)	9:00 (1:42)	4:00	14:00	9:00 (2:00)
Total sleep duration, h	11:48 (2.1)	7:06	17:30	11:36 (2:30)	12:12 (2:06)	5:18	17:00	12:00 (3:18)
Night wakings, number	2.4 (1.3)	0.0	7.0	2.0 (1.0)	1.9 (1.3)	0.0	8.0	2.0 (2.0)
Nocturnal wakefulness, h	0:42 (1:00)	0:00	4:24	0:00 (1:06)	0:48 (1:00)	0:00	7:00	0:30 (0:54)
12 months								
Nocturnal sleep duration, h	8:00 (1:36)	2:36	14:18	7:54 (1:54)	8:30 (1:24)	4:00	12:00	8:30 (1:30)
Total sleep duration, h	10:12 (1:42)	5:30	15:54	10:06 (2.2)	11:36 (1:48)	5:30	17:00	11:30 (2:30)
Night wakings, number	2.6 (1.5)	0.0	7.0	3.0 (2.0)	0.9 (1.2)	0.0	6.0	0.0 (2.0)
Nocturnal wakefulness, h	1:18 (1:18)	0:00	6:12	1:00 (2:12)	0:54 (1:00)	0:000	5:00	0:30 (1:30)
24 months								
Nocturnal sleep duration, h	8:12 (1:24)	5:06	11:48	8:12 (2:06)	7:48 (2:00)	0:30	12:00	8:00 (2:00)
Total sleep duration, h	10:12 (1:42)	5:30	15:54	10:06 (2:12)	10:54 (2:00)	4:18	16:00	11:00 (2:00)
Night wakings, number	2.1 (1.2)	0.0	7.0	2.0 (2.0)	0.9 (1.2)	0.0	6.0	0.0 (1.0)
Nocturnal wakefulness, h	1:00 (1:12)	0:00	6:30	0:24 (1:36)	0:54 (1:00)	0:00	5:00	0:00 (1:30)

IQR: interquartile range (Q75-Q25).
SD: standard deviation.

more alert to perceive the child's waking periods. In our sample, about 50.0% of the children shared a bed with their mother at 3, 12, and 24 months of age (data not shown). Sensibility analysis after stratification by bed-sharing showed that at 12 and 24 months, the BISQ sensitivity was higher among children who shared a bed with their mother in comparison to those who did not (36.0% versus 21.3% at 12 months and 40.8% versus 26.7% at 24 months, respectively) (Supplementary Table). Thus, parents who sleep with children in the same bed actually become more alert to notice the periods of child wakefulness.

Table 3
Validity of the indicators[a] for sleep quality compared to actigraphy in children 3, 6, 12, and 24 months of age.

Indicators of sleep quality	Prevalence by actigraphy (95%CI)	Prevalence by BISQ (95%CI)	Sensitivity (95%CI)	Specificity (95%CI)	PPV (95%CI)	NPV (95%CI)	Accuracy (95%CI)
Children 3 months of age							
>3 night wakings	45.4 (40.8–50.0)	7.2 (5.1–10.0)	7.0 (4.0–11.3)	92.6 (88.7–95.5)	44.1 (27.2–62.1)	54.5 (49.7–59.2)	53.7 (49.1–58.3)
Nocturnal wakefulness > 1 h	49.6 (44.9–54.2)	50.6 (46.0–55.2)	54.8 (48.1–61.3)	53.4 (46.8–59.9)	53.6 (47.0–60.1)	54.6 (47.9–61.2)	54.1 (49.4–58.7)
Sleep duration < 9 h	12.9 (10.0–16.3)	1.5 (0.6–3.1)	0.0 (0.0–6.0)	98.3 (96.5–99.3)	0.0 (0.0–4.1)	86.9 (83.5–89.9)	85.6 (82.1–88.7)
1 indicator[b]	63.1 (58.5–67.5)	53.6 (48.9–58.2)	56.0 (50.1–61.8)	50.6 (42.8–58.3)	66.0 (59.7–71.9)	40.2 (33.6–47.1)	54.0 (49.3–58.6)
2 indicators[c]	35.4 (31.0–39.9)	5.6 (3.7–8.2)	5.5 (2.5–10.2)	94.3 (91.0–96.6)	34.6 (17.2–55.7)	64.6 (59.9–69.1)	62.9 (58.3–67.3)
3 indicators[d]	8.9 (6.5–11.9)	0.2 (0.0–1.2)	0.0 (0.0–8.6)	99.8 (98.7–100.0)	0.0 (0.0–97.5)	91.1 (88.1–93.5)	90.9 (87.9–93.4)
Children 6 months of age							
>3 night wakings	18.9 (14.9–23.3)	9.1 (6.3–12.7)	6.1 (1.7–14.8)	90.1 (86.1–93.3)	12.5 (3.5–29.0)	80.5 (75.7–84.7)	74.3 (69.4–78.8)
Nocturnal wakefulness > 1 h	27.3 (22.9–31.9)	22.5 (18.5–26.9)	27.5 (19.4–36.9)	79.4 (74.3–83.9)	33.3 (23.7–44.1)	74.5 (69.3–79.3)	65.3 (60.4–69.9)
Sleep durations < 9 h	6.9 (4.6–9.9)	5.4 (3.4–8.1)	3.7 (0.1–19.0)	94.5 (91.6–96.6)	4.8 (0.1–23.8)	93.0 (89.9–95.4)	88.2 (84.6–91.3)
1 indicator	35.9 (30.8–41.3)	31.8 (26.8–37.0)	37.2 (28.6–46.4)	71.3 (64.8–77.2)	42.1 (32.6–52.0)	67.0 (60.5–73.0)	59.1 (53.6–64.3)
2 indicators	14.2 (10.7–18.4)	6.8 (4.4–10.1)	4.2 (0.5–14.3)	92.7 (89.1–95.4)	8.7 (1.1–28.0)	85.4 (80.9–89.1)	80.1 (75.5–84.2)
3 indicators	3.0 (1.5–5.2)	0.6 (0.1–2.1)	0.0 (0.0–30.8)	99.4 (97.8–99.9)	0.0 (0.0–84.2)	97.0 (94.6–98.6)	96.4 (93.9–98.1)
Children 12 months of age							
>3 night wakings	25.3 (21.1–29.9)	3.5 (2.2–5.4)	1.0 (0.03–5.5)	96.6 (93.8–98.4)	9.1 (0.2–41.3)	74.2 (69.5–78.5)	72.3 (67.6–76.7)
Nocturnal wakefulness >1 h	49.6 (44.6–54.6)	30.3 (26.5–34.2)	33.0 (26.4–40.1)	75.0 (68.4–80.8)	56.1 (46.5–65.4)	53.6 (47.5–59.5)	54.3 (49.3–59.3)
Sleep in 24 h <9 h	24.0 (20.0–28.9)	5.1 (3.5–7.3)	6.4 (2.4–13.4)	95.2 (92.1–97.4)	30.0 (11.9–54.3)	76.0 (71.3–80.3)	73.6 (68.9–78.0)
1 indicator	59.3 (54.2–64.3)	31.6 (27.0–36.5)	32.8 (26.7–39.2)	70.1 (62.2–77.1)	61.5 (52.2–70.1)	41.7 (35.7–47.9)	47.9 (42.8–53.0)
2 indicators	31.9 (27.2–36.8)	4.4 (2.6–7.0)	4.1 (1.3–9.2)	95.4 (92.2–97.6)	29.4 (10.3–56.0)	68.0 (63.0–72.8)	66.3 (61.4–71.0)
3 indicators	8.5 (6.9–11.7)	0,0 (0.0–58.3)	–	–	–	–	–
Children 24 months of age							
>3 night wakings	11.6 (8.4–15.4)	4.9 (2.9–7.8)	5.0 (0.6–16.9)	95.1 (92.0–97.2)	11.8 (1.5–36.4)	88.4 (84.5–91.7)	84.5 (80.4–88.3)
Nocturnal wakefulness >1 h	38.6 (33.4–43.9)	25.5 (21.0–30.6)	27.8 (20.4–36.3)	75.9 (69.6–81.5)	42.0 (31.6–53.0)	62.6 (56.4–68.6)	57.4 (52.0–62.7)
Sleep duration <9 h	24.2 (20.1–28.9)	12.5 (9.3–16.3)	6.6 (2.46–13.8)	85.6 (81.0–89.5)	12.8 (69.1–78.8)	74.2 (69.1–78.8)	66.4 (61.5–71.2)
1 indicator	54.2 (47.8–60.4)	36.0 (30.1–42.2)	35.8 (27.8–44.4)	63.8 (54.4–72.5)	53.8 (43.1–64.4)	45.7 (37.8–53.7)	48.6 (42.3–55.0)
2 indicators	13.8 (9.8–18.7)	4.7 (2.5–8.1)	5.7 (0.7–19.2)	95.4 (91.7–97.8)	16.7 (2.1–48.4)	86.3 (81.3–90.4)	83.0 (77.8–87.4)
3 indicators	2.3 (0.9–5.1)	0.7 (0.1–2.8)	0.0 (0.0–45.9)	99.2 (97.1–99.9)	0.0 (0.0–84.2)	97.6 (94.9–99.1)	98.6 (93.9–98.6)

[a] > 3 night wakings, nocturnal wakefulness > 1 h, and sleep duration in 24 h < 9 h.
[b] Presence of at least one indicator.
[c] Presence of at least two indicators.
[d] Presence of three indicators.

Another relevant aspect is that the parents' report may be influenced by environmental, sociodemographic, and health factors. The fatigue caused by caring for the child with sleep problem can influence the parents' report. A multicenter study with 10,085 children showed that some 50% of the mothers had their own sleep affected by their children's sleep and that one-third reported that their functional skills were affected [33]. Another study showed that in the first years of the child's life, parents' sleep patterns are modified due to the care required, which can result in fatigue and other symptoms [14]. Factors related more directly to the mother's health can affect her report. Depressed mothers, for example, become more reactive to questions related to care for their infants and toddlers [34].

Nocturnal wakefulness showed similar results for sensitivity and specificity of around 50% at three months and around 30% for sensitivity and 70% for specificity at the other ages. Compared to the other indicators, nocturnal wakefulness showed the highest sensitivity at all ages, that is, greater ability of the parents to report the problem when present. This finding may corroborate the hypothesis that children who present nocturnal wakefulness greater than 1 h probably need the presence of one of the parents to go back to sleep. Since the parents are called to help, their reports become more accurate. The same logic (but the other way around) applies to the number of wakings and thus to sleep duration, which do not necessarily require the parents' presence and are thus more difficult to measure because as previously mentioned when children wake up they can go back to sleep naturally without requiring their parents' presence [13,16].

This study has strengths and limitations. Among the strengths, is the use of actigraphy as the gold standard to assess the validity of BISQ as a screening test. There is a growing number of researches showing the validity of actigraphy in sleep assessment by providing useful and reliable measures [9,11]. These studies addressed normal and clinical samples of individuals ranging from childhood to adulthood. Validation studies were all based on concomitantly obtained polysomnography and actigraphic records. Objective measures are useful to identify sleep problems even those not signalized by the child. Studies have shown that short sleep duration in childhood as assessed by actigraphy is associated with emotional and behavioral problems, attention deficit and hyperactivity, as well as with impairment in cognitive functions [35–39]. The high number of participants is another strength of our study.

Among the limitations, it is important to acknowledge the possibility of inherent errors in the gold standard, actigraphy. Because actigraphy measures the body's movements, there are limitations associated with its use in assessing sleep. For example, movement artifacts are a potential source of error. A child may be sleeping in a moving vehicle or even be rocked during sleep, and in such cases the actigraphy device detects movements that will likely be interpreted as wakefulness [28]. Other measurement errors may result from failure to use the equipment properly, when it can be removed or fall off temporarily, recording periods of non-use as sleep (although the recommendation is to use it full-time, even during baths). In this case, it is recommended to use sleep diaries in order to compare and make proper adjustments and corrections to the actigraphy data [40,41]. Other limitations include the short period of sleep evaluation by actigraphy (one only period of 24 horas) and the fact that we have no data on sleep diaries to monitor the use of the actigraph device.

The limitations notwithstanding, the literature lacks validation studies with sleep data from low and middle-income countries, as shown in a meta-analysis on validity and reliability of sleep time questionnaires among children and adolescents, which should be performed in different cultural contexts [42].

5. Conclusion

In summary, the high specificity of the BISQ sleep parameters supports the validity of parents' reports on sleep-related problems in childhood for use in epidemiological studies. Our findings reinforce the importance of using subjective instruments for identifying child sleep-related problems.

CRediT authorship contribution statement

Bianca Del-Ponte: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing - original draft, Writing - review & editing. **Mariana O. Xavier:** Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing - original draft, Writing - review & editing. **Diego G. Bassani:** Conceptualization, Funding acquisition, Data curation, Formal analysis, Investigation, Project administration, Resources, Software, Visualization, Writing - review & editing. **Luciana Tovo-Rodrigues:** Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Visualization, Writing - review & editing. **Camila S. Halal:** Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Resources, Validation, Visualization, Writing - review & editing. **Aline H. Shionuma:** Data curation, Formal analysis, Investigation, Methodology, Resources, Software, Supervision, Validation, Visualization, Writing - review & editing. **Kauana Ferreira Ulguim:** Data curation, Formal analysis, Investigation, Methodology, Resources, Software, Supervision, Validation, Visualization, Writing - review & editing. **Iná S. Santos:** Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing - original draft, Writing - review & editing.

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Conflict of interest

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: https://doi.org/10.1016/j.sleep.2019.12.018.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.sleep.2019.12.018.

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