ORIGINAL PAPER

Igor A. Kelmanson

Snoring, noisy breathing in sleep and daytime behaviour in 2–4-month-old infants

Abstract The study aimed at evaluating possible associations between snoring and/or noisy breathing in sleep and daytime behaviour in 2–4-month-old infants using the Early Infancy Temperament Questionnaire (EITQ) as a tool. It covered the period from 1997 to 1998 and comprised 200 randomly selected clinically healthy infants aged 2–4 months from the community who were singletons and born in St. Petersburg within the chosen period. The mothers were asked to complete the questionnaires addressing infant, maternal, and major demographic characteristics, some infant care practices as well as the infant's habitual breathing symptoms during sleep. As a part of interview, the mothers answered the EITQ consisting of 76 items which describe different aspects of infant behaviour. Groups of questions were added according to a scoring sheet to produce total scores describing nine different aspects of infant temperament: activity, rhythm, approach, adaptability, intensity, mood, persistence, distractibility and threshold. In 129 cases (64.5%), mothers reported no respiratory disturbances during sleep in their infants. Mothers of ten infants (5.0%) described their babies as habitual snorers; 48 babies (24.0%) were characterised as having other than snoring noisy breathing during sleep, and 13 (6.5%) habitually had both snoring and noisy breathing. Symptomatic infants were rated as being moodier when awake compared with asymptomatic ones and most moodiness was the feature of those infants who had both snoring and noisy breathing during sleep. These associations remained after adjustment had been made for major potential confounders.

Conclusion Snoring and noisy breathing during sleep, rather common symptoms in young infants, may be associated with specific behavioural disturbances, and moody infants should be investigated carefully for possible obscure respiratory problems.

Key words Behaviour · Infants · Sleep · Snoring · Temperament

Abbreviations *EITQ* early infancy temperament questionnaire · *SID* sudden infant death

Introduction

Much interest has been raised in cognitive and behavioural functioning of infants and children presenting with obstructive sleep disordered breathing. Reported consequences in preschool and school aged children were poor academic performance, inattention, hyperactivity, contrariety, restlessness, and more aggressive behaviour [1, 2, 6, 7, 11, 15]. In infancy, babies with recurrent and prolonged sleep apnoeas were more lethargic [5], more exhausted at feeding [23], had abnormal spontaneous movements [9], and sometimes were even developmentally delayed [30]. Obstructive

I. A. Kelmanson (✉)
Department of Paediatrics No.3,
St. Petersburg State Paediatric Medical Academy,
Litovskaya 2, St. Petersburg, 194100 Russia
e-mail: ikel@atrium.cor.neva.ru
Tel.: +7-812-5352850; Fax: +7-812-5352850

sleep apnoeas in infants were implicated in the mechanisms of sudden infant death (SID) [21, 37, 38], and it was shown that some SID victims had certain behavioural peculiarities including less activity [26], less intense reactions to environmental stimuli, and more abnormal cries [9, 33]. Partial or complete repetitive obstructions of the upper airway during sleep in infants give rise to clinical symptoms associated with chronic snoring. There is no general agreement whether and to what extent infants with parental-reported primary snoring during sleep may progress to develop obstructive sleep apnoea. While some authors argued that parental concern about infant's breathing patterns during sleep was a poor predictor of polysomnographic abnormalities [31], others reported that snoring and/or noisy (heavy, audible, gurgling) breathing in infants was associated with confirmed prolonged and repetitive obstructive sleep apnoeas [14, 23]. The number and length of obstructive sleep apnoeas in snoring infants may be a less important adverse factor than the repetitive inspiratory increases in upper airway resistance, even if these are associated only with a partial airway collapse and do not lead to pronounced blood oxygen desaturation [13]. It seems likely that some otherwise healthy infants presenting with snoring and/or noisy breathing during sleep may also have certain daytime behavioural disturbances, however, this issue has so far not been specifically addressed.

To bridge the gap, this study aimed at evaluating a possible association between maternal-reported snoring and/or noisy breathing during sleep in 2–4-month-old infants, the age known for peak incidence of SID [18], and their behavioural characteristics as estimated by the Early Infancy Temperament Questionnaire (EITQ) [32].

Subjects and methods

The study covered the period from 1997 to 1998 and comprised 200 randomly selected, apparently healthy infants from the community (105 boys, 95 girls), aged 2–4 months who were singletons born in St. Petersburg within the chosen period and living in an inner city area. According to the study design, none of the infants who entered the survey suffered allergies, had a family history of asthma and/or hereditary respiratory diseases, repetitive and/or protracted respiratory infections, upper airway and/or craniofacial anomalies, and were not administered any medications, particularly sedative drugs known for their depressive effect on respiration [20]. The mothers were asked to complete the questionnaires addressing infant, maternal, major demographic characteristics, infant care practices as well as the infant's habitual symptoms during sleep with particular emphasis on the presence of snoring and/or noisy breathing. All mothers of the recruited infants agreed to participate in the survey. Parental informed consent for participation was obtained in each case and the study was approved by an institutional ethics committee. To insure reliability and to minimise recall bias, particular attention was paid to thorough analysis of pre-existing medical records which served as an only source of information about such particular variables as infant's birth weight, length of gestation, or Apgar score at birth. As a part of the interview, the mothers were requested to complete the EITQ consisting of 76 items which describe different aspects of infant behaviour. All of the items had six possible responses:

1 Almost never
2 Rarely
3 Variable, usually does not
4 Variable, usually does
5 Frequently
6 Almost always

Groups of questions were added according to a scoring sheet to produce total scores describing nine different aspects of infant temperament: activity, rhythm, approach, adaptability, intensity, mood, persistence, distractibility and threshold. Each of the above were scored from 1 to 6.

Statistics

Statistical analysis was based on the chi-square test with Yates's correction for category variables and the Mann-Whitney U test for continuous variables. The Kruskall-Wallis test (non-parametric ANOVA) was performed to evaluate possible associations between reported breathing disturbances in sleep and particular temperament scores in which the presence and the type of breathing disturbances in sleep served as grouping variables, while the temperament score was considered as a dependent one. To further adjust for possible confounders and modifying factors, multiple linear regression analysis was performed in which temperament score in question served as the dependent variable, while infant's category (symptomatic versus asymptomatic) along with potential confounders in consideration were entered into the model as independent variables (numerical directly, and categorical first coded as a series of binary (0/1) variables comparing each category with a reference one). Approximation was based on maximum likelihood method. The significance of association between infant category and temperament score after adjustment was judged looking at the corresponding partial regression coefficient in the model [4]. The value for significance was set at $P < 0.05$. The StatView 4.1 statistical package was used in the data analysis.

Results

In 129 (64.5%) of 200 cases, mothers reported no symptoms of breathing disturbances during sleep in their infants. Mothers of ten (5.0%) infants described their babies as habitual snorers. In 48 (24.0%) observations, the infants were characterised as usually having noisy breathing other than snoring during sleep. In 13 (6.5%) cases, mothers were able to report both snoring and noisy breathing during sleep in their infants.

Table 1 summarises infant, maternal and major demographic characteristics in both symptomatic and asymptomatic groups. Symptomatic infants were insignificantly heavier at birth (difference in mean 138 g) and significantly heavier at study (difference in mean 474 g); more frequently they were first-born infants. No significant difference between the two groups was found for the rest of the infant, maternal and demographic characteristics.

The Kruskall-Wallis test failed to reveal any statistically significant association between the presence and type of respiratory symptoms during sleep and such aspects of infant behaviour as activity, rhythm, approach, adaptability, intensity, persistence, distractibility and threshold. However, the presence of respiratory symptoms during sleep was statistically significantly

Table 1 Infant and parental major characteristics in symptomatic and asymptomatic groups. Absolute figures (%) or mean values ± SD

Characteristic	Snoring and/or noisy breathing in sleep		P
	Yes (n = 71)	No (n = 129)	
Gender			
Boys	42 (59)	63 (49)	0.21
Girls	29 (41)	16 (51)	
Age at study (months)	3 ± 1	3 ± 1	0.76
Weight at study (g)	5943 ± 1112	5469 ± 1031	0.01
Birth weight (g)	3482 ± 558	3344 ± 484	0.07
Gestational age (weeks)	39 ± 2	39 ± 1	0.44
Birth order			
1	62 (87)	95 (74)	0.04
2	8 (11)	26 (20)	
≥3	1 (2)	8 (6)	
Labour induction			
No	51 (72)	93 (72)	0.90
Yes	20 (28)	36 (28)	
Mode of presentation			
Vertex	66 (93)	125 (97)	0.35
Breach	5 (7)	4 (3)	
Apgar score at 1 min	8 ± 1	8 ± 1	0.78
Apgar score at 5 min	8 ± 1	9 ± 1	0.18
Admission to neonatal intensive care unit			
No	65 (92)	123 (95)	0.44
Yes	6 (8)	6 (5)	
Initial feeding			
Breast only	57 (80)	106 (82)	0.92
Breast and bottle	8 (11)	14 (11)	
Bottle only	6 (9)	9 (7)	
Feeding at study			
Breast only	38 (54)	62 (48)	0.76
Breast and bottle	14 (20)	28 (22)	
Bottle only	19 (26)	39 (30)	
Repetitive regurgitation			
No	66 (93)	124 (96)	0.52
Yes	5 (7)	5 (4)	
Regular use of a pacifier			
No	24 (34)	55 (43)	0.29
Yes	47 (66)	74 (57)	
Maternal age (years)	27 ± 6	26 ± 6	0.47
Maternal smoking in pregnancy			
No	57 (80)	106 (82)	0.89
Yes	14 (20)	23 (18)	
Maternal smoking after pregnancy			
No	66 (93)	122 (95)	0.88
Yes	5 (7)	7 (5)	
Maternal education			
Higher	21 (30)	37 (29)	0.40
Incomplete higher	12 (17)	20 (16)	
Secondary	34 (48)	70 (54)	
Incomplete secondary	4 (5)	2 (1)	
Marital status			
Married	55 (78)	103 (80)	0.26
Cohabiting	13 (18)	15 (12)	
Single	3 (4)	11 (8)	

Table 1 (*Continued*)

Characteristic	Snoring and/or noisy breathing in sleep		P
	Yes (n = 71)	No (n = 129)	
Parent-infant room sharing			
No	8 (11)	13 (10)	0.98
Yes	63 (89)	116 (90)	
Parent-infant bed sharing			
No	59 (83)	113 (88)	0.51
Yes	12 (17)	16 (12)	
Position the baby is usually put to sleep			
Prone	5 (7)	3 (2)	0.18
Supine	40 (56)	64 (50)	
Side	22 (31)	56 (43)	
Varying	4 (6)	6 (5)	
Type of mattress			
Soft	4 (6)	4 (2)	0.26
Medium	36 (50)	80 (63)	
Firm	31 (44)	45 (35)	
Number of blankets over the infant			
1	68 (96)	123 (95)	0.83
≥2	3 (4)	6 (5)	
Restless sleep			
No	68 (96)	122 (95)	0.97
Yes	3 (4)	7 (5)	
Excessive sweating during sleep			
No	51 (72)	99 (77)	0.20
Skin wet	17 (24)	26 (20)	
Clothes wet	1 (1)	4 (3)	
Clothes need to be changed	2 (3)	0 (0)	

associated with the infant's mood (H corrected for ties = 9.92; $P = 0.019$), in that asymptomatic infants were characterised by more positive mood (i.e., exhibited more pleasant behaviour during the day) compared with symptomatic ones, and a most negative mood was the feature of those infants who had both snoring and noisy breathing during sleep (Fig. 1). This association between respiratory disorders and infant mood remained after adjustment had been made for such potential confounders as infant gender, birth weight, gestational age, Apgar score at 1 and 5 min, admission to the neonatal intensive care unit, infant age and weight at study, mode of feeding at study, parity, maternal age, maternal education, marital status, maternal smoking during and after pregnancy, parent-infant bed and room sharing during sleep, as well as for the simultaneous influence of all the above variables (Table 2).

Discussion

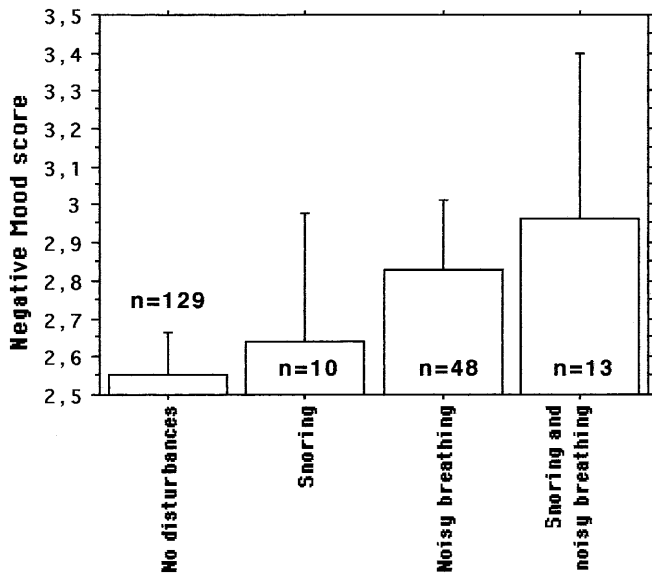The study aimed to evaluate a possible association between snoring and/or noisy breathing during sleep and

Fig. 1 Infant mood scores as a function of breathing disturbances in sleep. Box and whiskers plots display mean values and standard deviations

Table 2 Significance values of partial linear regression coefficients of snoring and/or noisy breathing on infant mood score after adjustment for several potential confounders

Adjusting variable	P
Without adjustment	0.004
Gender	0.004
Infant's age at study	0.002
Infant's weight at study	0.0008
Birth weight	0.003
Gestational age	0.0004
Apgar score at 1 min	0.006
Apgar score at 5 min	0.006
Admission to neonatal intensive care unit	0.003
Birth order	0.006
Lack of breast feeding at study	0.004
Maternal age	0.003
Maternal education other than higher	0.003
Marital status other than married	0.003
Maternal smoking in pregnancy	0.004
Maternal smoking after pregnancy	0.004
Parent-infant room sharing	0.004
Parent-infant bed sharing	0.007
All the above variables	0.049

behavioural features in 2–4-month-old infants. The findings were that among apparently clinically healthy 2–4-month-old infants, the interview-based prevalence figures on snoring and/or noisy breathing in sleep were as high as 35.5% which was in agreement with previous reports covering children up to 10 years of age [35]. Snoring (either isolated or in combination with noisy breathing during sleep) was reported in 11.5% observations and this is similar to previous findings in infants and children [1, 2, 10, 34].

Sleep disordered breathing is known to be more common in male infants and those born preterm and/or of low birth weight [24]. However, this study failed to reveal significant differences in gender distribution, gestational age and birth weight between symptomatic and asymptomatic babies. Likewise, no statistically significant difference between the two groups was found for such important factors known to be associated with a high risk for sleep disordered breathing in the infants as the frequency of maternal smoking during and after pregnancy [25] and infant's repetitive regurgitation [36]. Perhaps this may be ascribed, at least in part, to the relatively homogeneous sample covered by this study. If so, little concern should be raised about potential inadequacies of symptomatic and asymptomatic groups and biased findings as a result.

While obstructive sleep disordered breathing in infants and children is known to lead sometimes to feeding problems and growth failure [12, 24, 39], the infants with reported symptoms of snoring and/or noisy breathing during sleep were heavier by the time of study. One explanation may be that the severity of respiratory disturbances in symptomatic infants was insufficient to cause serious feeding troubles. On the other hand, a more negative mood which was a feature of symptomatic infants in this study is known to modify an infant's energy intake and expenditure, sometimes in the direction of excessive weight gain [43]. In the case of young infants with obstructive apnoeas, profuse sweating in sleep can frequently be observed [23]. This study failed to reveal more frequent maternal reports on excessive sweating in the group with sleep disordered breathing and one explanation may be that respiratory disturbances in the snoring and/or noisy breathing infants were insufficient to cause marked neurovegetative symptoms.

Although the EITQ has not been standardised for local populations, there has been previous experience in its use, with good parental comprehension and response [26–29]. The problem of standardisation was not a subject of major concern since a correlation study such as this does not aim to compare the babies with any reference values, however, in both groups the values of infant temperament scores were within the reported normal ranges [32].

The principal finding of this survey was an association between snoring and/or noisy breathing during sleep in infants with a more negative mood when awake. Several explanations may be offered. It seems most logical to suggest that respiratory troubles during sleep may have a real causal effect on infant behaviour and the same conclusion was drawn from previous interventional studies in children with sleep disordered breathing [3]. A causal effect of respiratory disturbances in sleep on negative mood in the infants is substantiated by a revealed "dose-response" effect in that the infants having both snoring and noisy breathing during sleep presented with more negative mood than those with only one of the above symptoms. According to previous findings, infants and children whose parents were able to report their snoring had objective evidence for more disrupted

sleep [1, 42]. Obstructive sleep apnoeas are also known to be associated with a total shorter sleep time and frequent arousals [24]. In its turn, brief sleep was shown to be associated with negative mood in the infants [40, 41]. Although in this study maternal reports failed to confirm more frequent restless sleep in the symptomatic infants, this cannot exclude minor sleep disturbances in these babies which remained obscure to the observers. Much less likely seems a reverse causality in that an infant's snoring during sleep can upset his/her mother to such a degree that it could in turn affect an infant. Moreover, none of the mothers reported difficulties when handling the infant which is another argument against such a cause. An association between breathing disturbances during sleep and infant daytime behaviour also may be ascribed to the influence of some other factor(s), both related to breathing patterns during sleep and infant behaviour, which remained beyond the reach of this study. Although somewhat reminiscent, behavioural features in snoring and/or noisy breathing infants were not the same as previously reported in infants and children with recurrent obstructive sleep apnoeas. More negative mood was not previously indicated as a behavioural feature of SID victims. Meanwhile, parent-infant bed sharing is known to be associated with a risk for SID and was also linked with more negative mood in the infants [27].

Several caveats should be acknowledged when looking at the findings of this study. First, information on infant behaviour and symptoms during sleep was reported by mothers leading to inevitable subjectivity of the estimates. A high proportion of the mothers from both groups were primiparas and thus potentially less experienced. Mothers of the young children who live in an inner city area as in this study often have depressive symptoms [16] which may also influence their perception. However, comparison between symptomatic and asymptomatic groups did not reveal significant differences in major maternal characteristics and infant care practices which might have influenced maternal perception and response. Although in some cases maternal responses might have been incorrect, such misinterpretation was non-differential since it was most unlikely that the mothers who responded positively to questions about snoring and/or noisy breathing might also respond positively to negative behaviour measures. Thus, such misinterpretation could not have served as a source of information bias and could not invalidate the results. Second, according to the study design, only 2–4-month-old infants entered the survey. Therefore, the results are relevant to that specified age group known for the highest risk of SID, but cannot be easily extended to other age groups and previous findings were that minor behavioural disturbances in the infants having apparent life-threatening events did not persist invariably with time [22]. Third, infant temperament is known to be subject to modifying influences of several environmental factors thus raising concern about possible confounding effects. However, in this study, symptomatic and asym-

ptomatic groups did not significantly differ in most of the infant, maternal and major demographic characteristics. In particular, no significant difference between the two groups was found for the habitual infant's sleep position which may influence airway protection mechanisms in sleep [19] and is associated with certain behavioural features [8, 28]. Likewise, no significant difference between symptomatic and asymptomatic infants was found for the frequency of the habitual use of a pacifier which may probably influence infant breathing patterns in sleep and is associated with certain daytime behavioural characteristics [29]. No statistically significant difference between the two groups was found for major bedding practices. Furthermore, the association revealed between respiratory symptoms and infant behaviour remained after adjustment had been made for major potential confounders thus affirming the validity of the findings.

Bearing all these limitations in mind and understanding that further studies in the field are needed, even minor breathing disturbances during sleep in otherwise healthy infants may be associated with specific behavioural disturbances. These features may probably reflect certain impairments in brain maturation and previous studies offered arguments on age-dependent causal relationships between brain development and infant behaviour [17]. Infants presenting with negative mood should be investigated cautiously for possible respiratory disorders during sleep.

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