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Breathing obstruction in relation to craniofacial and dental arch morphology in 4-year-old children

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SUMMARY The prevalence of breathing obstruction was determined in a cohort of 4-year-old children. Craniofacial morphology was studied in obstructed children and compared with data from a control group of 4-year-old children with ideal occlusion. Dental arch morphology was compared in obstructed and non-obstructed children in the group.

Parents of 95.5 per cent of the study base of 644 children answered a questionnaire concerning their child's nocturnal behaviour and related questions. The 48 children who, based on parental report, snored every night or stopped breathing when snoring (the 'snoring group'), showed a higher rate of disturbed sleep, mouth-breathing, and a history of throat infections as compared with the rest of the cohort. These children were examined by both an orthodontist and an otorhinolaryngologist and, when indicated, they were also monitored in a sleep laboratory. Twenty-eight of the children were diagnosed as having a breathing obstruction (4.3 per cent of the cohort) and six children (0.9 per cent) had sleep apnoea (mean apnoea-hypopnoea index of 17.3), using the same definition as that for adults.

Cephalometric values among the obstructed children differed from those of a Swedish sample of the same age with ideal occlusion. They had a smaller cranial base angle and a lower ratio of posterior/anterior total face height. Small, but not significant differences were seen for NSL–ML and NL–ML. Compared with 48 asymptomatic children from the same cohort, the obstructed children had a narrower maxilla, a deeper palatal height, and a shorter lower dental arch. In addition, the prevalence of lateral crossbite was significantly higher among the obstructed children.

Introduction

Snoring is a sign of obstructed nocturnal breathing. In childhood, snoring and obstructive sleep apnoea (OSA) is most commonly caused by adeno-tonsillar enlargement. Breathing obstruction can be a serious condition, which may cause not only restless sleep and day time fatigue in children, but behavioural problems, such as aggressiveness and hyperactivity, as well as delayed growth and respiratory distress in extreme cases (Guilleminault and Stoohs, 1990).

School children with enlarged adenoids and mouth-breathing also have different craniofacial morphology in comparison with children with normal breathing, e.g. a shorter lower arch, longer facial and dentoalveolar heights, more narrow cranial and palatal widths, and a higher prevalence of crossbite (Linder-Aronson, 1970; Cheng *et al.*, 1988; Behlfelt, 1990).

According to Solow *et al.* (1993), individuals with breathing distress as a result of pharyngeal obstruction seem to alter the posture of the head to improve airflow, which, in turn, gives rise to an altered muscle pressure to the tissues. In growing children, changes in morphology and posture of the head are partly reversible after removal of any airway obstruction (Solow *et al.*, 1993).

Studies of the prevalence of snoring and apnoeas among children have been published in recent years (Ali *et al.*, 1993; Corbo *et al.*, 1989; Gislason and Bennediktsdottir, 1995; Owen *et al.*, 1996; Teculescu *et al.*, 1992). To our knowledge, no previous epidemiological study has examined craniofacial and dental arch morphology in conjunction with impaired breathing in pre-school children.

The purpose of the present investigation was:

- to estimate the prevalence of sleep-related breathing disorders in a cohort of 4-year-old children and to examine co-variates related to breathing obstruction;
- to compare the dental arch morphology of children with breathing obstruction and of those without any symptoms of obstruction;
- to compare the craniofacial morphology of the obstructed children with data from a Swedish control group with ideal occlusion.

Subjects and methods

Subjects

In Sweden, free dental care is offered within the public health care system up to the age of 20 years. Within this framework, an epidemiological study of breathing obstruction was performed on a cohort of 4-year-old children in Enköping, a small town in the middle of Sweden. All children born over 16 consecutive months were included —a total of 644 subjects.

Questionnaires

The parents of the children were sent questionnaires by mail. Those who did not respond were sent a second letter. If there was still no answer, the parents were, if possible, contacted by telephone. The questions to be answered concerned the child's sleeping habits, snoring, mouth-breathing, breathing irregularities, bedwetting, sucking habits, and previous throat infections. To investigate possible genetic factors related to the breathing distress of the child, the parents were also asked if they themselves had undergone a tonsillectomy or adenoidectomy, and/or had received orthodontic treatment during childhood.

Based on the parents answers to the questionnaires, a 'snoring group' was selected, which included those children who snored every night and/or had episodes of breathing pauses with snoring.

Clinical examinations

All the 'snorers' in the cohort were examined by an orthodontist (BLT). To establish controls for the present investigation and subsequent follow-up studies, all of the first 100 children of the cohort were also examined. All 'snorers' were then invited to an ear, nose, and throat examination carried out by two of the authors (J A-R or E H). When symptoms and signs of obstruction verified the data from the questionnaire, a full-night sleep study in the hospital was performed to confirm the diagnosis. The sleep study consisted of overnight monitoring using a thermistor at the nose and mouth to detect airflow, an electrostatic mattress registering breathing movements, position analysis, oximetry, and heart rate (Eden–Trace II, Nellcor Europé B.V., The Netherlands; Figure 1). The most important indicator was the clinical observation of the child's breathing during sleep. The children who did not show any clinical signs of obstruction

Figure 1 Polysomnographic instruments for recording sleep during overnight observation.

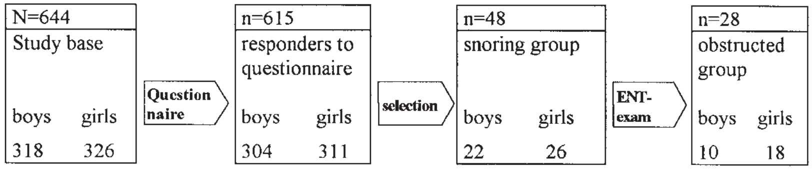

Figure 2 Allocation of subjects used in the analyses.

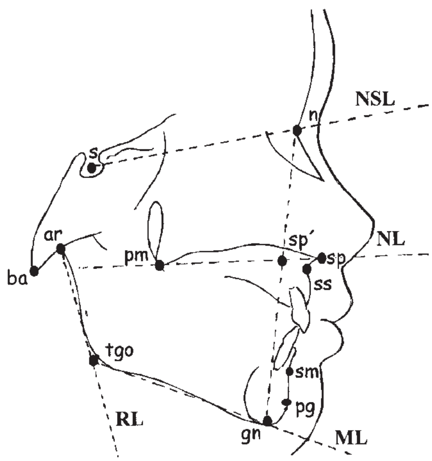

Figure 3 Reference points and lines used in the cephalometric analyses.

at the medical examination, were temporarily excluded from further investigation. Another questionnaire to follow up the whole cohort is planned for 2 years after this study. The children with clinically diagnosed sleep related breathing obstruction constituted the 'obstructed group'. The data of the various groups are presented in Figure 2.

Radiographic assessments

The children belonging to the obstructed group were examined cephalometrically. The cephalograms were taken in a standardized manner with the child's head fixed in a cephalostat with the sagittal plane parallel to the film and the head naturally orientated. The teeth were in an intercuspal position. Two different cephalostats were used because the children were examined either at an orthodontic office or in the hospital. The cephalometric reference points and lines used are those defined by Björk (1947) (Figure 3). The cephalometric landmarks were digitized by one author (BLT) and analysed using the Profile software program for geometric measurements (Jakobsson, 1988) with a digitizer. In all cases, the landmarks were digitized independently on a second occasion by the same investigator (BLT) and the error of the method was calculated. The magnification factor was not of importance since only ratios and angles were measured.

Under current Swedish regulations, non-symptomatic children from the present study base could not be radiographed to serve as controls. Lateral cephalograms were selected and analysed from another group of children from the same town in Sweden and used as controls. Those children had been examined earlier in conjunction with a study of posterior crossbite in the deciduous dentition (Thilander *et al.*, 1984). The group selected consisted of 20 boys and 20 girls, 4 years old with 'ideal' occlusion.

Biometric assessments

Study casts were made of as many of the first 100 children as possible and for all the 'snorers' in the cohort. The models from the obstructed children were compared with those from the non-symptomatic children from the cohort (48 models). The following variables were recorded: angle class, crossbite, overjet, overbite, length of the upper and lower arches, width at canines, and primary first and second molars, and palatal height. Linear dimensions of the dental arches were measured according to Moorrees *et al.* (1969) (Figure 4). The palatal height was measured at the midline, from the level of the gingival papilla between the primary molars with a three-dimensional calliper. For measuring distances a digital calliper (Mitutoyo

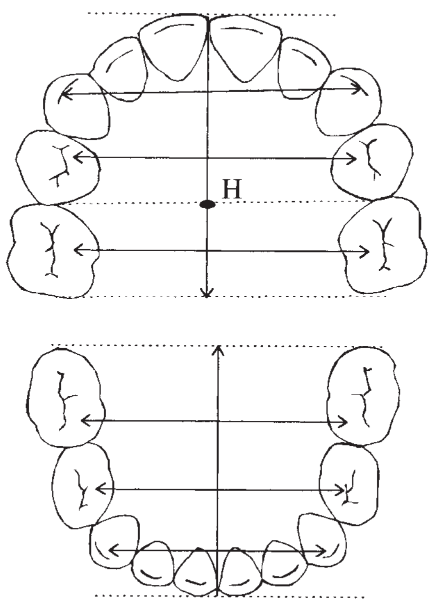

Figure 4 Dental arch measurements of the maxilla and mandible. Inter-canine width measured between the mid-points of the cusps, intermolar width measured between the tips of the mesio-lingual cusps of the primary molars, and arch length measured from the labial surfaces of the incisors perpendicular to a line connecting the distal surfaces of the second molars. Palatal height measured at point H (in the midline at the level between the molars).

model 1573–121 Mitutoyo Ltd., Tokyo, Japan) connected to a personal computer for data analysis was used (Jakobsson, 1989). Two measurements were taken at each distance. The program was designed to accept only differences smaller than 0.5 mm. The mean of the two measurements was recorded. Thirteen randomly selected models (from six cases and seven controls) were remeasured on a separate occasion and the error of method was calculated.

Statistical analysis

The frequencies of specific responses to the questionnaires were calculated (Table 1) for boys and girls, and for the total cohort. To determine whether answers to the questionnaires were different for the group of snoring children when compared with the remaining children in the cohort, a chi-square test was performed and P values obtained. Differences in cephalometric and biometric variables between obstructed children, and controls were tested for significance using a two-tailed t-test.

Error of methods

Duplicate determinations for biometric and cephalometric measurements were calculated according to the formula

$$s_e = \sqrt{\frac{\sum(a_2 - a_1)}{2n}}$$

where a_2 = the second, a_1 = the first measurement, and n = the number of duplicate determinations.

Results

Questionnaires

The age cohort consisted of 644 children (318 boys and 326 girls). Questionnaires were completed for 615 children (95.5 per cent: 304 boys and 311 girls). The mean age of the children whose parents completed the questionnaires, was 4.14 ± 0.10 years. The results from the questionnaires are presented in Table 1. No statistical difference in the answers was found between the genders except in bedwetting and sucking habits.

The responses showed that 37 children (6.0 per cent) snored every night and an additional 284 (46.3 per cent) 'sometimes' or 'when they had a cold'. Breathing pauses (apnoeas) were reported for 29 children (4.7 per cent). Eighteen of the children with apnoeas snored every night, 11 of them less often. Constant mouth-breathing was reported for 58 children (9.3 per cent).

A total of 48 children who snored every night and/or had breathing pauses in combination with snoring, constituted 'the snoring group'. These children were compared with the remainder of the cohort (Table 2).

Constant mouth-breathing was reported more than ten times as often for the snoring children than for the rest of the cohort (54.2 compared with 5.3 per cent, $P < 0.001$). Restless sleep every night was reported more often for the snoring group than for the rest of the cohort (16.7 versus 2.3 per cent, $P < 0.001$). A history of tonsillitis

Table 1 Percentage results from the questionnaire for 304 boys and 311 girls and total cohort.

Question	Boys	Girls	Total
Restless sleep:			
regularly	4.6	3.5	4.1
sometimes	27.3	30.9	29.1
Mouth-breathing			
regularly	11.2	7.1	9.1
Snoring:			
regularly	5.3	6.8	6.02
sometimes	47.4	45.3	46.3
Apnoea	4.3	5.1	4.7
Enureses:			
regularly	10.9	7.7	9.3
sometimes	21.7	14.1	18.0
Sucking habits:			
ongoing	29.6	37.3	33.5
earlier	45.4	41.5	43.4
Sucking to at least 3 years	48.7	57.23	53.0
Breastfed	90.8	92.0	91.4
Breastfed more than 6 months	51.6	53.7	52.7
History of tonsillitis	36.2	31.8	34.0
History of serveral episodes of tonsillitis	20.3	20.6	20.7
Earlier operated on with tonsillectomy	0.6	2.6	1.6
Earlier operated on with adenoidectomy	3.9	6.1	5.0
Either parent had orthodontic treatment	28.3	28.0	28.1
Either parent operated on with tonsillectomy	12.8	13.2	13.0
Either parent operated on with adenoidectomy	20.7	24.8	22.8

Table 2 Positive answers to the questionnaires (expressed as per cent) for the children in 'the snoring group' (children who snored every night and/or made breathing stops in combination with snoring) ($n = 48$) compared with those for the children in the rest of the cohort ($n = 567$). Comparison tested for significance with chi-square test.

Questions	Snoring group	chi square for trend	*P*-value
Restless sleep:			
regularly	16.6	17.84	<0.001***
sometimes	37.5	9.35	<0.01**
Mouth-breathing			
regularly	27.1	18.04	<0.001***
Enureses			
regularly	16.7	2.5	0.11
Sucking habits			
ongoing	43.6	1.98	0.16
Sucking to at least 3 years	60.4	1.10	0.29
Breastfed	83.3	3.25	0.72
Breastfed more than 6 months	45.8	0.7	0.40
History of tonsillitis	56.3	10.45	<0.01**
History of serveral episodes of tonsillitis	47.9	21.85	<0.001***
Earlier operated on with tonsillectomy	4.2		
Earlier operated on with adenoidectomy	18.8		
Either parent had orthodontic treatment	31.3	0.11	0.74
Either parent adenoidectomized	39.6	35.30	<0.001***
Either parent tonsillectomized	20.2	2.12	0.15

was also more frequent in the snoring group: among the children of the snoring group, 48.0 per cent were reported to have had tonsillitis more than once, compared with 18.3 per cent of the others ($P < 0.001$). A history of either parent having had their adenoids removed was more common among the children in the snoring group (39.5 versus 21.3 per cent, $P < 0.01$).

Clinical examination

Of the 48 'snorers', 45 underwent orthodontic and ENT examinations. (The parents of three children did not wish their child to be further examined.) Twenty-eight of the 'snorers' were diagnosed by clinical observation and monitoring as having sleep-related breathing obstruction. The prevalence of sleep-related breathing disorder was thereby found to be at least 4.3 per cent (28/644). However, only six of the children had a 'sleep apnoea syndrome' with a mean apnoea-hypopnoea index (AHI) of 17.3 defined according to the definition used for adults (ASDA Task Force, 1999). This would give an estimation of the prevalence of sleep apnoea in the cohort of 0.9 per cent (6/644). Seventeen children were found to have only periodic snoring sounds or asthmatic problems, but no clear obstructive signs of the adenoids or tonsils.

However, based only on the parents' answers to the questionnaire, the prevalence of sleep-related breathing disorders would have been 7.8 per cent (48/615; Figure 2).

Sucking habits

A large number of the children in the present study still had sucking habits at the age of four, whilst others had recently stopped the habit. However, there was no difference in the percentage of children with prolonged sucking habits in the snoring group and those in the remaining cohort. Likewise, there was no statistically significant difference in the percentage of children with prolonged sucking habits between the group of obstructed children who had dental casts taken ($n = 22$) and the group of non-symptomatic controls with dental casts taken ($n = 48$). No information was available concerning sucking habits or mouth-breathing among the children with ideal occlusion used as controls for the cephalometric analysis.

Cephalometric findings

Lateral skull radiographs were recorded in 24 of the 28 cases since four children refused the radiographic examination. Some children had difficulty in holding their teeth in centric occlusion and remaining still during the X-ray exposure. Thus, three cephalograms had to be excluded and one additional case could only be partially analysed. In the 'ideal' group of 4-year-old children ($n = 40$, 20 boys and 20 girls), there was no difference in cephalometric measurements between the gender groups. For this reason, the measurements from the 'obstructed group' were pooled. Means, standard deviations, and range for cephalometric variables in snoring children and 'ideal' controls are presented in Table 3.

In the group of obstructed children, significantly smaller angles of the cranial base (n–s–ar and n–s–ba) were seen. The angles between NSL–ML and NL–ML were larger in the snoring children, although the differences did not reach statistical significance. Among the obstructed children, ratios for posterior total face height to anterior total face height (s–tgo/n–gn) were significantly smaller which indicate 'high angle faces'.

The size of the combined method error in landmark localization and measurement was calculated. It did not exceed 0.8 (degrees or distance-ratios) except for the s–n–ss angle and the ss–n–sm angle where it was 1.1 degrees.

Biometric findings

It was possible to obtain and analyse 22 models from 28 'snorers'. The error of method was computed and was found to be less than 0.6 mm. The results from the biometric measurements are presented in Table 4. There were several differences between obstructed and non-symptomatic children: the maxillary width was smaller when measured at the primary canines, and at the first and second primary molars, and

Table 3 Cephalometric variables and ratios for obstructed children and 'ideal' controls, comparisons tested for significance with Student's two-tailed *t*-test.

Variable	obstructed group				'ideal' control group				
	n	Mean	SD	Range	*n*	Mean	SD	Range	*P*-value
Age	21	4.52	0.37	4.07 – 4.96	40	4.58	0.25	4.08 – 5.0	
Angles deg.									
n–s–ar	20	118.7	4.28	110 – 125	40	121.8	4.87	114 – 131	<0.05*
n–s–ba	21	126.6	4.12	119 – 135	40	130.6	4.33	124 – 143	<0.001***
n–s–pm	21	65.8	3.57	60 – 73	40	65.9	2.05	63 – 70	
NLS/NL	21	5.8	2.79	1 – 9	40	4.5	1.56	2 – 7	
NSL/ML	20	36.1	4.23	28 – 42	40	32.5	2.85	26 – 37	0.06
NL/ML	20	30.5	4.31	23 – 38	40	27.8	3.34	21 – 32	0.06
s–n–ss	21	82.5	3.76	78 – 92	40	83.3	2.50	78 – 89	
s–n–sm	20	77.4	3.28	72 – 83	40	78.7	2.38	72 – 82	
ss–n–sm	20	5.0	2.48	1 – 8	40	4.2	1.59	2 – 8	
s–n–pgn	20	76.7	3.16	71 – 83	40	78.6	2.54	73 – 83	
ML/RL	20	132.6	5.35	124 – 143	40	131.4	4.72	123 – 140	
Ratio %									
n–sp′/n–gn	20	41.0	1.60	35.4 – 43.6	40	41.2	1.39	37.5 – 43.5	
sp′–gn/n–gn	20	60.0	1.60	56.4 – 64.6	40	58.8	1.39	56.5 – 62.5	
n–sp′/sp′–gn	20	69.7	4.88	54.9 – 77.2	40	70.2	3.92	60.0 – 76.9	
s–tgo/n–gn	20	61.8	2.81	56.6 – 67.1	40	64.1	2.02	60.6 – 69.2	<0.001***

Table 4 Biometric variables for obstructed children and controls, comparisons tested for significance with Student's two-tailed *t*-test, age in years, distance in mm.

Variable	Obstructed children				Controls				
	n	Mean	SD	Range	*n*	Mean	SD	Range	*P*-value
Age	22	4.3	0.2	4.0 – 4.9	48	4.1	0.15	3.9 – 4.7	
Upper arch length	22	29.5	2.05	25.0 – 32.8	48	29.9	1.92	26.3 – 34.7	0.39
Upper intercanine width	22	26.4	2.64	21.9 – 30.5	48	28.4	2.56	23.7 – 33.2	0.004**
Upper inter first molar width	22	26.6	2.27	22.4 – 30.6	48	28.5	2.41	24.2 – 33.7	0.042*
Upper inter second molar width	22	31.2	2.33	27.1 – 35.4	48	32.7	2.38	28.5 – 37.7	0.018*
Lower arch length	22	24.1	1.44	21.6 – 26.9	48	25.0	1.74	20.6 – 30.3	0.045*
Lower canine width	22	23.1	1.12	20.4 – 25.4	48	23.2	1.85	20.1 – 28.5	0.63
Lower inter first molar width	22	26.7	1.23	21.9 – 28.5	48	25.5	1.82	20.9 – 29.5	0.69
Lower inter second molar width	22	29.3	1.47	26.0 – 31.8	48	28.5	2.08	24.1 – 32.4	0.11
Overjet	22	3.4	2.03	0.7 – 7.2	48	3.6	1.78	–0.6 – 8.39	0.68
Overbite	22	–0.7	2.20	–7.6 – +3.1	48	0.0	2.33	–5.6 – +3.5	0.25
Palatal height	17	13.3	1.43	10.1 – 15.6	26	12.3	1.02	10.4 – 14.6	0.018*

$^*P < 0.05$; $^{**}P < 0.01$; $^{***}P < 0.001$.

the length of the lower dental arch was shorter and the palate was higher. Descriptions of the occlusion in obstructed children and controls are presented in Table 5. Lateral cross-bite was more frequent among the obstructed children.

Discussion

There have been reports of only a limited number of epidemiological investigations concerning snoring in younger children in recent years (Ali *et al.*, 1993, Corbo *et al.*, 1989; Gislason and

Table 5 Orthodontic findings in the sagittal, transverse and vertical planes for obstructed children ($n = 22$) and non-symptomatic children ($n = 48$). Comparisons between proportions of diagnoses in the two groups tested with chi-square test.

Relationships	Diagnoses	Obstructed children	Control children	*P*-value
Sagittal	Angle Class I	19	38	0.58
	Angle Class II	3	9	
	Angle Class III		1	
Transverse	Lateral crossbite	7	5	0.04*
Vertical	Anterior open bite	11	20	0.51
	Deep bite		7	

$^*P < 0.05$.

Bennediktsdottir, 1995; Owen *et al.*, 1996; Teculescu *et al.*, 1992), and the results do not show large differences in the prevalence of snoring. When efforts have been made to detect whether the children have OSA the numbers vary more. The concept of OSA, is rarely used in the paediatric context, because children are more often affected by upper resistance syndrome than classic OSA (Guilleminault, 1997). The clinical relevance is related to their breathing distress, which includes all grades of breathing obstruction combined with habitual snoring.

In the present study, the prevalence of children with sleep apnoea, 0.9 per cent was close to that found in the British study by Ali *et al.* (1993), who reported a prevalence of 0.7 per cent in 5-year-old children. In an investigation performed in Iceland, the prevalence among children between 6 months and 6 years was estimated at 2.5 per cent (Gislason and Bennediktsdottir, 1995). The differences might be due to age variability among other factors. In studies from France and Italy, 10 and 7.3 per cent of pre-school children were defined as 'habitual snorers' (Corbo *et al.*, 1989; Teculescu *et al.*, 1992). However, these children were not sleep registered and their numbers are closer to the results obtained concerning snoring from the questionnaires in the present study.

In all these previous investigations, different physical and psychological aspects of snoring have been stressed. However, the connection between mouth-breathing, throat infections, and family occurrence of obstructive problems has not been investigated epidemiologically. The results of this research show that children who snore are more likely to be mouth-breathers. In addition, they have often had several episodes of tonsillitis and their parents are more likely to have had their adenoids removed during childhood.

The present investigation achieved a high response rate (95.5 per cent) to the questionnaire, increasing the validity. However, it is difficult to evaluate the individual answers, since what one parent regards as snoring could simply be called heavy breathing by another. Because of the general focus in the Swedish media on medical problems connected with snoring, these parents might also be more observant of their children's nightly behaviour. These problems may partly account for the difference between the results from the questionnaire and the following clinical investigation in the present study. If a few parents did not understand the questionnaire correctly or marked the wrong box, the effect on the results would, in any case, only be marginal because of the size of the cohort.

In this investigation, models from the first 100 children examined, who reported neither snoring nor mouth-breathing were used as controls—48 children in all. These children had not been examined by an otorhinolaryngologist to verify the absence of breathing difficulties and whilst this may, to some extent, diminish the power of the study, it is not reasonable to expect this to have any substantial impact on the outcome.

Although mouth-breathing is the condition of interest with regard to facial development, it is not in itself a useful question to ask parents when identifying children at risk of breathing obstruction. Open-mouth posture in young children is common and not necessarily a sign of predominant mouth-breathing (Gross *et al.*, 1993). Using the parental reports that the child snored every night and/or had episodes of breathing pauses with snoring, seems to be of more use in identifying children at risk for nocturnal breathing disturbances. Reports of other clinical symptoms, such as mouth-breathing (e.g. lips-apart posture), restless sleep, history of throat infections together with positive family history of breathing obstruction (adenoid enlargement) were reported far more frequently in the 'snoring group' than in the rest of the cohort.

A large number of the children in the present study still had sucking habits at the age of four and others had recently stopped. Although it is well known that the use of pacifiers, as well as finger sucking alter the facial and dental arch morphology (Larsson, 1986, 1987; Lindner, 1991), children with prolonged sucking habits were not excluded from this investigation. A cross-sectional study does not allow one to draw conclusions of causal relationships. The intention was to study the co-variation of breathing obstruction and certain morphological patterns. However, it was found that there was no significant difference in the percentage of children with prolonged sucking habits in the groups of snoring and non-snoring children. Likewise, there was no statistical difference in the percentage of children with prolonged sucking habits between the children in the obstructed group and those in the non-symptomatic control group with regard to biometric measurements. Among the children in the control group with 'ideal' occlusion used for the cephalometric analysis, no information was available concerning the percentages of children with prolonged sucking habits or mouth-breathing.

The finding that the width of the maxilla was narrower among obstructed children in the present study, is in agreement with the results of Pirilä *et al.* (1995), who also found that children with diagnosed OSA tended to have longer dental arches than non-obstructed children.

The present study clearly shows that children with breathing obstruction at 4 years of age, already demonstrate the same characteristics previously reported in older obstructed children —a narrower maxilla, a shorter lower dental arch, a larger anterior facial height, a tendency to posterior rotation of the maxilla and mandible, and a higher prevalence of lateral crossbites (Linder-Aronson, 1970; Behlfelt, 1990; Hultcrantz *et al.*, 1991). An early recognition of breathing obstruction seems to be important both for general health reasons and in order to avoid this negative development.

Increased anterior facial height and open mandibular plane angles are also common findings in studies concerning adult obstructed patients (Tangugsorn *et al.*, 1995). It may be that obstructed breathing in childhood is linked to snoring and sleep apnoea problems later in life. A more acute cranial-base angle was another main cephalometric finding among the 4-year-old snoring children in the present study. This is consistent with the theory suggested by Steinberg and Fraser (1995), based on investigations of adult obstructed cases, that sleep apnoea is a reflection of a form of craniofacial syndrome. On the other hand, many findings in the present study, such as the increased rate of throat infections, support the idea that there is a multifactorial aetiology for snoring and sleep apnoea in children.

The present investigation demonstrates that children with obstructed nocturnal breathing have a facial morphology, which is different from that of unaffected children at the age of 4 years. The question arises whether spontaneous recovery of the breathing pattern followed by a morphological normalization through growth is to be expected. The results in the present investigation generate questions that require further study in follow-up investigations.

Conclusions

The prevalence of sleep-related breathing disorders in 4-year-old children in Sweden was found to be at least 4.3 per cent (sleep apnoea syndrome 0.9 per cent). There were significant differences in dental arch morphology between obstructed and non-symptomatic children, as well as in craniofacial morphology between obstructed children and 'ideal' controls. Parental answers to simple questions about their child's nightly behaviour seem to be of value in selecting children at risk with regard to breathing disturbance and negative influence on facial morphology. Collaboration between orthodontists and otolaryngologists concerning patients with sleep-related breathing problems is strongly recommended.

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References

Ali N J, Pitson J D, Stradling R J 1993 Snoring, sleep disturbance, and behaviour in 4–5 year olds. Archives of Diseases in Childhood 68: 360–366

ASDA Task Force 1999 Report. Sleep (in press)

Behlfelt K 1990 Enlarged tonsils and the effect of tonsillectomy. Characteristics of the dentition and facial skeleton. Posture of head, hyoid bone and tongue, mode of breathing. Swedish Dental Journal, Suppl. 72

Björk A 1947 The face in profile. An anthropological X-ray investigation on Swedish children and conscripts. Svensk Tandläkaretidskrift 40 Suppl. 5B

Cheng M-C, Enlow D H, Papsidero M, Broadbent B H J, Oyen O, Sabat M 1988 Developmental effects of impaired breathing in the face of the growing child. Angle Orthodontist 58: 309–320

Corbo G, Fuciarelli F, Foresi A, DeBendetto F 1989 Snoring in children: association with respiratory symptoms and passive smoking. British Medical Journal 299: 1491–1494

Gislason T, Benediktsdottir B 1995 Snoring, apneic episodes, and nocturnal hypoxemia among children 6 months to 6 years old. An epidemiological study of lower limit of prevalence. Chest 107: 963–966

Gross A M *et al*. 1993 Rhinometry and open-mouth posture in young children. American Journal of Orthodontics and Dentofacial Orthopedics 103: 526–529

Guilleminault C 1997 Treatment of sleep disordered breathing in children. Somnologie Zeitschrift für Schlafforschung und Schlafmedizin 1, Suppl. 2

Guilleminault C, Stoohs R 1990 Chronic snoring and obstructive sleep apnoea syndrome in children. Lung, Suppl. 168: 912–919

Hultcrantz E, Larsson M, Hellquist R, Ahlqvist-Rastad J, Svanholm H, Jakobsson O P 1991 The influence of tonsillar obstruction and tonsillectomy on facial growth and dental arch morphology. International Journal of Pediatric Otorhinolaryngology 22: 125–134

Jakobsson O P 1988 Profile: a user-configurable system for the measurements of angles and distances on pictures. Computer Methods and Programs in Biomedicine 26: 123–128

Jakobsson O P 1989 Database interface for digital calipers. Computer Methods and Programs in Biomedicine 28: 51–55

Larsson E 1986 The effect of dummy-sucking on the occlusion—a review. European Journal of Orthodontics 8: 127–130

Larsson E 1987 The effects of finger-sucking on the occlusion: a review. European Journal of Orthodontics 9: 279–282

Lindner A 1991 Unilateral posterior cross-bite in preschool children with special reference to sucking habits. Thesis, Karolinska Institutet, Stockholm, Sweden

Linder-Aronson S 1970 Adenoids, their effect on mode of breathing and nasal airflow and their relationship to characteristics of the facial skeleton and the dentition. Acta Otolaryngologica Suppl. 265: 43

Moorrees C F A, Grøn A-M, Lebret L M L, Yen P K J, Fröhlich F J 1969 Growth studies of the dentition: a review. American Journal of Orthodontics 55: 600–616

Owen G O, Canter R J, Robinson A 1996 Snoring, apnoea and ENT symptoms in the paediatric community. Clinical Otolaryngology 21: 130–134

Pirilä K, Tahvanainen P, Huggare J, Neiminen P, Löppönen H 1995 Sleeping positions and dental arch dimensions in children with suspected obstructive sleep apnea syndrome. European Journal of Oral Science 103: 285–291

Solow B, Ovesen J, Würtzen Nielsen P, Wildschiødtz G, Tallgren A 1993 Head posture in obstructive sleep apnoea. European Journal of Orthodontics 15: 107–114

Steinberg B, Fraser B 1995 The cranial base in obstructive sleep apnea. Journal of Oral maxillofacial Surgery 53: 1150–1154

Tangugsorn V, Skatvedt O, Krogstad O, Lyberg T 1995 Obstructive sleep apnoea: a cephalometric study. Part I. Cervico-craniofacial skeletal morphology. European Journal of Orthodontics 17: 45–56

Teculescu D B, Caillier I, Perrin P, Rebstock E, Rauch A 1992 Snoring in French preschool children. Pediatric Pulmonology 13: 239–244

Thilander B, Wahlund S, Lennartsson B 1984 The effect of early interceptive treatment in children with posterior cross-bite. European Journal of Orthodontics 6: 25–34