SHORT REPORT

Severity of obstructive apnoea in children with Down syndrome who snore

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Diagnostic overnight polysomnograms of 33 children with Down syndrome who snored were reviewed. Mean age was 4.9 years, none had had adenotonsillectomy, 91% were non-obese (Down syndrome specific body mass index standard deviation score (BMI SDS) $<+2.0$) and yet 97% demonstrated obstructive sleep apnoea, with an average apnoea hypopnoea index (AHI) of 12.9 episodes per hour (normal <1) and an average oxygen desaturation of 4%. A higher AHI was associated with lower minimum SpO_2 , higher TcCO_2 and higher number of arousals from sleep per hour ($p<0.001$). Polysomnography should be a routine investigation for children with Down syndrome who snore regardless of body habitus.

Children with Down syndrome have a multitude of potential medical problems which require routine screening tests. Interestingly, snoring and obstructive apnoea are among the commonest problems encountered in Down syndrome and are associated independently with neurocognitive impairment. We considered whether polysomnography should be recommended as a routine test in children with Down syndrome who snored.

METHODS

In this retrospective study, we reviewed our experience over 7 years (1997–2004) of consecutive children with Down syndrome who presented to our sleep clinic with a history of snoring and underwent a diagnostic overnight polysomnogram. With ethics committee approval, we reviewed hospital records and cross-checked with our sleep unit database to identify a total of 63 studies in 46 children with Down syndrome. We excluded 13 children with previous adenotonsillectomy or diagnostic polysomnograms resulting in the initiation of supplemental oxygen therapy or non-invasive respiratory support (nasal CPAP). This left 33 children, all of whom had a waking oxygen saturation (SpO_2) $\geq 93\%$ and no haemodynamically significant or uncorrected cyanotic congenital heart disease.

Children were studied in a quiet darkened room overnight in the company of a parent for up to 12 h. Standard sleep staging leads were used to record electroencephalograms, electrooculograms and electromyograms (submental, abdominal and diaphragmatic). Respiratory parameters measured included thoracic and abdominal plethysmographic bands and the sum of these (Respiband, Ambulatory Monitoring, New York, USA), nasal airflow measured with a nasal cannulae to pressure transducer, mouth breathing via a thermistor (Triple Thermistor V7, Compumedics, Melbourne, Australia), SpO_2 (Biox 3700e oximeter, Ohmeda, Boulder, CO, USA) and transcutaneous carbon dioxide (TcCO_2 ; TINA TCM3, Radiometer, Copenhagen, Denmark). Also used were a position sensor and a single lead electrocardiogram. Data were acquired on a digital data acquisition system (Compumedics S Series,

V.1, Compumedics, Melbourne, Australia) and analysed using Compumedics Profusion software.

Sleep architecture was scored using standard criteria for our laboratory.¹ In summary, respiratory events were deemed significant if they lasted two or more respiratory cycles and were associated with a $\geq 3\%$ fall in SpO_2 and/or were terminated by an arousal. Obstructive apnoeas were defined as a reduction in airflow of $>80\%$ from baseline amplitude with continuing or increasing effort as reflected by the Resptrace and/or diaphragm electromyogram. Hypopnoeas were defined as a decrease in airflow to between 20% and 50% of the baseline amplitude. The apnoea hypopnoea index (AHI) was defined as the number of apnoeas or hypopnoeas occurring per hour of sleep time (total and for NREM and REM sleep) as a marker of severity of obstructive sleep apnoea (OSA). The arousal index was used to describe the number of arousals occurring per hour of sleep. In our laboratory, a diagnosis of OSA requires an $\text{AHI} > 1.0$, which is consistent with the parameters used in the study of Dyken *et al.*²

Statistical analysis was carried out using the SPSS statistical package (SPSS for Windows V.11, SPSS, Chicago, IL, USA) with statistical significance set at $p < 0.05$. Linear regression analysis was used to assess the association between age, body mass index standard deviation score (BMI SDS) and sleep parameters of apnoea, arousals and gas exchange. Tabulated data are presented as means $\pm$ standard deviations.

RESULTS

Twenty males and 13 females were studied at a mean age of 4.9 years (range 0.2–19 years). Ninety-one percent were non-obese.³ None of the children had acute medical issues at the time of study and all were clinically euthyroid. All patients snored during the studies.

Polysomnograms were sleep staged and scored for respiratory events,⁴ with more than 90% of events being obstructive apnoea or hypopnoea (partially obstructed breath). The major findings are summarised in table 1. The mean sleep efficiency (percentage of time asleep after lights out) was at the lower end of the normal range at 79.3% (normal $>80\%$). The number of episodes of arousal from sleep was increased significantly over normal. The arousal index (number of arousals from sleep per hour) consisted predominantly of respiratory (60%) and spontaneous arousals (32%) and was three times normal at 14.9 arousals per hour of sleep (normal <5).

One patient had primary snoring with an AHI of <1 event per hour of sleep (normal <1). The remainder of the patients had OSA, with nearly half having severe OSA, as illustrated in table 2. The AHI in REM sleep was three times higher than in NREM sleep and was associated with the lowest SpO_2 recorded. The average fall in SpO_2 was 3.9% with each apnoea.

Abbreviations: AHI, apnoea hypopnoea index; BMI SDS, body mass index standard deviation score; OSA, obstructive sleep apnoea; SpO_2 , oxygen saturation; TcCO_2 , transcutaneous carbon dioxide

Using linear regression, there was no correlation between age and AHI ($r^2 = 0.04$; $p = 0.15$), BMI SDS ($r^2 = 0.02$; $p = 0.48$) or arousal index ($r^2 = 0.28$; $p = 0.36$). However, the AHI correlated with average fall in SpO_2 ($r^2 = 0.49$; $p < 0.001$), lowest SpO_2 ($r^2 = 0.48$; $p < 0.001$), highest $TcCO_2$ ($r^2 = 0.36$; $p < 0.001$) and arousal index ($r^2 = 0.38$; $p < 0.001$).

DISCUSSION

Down syndrome is a very common and easily recognised chromosomal abnormality. The condition is known to be a predisposing factor for the development of sleep disordered breathing and in particular OSA, and was estimated in a recent prospective 5 year study to affect 50% to 80% of children with Down syndrome, prompting the authors to recommend routine polysomnography in all such children at age 3–4 years, independently of a history of snoring.⁵ In a non-selected cohort of 19 children with Down syndrome, aged between 3 and 18 years, a 79% prevalence of OSA was found despite the fact that 40% had previously had adenotonsillectomy.² This is consistent with the 97% prevalence of OSA in our cohort of children aged 0–18 years with Down syndrome who snored. None of our subjects had undergone adenotonsillectomy.

Sleep disordered breathing, predominantly with primary snoring and OSA, is also common in the general paediatric population. There is increasing evidence that children with sleep disordered breathing, including primary snoring and mild OSA, have a higher prevalence of behavioural problems, particularly externalising, hyperactive-type behaviours.⁶ It is believed that with treatment of upper airway obstruction, such neurocognitive abnormalities are improved in all patients.^{1, 5}

The present study demonstrated that 97% of consecutively referred children with Down syndrome who snore have moderate to severe OSA on overnight polysomnography (table 2). Interestingly, the frequency of the obstructive apnoeas was three times as evident in REM sleep, occurring approximately every 2 min with an average fall in oxygenation of 4% from a normal baseline ($SpO_2 > 93\%$). Furthermore, the mean arousal index of 14.9 episodes per hour of sleep was approximately three times higher than normal (< 5) and correlated with the degree of obstructive sleep apnoea ($p < 0.001$), supporting the observation that children with Down syndrome have fragmented sleep which is perhaps worse in the presence of OSA.^{2, 5}

Interestingly, in the present study, no association between BMI SDS and the degree of OSA was found. This may relate to the fact that, unlike other studies,^{2, 5} we used specific charts for Down syndrome BMI and half of our subjects were in the preschool age range. Moreover, this finding would support the high prevalence of OSA in children with Down syndrome who have had previous adenotonsillectomy, implicating contributory factors such as mid-face hypoplasia, muscle hypotonia, regrowth of adenoid lymphoid tissue or the presence of enlarged lingual tonsils.^{2, 5, 7} While this was a retrospective study, and not withstanding such limitations, our findings support the use of polysomnography in children with Down syndrome as a routine investigation, regardless of BMI, similarly to echocardiography.

However, with limited access to polysomnography for geographic and economic reasons, many clinicians may consider this investigation impractical. Other clinicians may rely on a history of snoring to identify those requiring a sleep study or adenotonsillectomy without polysomnography.

Table 1 Summary of polysomnographic data for all subjects

Patient	Sex	Age at study (years)	BMI SDS*	AHI	NREM AHI	REM AHI	Sleep efficiency (%)	Average fall in SpO_2 (%)	Total AI	Highest $TcCO_2$ (mm Hg)	Lowest SpO_2 (%)
1	F	0.2	-1	13.1	12.5	15.5	91.9	3	16.5	57	92
2	F	0.4	-0.9	18.3	5.6	40.9	78.9	4	28.7	53	82
3	M	0.7	-1.5	4.5	3.9	15.4	86.5	3	6.4	62	90
4	M	0.9	0.5	2.3	2.2	6.7	82.7	3	6.8	47	92
5	M	1.1	-2.2	14.8	13.1	25.9	87.3	3	20.7	50	88
6	M	1.2	0.1	9.7	3.7	24.0	75.4	4	23.6	49	87
7	M	1.2	1.7	9.0	4.7	24.1	88.3	5	12.5	60	81
8	F	1.3	0.5	1.5	0.7	4.6	96.1	4	5.9	49	92
9	M	1.3	0.6	28.0	10.9	67.8	63.2	5	9.0	64	64
10	M	1.4	-1.7	14.5	3.5	35.6	83.6	4	17.8	45	79
11	M	1.5	1.9	30.4	27.2	60.0	49.1	4	49.4	68	86
12	F	1.6	-1.1	3.5	1.2	10.7	88.7	4	9.7	58	87
13	M	1.7	-0.2	31.0	32.9	25.8	91.9	4	14.5	60	82
14	M	1.7	-0.5	2.3	0.9	7.1	90.1	3	9.1	54	94
15	M	2.2	0.8	6.2	2.1	15.5	84.7	4	7.7	53	89
16	M	3.0	0	8.8	4.5	18.9	86.1	3	10.9	60	92
17	F	3.7	1.7	14.0	6.6	43.8	81.6	4	14.9	62	88
18	M	3.7	-1.6	2.1	1.9	4.2	85.5	3	7.2	61	93
19	F	3.8	0.9	4.7	2.8	18.1	69.4	3	12.6	56	89
20	M	4.1	1	7.2	7.1	7.5	84.5	3	10.4	52	85
21	F	4.8	-0.1	1.2	0.5	4.6	54.7	3	7.7	47	91
22	F	5.2	-0.5	12.2	5.4	47.0	75.1	5	15.2	68	66
23	F	5.3	-1.9	1.4	1.5	0.8	94.7	3	6.6	52	96
24	F	7.3	0.4	3.0	1.6	10.5	81.9	3	8.6	51	89
25	F	9.1	2.1	27.3	18.6	107.1	62.6	5	26.4	61	84
26	M	9.3	$> +3.0$	51.3	46.1	73.7	93.4	7	16.6	68	64
27	M	11.8	-2.9	0.2	0	2.1	62.0	3	3.1	49	94
28	M	12.1	0.6	4.7	4.1	8.6	83.8	3	7.3	50	92
29	M	13.2	-2.4	4.5	5.3	0	70.8	3	4.5	51	91
30	F	13.7	1.8	23.1	23.7	23	80.6	6	23.6	60	74
31	F	13.8	-0.2	17.0	2.5	81.6	74.8	4	19.3	61	87
32	M	17.9	$> +3.0$	21.2	20.6	40.0	71.0	2	35.0	45	91
33	M	19.1	-1.8	31.6	32.3	25.5	66.3	5	23.8	60	83
Mean $\pm$ SD	NA	4.9 $\pm$ 5.4	NA	12.9 $\pm$ 12.0	9.4 $\pm$ 11.4	27.2 $\pm$ 26.0	79.3 $\pm$ 11.8	3.8 $\pm$ 1.1	14.9 $\pm$ 9.9	55.9 $\pm$ 6.7	85.9 $\pm$ 8.3

AHI, apnoea hypopnoea index; AI, arousal index; BMI SDS, body mass index standard deviation score; SpO_2 , oximetry estimation of arterial oxygen saturation; $TcCO_2$, transcutaneous carbon dioxide.

*Derived from Myreliid *et al.*³

Table 2 Severity of obstructive sleep apnoea

Degree of OSA*	Apnoea hypopnoea index	No. of patients (%)
Nil	<1	1 (3%)
Mild	1–5	12 (36%)
Moderate	5–10	5 (15%)
Severe	>10	15 (46%)

*Derived from Marcus *et al.*⁴
OSA, obstructive sleep apnoea.

Although a history of snoring reported by a parent is not always reliable, the results of the present study would support treating such a report as an added reason to consider a sleep study. One child (aged 10 years with small tonsils and no adenoid shadow on a lateral airways radiograph) had a normal polysomnogram. However, all the other children were referred for consideration of adenotonsillectomy which would probably have dramatically improved, but not completely resolved, the problem of OSA.

Given the adverse impact upon learning of recurrent oxygen desaturations occurring as a result of OSA in all children^{2,6} and the high prevalence of the problem in children of all ages with Down syndrome,⁵ we conclude that all children with Down syndrome who snore regardless of body habitus should be considered for overnight polysomnography to quantitate the severity of the sleep disordered breathing.

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ARCHIVIST

Maternal seafood intake and child development

The problem with seafood is that although it is “good for you”, it just might, on occasions and in some places, be “bad for you”. The goodness derives from its content of essential, long-chain omega-3 fatty acids, such as docosahexanoic and eicosapentanoic acids, which are essential for brain development. The badness would derive from toxins in fish, such as methylmercury and polychlorinated biphenyls. All fish contain methylmercury, but the only known cases of fetal damage from this source occurred in Japan half a century ago and were due to massive industrial water pollution. There has been concern, however, that in some fish-eating populations methylmercury might impair fetal neurodevelopment. In 2004 US national guidelines were published advocating a fish intake for pregnant women of no more than 340 g (three portions) a week. Now data from the Avon Longitudinal Study of Parents and Children (ALSPAC) have suggested that such a restriction might be harmful to the fetus (Joseph R Hibbeln and colleagues *Lancet* 2007;**369**:578–85; see also Comment, *ibid*: 537–8).

The ALSPAC cohort was enrolled in the Bristol area in 1991–92. A total of 11 875 women completed a food questionnaire at 32 weeks of pregnancy and child development was assessed from maternal questionnaires when the children were 6, 18, 30, 42 and 81 months old. At 8 years, IQ was assessed using an abbreviated form of the WISC-III^{UK}. After adjustment for multiple confounding variables, maternal seafood intake <340 g a week was associated with a significant increase in risk of low verbal IQ (lowest quartile) in the child compared with a higher intake. Among women who ate no seafood, the increase in risk was 48% and among those with a weekly intake of 1–340 g it was 9%. For low full scale IQ, the corresponding increases in risk were 29% and 19%. Low seafood intake was also associated with poorer outcomes for prosocial behaviour, fine motor skills, communication and social development.

The nutritional benefits of seafood are likely to outweigh any potential harm from its content of toxins. It is pointed out that seafood in the UK is likely to have a higher methylmercury content than in the USA, adding strength to the contention that the US advice for restricted seafood intakes during pregnancy is faulty.