Symptoms of inattention and hyperactivity in children with habitual snoring: evidence from a community-based study in Istanbul

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Accepted for publication 24 May 2005

Abstract

Background Neurobehavioural symptoms of inattention and hyperactivity are common in children with sleep-disordered breathing (SDB). Prevalence rates of habitual snoring and attention deficit hyperactivity disorder (ADHD) are very similar and both have a substantial negative effect on children's behavioural health.

Objective We examined the differences for subjective attentional and hyperactivity measures reported by parents and teachers among primary school children with habitual snoring and age- and sex-matched controls in a community-based case-control study in Istanbul.

Methods In 2002, a survey was carried out to determine the prevalence of snoring in 2147 primary school children. After one year, in 2003, 151 children with habitual snoring and 302 controls from this survey were studied with parental SDB questionnaire, Conners' Parent (Conners-P) and Teacher Scales, and an inattention hyperactivity scale (IHS). Exclusion criteria included history of ADHD diagnosis, controls who started to snore and habitual snorers (HS) who no longer snored in this follow-up study.

Results Ninety-six HS and 190 control subjects (mean age: 9.4 ± 1.3) were evaluated. HS had significantly more symptoms of hyperactivity (Conners-ADHD index) (P: 0.033), attentional (P: 0.019), and conduct and oppositional defiant in subscales (P: 0.001) of Conners-P and IHS-Parents. A pooled score of Conners-P ADHD Index > 60 and IHS-Parent score > 1.25 showed considerable difference in HS when compared with controls (5.1% vs. 1.4%) ($P < 0.0001$). Daytime hyperactivity and excessive daytime sleepiness reported by parents correlated with scores of Conners-P and IHS-P ($P < 0.01$). Teachers' observations showed significant correlations with learning disability and the level of academic performance in HS ($P < 0.01$). Other behavioural parameters related to SDB were not significantly correlated with teachers' ADHD ratings in HS.

Conclusion Increased rates of moderate hyperactivity as well as conduct and oppositional defiant symptoms in HS reported by the parents might reflect a negative impact on overall neurobehavioural health. The teachers' scores yielded no significant results among HS and controls. This may be caused by the limitation due to shared method variance. The negative effect of crowded classes on teachers' evaluations must be also taken into consideration. After exclusion of a diagnosis of ADHD in children

Keywords
behavioural scales, children, habitual snoring, hyperactivity, inattention

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presenting with hyperactivity and inattention, children with habitual snoring with prominent scores of behavioural measures should be considered as candidates for further assessment by a sleep specialist.

Introduction

Frequent snoring is a common condition in prepubertal children affecting approximately 4.9–12% of all children of this age (Ferreira *et al*. 2000; Brunetti *et al*. 2001; Ersu *et al*. 2004; Kaditis *et al*. 2004). Children who snore but do not fulfil the criteria for obstructive sleep apnoea (OSA) are considered to have primary snoring, i.e. habitual snoring (O'Brien *et al*. 2004) which might indicate the presence of increased upper airway resistance without alterations in alveolar oxygenation (Praud 2004). Clinical sleep studies report that behavioural problems that resemble attention deficit hyperactivity disorder (ADHD) are common among children with sleep-disordered breathing (SDB) problems (Chervin *et al*. 2002; O'Brien *et al*. 2003).

Increased work of breathing, sleep fragmentation and intermittent hypoxaemia in SDB are the possible contributing factors for the alterations in the neurochemical substrate of the prefrontal cortex that may result in executive dysfunction (Beebe & Gozal 2002; O'Brien & Gozal 2002).

ADHD is the most frequently encountered paediatric neurodevelopmental disorder with the prevalence of 3–12% (Dulcan 1997; Scahill & Schwab-Stone 2000), and in some occasions unrecognized medical conditions underlie the problematic behaviour, including SDB (Accardo 1999; Gozal *et al*. 2004). SDB can lead to ADHD-like symptoms in home recognized by parents (Gottlieb *et al*. 2003; O'Brien *et al*. 2003) or school settings described by teachers (Gozal 1998; Urschitz *et al*. 2003) that can be misperceived and potentially delay the diagnosis of both SDB and related psychiatric morbidity.

Diagnostic and Statistical Manual of Mental Disorders, fourth edition (DSM-IV) category C symptoms of ADHD diagnostic criteria entail that the symptoms must be present in both home and school environment (APA 1994). However, studies that evaluate ADHD in relation to SDB are conducted either using parent or teacher assessments (O'Brien & Gozal 2002; Schechter 2002). Thus, there is a strong need for an evaluation of the symptoms of ADHD in habitual snorers (HS) in both home and school settings at the same time.

The aim of our study was to examine the differences for hyperactivity and attentional measures between primary school children with habitual snoring, and age- and sex-matched controls in a community-based case-control study.

Methods

Study population

Approval by the Regional Director of Education that serves as the Institute of Human Subject Protection Committee for the schools in Istanbul was obtained prior to the study. In May 2002, a survey was carried out to determine the prevalence of HS and related diurnal symptoms in 2147 primary school children in Istanbul (Ersu *et al*. 2004). Multistage randomized sampling was used for the determination of 72 schools out of nine districts. Those districts were randomly chosen from 32 school districts in the city of Istanbul with the population of approximately 12 million people. The prevalence of HS in children aged 5–13 years was estimated to be 7.0% ($n = 151$) in this study (Ersu *et al*. 2004). After one year, in May 2003, 151 children with habitual snoring and two age- and sex-matched controls ($n = 302$) for each HS from the initial prevalence study were studied. Exclusion criteria included the history of ADHD diagnosis reported by parents. While ADHD is a behavioural phenotype, it is usually presented with co-morbid conditions such as oppositional defiant, conduct problems and academic difficulties that may resemble the behavioural consequences of habitual snoring. Therefore, children were excluded from

both groups to avoid the over-interpretation of any association between snoring and behavioural problems. Controls that started to snore and HS that did not snore any longer are also excluded.

Measures

Parental SDB questionnaire

A 55-item multiple-choice questionnaire formulated according to the Brouillette and colleagues' (1982, 1984) and Carroll and colleagues' (1995) guidelines were completed by the parents and provided information regarding sleep habits, nighttime symptoms (total sleep time, sleep latency, presence and frequency of snoring, restless sleep and sleep arousals), and daytime symptoms (sleepiness in different situations, learning disability, school performance and hyperactivity). An envelope containing the questionnaire, the behavioural assessments described below, and a personally addressed letter asking for parental consent were distributed to children at school with the help of their teachers to be filled in by their parents within 3 days. Parents reported snoring and other measures on a 4-point scale: 0 (never), 1 (occasionally), 2 (often) and 3 (always). Habitual snoring and hyperactivity were considered if they were reported by parents as either 'often' or 'always' on a 4-point Likert scale in parental SDB questionnaire. The stability of the questionnaire was tested on an independent sample of 65 school-aged children prior to the epidemiological survey (Ersu *et al.* 2004).

Behavioural assessments

Conners' Parent Rating Scale-48 (CPRS) is a well-validated, 48-item instrument that is widely accepted to identify ADHD behavioural problems in children (Conners 1997). The Turkish CPRS validation has been made by Dereboy and colleagues (1998), and yielded six factors such as oppositional, conduct, inattention, hyperactivity, anxious and psychosomatic.

Conners' Teacher Rating Scale-28 (CTRS) is a commonly used research and clinical tool for assessing children's behaviour in the classroom and composed of 28 items (Goyette *et al.* 1978). The validation of Turkish CTRS was conducted by Sener and colleagues (1995), and includes three factors: inattention, hyperactivity/impulsivity and conduct problems. Symptoms are rated by parents or teachers on a 4-point scale and raw scores are converted to age- and sex-adjusted *t*-scores. Factor totals are standardized with *t*-scores starting from 0 to 100 points with a mean of 50 points and a standard deviation (SD) of 10 points. Scores that exceed this average by 1 SD (10 points) to 2 SD (20 points) are commonly considered to reflect hyperactive behaviour. Both instruments contain an ADHD index, composed of 12 most relevant items that show symptomatology consistent with a diagnosis of ADHD (Conners 1999). In this study, both CPRS- and CTRS-ADHD indexes >60 were considered to represent hyperactive behaviour.

An inattention hyperactivity scale (IHS) is derived from 18 DSM-IV category A symptoms of ADHD diagnostic criteria (APA 1994). The validity of the instrument in the assessment of ADHD behaviour has been well established (Gadow & Sprafkin 1994). Responses are given on a 4-point scale from 0 to 3 (0 = never, 1 = occasionally, 2 = often, 3 = always). A mean item response, IHS score, greater than 1.25 was considered to be high in our study. IHS-P score and IHS-T score, respectively, for parents and teachers correspond to mean scores of 12 or more positive (i.e. ≥2 points for each item on 4-point scale) responses among the 18 symptom-items of ADHD. Six symptoms among nine that relate to inattention and six among nine that relate to hyperactive-impulsive behaviour are needed to support the diagnosis of ADHD, combined type in DSM-IV (APA 1994).

Both Conners' ADHD index (O'Brien *et al.* 2003) and IHS scores (Chervin *et al.* 1997, 2002) have been used in previous studies of SDB children. CTRS and IHS-T were filled out by teachers in 3 days, and all the survey materials were collected back from the schools by researchers.

Data analysis

Statistical analysis was done using a statistical software package (Version 11.0 for Windows; SPSS, Chicago, IL). Comparisons of the demographic factors, SDB questionnaire variables, and behav-

ioural scores of study groups were made with independent *t*-tests for continuous variables, or Fisher's exact test for dichotomous variables. Bonferroni corrections were applied to control for multiple comparisons.

Data were summarized with means and SD unless otherwise indicated. Correlation analyses were performed to evaluate potential relations between behavioural scores and sleep variables in parental SDB questionnaire. Conners' and IHS Total T scores for parents and teachers were considered to reflect hyperactive behaviour in correlation analyses. The level of significance was set at $P < 0.05$, unless otherwise stated.

Results

Subjects

Response rate was 85.9%; 306 out of total 453 SDB questionnaires were fully completed, returned and analysed. Forty-eight control children who started to snore on May 2003 and seven HS from prevalence study who did not snore any longer were excluded from their groups. There were 105 HS and 201 healthy controls that never snored in 2003. Eight and a half per cent of HS ($n = 9$) and 5.3% of controls ($n = 11$) who had a clinical diagnosis of ADHD reported by parents were excluded from both groups. Hence, there were 96 HS and 190 controls evaluated for sleep variables and behavioural measures. There were equal amount of girls and boys in both groups and mean age was 9.4 ± 1.3 (range: 7.1–13.5) for all the participants. Mean ages were similar for both HS and control groups. HS was common in the 7- to 10-year age group (61.5%), and the percentage was lower in the 10- to 13-year age group (38.6%). The distribution of HS in girls and boys in different age groups did not differ. Nine school districts consisted of 72 schools with different socio-economic levels and ranged from very poor to upscale neighbourhoods. Maternal educational level, occupation and smoking rates were similar in both groups.

Table 1 outlines the demographic characteristics of HS and controls.

Parental SDB questionnaire

Table 2 shows parental SDB questionnaire findings in both groups. Parental anxiety during child's sleep was more than three times likely in HS than

Table 1. Demographic characteristics of 96 habitual snorers (HS) and 190 control subjects

	HS ($n = 96$)	Controls ($n = 190$)
Mean age (years; range)	9.3 ± 1.4 (7.2–13.5)	9.4 ± 1.2 (7.1–13.2)
Male gender	54 (56.3%)	107 (56.3%)
Maternal educational status		
Primary school	51 (53.1%)	107 (56.3%)
Junior high school	16 (16.7%)	22 (11.6%)
Senior high school	23 (24.0%)	28 (14.7%)
Collage or higher	6 (6.2%)	7 (3.7%)
Missing	0	26 (13.7%)
Maternal labour status		
Housewife (not working)	77 (80.2%)	145 (76.3%)
Manual worker*	5 (5.2%)	8 (4.2%)
State officer†	8 (8.4%)	17 (9%)
Other	2 (2.1%)	4 (2.1%)
Missing	4 (4.1%)	16 (8.4%)
Maternal smoking		
Yes	28 (29.2%)	17 (22.7%)
No	58 (60.4%)	116 (77.3%)
Missing	10 (10.4%)	40 (21.1%)

*'Manual worker': Women who are mostly educated to primary school level and are in a position that needs handwork (i.e. cleaning services, textile industry, tailor assistance, etc.). They may or may not be governmentally insured.
†'State officer': Women who are educated to high school or university level, are usually in office work, and have governmental health insurances (i.e. nurse, doctor, lawyer, teacher, etc.)

Table 2. Parental SDB (sleep-disordered breathing) questionnaire findings in 96 habitual snorers (HS) and 190 control subjects

	HS ($n = 96$)	Controls ($n = 190$)	*P*-value
Total sleep time (min)	587.07 ± 58.9	590.35 ± 56.6	0.59
Sleep latency (min)	15.7 ± 13.4	15.8 ± 13.2	0.88
Sleep awakenings (%)	5.4	2.5	0.18
Restless sleep (%)	27.4	13.8	0.006*
Nocturnal enuresis (%)	6.3	1.2	0.02*
Increased parental anxiety during child's sleep (%)	26.3	7.6	0.000***
Sleepiness score	0.38 ± 0.64	0.17 ± 0.31	0.000***
Daytime sleepiness (%)			
In public places	8.2	1.7	0.03*
While watching television	27.2	9.4	0.001**
Daytime hyperactivity (%)	45.3***	22.2	0.000***
Learning disability (%)	21.1	15.1	0.15
Academic performance (% of failed subjects)	3.3	1.8	0.9

*$P < 0.05$; **$P < 0.001$; ***$P < 0.0001$.

controls ($P < 0.0001$). Sleepiness score, mean score of the sum of 'often' or 'always' answers to the questions such as 'Does your child feel sleepy in different conditions such as in public places, during watching TV, or playing with friends?', was twofold higher in HS than controls ($P < 0.0001$). Particularly, sleepiness during watching TV was significantly increased in HS group (*P*: 0.001). Parents were asked if their child looked restless, fidgety or hyperactive most of the time during day and 44 of HS children's mothers answered as either 'often' or 'always' ($P < 0.0001$). Hyperactivity reported as 'sometimes' might reflect moderate levels of increased activity during daytime and was reported as 26.4% in HS vs. 12.1% in controls (*P*: 0.006). Although the rates of learning disability (i.e. reading, writing, and both) did not differ among groups; specific reading disorder was reported as 7.8% in HS, in contrast to 3.0% of controls (*P*: 0.054). The answer to the question of 'What do you think about your child's academic performance?' was scored from 'failure (0)' to 'successful (3)' in a 4-point scale. The percentages of results from poor (1) to successful (3) did not change among groups. Although school failure was reported nearly twice more in HS, the difference was not significant.

Behavioural assessments

The results of behavioural assessments reported by parents and teachers are shown in Table 3. HS performed significantly worse than control subjects on several subscales of Conners' and IHS. Mean *t*-scores were within normal range for both groups. All of the significant differences were in the parental scale scores of hyperactivity, inattention, conduct and oppositional defiant symptoms. The pooled score of CPRS-ADHD index +1 SD and IHS > 1.25 was positive in 5.1% of HS while only 1.4% of normal children showed positive scores ($P < 0.0001$). However, teachers' pooled scores were high in both groups (10.9% and 9.5% in HS and controls, respectively).

Relationship between behavioural function and parental SDB questionnaire

The correlations between the behaviour scores and SDB questionnaire variables in 96 HS subjects are shown in Table 4. Parents' and teachers' Conners' Rating Scales and DSM-IV ADHD criteria (IHS scores) were chosen to reflect hyperactive behaviour. Daytime hyperactivity, learning disability and sleepiness while watching television were significantly correlated with parent scores. Level of academic performance was negatively correlated with all behavioural domains. Teacher ratings showed significant correlations with learning disability (positively) and level of academic performance (negatively). Other variables of SDB outlined in Table 2 did not correlate with hyperactive behaviours reported by teachers.

Table 3. Neurobehavioural assessments in 96 habitual snorers (HS) and 190 control subjects using the Conners' rating scales and inattention hyperactivity scale (IHS)

	HS ($n = 96$)	Controls ($n = 190$)	*P*-value
Parent scores (mean, SD)			
CPRS subscales‡			
CPRS-hyperactive	52.2 ± 9.5	48.0 ± 9.9	0.65
CPRS-inattentive	52.6 ± 10.9	47.8 ± 8.7	0.29
CPRS-conduct	53.9 ± 11.7	47.2 ± 7.8	0.001†
CPRS-oppositional defiant	53.8 ± 10.4	47.0 ± 8.4	0.001†
CPRS-anxiety	51.7 ± 10.8	48.5 ± 9.4	0.290
CPRS-psychosomatic	53.2 ± 9.7	48.0 ± 9.4	0.98
IHS-P subscales§			
IHS-P hyperactive	8.1 ± 6.8	5.4 ± 5.3	0.032
IHS-P inattentive	6.2 ± 5.4	3.5 ± 3.7	0.019†
CPRS total	53.4 ± 10.8	47.0 ± 8.7	0.047*
CPRS-ADHD index	53.1 ± 9.2	47.5 ± 7.3	0.033*
CPRS-ADHD index >60 (%)	24.1	6.5	0.000**
IHS-P Total	14.3 ± 10.9	8.9 ± 8.1	0.007*
IHS-*P* >1.25 (%)	14.6	3.3	0.002*
CPRS-ADHD index >60 and IHS-*P* >1.25 (%)	5.1	1.4	0.000**
Teacher scores (mean, SD)			
CTRS subscales¶	50.9 ± 9.1	50.0 ± 16.8	0.70
CTRS-hyperactive/impulsive	50.0 ± 9.9	48.8 ± 10.2	0.63
CTRS-inattentive	50.9 ± 9.8	49.5 ± 10.6	0.69
CTRS-conduct			
IHS-T subscales§	6.9 ± 7.3	6.2 ± 7.8	0.56
IHS-T hyperactive	7.1 ± 7.1	5.6 ± 6.2	0.18
IHS-T inattentive			
CTRS-total	50.8 ± 9.9	49.3 ± 10.4	0.43
CTRS-ADHD index	50.5 ± 8.01	49.4 ± 8.9	0.15
CTRS-ADHD index >60 (%)	12.7	12.7	0.58
IHS-T Total	14.0 ± 12.8	11.8 ± 12.4	0.77
IHS-T >1.25 (%)	20.5	15.0	0.18
CTRS-ADHD index >60 and IHS-T >1.25 (%)	10.9	9.5	0.43

CPRS, Conners' Parent Rating Scale; CTRS, Conners' Teacher Rating Scale; CPRS-ADHD index, Inattention and hyperactivity score derived from Conners' Parent Rating Scales; IHS-P, Inattention hyperactivity score derived from DSM-IV category A symptoms of ADHD diagnostic criteria described by parents; IHS-T, Inattention hyperactivity score derived from DSM-IV category A symptoms of ADHD diagnostic criteria described by teachers.

*$P < 0.05$, **$P < 0.0001$.

†Significant results where Bonferroni procedure is applied.

Significance levels are set after Bonferroni procedure:

‡P : 0.008 for CPRS subscores.

§P : 0.025 for IHS-Parent and Teacher subscores.

¶P : 0.016 for CTRS subscores.

Discussion

The results of this study indicate that behavioural symptoms of ADHD are prevalent in children with habitual snoring, when compared with community sample of non-snoring control subjects. Even though the children with a history of ADHD were excluded from the groups, behavioural scales of Conners' and IHS revealed that hyperactivity and related problems are more likely to be present in HS. This study differs from previous research because both parent and teacher well-validated behavioural instruments are administered simultaneously in a case-control design. The association between problem behaviours and adenotonsillar enlargement in children was noted by Hill (1889). The issue remained unvisited until Guilleminault and colleagues (1982) reported the behavioural and physical consequences of OSA. Since then, several studies documented that HS often demonstrate behaviours that may resemble ADHD (Chervin *et al*. 1997; Blunden *et al*. 2000) and up

Table 4. Relationships between hyperactive behaviour based on neurobehavioural measures and parental SDB (sleep-disordered breathing) questionnaire variables in 96 habitual snorers (HS) subjects

Behavioural scores (Total T score)	Parental SDB questionnaire variables					
	Positive correlation	***r***	**Negative correlation**	***r***	**No significant correlation**	***r***
Conners-Parent	Daytime hyperactivity	(0.481**)	Level of academic performance	(–0.319**)	Sleepiness score	(0.225)
	Learning disability	(0.368**)				
	Sleepiness while watching television	(0.272*)				
	Nocturnal enuresis	(0.254*)				
	Sleep awakenings	(0.243*)				
IHS-Parent	Daytime hyperactivity	(0.451**)	Level of academic performance	(–0.525**)	Sleep awakenings	(0.181)
	Learning disability	(0.395**)			Nocturnal enuresis	(0.114)
	Sleepiness while watching television	(0.377**)				
	Sleepiness score	(0.376**)				
Conners-Teacher	Learning disability	(0.344**)	Level of academic performance	(–0.339**)	Daytime hyperactivity	(0.137)
					Nocturnal enuresis	(0.10)
					Sleep awakenings	(0.09)
					Sleepiness while watching television	(0.076)
					Sleepiness score	(0.075)
IHS-Teacher	Learning disability	(0.313**)	Level of academic performance	(–0.444**)	Sleepiness score	(0.134)
					Daytime hyperactivity	(0.132)
					Sleepiness while watching television	(0.048)
					Nocturnal enuresis	(0.01)
					Sleep awakenings	(0.002)

P-values are expressed as $*P < 0.05$, $**P < 0.01$.

Correlational values are expressed as 'r'.

Conners-Parent Total T score: Total T scores derived from Conners' Parent Rating Scales.

IHS-Parent Total T score: Total T scores of inattention hyperactivity scale derived from DSM-IV category A symptoms of ADHD diagnostic criteria described by parents.

Conners-Teacher Total T score: Total T scores derived from Conners' Teacher Rating Scales.

IHS-teacher Total T score: Total T scores of inattention hyperactivity scale derived from DSM-IV category A symptoms of ADHD diagnostic criteria described by teachers.

to one-third of all children with frequent snoring display significant hyperactivity and inattention (Ali *et al*. 1993; Chervin *et al*. 2002). Similarly, habitual snoring was found to be associated with an increased likelihood of hyperactivity in our study (14.6–24.1% and 1.4–6.5% in HS and control subjects, respectively).

On the contrary, Janusz (1999) and Cooper and colleagues (2004) both reported that the sleep abnormalities of SDB and ADHD had no contributions to one another. They concluded that minimal attentional difficulties demonstrated by children may suggest attention-seeking behaviours rather than ADHD. Although Cooper and colleagues (2004) included polysomnography (PSG) evaluations, both studies consisted of small study populations which may not efficiently show the relationship between ADHD behaviours and SDB.

Conduct and oppositional problems reported in behavioural scales were notably higher in HS in our study. In a prospective study of 872 children evaluated by parental rating scales, Chervin and colleagues (2003) concluded that bullying and other explicit aggressive behaviours were generally two to three times more frequent among children at high risk for SDB than among remaining children. Studies of children with SDB suggested that inattentive, hyperactive and aggressive behaviour are all essential components of sleep disturbances (Guilleminault *et al*. 1982). The current hypothesis is that sleep fragmentation resulting from recurrent arousals may result in prefrontal cortex dysfunction at vulnerable periods of brain development, therefore reflecting as executive dysfunction in pre-pubertal children (Beebe & Gozal 2002). ADHD, conduct and oppositional defiant disorders have been found to co-occur in 30–50% of cases in both epidemiologic and clinical samples (Biederman *et al*. 1991). The typical age of onset of both disorders is also pre-pubertal like SDB and ADHD, therefore careful diagnosis of conduct and oppositional defiant disorders may be crucial for timely intervention to prevent social dysfunction (Spencer *et al*. 1999).

We emphasized the importance of obtaining teachers' observations in the methods section for evaluating behavioural symptoms of ADHD, and we expected significant results from teacher scales. However, no significant difference was found in behavioural scales at school setting between the two study groups. The guidelines (Dulcan 1997; AAP 2000) suggest that the diagnosis of ADHD must include core symptoms of inattention, hyperactivity and impulsivity in more than one setting to meet DSM-IV criteria (Conners 1999). The validity and reliability measures of Turkish version of CTRS are well established (Sener *et al*. 1995). On the other hand, the discriminative power of teachers' ADHD ratings seems to stem from teachers' opportunity to observe children objectively during class work (Hinsaw 1987). In our study, the rating quality may be negatively effected as the classes were overcrowded (>40 students in a class) and the educational programme was highly loaded. We may speculate that teachers have answered the items rapidly and rated both the HS and control groups with quite high behavioural scores of ADHD. In our study, the rates of hyperactivity reported by teachers (i.e. pooled ADHD scores) were similarly high in both HS (10.9%) and controls (9.5%). These results make contrast to the rates of hyperactivity reported by parents using the similar scales (5.1% for HS, and 1.4% for controls).

Why teacher data yielded no significant findings while parental ratings were significantly different could be explained due to artefacts resulted from shared method variance. That is to say, the relationship between parent-reported sleep and parent-reported behavioural functioning might be a function of common reporter, also called as 'reporter bias'. This effect is quite prominent in correlational analyses where teachers' scores significantly correlated with only learning disability and level of academic performance in our study. On the contrary, parental behavioural scores were significantly correlated with most of the parent-reported sleep variables.

Both teachers' and parents' behavioural scores were significantly correlated with learning disability and level of academic performance in HS, when correlational analyses were performed. However, we found no differences in academic achievement and overall learning disability between the two groups. One explanation to this might be the percentages of results from poor to successful were similar among groups, except school failure was

reported nearly twice more in HS. In contrast, habitual snoring was associated with poor academic performance in Urschitz's study (Urschitz *et al.* 2003) of 1144 children. Schooling problems have been repeatedly reported in children with SDB (Gozal 1998; Gozal & Pope 2001), and improvements in learning have been reported following treatment for SDB in children (Gozal 1998). Analysing the associations between academic problems and HS were not the primary prospective aim of our study protocol. A more precise evaluation of academic scoring similar to the method of Urschitz and colleagues (2003) might help yield more consistent results. Therefore, our findings on academic problems have a need of verification with further comprehensive cognitive assessments.

Increased rates of excessive daytime sleepiness were significantly more often in HS when compared with controls. In a cross-sectional study of Melendres and colleagues (2004), both the sleepiness and Conners' scores were higher in primary school children with suspected SDB in contrast to controls. Daytime sleepiness, hyperactivity and restless sleep were all significantly more common in the HS than in those who never snored in a community-based study (Ali *et al.* 1994). Restless sleep may contribute to difficulties with attentional focus and can imitate the components of ADHD (Accardo 1999). Children having ADHD symptoms with a medical history of frequent snoring and restless sleep should be candidates for a paediatric respiratory consultation to rule out significant upper airway obstruction.

A potentially serious consequence of intermittent hypoxia during sleep may involve its long-term effects on neuronal function, such as neuronal loss through programmed cell death within prefrontal cortex (Beebe & Gozal 2002). Even in the absence of OSA, snoring is associated with significant deficits in neurobehavioural function in children (Blunden *et al.* 2000; O'Brien *et al.* 2004). Recent studies have shown that primary snoring is not as 'benign' as was first thought and is associated with cognitive problems, including reduced verbal and total intelligence scores, reduced attention and memory deficits (Kennedy *et al.* 2004). In our previous study (Ersu *et al.* 2004), both habitual and high-risk snorers had similar high rates of daytime sleepiness and hyperactivity although their physical symptoms such as blue colouring during sleep and observed apnoea were significantly reported in favour of high-risk group.

Limitations

Our study mainly relied on parental and teacher reports rather than objectively collected sleep measures such as PSG. Our habitual snoring group most probably include OSA cases, as current evidence suggest up to 12–15% (AAP 2000) HS may indeed be diagnosed as OSA by means of PSG. Overnight PSG is recognized as the gold standard for the diagnosis of OSA (Schechter 2002). On the other hand, Montgomery-Downs and colleagues (2004) concluded that parental-report questionnaires of habitual snoring can be used as substitute predictors of SDB behaviours, provided that careful attention is paid to age and risk states, and aim of screening.

As discussed earlier, reporter bias has to be mentioned as a limitation in our study. Although we included teacher reports besides parental observations of sleep and behaviour, teacher data did not yield significant results among groups. So the possibility of artefacts due to shared method variance remains.

When our study subjects are taken into consideration, further face-to-face assessment of HS with the possible ADHD diagnosis would help to illuminate the relationship between habitual snoring and ADHD.

Conclusions

Habitual snoring is related to considerable behavioural problems including ADHD symptoms when compared with children who never snored. Co-occurrence of sleep awakenings, excessive daytime sleepiness and hyperactivity in children with habitual snoring should alarm physicians for further medical assessments. After excluding ADHD and any other psychopathology with clinical interview, children with habitual snoring who have elevated scores of Conner's and IHS should be considered for further evaluation by a sleep specialist.

Acknowledgements

This study was presented in 16th International Association of Child and Adolescent Psychiatry and Allied Professionals (IACAPAP) Congress, Berlin, 22–26 August 2004. It was supported by International Donald Cohen Young Researchers Fellowship Programme in 16th IACAPAP Congress as a poster presentation. The authors thank to all students, parents and teachers for their participation in this study, and the principals of the schools and Regional Director of Education of Istanbul, who made this study possible by approving and supporting the process.

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