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Clinical and polygraphic evolution of sleep-related breathing disorders in adolescents

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ABSTRACT: **It has been suggested that sleep-related breathing disorders (SRBD) involve a continuum that develops over the course of life. If modifiable factors could be identified, the progression of SRBD could perhaps be addressed early in life. Although some studies have looked at the evolution of SRBD in pre-pubertal children, very few studies obtained data in adolescents.**

Anthropometric, clinical and polygraphic variables were collected during a 4-yr follow-up study among 148 normal adolescents after initial cross-sectional analysis.

From a total of 267 adolescents studied at baseline (mean $\pm$ SD age 14.3 $\pm$ 2.1 yrs), 148 (55.4%) were followed up for 4 yrs. During follow-up, there were no significant changes in snoring and polygraphic parameters. However, a tendency toward weight gain with centrally distributed fat was observed. Habitual snorers had a significantly higher body mass index and more centrally distributed fat than nonsnorers. Males had a higher snoring prevalence and a higher number of respiratory events than females. Snoring at baseline, male sex and poor academic performance were significant predictors of snoring at follow-up.

Snoring tends to persist during adolescence and male sex acts as a risk factor. A relationship between snoring and academic performance was observed. These findings may have implications for long-term management of sleep-related breathing disorders.

KEYWORDS: **Adolescence, follow-up, obesity, sex, sleep-related breathing disorders**

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STATEMENT OF INTEREST
None declared.

It has been suggested that sleep-related breathing disorders (SRBD) in childhood may be a risk factor for later development of adult sleep apnoea [1]. Several factors may play a role in linking childhood SRBD to the adult form of obstructive sleep apnoea, including complex genetic factors influencing upper airway morphology, uncorrected upper airway obstruction and obesity [2, 3]. In this context, preventative strategies identifying and acting on modifiable risk factors may be of paramount importance for preventing and slowing the progression of SRBD. This may have major clinical implications in the light of the current evidence linking sleep apnoea/hypopnoea syndrome (SAHS) with traffic accidents [4], increased cardiovascular risk [5] and overall mortality [6].

The natural history of snoring and SRBD in childhood and adolescence remains controversial. Recent research has reported that SRBD may be associated with behavioural and cognitive dysfunction [7, 8]. In contrast, other studies have suggested that childhood SRBD has a benign course in most cases. However, previous studies were limited to samples of pre-pubertal children, and changes during adolescence were not addressed [9, 10].

Adolescence may be crucial in the development of SRBD because hormonal changes during this period lead to anthropometric changes and muscle development that affects the entire organism, including the upper airway [11].

The general features of SRBD in the adolescent age group have been reported previously [12–15]. A cross-sectional study was carried out by the present authors between 1997 and 2000 in a population of 267 adolescents ranging 11–19 yrs of age. To shed more light on the natural history of SRBD during adolescence, the original population was prospectively followed up between 2002

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and 2004. In the present study, anthropometric, clinical and polygraphic variables were collected from 148 normal adolescents during a 4-yr follow-up period from the initial baseline assessment.

METHODS

Study design

The present study is the second prospective phase of a cross-sectional study carried out by the current authors between 1997 and 2000 in a population of 267 adolescents ranging 11–19 yrs of age. The study group was prospectively followed up between 2002 and 2004. The Institutional Review Board and Local Education Authorities (Seville, Spain) approved the study protocol. Adolescents gave written informed consent along with the written informed consent of their parent or legal guardian. Adolescents participating in the original cross-sectional study were contacted after a 4-yr follow-up period. Families were initially invited to participate by letter. After 1 month, each potential participant was contacted by telephone and the study protocol was explained in more detail.

Questionnaire

A previously reported questionnaire [12–15] (see online supplementary data) was used in the follow-up study. The questionnaire was completed by a technician, and data were provided by the subject and their parents. Questions were answered at the adolescent's home, on the same night as the polygraphic recording was taken. Snorers answered ''sometimes'' or ''often'' to the question on snoring, while nonsnorers answered ''never'' or ''rarely''. Subjects who snored often were considered habitual snorers. Academic performances were classified as poor, average or good.

Height and weight were measured at baseline and upon completion of follow-up to calculate the body mass index (BMI; $kg \cdot m^{-2}$). Neck, waist and hip circumferences were measured in all subjects. Waist-to-hip ratio (WHR) and neck-to-height ratio (neck circumference divided by height cm) were calculated [12]. The relationship between BMI and WHR values at baseline and follow-up (BMI_2/BMI_1 and WHR_2/WHR_1 ratios, respectively) were also determined. The BMI z-score was defined as the deviation of the value of BMI for an individual from the mean value of the reference population divided by the SD for the reference population [16, 17].

Respiratory polygraphy

The overnight home polygraphy was performed using a portable ambulatory device (Apnoescreen II; Erich Jaeger GmbH, Wuerzburg, Germany) with continuous monitoring of oronasal airflow (thermistor), chest and abdominal respiratory movements (thoracic and abdominal belts), arterial oxygen saturation (S_{a,O_2}; digital pulse oximetry), heart rate (finger probe), electrocardiography, body position (mercury sensor) and actigraphy (wristband with activity sensor) [12, 15]. The specific program for the analysis of the recordings was improved in the second phase to enable the recordings to be reproduced in real time. The recordings obtained in both phases were analysed manually with this new program. The following parameters were assessed: 1) apnoea, defined as an absence of oronasal airflow lasting $\geqslant$5 s [18]; 2) hypopnoea, defined as a reduction of oronasal airflow to $\geqslant$50% of the preceding breathing amplitude and a duration of $\geqslant$5 s with a reduction in the oxygen saturation; 3) desaturation, defined as a drop $\geqslant$4% in S_{a,O_2}; and 4) cardiac event, defined as a change in cardiac frequency of $\geqslant$10 $beats \cdot min^{-1}$ over $\geqslant$10 s associated with apnoea, hypopnoea or desaturation.

The variables analysed were: total recording time (TRT); TRT in the supine position; baseline S_{a,O_2} obtained from the automatic analysis during the first minutes of recording; S_{a,O_2} nadir (lowest value recorded during TRT); percentage of TRT with S_{a,O_2} <90%; desaturation index: the number of oxygen desaturation events per hour in the manual analysis; respiratory disturbance index (RDI): the number of apnoeas plus hypopnoeas per hour; and RDI in the supine position (RDI_{supine}).

Statistical analysis

The results are expressed as mean$\pm$SD or as percentages. To compare independent qualitative variables, the Chi-squared test and the McNemar test were employed to analyse the trend in the shift of the distribution of these variables. To compare continuous quantitative variables, a paired and unpaired t-test was used for independent samples or related samples respectively, depending on the case. The Levene test was used to assess the equality of variances, adjusting the p-value of the latter if they proved to be unequal. Variables that were significantly associated with snoring in the bivariate analysis were included in the multiple logistic regression model, and the odds ratio (OR) and confidence interval (CI) were estimated for each variable, to act as risk factors for the dependent variable ''snoring''. In addition, a binary logistic regression analysis was performed with the presence of $\geqslant$5 RDI (obtained in the polygraphy at follow-up) as the dependent variable. Baseline anthropometric, clinical and polygraphic variables were entered into the model as potential predictors. A p-value <0.05 was considered statistically significant.

RESULTS

From a total of 267 adolescents studied at baseline, 204 were contacted after a 4-yr follow-up period. The remaining 63 subjects were lost to follow-up. In total, 148 individuals (72.5% of the subjects contacted, 55.4% of the initial study cohort) agreed to participate in the second part of the study. The final sample consisted of 76 females (51.4%) and 72 males (48.6%), with a mean$\pm$SD (range) age of 18.5$\pm$2.3 (14–24) yrs.

As can be seen in table 1, there were no significant differences on baseline anthropometric, clinical or polygraphic parameters between completers and those who were lost to follow-up. A tendency toward weight gain with centrally distributed fat was observed in the 148 study participants, especially in males (table 2). At long-term follow-up, males presented with higher values than females in all the anthropometric parameters evaluated (table 3).

Of the 148 individuals included in the study, three subjects were unable to answer to the question about snoring at the follow-up assessment. In total, 29 subjects who answered sometimes (n=11, 7.4%) or often (n=18, 12.1%) to the question about snoring were classified as snorers at follow-up. The nonsnorer group included 116 subjects who answered never (n=99, 66.8%) or rarely (n=17, 11.4%). The percentage of snorers observed at follow-up (19.6 %) was lower than that

TABLE 1 Baseline characteristics of subjects who did or did not complete the follow-up study

	Included	Not included	p-value
Subjects n	148	119	
Males	72 (48.6)	48 (40.3)	NS
Females	76 (51.4)	71 (59.6)	NS
Age yrs	14.3±2.1	14.7±2.1	NS
Social status			
Manual work	80 (54.1)	79 (66.3)	NS
Nonmanual work	68 (45.9)	40 (33.6)	
BMI kg·m^-2	21.6±3.6	21.8±3.7	NS
Snorers	42 (28.3)	41 (34.4)	NS
RDI	3.43±1.8	2.5±1.8	NS
DI	2.02±2.2	1.6±2.1	NS

Data are presented as n (%) or mean±SD, unless otherwise stated. BMI: body mass index; RDI: respiratory disturbance index (number of apnoeas plus hypopnoeas per hour of recording); DI: desaturation index (number of desaturations per hour of recording); NS: nonsignificant.

observed at baseline (27.6%). However, there was no significant trend over time according to the McNemar test (table 4). As shown in table 4, 17 subjects (eight females and nine males) classified as snorers at the initial assessment (answered sometimes or often for the question on snoring) were classified as nonsnorers at follow-up (answered never or rarely at follow-up). These subjects were classified as ex-snorers. Although ex-snorers had not lost weight, the average BMI z-score had decreased significantly from baseline values. In others words, the BMI z-score had moved away from the general tendency to gain weight and show a more central fat distribution pattern, maintaining anthropometric values similar to those at baseline (table 5).

As can be seen in table 4, there were seven subjects (four females and three males) who answered never or rarely to the question on snoring at baseline, but sometimes or often at the end of follow-up (no snore 1 and snore 2 group). A tendency toward weight gain with centrally distributed fat was observed during

TABLE 2 Changes in anthropometric measures during a 4-yr follow-up in the overall cohort#

	Baseline	Long-term follow-up	p-value
Age yrs	14.3±2.1	18.5±2.3	
BMI kg·m^-2	21.6±3.6	22.6±3.8	<0.001
WHR	0.79±0.08	0.82 ±0.08	<0.001
NHR	0.19±0.01	0.2±0.02	0.003
BMI2/BMI1		105.13±14.49	
WHR2/WHR1		104.12±10.77	

Data are presented as mean± SD, unless otherwise stated. BMI: body mass index; WHR: waist-to-hip ratio; NHR: neck-to-height ratio; BMI2/BMI1: BMI at the end of follow-up/BMI at baseline; WHR2/WHR1: WHR at the end of follow-up/ WHR at baseline. #: n=148.

TABLE 3 Anthropometric measures stratified by sex at the end of follow-up

	Females	Males	p-value
Subjects n	76	72	
z-score BMI	0.15±1.15	0.25±1.07	NS
WHR	0.77±0.06	0.87±0.05	<0.001
NHR	0.19±0.01	0.21±0.02	<0.001
BMI2/BMI1	102.41±9.69	108±17.87	0.02
WHR2/WHR1	103.24±9.77	105.06±11.73	NS

Data are presented as mean± SD, unless otherwise stated. BMI: body mass index; z-score BMI: deviation of the value for an individual from the mean value of the reference population divided by the SD for the reference population; WHR: waist-to-hip ratio; NHR: neck-to-height ratio; BMI2/BMI1: BMI at the end of follow-up/BMI at baseline; WHR2/WHR1: WHR at the end of follow-up/WHR at baseline; NS: nonsignificant.

follow-up (table 6). However, this difference failed to reach statistical significance, probably due to the small sample size.

Among the 18 subjects who were habitual snorers (snoring often) at long-term follow-up, there was a predominance of males (14 male *versus* four females; p=0.01), with 14 of them being classified as habitual snorers at baseline (table 4). No differences were found between the 18 habitual snorers and 99 nonsnorers with regard to the professional level of their parents (manual work: 55.5 *versus* 52.5%; nonmanual work: 44.4 *versus* 47.4%) or some habits in adolescence, such as alcohol consumption (44.4 and 37.3% of snorers and nonsnorers, respectively) or cigarette smoking (33.3 and 24.2% of snorers and nonsnorers, respectively).

Both at baseline and after follow-up, patients classified as habitual snorers (n=18), had significantly higher z-score values for BMI, and more centrally distributed fat than nonsnorers (table 7). Table 7 also depicts symptoms related to SRBD in habitual snorers and nonsnorers at baseline and follow-up. There was no difference between the academic performances of habitual snorers compared with nonsnorers at baseline. However, at the end of the follow-up, good grades were achieved by 33.3% of habitual snorers compared with 57.5% of nonsnorers. Moreover, 16.6% of habitual snorers earned poor grades compared with 7.0% of nonsnorers (p=0.005).

In the entire study cohort, data were collected by questionnaire at the end of follow-up on education level and working status. Data on these variables were collected retrospectively for subjects who were not yet studying. Results were as follows: manual work, n=10; mean education level (compulsory secondary school, bachelor or nonuniversity degree), n=88; higher education level (university degree), n=50.

Table 8 presents the polygraphic changes in the entire study cohort at baseline and follow-up. Polygraphic results at follow-up stratified by sex are depicted in table 9. A binary logistic regression analysis was performed with the presence of $\geqslant$5 RDI (obtained in follow-up polygraphy) as the dependent variable. Male sex showed a slight but not significant association with $\geqslant$5 RDI (95% CI 0.149–1.017, p=0.054). No

TABLE 4 Changes in the prevalence of snoring during a 4-yr follow-up

Baseline	Long-term follow-up			
	N	R	S	O
N	76	9	2	3
R	7	3	2	0
S	11	2	4	1
O	1	3	3	14

Data are expressed as the number of subjects. Subjects (and/or their relatives) were asked: ''Does he/she snore?'' Responses were recorded as N (never), R (rarely: once per week or less), S (sometimes: twice per week), O (often: three or more times per week). Data were missing for four subjects at baseline and three subjects at follow-up. McNemar test: p=0.084.

other anthropometric, clinical and polygraphic variables were found to be significant predictors of ⩾5 RDI at follow-up.

The presence of snoring at baseline was a strong predictor of snoring at follow-up (OR 41.9, 95% CI 8.7–200.8; $p<0.001$). Multiple logistic regression analysis identified male sex (OR 3.07, 95% CI 1.22–7.68; $p=0.01$) as a significant independent predictor of snoring at follow-up. In contrast, good academic performances were independently associated with a reduced risk of snoring at follow-up (OR 0.47, 95% CI 0.28–0.78; $p=0.004$).

DISCUSSION

The evolution of snoring and the polygraphic findings after 4 yrs have tended toward stability, despite the fact that there was a significant tendency to gain weight and develop a pattern of more central body fat distribution. Adolescents who snored at baseline and no longer snored at long-term follow-up did not follow this trend and maintained stable anthropometric parameters. Habitual snorers had a higher BMI and a greater tendency toward central body fat distribution than nonsnorer subjects in both stages of the study. They also had poorer academic performance than the nonsnorers in the second phase. At baseline, snorers described symptoms that are common in SRBD of children [12]. At long-term follow-up, snorer adolescents had other symptoms, such as nocturnal awakenings and asthenia, with a pattern similar to SAHS in adults. In the present study, habitual smokers were predominantly male and, moreover, males experienced more respiratory events (apnoeas and hypopnoeas) during respiratory polygraphy than females, differences that were not observed in the previous phase.

TABLE 5 Changes in anthropometric measures during a 4-yr follow-up in 17 ex-snorers

	Baseline	Long-term follow-up	p-value
Age yrs	13.94±2.13	17.82±2.4	
NHR	0.20±0.02	0.20±0.03	NS
z-score BMI	0.68±1.2	0.07±0.72	0.016
WHR	0.85±0.10	0.83±0.06	NS
BMI2/BMI1		98.59±14.35	
WHR2/WHR1		98.06±12.06	

Data are presented as mean±SD, unless otherwise stated. NHR: neck-to-height ratio; BMI: body mass index; z-score BMI: deviation of the value for an individual from the mean value of the reference population divided by the SD for the reference population; WHR: waist-to-hip ratio; BMI2/BMI1: BMI at the end of follow-up/BMI at baseline; WHR2/WHR1: WHR at the end of follow-up/WHR at baseline; NS: nonsignificant.

TABLE 6 Changes in anthropometric measures during a 4-yr follow-up in the no snore 1 and snore 2 groups#

	Baseline	Long-term follow-up	p-value
Age yrs	16.14±2.5	20.2±2.5	
BMI kg·m^{-2}	21.4±4.3	22.3±4.9	0.09
NHR	0.19±0.01	0.2±0.01	0.18
WHR	0.76±0.05	0.82±0.05	0.06

Data are presented as mean±SD, unless otherwise stated. BMI: body mass index; NHR: neck-to-height ratio; WHR: waist-to-hip ratio. #: n=7.

An important strength of the present study is that it was prospective and carried out over a longer follow-up period compared with previous studies [19, 20]. It is worth noting that short observation periods may often not be sufficient to assess the natural history of chronic disorders such as SRBD. Among a total of 267 adolescents studied at baseline, 204 were contacted after a 4-yr follow-up period. In total, 148 subjects (72.5% of the subjects contacted, 55.4% of the initial study cohort) agreed to participate in the second phase of the study. The test–re-test reliability achieved in the present study (55.4%) is close to the threshold values recommended for cohort studies [21]. Although loss to follow-up is problematic in most cohort studies and often leads to bias, in the current study, baseline anthropometric, clinical and polygraphic characteristics of subjects who did (n=148) or did not (n=119) complete the follow-up study were similar (table 1). Thus, a major bias related to test–re-test reliability is unlikely in the present study. The participation rate is similar to that reported previously in a population-based cohort study [9], and higher than those reported in previous follow-up [22] and cross-sectional studies [23]. This is an important strength of the present study because long time intervals have generally been negatively related to response rates [24].

The questionnaire was completed by a technician, and data were provided by the subjects and their parents. This methodology is in keeping with that used in adult patients with suspected SRBD, *i.e.* history collected by the physician from the patient and their partner. The presence of snoring was validated based on data provided by parents, since no partner is available during adolescence. This is an inherent shortcoming of studies conducted in this age range. It is believed that long-term data provided by the parents are more reliable

TABLE 7 Changes in anthropometric and clinical parameters in habitual snorers and nonsnorers during a 4-yr follow-up

	Nonsnorers	Habitual snorers	p-value
Subjects n	99	18	
Anthropometric variables			
Baseline NHR	0.19±0.01	0.2±0.01	0.018
Long-term follow-up NHR	0.2±0.01	0.22±0.04	0.08
Baseline z-score BMI	0.2±0.95	0.89±1.31	0.04
Long-term follow-up z-score BMI	0.03±0.97	0.91±1.61	0.03
Baseline WHR	0.78±0.08	0.82±0.05	0.022
Long-term follow-up WHR	0.81±0.08	0.88±0.04	0.000
Questionnaire			
Apnoeas	0 (0)	1 (5.5)	NS
Restless sleep	18 (18.1)	5 (27.7)	NS
Awakenings at night	28 (28.2)	10 (55.5)	0.03
Laboured breathing	6 (6.0)	2 (11.1)	NS
Daytime sleepiness	24 (24.2)	4 (22.2)	NS
Asthenia	24 (24.2)	9 (50.0)	0.04

Data are presented as mean±SD or n (%), unless otherwise stated. NHR: neck-to-height ratio; BMI: body mass index; z-score BMI: deviation of the value for an individual from the mean value of the reference population divided by the SD for the reference population; WHR: waist-to-hip ratio; NS: nonsignificant.

than those collected by a microphone during a single night for classifying subjects as either snorers or nonsnorers.

With regard to the methodology used for respiratory polygraphy, nasal cannula pressure recordings for nasal flow were not used at baseline. Therefore, this parameter was excluded from follow-up assessments for consistency with baseline evaluations. Oronasal airflow was monitored with a thermistor at baseline and at the end of the follow-up.

TABLE 8 Changes in polygraphic parameters during a 4-yr follow-up

	Baseline	Long-term follow-up	p-value
TRT min	512.88±74.5	461.68±90.51	0.000
S_{a,O_2} min	86.07±9.31	87.63±5.81	NS
CT90	0.07±0.41	0.07±0.39	NS
DI	2.02±2.25	2.46± 2.62	NS
RDI	3.43±1.88	3.33±1.95	NS
RDIsupine	4.3±3.27	3.99±3.66	NS
Cardiac events	26.2±14.04	21.5±14.04	0.002

Data are presented as mean±SD, unless otherwise stated. TRT: total recording time; S_{a,O_2}: arterial oxygen saturation; CT90: percentage of TRT with S_{a,O_2} <90%; DI: desaturation index (number of desaturations per hour of recording); RDI: respiratory disturbance index (number of apnoeas plus hypopnoeas per hour of recording); RDIsupine: RDI in the supine position; cardiac events: change in cardiac frequency of ≥10 beats·min^{-1} over ≥10 s associated with apnoea, hypopnoea or desaturation; NS: nonsignificant.

TABLE 9 Changes in polygraphic parameters during a 4-yr follow-up stratified by sex

	Females	Males	p-value
DI			
Baseline	1.54±2.10	2.53±2.30	0.007
Long-term follow-up	2.07±2.52	2.88±2.67	0.06
RDI			
Baseline	3.21±1.90	3.65±1.84	NS
Long-term follow-up	3.01±1.70	3.67±2.14	0.04
Supine RDI			
Baseline	3.83±2.75	4.79±3.70	NS
Long-term follow-up	3.38±2.35	4.63±4.59	0.03
Cardiac events			
Baseline	23.95±15.01	28.57±12.62	0.04
Long-term follow-up	20.54±11.15	22.51±16.57	NS

Data are presented as mean±SD, unless otherwise stated. DI: desaturation index (number of desaturations per hour of recording); RDI: respiratory disturbance index (number of apnoeas plus hypopnoeas per hour of recording); cardiac events: change in cardiac frequency ≥10 beats·min^{-1} during ≥10 s, associated with apnoea, hypopnoea or desaturation; NS: nonsignificant.

It was found that 19.5% of the sample of adolescents snored at follow-up, with a prevalence of habitual snoring of 12.1%. These rates were slightly higher than those reported previously in younger children [25, 26], but similar to those observed among adolescents [27] and lower than those reported in adults [28]. Thus, the prevalence of snorers in the current adolescent age group was intermediate between those observed in childhood and adulthood. This finding was expected given the age range of the study population.

The American Academy of Pediatrics [29] has argued that snoring in children tends to resolve in most cases, thereby presenting a fairly benign course. Two recent studies in children aged 9–13 yrs have demonstrated that a significant decrease occurred in the prevalence of habitual snorers by the end of the follow-up [9, 10]. However, the current data (table 4) showed that snoring tends to persist during adolescence. It is thus posited that the significant increase in the upper airway diameter occurring at ~10 yrs of age (as a result of body growth and the reduction in the upper airway lymphoid tissue) may be counteracted by increased oropharyngeal muscle development mediated, in part, by hormonal influences, as well as by the tendency to develop central accumulation of fat with weight gain during adolescence. In the present study, snoring at baseline independently predicted snoring at follow-up (OR 41.9, 95% CI 8.7–200.8; p<0.001). This result reinforced the idea that snoring during adolescence tends to persist in the absence of therapeutic intervention.

During adolescence, fat-free mass tends to increase and patterns of fat distribution change, especially in males [30], which is considered normal at this stage of life. An exaggeration of this tendency could contribute to the so-called epidemic of child obesity that is currently affecting children in all developed countries. A European cross-sectional, multicentre study [31] found as high a percentage of overweight and obese adolescents in Europe as those reported in studies involving children in the USA. All these studies compared cross-sectional samples obtained in different years. The same initial series of subjects have been followed over 4 yrs and the same significant trend was detected, especially in males, toward gaining weight and developing a more central body fat distribution pattern (tables 2 and 3). Of interest is also the observation that habitual snorers had a significantly higher BMI and more centrally distributed fat than nonsnorers. In agreement with these results, several previous studies have shown that obesity is an important determinant of habitual snoring and SRBD in children and adolescents [9, 12, 32, 33]. A more central pattern of body fat distribution has been also associated with the presence of SRBD in adults, obese children and adolescents [34, 35], as well as with metabolic or vascular complications in both adults [36] and children [37]. The subjects in the present study considered ex-snorers have moved away from the trend toward developing central obesity (tables 5 and 6). These data suggest that healthcare interventions aimed to prevent or reduce the prevalence of obesity in children and adolescents may also exert beneficial effects on SRBD-related symptoms.

There are data about the relationship between snoring and school performance, especially since the study of GOZAL and POPE [38] who reported that children who habitually snored during childhood are more likely to exhibit poor academic performance, even years after the snoring had been resolved. In the present study, there was no difference in academic performance of habitual snorers and nonsnorers at baseline. However, a higher percentage of habitual snorers earned poor grades compared with nonsnorers at follow-up. This finding was further substantiated by the fact that poor academic performance was a significant predictor of snoring at follow-up in multiple logistic regression analysis.

The prevalence of SRBD is the same in children of both sexes [12, 39, 40], and the differences between males and females that develop during puberty are usually attributed to sex hormones. In the first phase of the present study, there was no male predominance among the snorers [12], but when the population was divided by stage of pubertal development, sex-related differences were observed among the post-pubertal adolescents, with a higher prevalence of snoring and more polygraphic disturbances in males [15]. In the current longitudinal study, a predominance of males among the habitual snorers (14 out of 18) was found at long-term follow-up. Moreover, in the multiple regression analysis, male sex was shown to have an OR of 3.07 for the dependent variable snoring. Thus, male sex seems to become a risk factor for the development of SRBD once a child reaches puberty. The males in the current study also presented higher RDI and RDI_{supine} in the polygraphic recording of the second phase (table 9), a circumstance that had not been observed 4 yrs previously, and which is a finding consistent with those described in epidemiological studies in adults [28].

In addition, binary logistic regression revealed that male sex had a slight but not significant association with $\geqslant 5$ RDI obtained at follow-up polygraphy. It should be noted, however, that respiratory polygraphic results at baseline and follow-up (table 8) were within the normal ranges for adolescents [41–44]. The present study showed no changes in polygraphic data during the follow-up, the only exception being a decrease in the number of cardiac events. This result is likely to be ascribed to the role of these events as markers of autonomic arousal in the youngest children [45].

In conclusion, it appears that habitual snoring tends to persist during adolescence if no intervention is undertaken to modify its natural history. This could be achieved, in part, by avoiding the tendency of adolescents to gain weight. There is a relationship between snoring and school performance. Besides, male sex becomes a risk factor for sleep-related breathing disorders in adolescence.

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