ORIGINAL ARTICLE

Wheeze and Asthma in Children

Associations With Body Mass Index, Regular Sports, Television Viewing, and Diet

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Background: Obesity, physical activity, and dietary habits are distinct but strongly interrelated lifestyle factors that may be relevant to the prevalence of wheeze and asthma in children. Our goal was to analyze the relationship of body mass index (BMI), regular sports participation, TV viewing, and diet with current wheezing and asthma.

Methods: We investigated 20,016 children, aged 6–7 years, who were enrolled in a population-based study. Parents completed standardized questionnaires. Logistic regression was used to estimate odds ratios (ORs) and 95% confidence intervals (CIs), while adjusting for several confounders and simultaneously considering BMI, regular sports activity, TV viewing and selected dietary items.

Results: A total of 1575 children (7.9%) reported current wheezing and 1343 (6.7%) reported current asthma. In a multivariate model, an elevated BMI was associated with wheeze and current asthma: children from the highest quintile (compared with the lowest quintile) had an increased risk of wheeze (OR = 1.47; CI = 1.20–1.82) or current asthma (1.61; 1.28–2.01). Wheeze or asthma was not associated with regular sports activity. Subjects who spent 5 or more hours per day watching television were more likely to experience wheeze (1.53; 1.08–2.17) or current asthma (1.51; 1.04–2.2) compared with those who viewed TV less than 1 hour a day. Adding salt to food was strongly and independently associated with current wheeze (2.58; 1.41–4.71) and current asthma (2.68; 1.41–5.09).

Conclusions: Our data support the hypothesis that high body weight, spending a lot of time watching television, and a salty diet each independently increase the risk of asthma symptoms in children.

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Dietary and other lifestyle habits in western society have been changing over recent decades, particularly in children, and asthma prevalence has been increasing. Childhood obesity is now a common chronic condition due to changes in dietary habits and a reduction in physical activity. Obesity may be related to asthma, either directly or through complex genetic interactions with environmental exposures, including physical activity and diet.[1] On the other hand, dietary habits per se, especially diets poor in fruit and vegetables (which contain antioxidants) and possibly high salt intake can directly influence the risk of childhood wheezing.[2–4] An additional factor that has been changing in recent decades is the amount of time that children spend watching television or playing with video games. TV viewing has several deleterious effects on children's health.[5] It is considered a strong risk factor for obesity in children due to reduced physical activity, and also due to increased dietary energy intake either during viewing or as a result of food advertising.[6,7] Moreover, the consumption of fruits and vegetables is strongly reduced when television viewing is frequent.[7] Thus, TV watching might affect the respiratory health of children both by increasing the risk of obesity and by changing dietary habits. Several studies have evaluated the association between body mass index (BMI) and various food groups, and their effects on wheeze and other respiratory conditions in children.[2,8–11] However, most studies on the relationship of BMI with asthma have not taken diet into account, while studies on

TABLE 1. Descriptive Characteristics, Regular sports, TV Watching, and Dietary Habits of the Children Participating to SIDRIA-2 According to BMI Quintiles, Italy, 2002

	BMI (Quintiles)							
	I (n = 3238) %	II (n = 3267) %	III (n = 3062) %	IV (n = 3124) %	V (n = 3168) %	*P* for Trend	Missing BMI (n = 4157) %	Total Number of Subjects (n = 20016)
BMI; kg/m^2								
Mean (SD)	14.0 (0.8)	15.4 (0.3)	16.5 (0.3)	17.9 (0.5)	21.1 (2.4)			
Boys	14.0	15.4	16.5	17.9	21.1			
Girls	13.9	15.4	16.5	17.9	21.2			
Range	7.8–14.8	14.8–16.0	16.0–17.1	17.1–18.9	18.9–40.0			
Male sex	49	50	53	53	54	0.00	50	10,294
Latitude of study area								
North	59	57	54	51	45		50	10,522
Center	30	32	34	35	35		32	6,536
South	11	11	12	15	20	0.00	18	2,958
Parental education								
Primary school	2	2	2	2	4		5	581
Middle school	23	24	23	28	31		32	5,423
High school	49	47	51	48	49		42	9,485
University	26	27	24	22	15	0.00	19	4,369
At least one parent current smoker	41	44	44	47	53	0.00	49	9,267
Family asthma or rhinitis	35	35	34	31	30	0.00	30	6,507
Mold in children's bedroom	11	11	10	10	9	0.16	11	2,096
Season of data collection								
Spring	22	24	23	22	23		24	4,657
Winter	78	76	77	78	77	0.92	76	15,359
Person who filled in questionnaire								
Mother only	55	53	53	54	54		59	8,612
Other person	44	46	45	44	45	0.99	37	
Children's country of birth								
Italy	97	98	98	97	97		95	19,369
Other country	3	2	2	3	3	0.29	5	647
Frequency of regular sports								
None	22	21	21	23	25		29	4,722
Rarely	33	34	30	29	29		28	6,050
1–2 times/wk	34	36	38	37	36		28	6,902
≥3 times/wk	7	6	7	7	8	0.84	6	1,317
Time spent watching TV per day; h								
<1	26	25	24	21	17		22	4,469
1–3	64	65	66	67	68		59	12,864
>3–5	8	8	7	10	11		10	1,765
>5	3	2	3	3	5	0.00	5	684
Adding salt to food at the table								
Never	70	71	72	71	71		67	14,036
Sometimes	26	26	26	26	26		26	5,246
Often, after having tasted	2	2	1	2	2		2	408
Often, before having tasted	1	1	1	0	1	0.34	1	134

(*Continued*)

TABLE 1. (*Continued*)

	BMI (Quintiles)							
	I (n = 3238) %	II (n = 3267) %	III (n = 3062) %	IV (n = 3124) %	V (n = 3168) %	*P* for Trend	Missing BMI (n = 4157) %	Total Number of Subjects (n = 20016)
Consumption of summer tomatoes (times per wk)								
Never	26	27	28	25	27		25	5,201
1–2	33	32	33	33	33		33	6,554
3–4	27	28	26	27	24		23	5,158
5+	11	10	11	11	11	0.21	10	2,124
Consumption of fresh fruit (times per wk)								
Never	7	8	7	7	8		9	1,538
1–2	18	19	19	19	20		19	3,817
3–4	26	26	25	26	27		24	5,117
5+	46	44	45	45	41	0.03	39	8,624

diet have not considered the possible confounding role of body mass.[2,9–11]

Our aim was to examine, in a large sample of Italian children, the independent associations of BMI, regular sports activity, TV watching, and dietary habits with the prevalence of wheeze and current asthma.

METHODS

Children were enrolled within the SIDRIA-2 project (Studi Italiani sui Disturbi Respiratori nell'Infanzia e l'Ambiente), a large multicenter, population-based study conducted in Italy[12] within the framework of the International Study of Asthma and Allergies in Childhood (ISAAC).[13] The SIDRIA-2 study design has been described elsewhere[12] and is summarized briefly in an online appendix. Standardized, self administered questionnaires (available with the online version of the article) completed by parents were used to collect information on the asthma and allergy histories of the children as well as information on various known or suspected risk factors for respiratory and allergic diseases (ie, parental smoking and family history of asthma or rhinitis).

We evaluated 2 outcome variables: "current wheeze," defined as any wheezing in the last 12 months, and "current asthma," defined as lifetime asthma and either asthma symptoms during the last year (one or more wheezing episodes, shortness of breath with wheeze, wheeze with exercise, dyspnoea, morning chest tightness) or treatment for medically diagnosed asthma or a hospital admission for asthma in the last 12 months.

The questionnaire included questions about the child's participation in regular sports (ie, formal games or other forms of aerobic exercise [none, rarely, 1–2 times/wk, 3+ times/wk]), time spent watching TV (<1, 1–3, >3–5, 5+ hours per day) and weekly consumption of different foods (never, 1–2 times per week, 3–4 times per week, 5–7 times per week). Salt intake was evaluated with the question: "During meals how often does he/she add salt to the food? (never, sometimes, often after having tasted, often before having tasted)."

Children's weight (kg) and height (m) were reported to calculate BMI (weight/height^2). Parental report of body mass was affected by missing data. Because the exclusion of subjects with missing values reduces precision and also might produce biased estimates, we ran an additional analysis using a multiple imputation technique[14,15] (described in the online appendix).

Logistic regression was performed to estimate the associations (odds ratios [ORs], and 95% confidence intervals [CIs]) between BMI (quintiles), regular physical activity, TV watching, and food consumption (salt intake, summer tomatoes, fresh fruit) with the 2 outcome variables. In each specific exposure-outcome evaluation, we adjusted for the following confounders chosen a priori: sex, study area, parental education, parental smoking, parental asthma or rhinitis, and questionnaire respondent (mother, father or both), season of data collection, and presence of mold in children's bedroom. A test for trend was conducted. All analyses were performed using STATA software (StataCorp, College Station, TX).

RESULTS

Valid questionnaires were returned for 20,016 children (89% of the target). Of these, 51% were boys and the mean (SD) age was 6.7 (0.65) years. The mean (SD) BMI for boys (17.0 [0.3] kg/m^2) was slightly higher than for girls (16.9 [0.3] kg/m^2). Characteristics of the sample according to BMI quintiles are shown in Table 1. For children with high BMIs, T1
parental education, and prevalence of family history of asthma or rhinitis was low, but frequency of parental smoking was high. Children with elevated BMIs spent more time watching television than thinner children. Dietary habits changed slightly over the BMI quintiles. Children with ele-

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vated BMIs ate fresh fruit less often than other children, but no differences were observed for consumption of salt and tomatoes according to BMI quintiles. Subjects who did not provide data on height and weight (21%) were from less educated families, had a high prevalence of parental smoking, spent more time watching television, and ate fresh fruit less often than other children.

Table 2 presents the characteristics and dietary habits of children according to time spent watching television. Boys spent more time than girls watching TV. Children who spent T2

TABLE 2. Descriptive Characteristics, Regular Sports and Dietary Habits of the Children According to Hours Spent Watching Television Per Day

	Time Spent Watching Television per d; h					
	<1 (n = 4469) %	1–3 (n = 12864) %	3–5 (n = 1765) %	>5 (n = 684) %	*P* for Trend	Total Number of Subjects (n = 19782)
Male sex	46	53	54	57	0.00	10,188
Latitude of study area						
North	58	52	47	46		10,403
Center	31	34	31	31		6,454
South	11	15	22	23	0.00	2,925
Parental education						
Primary school	2	2	5	8		567
Middle school	21	28	36	35		5,370
High school	46	49	45	43		9,424
University	31	21	13	13	0.00	4,331
At least one parent current smoker	42	47	54	53	0.00	9,193
Family asthma or rhinitis	33	33	29	30	0.00	6,459
Mold in children's bedroom	9	11	14	11	0.00	2,075
Season of data collection						
Spring	26	22	22	24		4,606
Winter	74	78	78	76	0.00	15,176
Person who filled in questionnaire						
Mother only	59	54	56	58		10,889
Other person	40	45	43	39	0.05	8,549
Children's country of birth						
Italy	98	97	95	94		19,165
Other country	2	3	5	6	0.00	617
Frequency of regular sports						
None	21	24	30	33		4,698
Rarely	31	31	27	26		6,023
1–2 times/wk	35	35	34	30		6,881
≥3 times/wk	8	6	6	7	0.00	1,315
Adding salt to food at the table						
Never	73	71	66	64		13,967
Sometimes	25	26	29	29		5,220
Often, after having tasted	2	2	4	4		405
Often, before having tasted	1	1	1	3	0.00	133
Consumption of summer tomatoes (times per wk)						
Never	22	27	29	29		5,173
1–2	32	33	33	33		6,496
3–4	28	26	23	22		5,124
5+	13	10	9	11	0.00	2,107
Consumption of fresh fruit (times per wk)						
Never	6	8	10	11		1,526
1–2	17	19	22	21		3,795
3–4	23	27	27	24		5,086
5+	49	42	36	39	0.00	8,554

5 hours or more per day watching TV came from less educated families; their parents were more likely to be smokers than those who watched less than 1 h/d; they were less likely to report parental asthma or rhinitis; they were more likely to not play sports regularly; and they were more likely to use salt, and not to consume fruit or tomatoes.

A total of 1575 children (7.9%) reported wheezing in the last 12 months, whereas current asthma occurred in 1343 (6.7%) children. Table 3 shows the associations of BMI, regular physical activity, TV viewing and dietary factors with respiratory symptoms with the risk of both wheeze and current asthma increased steadily and significantly with increasing BMI. In a separate analysis by sex, the association of BMI with wheeze and current asthma was stronger among girls; ORs for wheeze in girls were 1.42, 1.56, and 1.89 for the 3rd, 4th, and 5th quintiles, respectively, and for current asthma were 1.63, 1.87, and 2.11, respectively. In boys, the association was limited to the 5th quintile for both wheeze (OR = 1.37) and current asthma (OR = 1.53). No association was found between regular sports activity and asthma symptoms. Children who spent 5 or more hours per day watching television were more likely to experience wheeze and current asthma. Adding salt to food was a strong risk factor for wheeze and current asthma; the ORs for both outcomes were higher than 2.0 for children who often added salt to food before tasting it. High consumption of summer tomatoes and fresh fruit was associated with less wheezing. Fresh fruit consumption was also linked to less asthma.

Results of the final logistic regression analysis that simultaneously included all confounders, as well as BMI, regular sports activity, TV watching, and the dietary variables, are shown in Table 4. The results for BMI and TV

TABLE 3. Associations of Wheeze and Asthma with BMI, Regular Sports, TV Watching, and Some Dietary Habits

	Wheeze (n = 1575)			Current Asthma (n = 1343)		
	%	OR (95% CI)[a]	*P* for Trend	%	OR (95% CI)[a]	*P* for Trend
BMI (quintiles)						
I[b]	6.1	1.00		5.1	1.00	
II	7.0	1.11 (0.90–1.36)		6.2	1.19 (0.95–1.49)	
III	7.9	1.22 (0.99–1.50)		6.3	1.20 (0.95–1.51)	
IV	7.8	1.26 (1.02–1.54)		6.9	1.37 (1.10–1.72)	
V	9.6	1.54 (1.26–1.88)	0.000	8.7	1.66 (1.34–2.07)	0.000
Frequency of regular sports						
None[b]	8.3	1.00		8.4	1.00	
Rarely	8.2	0.97 (0.84–1.13)		8.7	1.04 (0.87–1.23)	
1–2 times/wk	7.9	0.91 (0.78–1.06)		9.0	1.05 (0.89–1.24)	
≥3 times/wk	7.7	0.87 (0.68–1.11)	0.133	9.0	1.10 (0.85–1.42)	0.547
Time spent watching TV per day; h						
<1[b]	7.3	1.00		6.3	1.00	
1–3	7.8	1.00 (0.87–1.15)		6.7	0.99 (0.85–1.15)	
>3–5	9.0	1.18 (0.94–1.46)		7.1	1.09 (0.86–1.39)	
>5	10.8	1.51 (1.13–2.02)	0.007	9.2	1.42 (1.04–1.94)	0.143
Adding salt to food at the table						
Never[b]	7.6	1.00		6.4	1.00	
Sometimes	8.2	1.07 (0.94–1.21)		7.3	1.14 (1.00–1.32)	
Often, after having tasted	11.3	1.43 (1.01–2.01)		8.1	1.34 (0.92–1.96)	
Often, before having tasted	16.4	2.25 (1.35–3.73)	0.002	13.4	2.23 (1.30–3.85)	0.001
Consumption of summer tomatoes (times per wk)						
Never[b]	8.9	1.00		7.6	1.00	
1–2	8.0	0.94 (0.82–1.08)		6.6	0.89 (0.76–1.03)	
3–4	7.0	0.84 (0.71–0.97)		5.9	0.82 (0.70–0.97)	
5+	6.6	0.82 (0.67–1.01)	0.004	6.4	0.92 (0.74–1.14)	0.089
Consumption of fresh fruit (times per wk)						
Never[b]	10.1	1.00		8.8	1.00	
1–2	8.1	0.83 (0.67–1.04)		7.0	0.84 (0.66–1.06)	
3–4	7.5	0.76 (0.61–0.94)		6.3	0.73 (0.58–0.92)	
5+	7.5	0.76 (0.62–0.93)	0.010	6.3	0.76 (0.61–0.95)	0.019

[a]Adjusted for sex, age, study center, season, person filling the questionnaire, parental education, parental smoking, mold in child's bedroom, history of family asthma or rhinitis.
[b]Reference category.

TABLE 4. Associations of Wheeze and Asthma With BMI, Regular Sports, TV Watching, and Some Dietary Habits After Multiple Adjustment

	Wheeze (n = 1575)		Current Asthma (n = 1343)	
	OR (95% CI)[a]	*P* for Trend	OR (95% CI)[a]	*P* for Trend
BMI (quintiles)				
I[b]	1.00		1.00	
II	1.09 (0.88–1.35)		1.18 (0.93–1.49)	
III	1.18 (0.96–1.47)		1.17 (0.92–1.49)	
IV	1.23 (0.99–1.52)		1.27 (1.00–1.61)	
V	1.47 (1.20–1.82)	0.000	1.61 (1.28–2.01)	0.000
Frequency of regular sports				
None[b]	1.00		1.00	
Rarely	0.96 (0.80–1.16)		1.05 (0.85–1.29)	
1–2 times/wk	0.98 (0.82–1.17)		1.13 (0.93–1.38)	
≥3 times/wk	0.99 (0.75–1.31)	0.113	1.33 (0.99–1.77)	0.069
Time spent watching TV per day; h				
<1[b]	1.00		1.00	
1–3	0.99 (0.84–1.17)		1.00 (0.83–1.20)	
>3–5	1.32 (1.03–1.71)		1.20 (0.90–1.59)	
>5	1.53 (1.08–2.17)	0.006	1.51 (1.04–2.2)	0.090
Adding salt to food at the table				
Never[b]	1.00		1.00	
Sometimes	1.05 (0.90–1.22)		1.22 (1.04–1.43)	
Often, after having tasted	1.03 (0.65–1.64)		1.12 (0.70–1.82)	
Often, before having tasted	2.58 (1.41–4.71)	0.106	2.68 (1.41–5.09)	0.002
Consumption of summer tomatoes (times per wk)				
Never[b]	1.00		1.00	
1–2	0.99 (0.83–1.16)		1.00 (0.83–1.20)	
3–4	0.89 (0.74–1.07)		0.93 (0.76–1.13)	
5+	0.88 (0.69–1.12)	0.085	0.99 (0.76–1.28)	0.679
Consumption of fresh fruit (times per wk)				
Never[b]	1.00		1.00	
1–2	0.94 (0.72–1.22)		0.86 (0.64–1.14)	
3–4	0.86 (0.66–1.11)		0.84 (0.63–1.11)	
5+	0.90 (0.70–1.16)	0.390	0.86 (0.65–1.13)	0.522

[a]Adjusted for all confounders considered a priori (as in Table 3) plus BMI, regular sports, TV watching, and dietary variables.
[b]Reference category.

watching were substantially unchanged. Salt intake remained strongly associated with both outcomes, while the protective effects of fresh fruits and summer tomatoes were reduced. The inclusion of salt intake in the model was mainly responsible for weakening the effect of fresh fruits and tomatoes.

The results obtained with the multiple imputation method for missing BMI data were very similar although the effect estimates for BMI were slightly weakened (eTables 1 and 2).

DISCUSSION

In a large national cross-sectional sample of children, BMI and television viewing were independent predictors of current wheeze and asthma even when adjusting for various known risk factors for asthma. Among dietary factors, salt intake remained a strong predictor whereas other food groups were marginally related to wheeze and asthma after adjusting for BMI and TV viewing.

BMI and Asthma

Our results regarding BMI agree with several other cross-sectional studies in finding obesity is associated with the prevalence of asthma in children,[8–11] although another study failed to support this relationship.[16] Two cross-sectional surveys performed in children in the same schools 5 years apart found that BMI was associated with an increased risk of asthma in 2000 but not in 1995.[17] Longitudinal studies have found that BMI is related to both persistence[18] and incidence of asthma.[19–21] In our investigation, the relationship was stronger in girls than in boys, as found in previous cross-sectional[9,10,22] and cohort studies.[19]

There are several possible mechanisms by which increased BMI might be related to respiratory health.[1,23,24] First, obesity and asthma may share genetic risk factors.[1] Second, there are mechanical factors that affect the relation between lung volume at the end of expiration (functional residual capacity, which is lower in obese subjects), breathing patterns (obese subjects have a breathing pattern with higher frequencies and lower tidal volume), and alterations of the smooth muscle structure and functioning. Even so, the causal role of obesity in determining the onset of asthma is still being debated.[25,28] BMI was not associated with bronchial responsiveness to methacholine or histamine,[9,21,26] whereas associations have been found with atopy and bronchial caliber, mainly in girls.[9,26] Repeated cross-sectional studies in the same population[17,19,22,27] suggest that the BMI-asthma association could be a new phenomenon.

Physical Activity and Asthma

Because reduced physical activity has been suggested as one of the mechanisms that connect obesity to asthma,[23] we investigated both time spent playing sports and time spent watching television. We found that regular participation in sports was not related to BMI or respiratory symptoms. Because detailed levels of physical activity are difficult to measure in a large population study, data are scarce;[28–30] 2 studies suggest a possible protective effect of high physical activity on asthma.[28–29] Our data are limited in that we cannot account for unmeasured physical activity; therefore, we cannot exclude a possible effect of regular sports.

TV Viewing, BMI, and Asthma

We found that time spent watching TV was independently related to increased BMI, and to less regular participation in sports. Television viewing for many hours during the day is considered a risk factor for obesity in children.[31] Moreover, reductions in children's television viewing can prevent obesity.[32] Television viewing has been associated with unhealthy eating patterns, such as a low intake of fruit and vegetables[7] and high caloric intake.[6] In a recent cohort study[31] among adolescents, the correlation between television viewing and BMI was stronger than the correlations between BMI and diet or physical activity. Our data are in agreement with these findings: children who spent a lot of time watching television showed a higher BMI; they ate fewer tomatoes, fruit and citrus; and they added more salt to their food. Moreover, they were more likely to be exposed to parental smoking. A recent population study on children showed that the adjusted population-attributable fractions for watching television more than 1 h/d on overweight was 13% and on obesity 19%.[33]

TV watching was associated with respiratory symptoms. In a previous paper, TV watching was used as a proxy for low levels of physical activity, and a borderline association was found with wheeze and asthma in children aged 2–5 years.[8] In a very recent study in Taiwan, television watching more than 3 h/d was associated with increased frequency of respiratory symptoms in children.[28] A survey performed in Athens in school children aged 10–12 years demonstrated that a 1-hour increase in TV viewing or video games increased the odds of asthma by 10%.[29] In addition, prolonged periods of watching videotapes have been associated with a decreased frequency of spontaneous sighs, a physiologic phenomenon that helps regulate airway tone;[34] some forms of childhood behavior; (TV, videos, computer games, etc.) might be associated with sigh rates that are low enough to increase nonspecific bronchial hyperreactivity.[35] However, some unmeasured indoor exposures (eg, endotoxins and allergens, passive smoking from others family members, and other irritant exposures) could play a role in explaining the association between TV watching and respiratory symptoms.

Diet and Asthma

The relationship between diet and asthma has been recently reviewed.[36] The hypothesis of a role of salt intake in asthma is based on the key role of sodium in maintaining nerve and muscle function. We found a dose-response effect for salt intake with both respiratory outcomes. The relationship between salt intake and asthma has been debated for a long time. In a previous population study of children in Italy, table salt use was related to respiratory symptoms such as wheeze, cough, and phlegm especially in boys, but no relation was found with bronchial hyper-responsiveness for either sex.[3] A recent double-blind crossover trial supported the role of dietary salt as a modifier of the severity of exercise-induced asthma. Asthmatic subjects had reduced lung function and increased airway inflammation (as demonstrated by sputum analysis) with high salt intake than with low salt intake.[37] In asthmatics, dietary salt intake was related to bronchial response to methacholine[38] and to histamine,[39] although other studies have failed to confirm this finding in population surveys.[40] Our data confirm[2] that high fruit and tomato consumption may reduce the risk of wheeze and asthma, although this association was reduced when BMI, physical activity, TV watching, and salt intake were added to the model. In particular, high salt intake was strongly associated with low fruit consumption and the inclusion of the 2 variables in the model reduced the effect of fruits.

High BMI, reduced physical activity, television watching, and an unhealthy diet seem to form a vicious circle[8] and there may be a single factor that connects all these elements. In a recent review,[24] the authors defined obesity as a condition that leads to a systemic proinflammatory state. They focused their attention to the role of leptin, a protein hormone that is higher in obese subjects and is a mediator of inflammation. Leptin also has a role in normal lung development and has been found to modulate immune response and increase airway responsiveness. A cohort study found that physical activity and television watching are associated with several biomarkers of obesity, including leptin.[41] Leptin con-

centrations decreased when physical activity increased, although it also increased when many hours were spent watching television, even adjusting for BMI. In addition, a diet poor in vegetables and fruit has been found to increase the concentration of leptin.[42] One may speculate that increased levels of leptin due to reduced physical activity, frequent television watching and unhealthy diet may link high BMI and asthma.[24]

Limitations of the Study

There are validity issues in these data. BMI was calculated by parental-reported height and weight, and there were many missing values (21%). Self-reported height and weight are cost-effective and are often used in epidemiologic studies.[43] A study in adults has shown under-reporting of weight and over-reporting of height, leading to an under-estimation of BMI.[44] Other authors have suggested that socioeconomic status,[45] sex, and age[46] may have influenced the validity of their data. Because we were concerned about the validity of the parental report, we had trained nurses measure the heights and weights of 1198 children (fifth grade) in Rome at their schools, following a standard protocol. We found that the mean (SD) measured BMI was 19.5 (3.66) kg/m^2, whereas the reported BMI was 19.1 (3.20) kg/m^2; the intraclass correlation coefficient[47] was 0.82. When our data were compared with Italian cross-sectional growth charts,[48] our 3rd, 50th, and 97th percentile for boys (13.4, 16.5, and 23.2 kg/m^2) and girls (13.2, 16.4, and 23.1 kg/m^2), respectively, were very close to the national data in the same age range (13.8, 16.2, 22.2 kg/m^2 and 13.5, 16.2, 22.6 kg/m^2, respectively). We applied a multiple imputation technique to deal with missing data, as reported in the online appendix. Overall results were confirmed, although some of the odds ratios were slightly weakened as expected with this approach.

In conclusion, our data confirm that high body weight and a salty diet increase the risk of respiratory symptoms in children. The effect of TV viewing was present even when several confounders were considered.

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