

Increased body mass index and bronchial impairment in allergic rhinitis

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ABSTRACT

Background: Several studies have outlined a possible relationship between an increased body mass index (BMI) and respiratory allergic diseases, such as asthma and allergic rhinitis (AR). The aim of this study was to analyze the relationship among BMI, spirometry, bronchial hyperreactivity (BHR), and fractional concentration of exhaled nitric oxide (FeNO) in a cohort of AR patients.

Methods: The study included 155 patients with persistent AR alone and 155 healthy controls. All subjects were evaluated performing skin-prick test, spirometry, bronchoprovocation test with methacholine, and FeNO measurement.

Results: BMI values were significantly higher in AR patients than in control subjects ($p = 0.038$). Overweight/obese AR patients had more altered functional and inflammatory parameters than normal weight patients. BMI > 25 is a risk factor for (i) early bronchial airflow limitation (odds ratio [OR], 3.81), (ii) high FeNO values (OR, 1.96), and BHR (OR, 3.29).

Conclusions: The present study may suggest that BMI assessment should be routinely considered in AR patients for assessing risk for early bronchial impairment, such as suggesting possible evolution to asthma.

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The prevalence of obesity and associated comorbidities have dramatically increased worldwide, taking epidemic proportion.¹ Low-grade systemic inflammation characterizes obesity. In fact, inflammatory markers, such as C-reactive protein and interleukin-6, are raised in obese subjects.¹ Increased body mass index (BMI) and respiratory allergic diseases, such as asthma and allergic rhinitis (AR), may be related.^{2–4} Nevertheless, the mechanism for the association between respiratory allergic diseases and obesity and the reasons for the apparent difference between men and women remain unclear.² Because both respiratory allergic diseases and obesity are characterized by inflammation, a common inflammatory pathway has been proposed as a plausible explanation for the association between respiratory allergy and obesity.⁵ The current view of adipose tissue is that of an active secretory organ, sending out and responding to signals that modulate appetite, energy expenditure, insulin sensitivity, endocrine and reproductive systems, bone metabolism, inflammation, and immunity.^{1,6} Moreover, adipose tissue produces adipokines, including leptin and adiponectin, concurring to maintain and amplify inflammation.^{1,7}

BMI is considered a universal indicator of adiposity according to World Health Organization criteria.⁸ Previously, we reported that BMI is related to both AR and bronchial hyperreactivity (BHR) to methacholine.⁹

On the other hand, AR is frequently associated with asthma.¹⁰ In this regard, many AR patients may have BHR; this condition may mean a bronchial involvement and may also suggest the possible evolution in asthma. Therefore, the assessment of BHR in a patient with AR may have a relevant prognostic role. In addition, AR patients may frequently present slight impairment of lung function: altered forced expiratory flow at 25–75% (FEF_{25–75}) values (such as $<65\%$ of predicted) may suggest a bronchial involvement in AR.¹¹ Further-

more, asthma is characterized by bronchial inflammation that may be assessed by measuring the fractional concentration of exhaled nitric oxide (FeNO) and there is international consensus on the testing methodology.¹²

Therefore, the aim of the present study was to investigate a possible relationship between BMI and bronchial parameters, including FEF_{25–75}, BHR, and FeNO in patients with persistent AR.

MATERIALS AND METHODS

Patients

This cross-sectional study included 155 patients, suffering from persistent AR. They were Navy soldiers who were referred to the Navy Medical Service for mandatory certification of their health status. The visit included clinical examination, visual analog scale (VAS) assessment, skin-prick test, spirometry, methacholine challenge, and FeNO measurement. An equal number of healthy subjects (155 subjects) were enrolled as normal controls. The Navy Review Board approved the study procedure and written informed consent was obtained from each subject.

Study Design and Setting

A detailed clinical history was taken and a complete physical examination was performed. The patients were enrolled in the study based on a diagnosis of persistent AR made by the concordance between positive skin-prick test and presence of nasal symptoms after exposure to sensitizing allergen, according to validated criteria.¹⁰ Exclusion criteria were any prior documented history of asthma or referral for asthma symptoms, including cough, wheezing, dyspnea, and shortness of breathing; impaired forced expiratory volume at 1 second (FEV₁) values (such as $<80\%$ of the predicted) and <0.7 FEV₁/forced vital capacity (FVC) ratio; presence of acute (in the last 4 weeks) or chronic upper respiratory infections; anatomic nasal disorders (*i.e.*, nasal polyps, clinically relevant septum deviation, *etc.*); previous or current intensive smoking, such as >30 cigarettes/day (screened by expired CO assessment, such as analyzing carboxyhemoglobin and carbon monoxide levels in a single breath using the Bedfont Micro Smokerlyzer III; Bedfont Scientific, Ltd., & Decode, Kent, U.K.); previous or current specific immunotherapy; and use of nasal or oral corticosteroids, nasal or oral vasoconstrictors, antileu-

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kotrienes, and antihistamines during the previous 4 weeks. Subjects under drug treatment or with acute upper respiratory airway infection returned after adequate time.

Age, gender, smoking, duration of rhinitis, VAS, FVC, FEV₁, FEV₁/FVC, FEF_{25–75}, FeNO, and MCH Provocative Concentration able to induce a fall < 20% of the baseline FEV₁ value (PC₂₀) were registered for all patients in the analysis.

VAS Assessment

VAS was used to assess the subjective feeling of nasal respiration. The VAS consisted of one ruler asking for symptoms. VAS was used to measure the subjective perception of nasal respiration: it ranges from 0 (complete nose patency) to 10 cm (complete nose obstruction).

Skin-Prick Test

It was performed as stated by the European Academy of Allergy and Clinical Immunology.¹³ The panel consisted of house-dust mites (*Dermatophagoides farinae* and *Dermatophagoides pteronyssinus*), cat, dog, grasses mix, *Compositae* mix, *Parietaria officinalis*, birch, hazel, olive tree, *Alternaria tenuis*, *Cladosporium*, and *Aspergilli* mix (Stallergenes, Milan, Italy).

Spirometry

Spirometry was performed using a computer-assisted spirometer (Pulmolab 435-Spiro 235; predictive values ECCS 1993; Morgan, London, U.K.), with optoelectronic whirl flowmeter. This spirometer fulfills the American Thoracic Society (ATS)/European Respiratory Society standards according to guidelines.¹⁴ It was performed as stated by the European Respiratory Society.^{14,15}

Methacholine Bronchial Challenge

Methacholine bronchial challenge was performed to evaluate BHR only if basal FEV₁ was ≥80% of predicted. Aerosol was delivered using a dosimetric computerized supply (MEFAR MB3; Marcos, Brescia, Italy). The test was performed following the ATS guidelines for methacholine challenge.¹⁶ The threshold concentration causing a 20% fall of FEV₁ (PC₂₀) was calculated.

Degree of BHR Severity

Three categories of BHR were considered based on PC₂₀: severe PC₂₀ < 1 mg/mL; mild-moderate PC₂₀ between 1 and 4 mg/mL; borderline PC₂₀ ranging from 4 to 16 mg/mL, according with the criteria of the ATS guidelines for methacholine challenge.¹⁶ Subjects without response to the cumulative dose of 16 mg/mL were considered as having normal bronchial responsiveness.

NO Measurement

FeNO was measured with a chemoluminescence analyzer (QUARK NO-Breath; COSMED s.r.l., Milan, Italy); the detection limit of the apparatus was 1–5 parts per billion (ppb), as required by ATS guidelines, with a resolution of 1 ppb. The analyzer was calibrated daily, using a certified NO mixture. eNO was recorded with the single-breath method according to published guidelines.¹² Subjects inhaled to total lung capacity from NO-free air and exhaled a single breath (without nose clip) through a mouthpiece at a mouth pressure of 45 cm of water and at an expiratory flow of 50 mL/s. Mouth pressure was displayed on a computer screen in order for the patients to maintain a steady flow. The measurement was rejected if a stable flow was not maintained for at least 6 seconds of exhalation. NO was measured at the plateau and expressed in parts per billion.

Statistical Methods

Count and percentage for categorical factors and mean with standard deviation (SD), or median with interquartile range, were shown for each characteristic.

Differences between controls and AR patients for categorical variables (smoking habit, BMI categorized, BHR severity, and categorized FEF_{25–75}) were assessed by χ^2 -test.

Differences between controls and AR patients and between patients with normal weight versus overweight/obese patients for normally distributed characteristics (*i.e.*, age, BMI, FEF_{25–75}, FVC, FEV₁, and FEV₁/FVC) were analyzed by Student's *t*-test for independent samples or in alternative with nonparametric Mann-Whitney test for other characteristics (VAS and FeNO).

The correlation between BMI and other continuous characteristics, for both controls and AR patients, was evaluated by mean of Pearson correlation coefficient or by nonparametric Spearman's rank correlation (VAS).

The correlation coefficients obtained in controls and allergic patients were compared using *z* test after the Fisher *r*-to-*z* transformation of coefficients.

One-way ANOVA and Student's *t*-test for independent samples were used to evaluate any difference in BMI, respectively, for classified BHR and for classified FEF_{25–75} for controls and AR patients.

Association between BMI and clinical characteristics was also tested after adjustment for possible confounding characteristics, as age, gender, and smoking, using analysis of covariance models.

When BMI was categorized according to World Health Organization classification, association with altered values of FEF_{25–75} and FeNO and with BHR was tested by χ^2 -test and associated odds ratio (OR) with the corresponding 95% CI were reported to quantify the increased probability of abnormal values of FEF_{25–75} and FeNO and of severe or mild/moderate grade of severity of BHR in overweight patients compared with patients with normal weight.

Moreover, a receiving operator characteristic (ROC) curve was used to test the validity of BMI as a diagnostic tool to correctly identify patients with abnormal values of either FEF_{25–75} or FeNO and patients with severe or mild BHR.

For each ROC curve the area under curve (AUC) with the corresponding 95% CI was shown and the best cutoff value on the BMI scale to maximize both sensitivity and specificity was detected.

A *z* test was also used to assess if AUC was significantly different from 0.5 and, consequently, if BMI had an ability to distinguish between pathological and not pathological patients.

A value of *p* < 0.05 was considered statistically significant. SPSS (v.20; IBM Corp., Armonk, NY) and Stata (v.11; StataCorp., Lakeway Drive, TX) were used for computation.

RESULTS

Clinical and Demographic Characteristics

Table 1 shows demographic, clinical, functional, and inflammatory characteristics of healthy subjects and AR patients.

AR Patients were slightly younger, with a lower prevalence of male subjects.

BMI was slightly higher in AR patients compared with normal subjects (*p* = 0.038). Moreover, a significantly (*p* = 0.023) higher percentage of overweight (BMI ≥ 25) or obese (BMI ≥ 30) subjects was observed among AR patients compared with controls.

Obese and overweight patients were considered together, because only eight patients (five allergic patients) were obese. Furthermore, only one patient had BMI < 18.5 (underweight) and was considered in the normal weight class.

Furthermore, AR patients had lower values of both FEV₁/FVC and FEF_{25–75} (*p* < 0.001), and higher FeNO values (*p* < 0.001) than normal controls.

Table 1 Descriptive analysis of demographic, clinical, functional, and inflammatory characteristics separated for allergy presence

Demographic and Clinical Characteristics	Controls (<i>n</i> = 155)	AR Patients (<i>n</i> = 155)	<i>p</i> Value
Age (yr)	29.4 (7.5)	26.4 (6.3)	<0.001
Males, <i>n</i> (%)	144 (92.9%)	126 (81.3%)	0.002
Years since the first diagnosis		5.3 (4.6)	
Smoking			0.57
0 cigarette/day	127 (81.9%)	129 (83.2%)	
1–10 cigarettes/day	18 (11.6%)	20 (12.9%)	
11–30 cigarettes/day	10 (6.5%)	6 (3.9%)	
BMI	24.7 (2.5)	25.3 (2.6)	0.038
BMI categories			0.023
≤24.99 (underweight and normal range)	88 (56.8%)	68 (43.9%)	
≥25.00 (overweight and obese)	67 (43.2%)	87 (56.1%)	
VAS, median (range)	0.00 (0.00–2.00)	2.00 (1.00–9.00)	<0.001
PC ₂₀		1590 (1370–1590)	
BHR			
PC ₂₀ > 16 mg/mL	155 (100%)	112 (72.3%)	
4 mg/mL < PC ₂₀ = 16 mg/mL		20 (12.9)	
1 mg/mL ≤ PC ₂₀ ≤ 4 mg/mL		18 (11.6%)	
PC ₂₀ < 1 mg/mL		5 (3.2%)	
FEF _{25–75}	104.1 (24.9)	90.7 (24.7)	<0.001
FEF _{25–75}			0.09
≤65%	8 (5.2%)	16 (10.3%)	
>65%	147 (94.8%)	139 (89.7%)	
FVC	97.5 (11.3)	101.9 (11.1)	0.001
FEV ₁	99.7 (11.8)	99.1 (11.5)	0.64
FEV ₁ /FVC	84.4 (5.4)	81.9 (4.9)	<0.001
FeNO	11.00 (2.00–36.00)	24.00 (2.00–110.00)	<0.001
FeNO categorized			
≤ 25	149 (96.1%)	79 (51.0)	<0.001
>25	6 (3.9%)	76 (49%)	

Results are reported as mean (standard deviation) if not differently reported.

BMI = body mass index; BHR = bronchial hyperreactivity; AR = allergic rhinitis; FeNO = fractional concentration of exhaled nitric oxide; FEF_{25–75} = forced expiratory flow at 25–75%; FEV₁ = forced expiratory volume at 1 s; FVC = forced vital capacity; VAS = visual analog scale.

Table 2 Correlations between body mass index and clinical characteristics

	BMI		<i>p</i> Value*
	Controls (<i>n</i> = 155)	AR Patients (<i>n</i> = 155)	
FEF _{25–75}	<i>r</i> = 0.153 <i>p</i> = 0.06	<i>r</i> = −0.191 <i>p</i> = 0.017*	0.002
FEV ₁	<i>r</i> = −0.038 <i>p</i> = 0.63	<i>r</i> = −0.201 <i>p</i> = 0.012*	0.15
FVC	<i>r</i> = −0.062 <i>p</i> = 0.44	<i>r</i> = −0.030 <i>p</i> = 0.71	0.78
FEV ₁ /FVC	<i>r</i> = 0.04 <i>p</i> = 0.63	<i>r</i> = −0.27 <i>p</i> = 0.001	0.006
FeNO	<i>r</i> = −0.021 <i>p</i> = 0.80	<i>r</i> = −0.144 <i>p</i> = 0.07	0.28
PC ₂₀	//	<i>r</i> = −0.195 <i>p</i> = 0.015*	—
VAS	<i>ρ</i> = 0.029 <i>p</i> = 0.72	<i>ρ</i> = 0.175 <i>p</i> = 0.029*	0.20

*The *p* value for the difference between correlation coefficient in AR patients and healthy subjects.

r = Pearson correlation coefficient; *ρ* = Spearman's correlation coefficient; *p* = *p* value for the correlation coefficient; AR = allergic rhinitis; BMI = body mass index; BHR = bronchial hyperreactivity; AR = allergic rhinitis; FeNO = fractional concentration of exhaled nitric oxide; FEF_{25–75} = forced expiratory flow at 25–75%; FEV₁ = forced expiratory volume at 1 s; FVC = forced vital capacity; VAS = visual analog scale.

Functional and Inflammatory Characteristics and BMI Values

Significant, even if weak, negative correlations (Table 2) were observed in allergic patients between BMI and continuous values of FEF_{25–75} (*r* = −0.19), FEV₁ (*r* = −0.20), FEV₁/FVC (*r* = −0.27), and BHR (*r* = −0.20), and a positive weak correlation was observed between BMI and VAS (*r* = 0.18). In contrast, no significant correlations between BMI and spirometric characteristics were observed in the control group. A significant difference between BMI and both FEF_{25–75} and FEV₁/FVC was observed, comparing allergic with normal controls.

When both PC₂₀ and FEF_{25–75} were categorized, a significantly higher mean BMI was observed in the most severe BHR categories (*p* = 0.003), in patients with abnormal FEF_{25–75} values (*p* = 0.008), and in patients with altered FeNO values (*p* = 0.042).

Particularly about BHR, a significant BMI difference was observed comparing negative (mean [SD], 25.1 [2.4]) with mild/moderate (mean [SD], 26.6 [3.3]) patients (*p* = 0.028). Patients with severe BHR (only five) had no significant difference, even if they had an higher mean BMI (mean [SD], 27.8 [1.9]).

Patients with abnormal FEF_{25–75} values had a mean BMI of 26.9 (SD, 2.2), and patients with normal values had mean BMI of 25.1 (SD, 2.6). Furthermore, patients with pathological FeNO values had mean a BMI of 25.7 (SD, 2.6), whereas patients with normal FeNO values had a mean BMI of 24.9 (SD, 2.6).

In contrast, no differences (*p* = 0.46) about BMI were found in normal subjects, considering the FEF_{25–75} values.

Table 3 Descriptive analysis of clinical characteristics, grouped by allergy and BMI categories

Clinical Characteristics	Controls (<i>n</i> = 155)		<i>p</i> Value	AR Patients (<i>n</i> = 155)		<i>p</i> Value
	Normal	Overweight or Obese		Normal	Overweight or Obese	
FEF ₂₅₋₇₅	104.4 (26)	103.7 (23.6)	0.86	95.9 (24.6)	86.6 (24.1)	0.02
FEV ₁	100.7 (12.5)	98.4 (10.8)	0.24	101.3 (10)	97.3 (12.3)	0.029
FVC	98.5 (11.7)	96.2 (10.8)	0.21	102.3 (10.3)	101.6 (11.8)	0.69
FEV ₁ /FVC	84.5 (5.8)	84.3 (4.9)	0.89	83.2 (4.9)	80.9 (4.6)	0.003
FeNO	11 (2–29)	10 (2–36)	0.67	20.5 (2–110)	28 (5–90)	0.054
VAS	0 (0–2)	0 (0–2)	0.44	2 (1–5)	2 (1–9)	0.23

Results are reported as mean (standard deviation) or median (range).

AR = allergic rhinitis; FeNO = fractional concentration of exhaled nitric oxide; FEF₂₅₋₂₇ = forced expiratory flow at 25–75%; FEV₁ = forced expiratory volume at 1 s; FVC = forced vital capacity; VAS = visual analog scale.

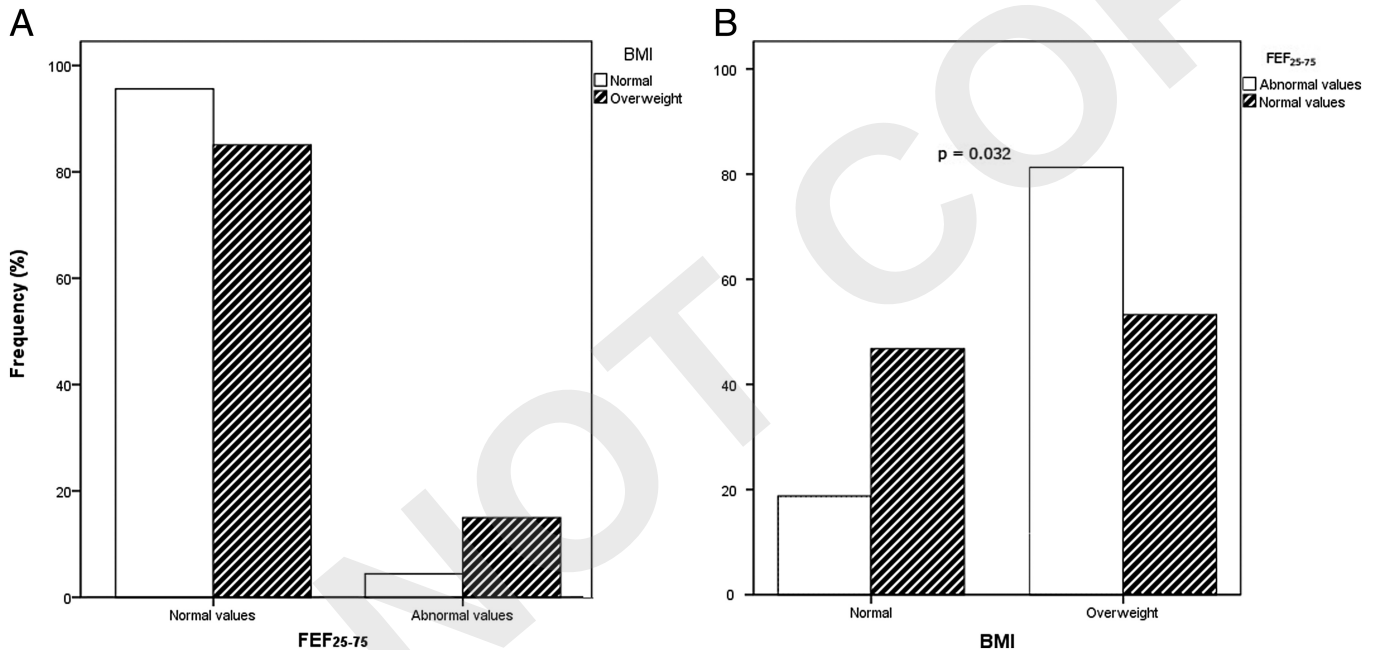


Figure 1. Joined distribution of FEF₂₅₋₇₅ and BMI. (A) Percentages of abnormal and normal FEF₂₅₋₇₅ values are calculated on the total of normal and overweight patients. (B) Percentages of normal and overweight patients are calculated on the total of abnormal and normal FEF₂₅₋₇₅ values. FEF₂₅₋₇₅, forced expiratory flow at 25–75%; BMI, body mass index.

The association between BMI and functional characteristics did not seem to change, adjusting for other characteristics, such as age, gender, and smoking.

Overweight Patients and Altered Parameters

Subsequently, BMI was categorized, according to classification reported in Table 1. Table 3 shows the differences of continuous characteristics, comparing normal weight patients with overweight/obese ones, separately for allergic patients and control subjects.

In control subjects, the impact of abnormal weight on spirometric characteristics was not significant (left side). Significantly lower values were observed for FEF₂₅₋₇₅, FEV₁, and FEV₁/FVC (with a trend toward higher values of FeNO) in overweight AR patients compared with normal weight ones.

In allergic patients with normal BMI, only 4.4% had abnormal FEF₂₅₋₇₅ values (Fig. 1 A) compared with 14.9% of overweight patients (OR_{FEF₂₅₋₇₅} [overweight versus normal weight] = 3.81; 95% CI, 1.04–13.95) and 13/16 (81.3%) patients with abnormal FEF₂₅₋₇₅ were overweight or obese compared with 53.2% of patients with normal FEF₂₅₋₇₅ (Fig. 1 B).

Furthermore, considering pathological FeNO values, 60.3% of patients with normal BMI had normal FeNO, and 56.3% of overweight

patients had pathological FeNO (Fig. 2 A) with a significant (*p* = 0.04) association between BMI and FeNO (OR_{FeNO} [overweight versus normal weight] = 1.96; 95% CI, 1.03–3.73). In addition, 49 (64.5%) patients with pathological FeNO were overweight (Fig. 2 B).

In patients with normal weight, only 7.4% had mild/moderate or severe BHR in comparison with 20.7% overweight patients (OR [overweight versus normal weight] = 3.29 [1.15–9.37]; Fig. 3 A) and 18/23 (78.3%) patients with severe or mild/moderate BHR were overweight compared with 60% patients with borderline BHR, and 50.9% patients with negative BHR (Fig. 3 B).

Using abnormal FEF₂₅₋₇₅ values as a characteristic to classify the patients, a value ≥ 26 of BMI (Fig. 4) were permitted to have a sensitivity of 75% (patients with BMI ≥ 26 and abnormal FEF₂₅₋₇₅) and a specificity of 62.6% (patients with BMI < 26 and normal FEF₂₅₋₇₅).

On the contrary, BMI value of 26.6 gave a sensitivity of 68.8% and a specificity of 67.6%. The AUC was ~ 0.73 (95% CI, 0.59–0.87; *p* = 0.001).

Using BMI as a characteristic to distinguish patients with severe or mild grade of BHR from patients with negative or borderline BHR (Fig. 5), the AUC of ROC curve was ~ 0.70 (95% CI, 0.57–0.83; *p* = 0.003). One possible cutoff BMI value was set to 25.8: all patients with it had 78.3% of probability (sensitivity) to have mild or severe BHR,

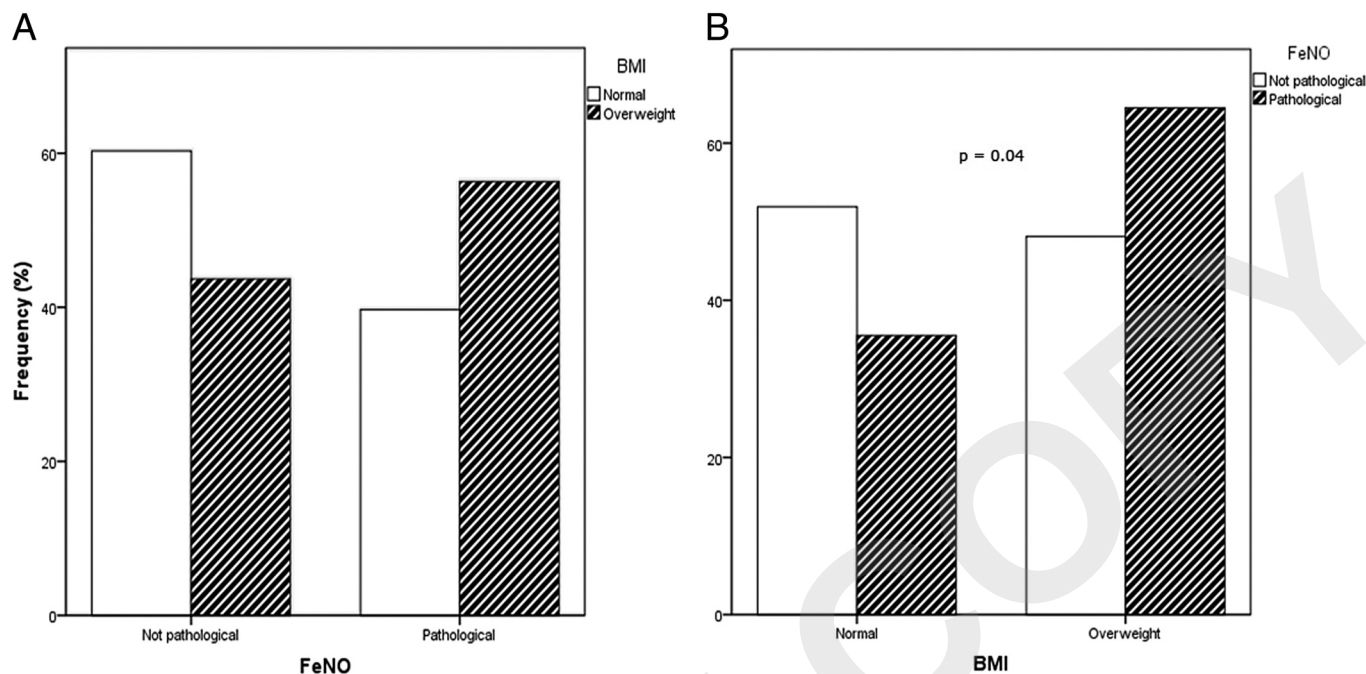


Figure 2. Jointed distribution of FeNO and BMI. (A) percentages of pathological and normal FeNO values are calculated on the total of normal and overweight patients. (B) Percentages of normal and overweight patients are calculated on the total of abnormal and normal FeNO values. FeNO, fractional concentration of exhaled nitric oxide; BMI, body mass index.

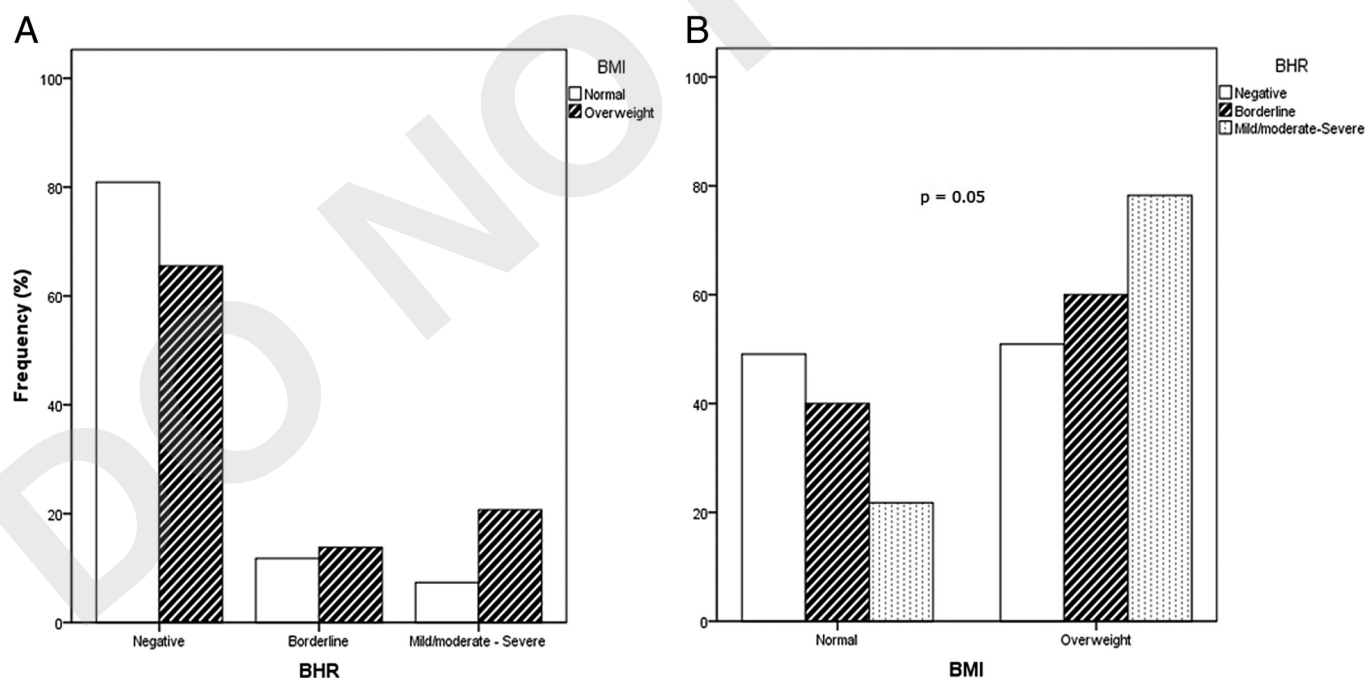


Figure 3. Jointed distribution of BHR severity and BMI. (A) Percentages of classes of BHR severity are calculated on the total of normal and overweight patients. (B) Percentages of normal and overweight patients are calculated on the total of BHR severity. BHR, bronchial hyperreactivity; BMI, body mass index.

whereas patients with lower values had 62.1% of probability (specificity) to have borderline or negative BHR. For a cutoff of 26.6 BMI, sensitivity of 69.6% and specificity of 71.2% were detected.

Using BMI to distinguish patients with pathological FeNO values, the AUC was 0.60 (95% CI, 0.51–0.69; *p* = 0.033). With a cutoff of BMI 25.6, the sensitivity was 52.6% and the specificity 64.6%, and cutoff of 25 gave sensitivity 64.5% and specificity 51.9%.

DISCUSSION

There is evidence that the prevalence of allergic disorders has increased worldwide in developed countries.¹⁷ Although several environmental factors have been hypothesized to be involved in the development of allergic diseases, none could fully explain this rapid prevalence increase. Moreover, some lifestyle factors, including di-

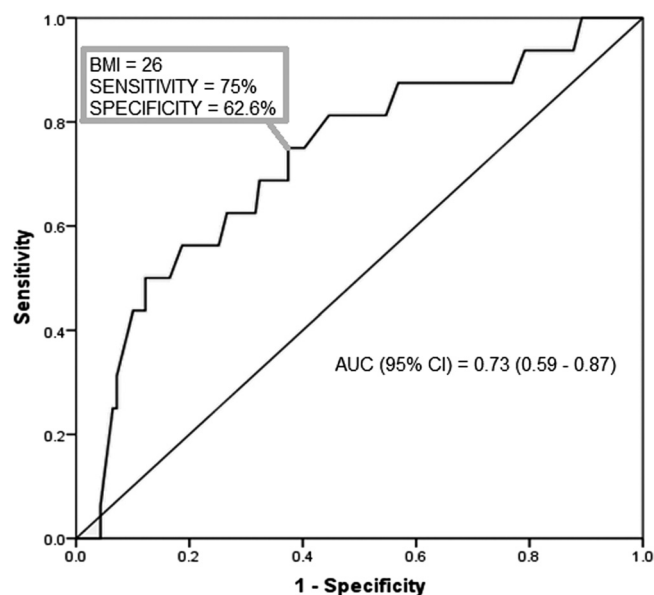


Figure 4. ROC curve for BMI as tested to detect patients with abnormal FEF_{25-75} values. ROC, receiving operator characteristic; BMI, body mass index; FEF_{25-75} , forced expiratory flow at 25–75%.

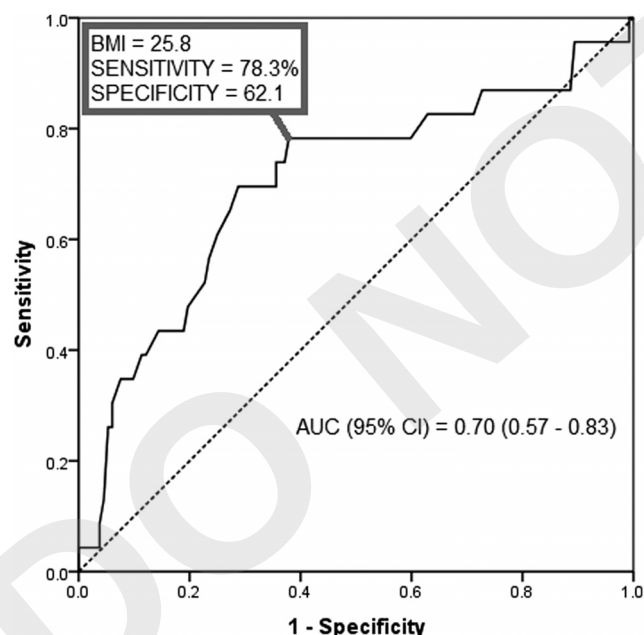


Figure 5. ROC curve for BMI as tested to detect patients with severe or mild/moderate BHR. ROC, receiving operator characteristic; BMI, body mass index; BHR, bronchial hyperreactivity.

etary aspects, alcohol consumption, physical inactivity, and obesity, have recently obtained distinctive regard. Indeed, the increase in affluence, typical of the western society, may result in increased availability of food and decreased physical activity; both of them may contribute to promoting obesity and overweight. In addition, there is evidence that obesity and being overweight are linked with allergic diseases probably because of the immune activity exerted by the adipose tissue, producing adipokines, on allergy. Obesity has been associated with an increased risk of asthma both in children and in adults.^{17,18} However, the real association between obesity and allergic disorders is still unclear. Many cross-sectional surveys pointed out

that obesity is a risk factor for asthma (OR ranging between 1.1 and 3.0) and that obesity may precede asthma onset.

On the other hand, only three studies investigated the effects of obesity on AR. The first study, conducted on a large cohort of Swedish military conscripts, reported that obesity was not associated with AR in patients with nasal symptoms only.⁴ The second study evidenced that the risk of AR increased with increasing BMI among women but not among men.¹⁹ The last study was conducted by our group and indicated that there was a significant relationship between BMI and AR and between BMI and BHR.⁹ Therefore, we decided to continue this issue, investigating also clinical and inflammatory parameters in a larger cohort of AR patients compared with normal subjects.

First, the present study showed that AR patients had a significantly higher BMI than normal subjects, confirming the relevant role exerted by adipose tissue on allergy. About $\frac{1}{4}$ of AR patients had BHR, FEF_{25-75} was significantly lower in AR patients than in controls (this parameter may suggest a precocious bronchial involvement), and FeNO was significantly higher in AR patients (suggesting presence of bronchial eosinophilic inflammation). These three findings underline the frequent link between nose and bronchi.

Second, overweight/obese AR patients show significant impaired spirometric parameters in comparison with normal weight patients as well as altered FeNO values. In addition, overweight/obese AR patients had more severe BHR than normal weight patients.

More interestingly from a practical point of view, raised BMI (such as >25) may be considered a risk factor for having (i) altered FEF_{25-75} values such as $<65\%$ of predicted, with OR of 3.81, (ii) elevated FeNO values with OR of 1.96, and (iii) mild–severe BHR with OR of 3.29. Therefore, overweight/obesity may represent a relevant risk factor for asthma evolution in AR patients.

We previously reported that AR duration and mite allergy are two relevant predictors in AR patients, because they may suggest (i) early airflow limitation detected by impaired FEV_1 values,²⁰ (ii) bronchial reversibility such a positive response to bronchodilation testing,²¹ and (iii) severe BHR.²² The present study provided further evidence that overweight/obesity may be risk factor for bronchial impairment in AR patients, mainly concerning precocious bronchial obstruction (as detected by low FEF_{25-75} values), moderate–severe BHR, and allergic inflammation (as assessed by FeNO). In addition, the present study confirms previous reports underlining the close link between adiposity and airway disorders.^{23–25}

However, this study may have some limitation: it has been conducted on a restricted and selected cohort of patients, mainly concerning gender and age; BMI may be a simplistic tool for measuring overweight/obesity; and the methodology was principally based on clinical grounds and was cross-sectional. On the other hand, all patients were carefully examined and full functional parameters were performed.

In conclusion, the present study may suggest that BMI assessment should be routinely considered in AR patients for individuating early bronchial impairment.

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