

RESEARCH PAPER

Association between anthropometric markers and asthma control, quality of life and pulmonary function in adults with asthma

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Abstract

Background: The role of abdominal fat and body fat (BF) in the evaluation of nutritional status in asthma has been considered recently. The present study aimed to evaluate the association between different anthropometric markers and asthma control, pulmonary function and quality of life. A secondary objective was to determine the agreement between the anthropometric markers with respect to assessing obesity in adults with asthma.

Methods: This cross-sectional study enrolled adult asthma patients attending an outpatient asthma clinic in southern Brazil. Patients were evaluated regarding sociodemographic data, lung function, asthma control, nutritional status and health-related quality of life (Asthma Quality of Life Questionnaire; AQLQ). Nutritional status was classified by body mass index (BMI), waist circumference (WC) and BF.

Results: The mean (SD) age of the 198 patients was 56.2 (14.8) years. The prevalence of uncontrolled asthma among subjects who were overweight as diagnosed by their BMI was 64.6% higher than in those who were normal weight. An increase in a measure of BMI (1 kg m^{-2}) decreases approximately 44–59% of symptoms, activity limitations and emotional function domains of the AQLQ, whereas an increase in a measure in WC (1 cm) decreases approximately 24–30% of the same domains. Agreement between BMI and BF was 0.566 and that between BMI and WC was 0.597 by Kendall's Tau-b test.

Conclusions: The prevalence of uncontrolled asthma is greater in overweight subjects than in normal weight subjects. WC and BMI were negatively associated with symptoms, activity limitations and emotional function domains of the AQLQ. BMI appears to be sufficient to diagnose the nutritional status of subjects with asthma in this population.

Introduction

Obesity has been identified as a risk factor for adult asthma^(1,2). Numerous studies have shown a relationship between an increased body mass index (BMI) and asthma^(3–5).

Also, an excess of body fat (BF) and abdominal fat may be an important risk factor for asthma^(6,7).

The relationships, interactions and associations between obesity and asthma are multifactorial and complex^(8,9). Obese subjects are more likely to have uncontrolled

asthma compared to nonobese subjects ⁽⁵⁾. Furthermore, obesity also is associated with decreased pulmonary function; more specifically, as represented by a decreased in forced expiratory volume in 1 s (FEV₁) and forced vital capacity (FVC) ⁽¹⁰⁾. Also, higher BMI values were associated with lower scores on the Asthma Quality of Life Questionnaire (AQLQ) ^(11,12).

The BMI is used as the anthropometric measure to determine individuals who are overweight or obese. This index is used as an epidemiological and clinical indicator, although it does not indicate the body composition distribution ⁽¹³⁾. Additionally, abdominal fat is associated with a reduction in lung function and poorly asthma control, although only a few studies have considered the role of abdominal fat and BF. Thus, anthropometric evaluation should therefore use other markers, such as waist circumference (WC) and BF measures ^(7,14–16).

The present study aimed to evaluate the association between different anthropometric markers (BMI, WC and BF) and asthma control, pulmonary function and quality of life. A secondary objective was to determine the agreement between the anthropometric markers with respect to assessing obesity in adults with asthma.

Materials and methods

This cross-sectional study included patients aged above 18 years of age with a diagnosis of asthma by Global Initiative for Asthma (GINA) criteria ⁽¹⁷⁾, attending, consecutively (from March to November 2013), an adult outpatient clinic for asthma at the Hospital de Clínicas de Porto Alegre, Porto Alegre, Rio Grande do Sul, Brazil. Excluded patients were those with a diagnosis of pulmonary disease other than asthma, an abnormal chest X-ray, bronchiectasis, emphysema, a smoking history of more than 10 pack-years, and a history of recent myocardial infarction, as well as pregnant women. The study was conducted in accordance with the guidelines laid down in the Declaration of Helsinki, and all procedures involving patients were approved by the Hospital de Clínicas Ethics Committee (protocol no. 12.0103). Written informed consent was obtained from all patients.

All subjects were interviewed by a researcher using a structured questionnaire that evaluated the variables: age, sex, self-related ethnicity, marital status, educational level, smoking status, comorbid conditions, asthma severity and asthma control.

Weight was measured to the nearest 0.1 kg using a calibrated electronic scale with subjects dressed in very light clothing and no shoes. Height was measured using a fixed tape measure with the participants standing shoeless on a hard surface against a wall. BMI was calculated as the ratio of weight to height squared (kg m⁻²) for each

subject. Subjects were grouped into three categories based on BMI: normal weight (<25.0 kg m⁻²), overweight (25.0–29.9 kg m⁻²) and obese (>30 kg m⁻²) ⁽¹⁸⁾. WC was used for abdominal fat classification and was measured, using an inelastic tape, at the midpoint of the lowest rib and iliac crest. Subjects were then classified, in accordance with sex-specific WC values, based on the cut-off points in relation to the risk of developing metabolic complications, as suggested by the World Health Organization ⁽¹⁹⁾, into three categories: (i) normal or not increased (<80 cm females, <94 cm males); (ii) increased (80–87.9 cm females, 94–101.9 cm males); and (iii) substantially increased (≥88 cm females, ≥102 cm males) ⁽¹⁸⁾.

Body composition (% body water, % BF and % muscle mass) was assessed by means of bioelectric impedance analysis. This method is based on conducting a painless electrical current of low intensity applied to the body via electrodes or cables connected to conductive surfaces, which are placed in contact with skin. Total BF, expressed as % BF was divided also into three categories according to age: (i) normal or not increased or (BF: <33% in women and <21% in men aged 20–39 years, BF: <35% in women and <23% in men aged 40–59 years, BF: <38% in women and <25% in men aged 60–79 years); (ii) increased (BF: ranging between 33% and 39% in women and between 21% and 26% in men aged 20–39 years, BF: ranging between 35% and 41% in women and between 23% and 29% in men aged 40–59 years, BF: ranging between 38% and 43% in women and 25–31% in men aged 60–79 years); and (iii) substantially increased (BF: ≥39% in women and ≥26% in men aged 20–39 years age, BF: ≥41% in women and ≥29% in men aged 40–59 years, BF: ≥43% in women and ≥31% in men aged 60–79 years) ⁽²⁰⁾.

The control of asthma was assessed by GINA criteria ⁽¹⁷⁾. Asthma was considered to be controlled if all these features were present: daytime symptoms twice a week or less, no limitations of activities, no nocturnal symptoms or awakenings, need for reliever/rescue treatment twice a week or less, normal airflow (FEV₁ and peak expiratory flow rate, ≥80% of predicted value). Asthma was considered partially controlled if one or two of the above features were absent. Asthma was considered to be uncontrolled if more than two features were absent or if asthma had caused hospital/emergency department admission in the previous 12 months.

To assess asthma severity, we used the GINA criteria ⁽¹⁷⁾ classification system in accordance with the daily medication regimen, which divides patients into four severity categories (mild intermittent, mild, moderate and severe persistent asthma) based on the frequency of symptoms, spirometry and the intensity of drug therapy.

Lung function (FEV₁ and FVC) was measured using a computerised spirometer (Jaeger, version 4.31; Jaeger,

Würzburg, Germany). The best of three acceptable manoeuvres of the forced expiratory curve was selected. FVC, FEV₁ and FEV₁/FVC were registered and expressed as a percentage of the predicted values and as absolute values⁽²¹⁾.

Health-related quality of life in asthma was assessed using the AQLQ developed by Juniper *et al.*⁽²²⁾. This questionnaire includes the domains: symptoms, activity limitations, emotional function and environmental stimuli. Each domain is scored from 1 to 7, where 1 indicates maximal impairment and 7 indicates no impairment.

The calculation of sample size was estimated in accordance with the study by Pakhale *et al.*⁽²³⁾. Considering a minimal difference in the total score of quality of life or in any of its domains (magnitude of effect) of 0.5 points between anthropometric marker categories (normal, increase and substantially increase), a SD of 1.0, with a standardised effect magnitude of 0.5, and two-way alpha = 0.05 and beta = 0.20 (or power = 0.80), 64 patients were required per group, totalling 192 patients.

Data were analysed using SPSS, version 19.0 (IBM Corp., Armonk, NY, USA) and were reported as the median (interquartile range), mean (SD) or percentage of subjects with the specified variable. The association between anthropometric markers and asthma control was assessed in a bivariate analysis (uncontrolled asthma as dependent variable) using Poisson regression controlled by age and sex. The association between anthropometric markers and pulmonary function and AQLQ domains was assessed by multivariable linear regression models controlled by age and sex. $P < 0.05$ was considered statistically significant. Agreement between BMI, WC and BF was evaluated using Kendall's Tau-b test.

Results

In total, 344 adult patients with asthma were evaluated with respect to participating in the present study. Of these, 71 were excluded in that 53 patients had a diagnosis of pulmonary disease other than asthma; eight patients had a smoking history of more than 10 pack-years; one woman was pregnant; seven patients presented an abnormality in their chest X-ray; and two patients had a recent history of myocardial infarction. Furthermore, 75 subjects decline to participate in the study. Therefore, in total, 198 patients were included in the present study.

The general characteristics of the study sample are shown in Table 1. Mean (SD) age was 56.2 (14.8) years, 81.8% were women and 75.3% of patients reported that they were whites. Regarding asthma classification, 144 patients (72.7%) were classified as having severe persistent asthma, 31 patients (15.7%) as having moderate persistent asthma and 23 patients (11.6%) as having mild

Table 1 General characteristics of the patients with asthma

Variable	N = 198
Sex, n (%)	
Female	162 (81.8%)
Age (years), mean (SD)	56.2 (14.8)
Ethnicity, n (%)	
White	150 (75.3%)
Nonwhite	48 (24.2%)
Age at diagnosis (years), median (IQR)	20.5 (2–46)
Smoking status, n (%)	
Never	138 (69.7%)
Former	60 (30.3%)
GINA severity classification, n (%)	
Mild	23 (11.6%)
Moderate	31 (15.7%)
Severe	144 (72.7%)
GINA asthma control, n (%)	
Controlled	52 (26.3%)
Partly controlled	28 (14.1%)
Uncontrolled	118 (59.6%)
Nutritional indicators, mean (SD)	
BMI (kg m ⁻²)	29.6 (5.7)
Body fat (% total weight)	35.4 (7.8)
Waist circumference (cm)	
Female (cm)	99.4 (12.9)
Male (cm)	99.3 (14.0)
Pulmonary function (pre-bronchodilator), mean (SD)	
FVC (L)	2.5 (0.9)
FVC % predicted	81.2 (21.3)
FEV ₁ (L)	1.7 (0.7)
FEV ₁ % predicted	68.2 (22.2)
FEV ₁ /FVC % predicted	82.1 (13.0)

BMI, body mass index; FEV₁, forced expiratory volume in 1 s; FVC, forced vital capacity; GINA, Global Initiative for Asthma; IQR, interquartile range; N, number of cases (% total cases).

persistent asthma. Over half (59.5%) of patients presented uncontrolled asthma. The mean (SD) BMI was 29.6 (5.7) kg m⁻², BF was 35.4% (7.8%) and WC was 99.4 (12.9) cm for females and 99.3 (14.0) cm for males. Considering nutritional status by BMI, 43 patients (21.7%) were classified as normal weight, 72 patients (36.4%) were classified as overweight and 83 patients (41.9%) were classified as obese. Abdominal adiposity was not increased in 24 patients (12.1%), whereas it was increased in 27 patients (13.6%) and substantially increased in 147 patients (74.2%). Total BF was normal in 72 patients (36.4%), increased in 69 patients (34.8%) and substantially increased in 57 patients (28.8%).

The relationship between different categorised anthropometric markers and asthma control was explored in Poisson regression models and is shown in Table 2. The prevalence of uncontrolled asthma among subjects who were overweight as diagnosed by BMI was 64.6% higher

Table 2 Poisson regression models controlled by age and sex: uncontrolled asthma as dependent variable

	PR	95% CI	P value
Overweight diagnosed by BMI	0.646	0.465–0.897	0.009
Overweight diagnosed by % BF	0.757	0.526–1.089	0.133
Overweight diagnosed by WC	0.857	0.544–1.348	0.503
Overweight diagnosed by BMI or WC or % BF	0.846	0.440–1.628	0.617

BF increased, BF: >33% in females and >21% in males aged 20–39 years, BF: >35% in females and >23% in males aged 40–59 years, BF: >38% in females and >25% in males aged 60–79 years; BF, body fat; BMI, body mass index; CI, confidence interval; Overweight, BMI > 25 kg m⁻²; PR, prevalence ratio; WC increased, WC > 80 cm in females and WC > 94 cm in males; WC, waist circumference. *P* < 0.05 was considered statistically significant (bold).

than in those who were normal weight (*P* = 0.009). There were no statistical associations between BF and WC with asthma control (*P* = 0.133 and 0.503, respectively). Also, there was no statistical association with asthma control when analysed together with a diagnosis of being overweight by anthropometric markers (overweight as diagnosed by BMI or WC or BF, *P* = 0.617).

Multiple linear regression analysis for an association of anthropometric markers with lung function and AQLQ domains is shown in Table 3. WC and BMI were significantly associated with symptoms, activity limitations and emotional function domains: an increase in a measure of BMI (1 kg m⁻²) decreases approximately 44–59% of symptoms, activity limitations and emotional function domains of the AQLQ, whereas an increase in a measure of WC (1 cm) decreases approximately 24–30% of the same domains. There was no statistical association between FEV₁ and environmental domain of the AQLQ and BMI, BF and WC (*P* > 0.05 for all analyses).

Agreement between BMI categories with BF and WC is shown in Table 4. Comparing the BMI with the BF and WC categories, 79% and 48.9% of the subjects with normal weight also had a normal BF and WC, respectively. In the BMI overweight category, 40.3% and 18.1% of subjects had an increased BF and WC, respectively. In addition, in the obese category, 54.2% and 98.8% also had a high BF and WC. Overall, the BMI showed moderate agreement with BF (Kendall's Tau-b test = 0.566, *P* < 0.001) and with WC (Kendall's Tau-b test = 0.597, *P* < 0.001). The most notable agreement occurred in the obese categories (BF = 54.2% and WC = 98.8%).

Discussion

The results of the present study show that the prevalence of uncontrolled asthma is greater in overweight subjects

Table 3 Multiple linear regression models for association of anthropometric markers with lung function and asthma quality of life questionnaire domains

	B-coefficient (95% CI)	r ² adjusted	P value
Lung function			
FEV ₁ (% predicted)			
WC	−0.058 (−0.299 to 0.183)	0.001	0.638
BMI	0.063 (−0.496 to 0.622)	0.000	0.825
BF	−0.047 (−0.573 to 0.478)	0.000	0.859
AQLQ domains			
Symptoms			
WC	−0.024 (−0.041 to −0.008)	0.067	0.004
BMI	−0.048 (−0.086 to −0.009)	0.056	0.016
BF	−0.017 (−0.053 to 0.020)	0.031	0.374
Activity limitations			
WC	−0.023 (−0.037 to −0.008)	0.099	0.003
BMI	−0.044 (−0.079 to −0.010)	0.087	0.011
BF	−0.019 (−0.051 to 0.014)	0.062	0.255
Emotional function			
WC	−0.030 (−0.050 to −0.207)	0.061	0.003
BMI	−0.059 (−0.016 to −0.012)	0.048	0.014
BF	−0.040 (−0.084 to 0.005)	0.034	0.081
Environmental			
WC	−0.012 (−0.030 to 0.006)	0.053	0.204
BMI	−0.018 (−0.061 to 0.024)	0.048	0.402
BF	−0.007 (−0.047 to 0.033)	0.045	0.713

AQLQ, asthma quality of life questionnaire; BF, body fat; BMI, body mass index; CI, confidence interval; FEV₁, forced expiratory volume in 1 s; WC, waist circumference.

Results are controlling for age and sex. *P* < 0.05 was considered statistically significant (bold).

diagnosed by BMI than in normal weight subjects also diagnosed by BMI. The BMI and WC were negatively associated with symptoms, activity limitations and emotional function domains of the AQLQ among adult asthma patients attending an outpatient clinic in a large, tertiary care, university-affiliated hospital in southern Brazil. Furthermore, BMI shows moderate agreement with WC and BF.

We observed a high prevalence of asthma subjects who were overweight as diagnosed by different anthropometric markers. In the present study, only being overweight as diagnosed by BMI was associated with asthma control evaluated by GINA criteria. Similarly, other studies^(5,24) have reported that obese adults with asthma had poorer disease control, as assessed by Asthma Questionnaire Control (ACQ)⁽²⁵⁾, than patients with a normal BMI. Similarly, Lavoie *et al.*⁽¹¹⁾ observed that patients with a higher BMI had higher scores on the ACQ, suggesting a relationship between obesity and uncontrolled asthma. Even when the diagnosis of being overweight was evaluated by WC and BF, no relationships with asthma control were found in the present study. Despite the WC being

Table 4 Agreement between body mass index categories with total body fat and waist circumference

Other classification criteria categories	BMI		
	Normal weight	Overweight	Obese
Normal			
BF	34 (79.0)	33 (45.8)	5 (6.0)
WC	21 (48.9)	3 (4.2)	–
Increased			
BF	7 (16.3)	29 (40.3)	33 (39.8)
WC	13 (30.2)	13 (18.1)	1 (1.2)
High			
BF	2 (4.7)	10 (13.9)	45 (54.2)
WC	9 (20.9)	56 (77.7)	82 (98.8)

BF, body fat; BF substantially increased (high), BF: $\geq 39\%$ in females and $\geq 26\%$ in males aged 20–39 years, BF: $\geq 41\%$ in female and $\geq 29\%$ in males aged 40–59 years, BF: $\geq 43\%$ in females and $\geq 31\%$ in males aged 60–79 years; BMI, body mass index; obesity, BMI > 30 kg m $^{-2}$; WC, waist circumference; WC substantially increased (high), WC ≥ 88 cm in females and WC ≥ 102 cm in males.

Results expressed as *n* (%). The values in bold represent the main diagonal of the agreement matrix.

Agreement between BMI and BF was 0.566 and between BMI and WC was 0.597 by Kendall's Tau-b test ($P < 0.001$ for both analyses).

suggested as an additional measure for identifying cardiovascular risk⁽²⁶⁾, the present study did not observe any association with asthma control.

In the present study, there were no relationships of BMI, WC and BF with FEV₁. By contrast, in a longitudinal study, Fenger *et al.*⁽²⁷⁾ showed that increasing adiposity was associated with decreasing FEV₁ and FVC in adult patients with asthma. In a cross-sectional study, Chen *et al.*⁽²⁸⁾ observed that WC was negatively associated with FEV₁ and FVC (on average, a 1-cm increase in WC was associated with a 13-mL reduction in FVC and a 11-mL reduction in FEV₁). On the other hand, in a retrospective observational study, Ghabashi *et al.*⁽²⁹⁾ found no associations of BMI with FEV₁ and FVC in adult asthmatics patients.

BMI and WC were negatively associated with symptoms, activity limitations and emotional function domains of the AQLQ. Lavoie *et al.*⁽¹¹⁾ found a similar relationship between BMI and environment and activity limitation in AQLQ domains in adults with asthma. Similarly, Mosen *et al.*⁽³⁰⁾ showed that obese adults were more likely to report poor symptoms, activity limitations, emotional function and environmental domains of the AQLQ compared to adults with normal BMI. These results indicate that individuals with a high BMI have the worst AQLQ domains because they are more restricted in their daily activities and, consequently, they have more symptoms in response to environmental and emotional factors.

In the present study, the best agreement between anthropometric markers for evaluation of nutritional status in adults with asthma was between BMI and WC. Similar to these findings, in a prospective study assessing the agreement between BMI and WC conducted in 386 healthy males, Rona *et al.*⁽³¹⁾ suggested that both BMI and WC are acceptable for assessing obesity. By contrast, Kurth *et al.*⁽³²⁾ investigated the effects of both BMI and WC on local grey matter volumes in a group of 115 healthy subjects and observed that WC is a more sensitive indicator than BMI, particularly in females. In addition, Janssen *et al.*⁽²⁶⁾ and Bigaard *et al.*⁽³³⁾, in a large cohort representative of the US population, observed that WC, either singly or together with BMI, may have a stronger relationship with some health outcomes than BMI alone. Nevertheless, the results of the present study show that, in this population, BMI is sufficient to assess nutritional status. In addition, BMI is inexpensive, quick and easy to use, and easy to understand for clinicians and the general population⁽¹⁸⁾.

The present study has some limitations to consider. First, it comprised a cross-sectional study and does not allow the establishment of causality. Second, the study was conducted in a referral centre in the public health system and probably included patients with more severe disease.

In conclusion, the prevalence of uncontrolled asthma is greater in overweight subjects diagnosed by BMI than in normal weight subjects also diagnosed by BMI. On the other hand, when the diagnosis of being overweight was evaluated by other anthropometric markers, no relationships with asthma control were found. Also, there were no relationships between anthropometric markers and pulmonary function. BMI and WC were negatively associated with symptoms, activity limitations and emotional function domains of the AQLQ. Furthermore, BMI only has a moderate agreement with BF and WC among adult asthma patients. Thus, the BMI appears to be sufficient for diagnosing the nutritional status of subjects with asthma in this population.

Conflict of interests, source of funding and authorship

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