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Abdominal adiposity is an early marker of pulmonary function impairment: Findings from a Mediterranean Italian female cohort

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Abstract *Background and aims:* Abdominal adiposity may influence the respiratory function, especially in women. The aim of this prospective study is to evaluate the predictive role of body mass index (BMI) and waist circumference (WC) on lung function in healthy women.
Methods and results: In 600 women randomly selected from the cohort of the "Progetto ATENA," anthropometric measures such as BMI, WC, and weight gain were recorded at baseline, and the spirometric parameters were measured 10 years later. The percentage values of forced expiratory volume in 1 s (FEV_1%) and forced vital capacity (FVC%) and the ratio of FEV_1/FVC were compared with the anthropometric measures after adjustment for several variables measured at baseline such as age, height, socioeconomic status, smoking habits, and history of respiratory allergies grouped in a basal model.

WC is significantly associated with a decreased FVC ($p = 0.008$) and an increased ratio of FEV_1/FVC ($p = 0.031$) after adjustment for the covariates of the basal model. The association between BMI and spirometric parameters reaches borderline significance only with the ratio of FEV_1/FVC ($p = 0.052$).
Conclusions: We suggest measuring both BMI and WC to assess the risk of future respiratory impairment.

Introduction

Recent evidence derived from population studies indicates that anthropometric markers of overweight or obesity are consistently associated with respiratory dysfunctions identifiable through symptoms and/or spirometric indices, even when concomitant diseases are absent [1–9].

Adiposity may alter pulmonary function affecting chest wall movement, airway size, respiratory muscle function, and ventilation/perfusion ratio. Especially, abdominal adiposity has been found to be associated with respiratory dysfunction. This condition plays an even more important role in women as fat is generally located in the hips [10,11]. Furthermore, inflammatory markers, known to be associated with impaired airway function, are increased when central adiposity is predominant [12–17].

There is an emerging need to determine anthropometric measurements that can help predict the risk of future respiratory dysfunctions; the aim is not only to increase the existing knowledge but also to refine the targets

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for intervention measures capable of reducing this risk. Special attention is paid to women's health, partly because this information is less available in women than in men, and partly because the increase in overweight and obesity has been more significant in women [18].

The prediction of future respiratory functions using anthropometric measurements is possible only through a prospective cohort study. Information from this type of studies is scarce. This paper aims at evaluating the predictive role of some simple anthropometric markers such as body mass index (BMI) and waist circumference (WC), measured at a baseline observation of a prospective study, on pulmonary function assessed years later.

Methods

Study population

Women evaluated in the present study are part of a large cohort study (Progetto ATENA), enrolled within a 4-year period starting from 1993, consisting of 5062 women (age: 30–69 years) inhabiting Naples, a city in Southern Italy; the latter study was designed to review the etiology of major chronic diseases in women [19]. In total, 690 participants were randomly selected at baseline for a face-to-face follow-up in the future. After 10 years they were invited for a new visit; 600 of them underwent spirometry with a technically readable examination. At baseline, the exclusion criterion was a previous diagnosis of major cardiovascular events, cancer, and disabling chronic disease. All participants gave written, informed consent, and the study was approved by the ethics committees of the School of Medicine of the Federico II University of Naples, Italy.

Baseline measurements

Anthropometric measurements were made with the subjects in indoor clothing and without shoes. BMI, used as a measure of general obesity, was calculated as weight (in kilograms) divided by height squared (meter squared). WC was measured midway between the bottom of the rib cage and the top of the iliac crest. The hip circumference was measured at the level of the trochanter major. Waist-to-hip ratio (WHR) was calculated as the ratio of waist to hip circumferences. The weight at age 20 was recorded at baseline interview and weight gain was calculated subtracting the weight at age 20 from the weight at baseline visit.

The socioeconomic status was evaluated on the basis of years of education, and women were divided into two categories: $\leq$8 years of schooling and $>$8 years of schooling.

The variable "pack-years" was calculated to describe the smoking habits. The study participants were grouped as never smokers, light smokers ($<$20 pack-years), moderate smokers ($\geq$20, $<$40 pack-years), and heavy smokers ($\geq$40 pack-years).

In order to assess the total impact of physical activity and energy expenditure (occupational, housework, and recreational activity), a "physical activity level" (PAL) index was used [20]. PAL takes into account any single activity of one day compared with the conditions of basal metabolism at complete rest: when PAL is equal to 1.00, there is only complete rest. Women with PAL $<$ 1.40 are inactive, between 1.40 and 1.69 are mildly active, between 1.70 and 1.99 are moderately active, and $>$2.00 are very active. Information on respiratory allergy was collected at baseline.

Follow-up of respiratory function

The participants underwent spirometry according to the guidelines of the American Thoracic Society 10 years after the baseline visit [21]. Spirometry was performed in the morning (8.00 a.m.–10.00 a.m.). All measures were made by a single operator using a calibrated, dry wedge bellows spirometer. Forced expiratory volume in 1 s (FEV_1) and forced vital capacity (FVC) were measured, using the best of three forced maneuvers. FEV_1% and FVC % of the predicted values and FEV_1/FVC ratio were recorded. The predicted lung function values were referred to ERS 1993 reference values for spirometry [22].

Statistical analysis

Continuous variables are expressed as mean and standard deviation and categorical variables as absolute number and percentage. For descriptive purposes, FVC%, FEV_1%, and FEV_1/FVC ratio are categorized in four classes by quartiles. The differences in patient characteristics among quartiles are tested by analysis of variance (ANOVA) and Pearson's chi-squared test for continuous and categorical variables, respectively. Different multiple linear regression models are fitted with FVC%, FEV_1%, and FEV_1/FVC ratio – each at a time – as a dependent variable. The covariates are included a priori in the model. The nonlinear association of the covariates is evaluated by restricted cubic splines according to Harrell [23]. All statistical tests are two-sided and p-values $<$ 0.05 are regarded significant. The data are analyzed using SAS version 9.2 (SAS Inc., Cary, NC, USA).

Results

The baseline characteristics of the participants are reported in Table 1. The distribution of the key characteristics of participants has been evaluated by quartiles of spirometric variables (data on FEV_1%, FVC%, and FEV_1/FVC ratio are reported in the appendix Tables e-1–e-3). Regarding FEV_1%, age, smoking, and height are significantly different in the quartiles; the trends analyzed are significant for respiratory allergy, smoking, height, and weight at 20 years and at borderline for WC. Considering FVC%, smoking and WC are significantly different in the quartiles, whereas the trends are significant for smoking and WC, and at borderline for education and age. Regarding FEV_1/FVC ratio, respiratory allergy, height, WC, BMI, and weight