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The effects of truncal adiposity in forced spirometry: Sex differences

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ABSTRACT

The aim of the current paper is to establish the influence of truncal fat accumulation on the spirometric results of a group of healthy individuals.

A cross-sectional study of 305 healthy, non-smoking adult subjects (144 males, 161 females) was conducted. Forced spirometry and dual-energy X-ray absorptiometry to quantify body fat were performed. Partial correlation and multiple linear regression analyses were performed.

In females, abdominal fat was negatively correlated with forced vital capacity (FVC) and forced expiratory volume in one second (FEV_1). In males, thoracic fat was negatively correlated with respiratory variables, as was abdominal fat. In the multiple linear regression, FEV_1 was the spirometric parameter that showed higher R^2 values in both sexes.

Truncal fat had a greater influence on FEV_1 than on FVC. In males, no significant differences between the influence of thoracic and abdominal fat on spirometric results were found, and total body fat was shown to have more influence than regional. In females, the influence of abdominal fat was higher.

1. Introduction

The negative effects of body fat accumulation are demonstrated in a series of chronic diseases, mainly cardiovascular and metabolic diseases such as diabetes. In the case of ventilatory function, it has not yet been established what the real influence of the body's fat compartment is on ventilatory function, and only in individuals who are severely obese has the association between excessive body fat accumulation and pulmonary function impairment been demonstrated (Ceylan et al., 2009; Leone et al., 2009; Ray et al., 1983; Steele et al., 2009). In recent years, several studies have attempted to clarify this point. Some research work has utilized body mass index (BMI) and body weight as indicators of adiposity; a clear association between these indicators and ventilatory function exists only in individuals with a very high body weight or BMI (Jones and Nzekwu, 2006 ; Thyagarajan et al., 2008). Other studies (Cotes et al., 2001; Lazarus et al., 1997; Lazarus et al., 1998; Ochs-Balcom et al., 2006) estimated body fat using different anthropometric measures, the most common being waist circumference (WC) and waist-to-hip ratio (WHR), which are estimates of the accumulated fat in the abdominal region. Some of these studies have found negative and significant associations between WHR and the main spirometric variables, as well as discovering differences between the sexes. However, it is necessary to estimate the quantity and distribution of body fat with more direct and accurate methods to accurately clarify their influence on pulmonary function. We suggest the use of dual-energy X-ray absorptiometry (DXA), a method that has proven valid and reliable in quantifying body fat (Glickman et al., 2004). In addition, DXA allows not only the quantification of total body fat, but also of the fat accumulated in different regions of the body. The current work is based on the hypothesis that truncal fat has a significant influence on the spirometric results of males and females who display a wide range of BMIs, not only on obese individuals.

2. Methods

2.1. Study participants

The sample consists of 305 participants (144 males and 161 females). They all came from the same urban environment, having a medium socio-economic level. They exhibited homogeneity in terms of

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hygienic and dietary habits and sporadic physical exercise throughout their lives. The age range was between 18 and 77 years, and all the participants were Caucasian. The criteria for inclusion in the study were the following:

- No current or past smoking habit.
- Absence of metabolic diseases or drug treatments that could alter the metabolism.
- Absence of muscular or neuromuscular diseases.
- Absence of a thoracic deformity, which is determined as a thoracic index within the average for the participant's age plus or minus two standard deviations.
- No evidence of alterations of the physiological curvature of the spine.
- Absence of chronic bronchopulmonary diseases and episodes of pneumothorax.
- Absence of diseases such as cancer and heart disease, which may affect fat distribution.

All participants voluntarily agreed to take the necessary tests for the study, and prior informed consent was given by all participants.

The characteristics of the study's population are shown in Table 1.

2.2. Procedures

To quantify adiposity, all individuals were subjected to a whole body DXA scan to obtain total and regional body fat measures. This technique uses a highly stable X-ray generator to produce a spectrum of broad energy-band levels. The apparatus consists of NaI crystal scintillation detectors placed in tandem. The source of radiation and the detectors are placed opposite each other and are mechanically connected so that they move simultaneously. The light beam passes in a posteroanterior direction through the tissue; this occurs as the patient lies perfectly still in a supine position. Depending on the density of the tissue that it passes through, energy is absorbed: the absorption rate is zero in air, small in fat, greater in soft tissues, and very significant in bone. Photons that have not been absorbed are captured by the detector, so the density of the area explored is proportional to the attenuation of radiation by the tissue.

All measures were provided in grams of fat. Body fat measures considered for the study are as follows:

Table 1
Descriptive Statistics of the studý population.

	Females (n = 161)	Males (n = 144)	p
Age (years)	46.4 ± 16.8 (18–75)	43.3 ± 16.7 (18–77)	
Height (cm)	159.9 ± 7 (143–185)	173.2 ± 7.5 (154–190)	**
Weight (Kg)	63.8 ± 10.1 (44–97)	80.9 ± 12.4 (60–119)	**
BMI	25 ± 4.3 (16.6–41,9)	26.9 ± 3.86 (19.7–40.8)	**
FVC (mL)	3334 ± 691 (1370–4720)	4711 ± 848 (2610–7000)	**
FEV_1 (mL)	2830 ± 614 (1150–4060)	3855 ± 785 (1890–5920)	**
PEF	6212 ± 1407 (2380–10390)	9066 ± 1959 (3170–13270)	**
$FEF_{25\%–75\%}$	3226 ± 943 (1040–6530)	3985 ± 1315 (1340–8660)	*
FEV_1/FVC	84 ± 5.8 (70–99)	82 ± 5.8 (71–95)	
Total body fat (Kg)	27.1 ± 8.4 (7.1–56)	23.1 ± 9.3 (6.6–58.6)	*
Truncal fat (Kg)	12.7 ± 4.7 (2–2.4)	12.3 ± 6 (2.8–39.5)	
Thoracic fat (Kg)	6.7 ± 2.5 (1.6–14.8)	6.8 ± 3.4 (1.6–21.7)	
Abdominal fat (Kg)	5.9 ± 2.3 (0.3–14.9)	5.4 ± 2.8 (10.8–17.8)	

BMI: body mass index; FVC: forced vital capacity; FEV1: forced expiratory volume in one second; PEF: peak expiratory flow; FEF 25%-75%: forced expiratory flow between 25% and 75% of forced vital capacity. Mean ± standard deviation, (minimum-maximum).

* $p < 0.05$.

** $p < 0.01$.

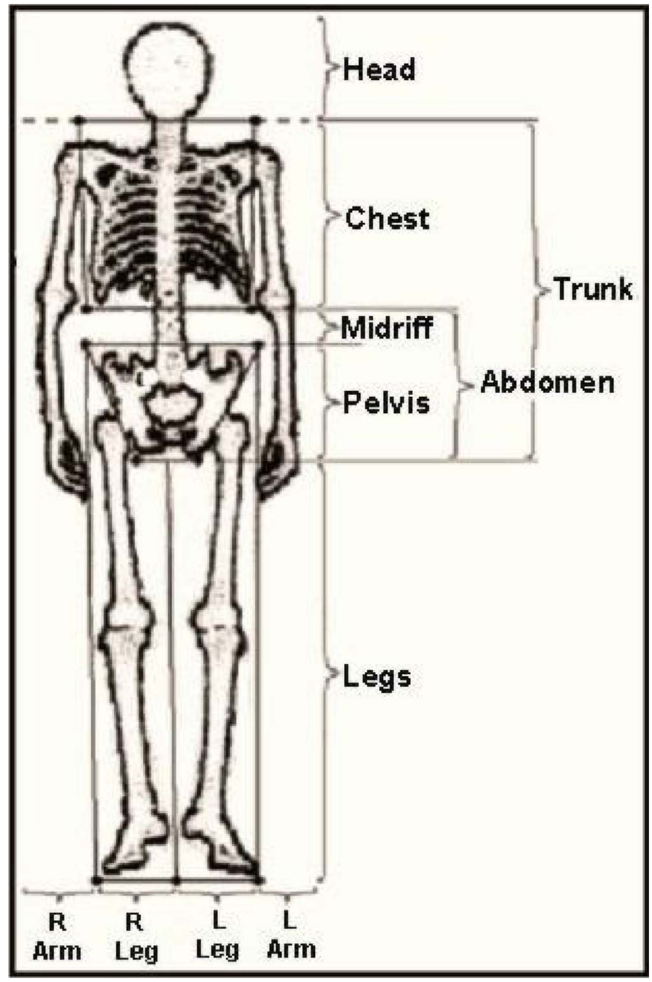

Fig. 1. DXA regions of interest.

− Total body fat (TF).

− Abdominal fat (AF) = Midriff fat (MF) + Pelvis fat (PF)

− Truncal fat (TrF) = Thoracic fat (ThF) + Abdominal fat (AF)

The DXA regions of interest are shown in Fig. 1, and they correspond to the various body fat measures considered.

A pencil-beam DXA densitometer Norland model XR-800TM (Norland, a Cooper Surgical Company, Fort Atkinson, WI, USA) was used. The DXA scans were obtained through the standard procedures for scanning and analysis, which were supplied by the manufacturer. Quality scans were performed daily to ensure precision control. All densitometria were performed following standardized protocols provided by the manufacturer and as described by Aguado et al. (Henche et al., 2007). All scans were carried out with the same device, in the same laboratory, and by the same skilled technician.

A pulmonary function evaluation was performed. Absolute values of forced vital capacity (FVC) and forced expiratory volume in one second (FEV_1) measured in milliliters were used as endpoints for lung function. Peak expiratory flow (PEF) and forced expiratory flow between 25% and 75% of forced vital capacity ($FEF_{25\%–75\%}$) were measured in liters per second.

A turbine spirometer Cosmed K4b2 was used. Prior to each test, a calibration of the turbine was performed. To obtain a successful completion of each spirometry, the recommended protocol of ATS/ERS (Miller et al., 2005) was followed. All studies were performed in the same laboratory and with the same environmental conditions.

A statistical analysis followed the tests. The arithmetic mean,