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Original article

Clinical usefulness of abdominal bioimpedance (ViScan) in the determination of visceral fat and its application in the diagnosis and management of obesity and its comorbidities[☆]

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SUMMARY

Background & aims: Visceral adipose tissue (VAT) has been shown to be profoundly responsible of most of the obesity-associated metabolic derangements. The measurement of VAT usually implies the use of imaging techniques such as magnetic resonance imaging or computed tomography (CT). Our aim was to evaluate the accuracy of the determination of VAT by means of abdominal bioimpedance (BIA) with the ViScan device in comparison with CT and its clinical usefulness in the management of obesity.
Methods: We studied a sample of 140 subjects (73 males/67 females) with BMI ranging from 17.7 to 50.4 kg/m^2 to evaluate the accuracy of the ViScan in comparison to CT to determine VAT. To further analyze ViScan's clinical usefulness we studied a separate cohort ($n = 2849$) analyzing cardiometabolic risk factors. Furthermore, we studied the ability of the ViScan to detect changes in VAT after weight gain ($n = 107$) or weight loss ($n = 335$). The study was performed from October 2009 through June 2015.
Results: ViScan determines VAT with a good accuracy in individuals with a CT-VAT up to 200 cm^2, and then with lower precision with increasing body mass, exhibiting a moderate–high correlation with CT-VAT ($r = 0.75$, $P < 0.001$). Importantly, VAT determination with the ViScan exhibits better correlations with several cardiometabolic risk factors such as glucose, triglycerides, HDL-cholesterol and markers of fatty liver than anthropometric measurements such as BMI or waist circumference. ViScan is able to detect VAT variations after body weight changes.
Conclusions: Since the possibility of measuring VAT by imaging techniques is not always available, abdominal BIA represents a good alternative to estimate VAT, allowing the identification of patients with increased VAT-related cardiometabolic risk and a better management of obese patients.
Trial registration: ClinicalTrials.gov NCT01055626 and NCT01572090.

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1. Introduction

Obesity represents one of the leading causes of death and disability, threatening many of the health gains achieved during the recent decades [1]. The latest prevalence figures obtained in the United States show that more than one third of Americans are obese (38%) [2]. Lower numbers are found in Europe, where an average of 17% of adults is obese [3]. Obesity is associated with an increased risk of cardiovascular disease, hypertension, diabetes mellitus, dyslipidemia, stroke, obstructive sleep apnea and the development of certain types of cancer [1]. This results in decreased life expectancy and higher mortality [4].

Obesity is a complex, multifactorial condition characterized by overaccumulation of body fat, with excess adiposity, but not excess body weight, being the real culprit of obesity-associated complications [5]. Adipose tissue is considered as an extremely active endocrine organ. Traditionally considered a mere energy store in the form of triglycerides, in recent years it has become clear that adipose tissue produces a wide variety of molecules involved in the control of many physiological processes such as the regulation of appetite, body weight, growth, reproduction and immunity, among others [6]. In addition to the amount of adipose tissue, adiposity distribution is also a major determinant of the incidence of obesity-associated comorbidities, with visceral adiposity showing a more pathogenic profile than the subcutaneous depot [7]. The pathophysiological evidences of the greater involvement of visceral adipose tissue (VAT) in the obesity-associated morbidity and mortality are increasing [4,7,8].

Body mass index (BMI) is the most frequently used tool for the diagnosis of obesity, but in spite of its wide use BMI is only a surrogate measure of body fatness and does not provide an accurate measure of body composition or body distribution [5]. The measurement of waist circumference (WC), waist-to-hip ratio (WHR) and, more recently, the waist-to-height ratio (WHtR) are simple measures, readily available and useful for estimating abdominal fat [9]. However, they do not allow discrimination between subcutaneous abdominal and visceral abdominal adipose tissues. Furthermore, those methods although being reproducible exhibit poor precision [10]. Imaging techniques such as computed tomography (CT) or magnetic resonance imaging (MRI) allow the quantification of abdominal adipose tissue discriminating between the subcutaneous and visceral depots [11]. However, the high cost, time consuming, the use of radiation in the case of CT, and the size problems in the case of morbid obese patients makes these techniques not very useful in everyday clinical practice. Thus, the interest in techniques that allow the quantification of VAT without the use of radiation or with equipments with reasonable cost and low-time and money consuming has grown in recent years. In this regard, bioelectric impedance (bioimpedance, BIA), based on the resistance that the body opposes to the passage of an electric current to determine fat-free mass and inferring body fat, represents an interesting alternative.

In the present study we aimed to evaluate the precision of the determination of the abdominal fat, and in particular visceral fat, by means of the Tanita AB-140 (ViScan, Tanita Corp., Tokyo, Japan) in comparison with CT and its clinical usefulness in the diagnosis and management of overweight and obese patients.

2. Methods

2.1. Study population

We studied a sample of 140 Caucasian subjects (73 males/67 females), aged 18–77 years (mean ± SD, 55 ± 11 y) including patients visiting the Departments of Endocrinology & Nutrition, Internal Medicine and Surgery of the Clínica Universidad de Navarra (Cohort 1). The study was performed to evaluate the accuracy of the BIA device ViScan in comparison to CT to determine total abdominal fat and VAT. To further validate the clinical usefulness of this equipment we studied a separate cohort including 2849 Caucasian subjects (1172 males/1677 females), aged 18–80 years (48 ± 14 y) with well-characterized cardiometabolic risk (Cohort 2). The study was performed from October 2009 through June 2015 (Fig. 1). Furthermore, we studied the ability of ViScan to detect changes in trunk and visceral fat after body weight gain or loss in 107 and 335 Caucasian subjects, respectively. Patients were recruited from those who exhibited weight gain of at least 2 kg in two separate medical visits, or those exhibiting weight loss of at least 2 kg achieved either by conventional dietary treatment (CDT, n = 214) or after Roux-en-Y gastric bypass (RYGB, n = 121), following previously described procedures [12]. The experimental design was approved, from an ethical and scientific standpoint, by the University of Navarra Ethical Committee (081/2009) and informed consent was obtained from all subjects.

2.2. Anthropometric measurements and physical activity

The anthropometric and body composition determinations as well as the blood extraction were performed on a single day. Body weight was measured wearing a swimming suit and cap to the nearest 0.1 kg with a digital scale. Height was determined with a Holtain stadiometer (Holtain Ltd., Crymych, UK) to the nearest 0.1 cm [5,13]. BMI was calculated as weight in kg divided by the square of height in meters. Blood pressure was measured as previously reported [5,14]. Physical activity level (PAL) was estimated by a validated questionnaire [15].

2.3. Body composition

Body density was calculated by air-displacement-plethysmography (Bod-Pod®, Life Measurements, Concord, California, USA). Body fat percentage (BF%) was calculated from body density by means of the Siri equation [5].

2.4. Abdominal and visceral adiposity by ViScan

Visceral and abdominal adiposity was quantified by the use of the abdominal BIA device ViScan (Tanita AB-140, Tanita Corp., Tokyo, Japan), designed to estimate visceral adiposity and trunk fat percentage. A wireless 'electrode belt' is placed on the bare midriff of the subject in supine position. The belt then uses dual frequency bioimpedance (6.25 and 50 kHz) to measure trunk and visceral fat resistance and transmit the readings via infrared to the base unit. The ViScan abdominal body composition device provides a measure of total abdominal adiposity [trunk fat percentage (range 0–75%) including intraabdominal adipose tissue and subcutaneous abdominal adipose tissue] and intraabdominal adipose tissue, which is expressed as 'visceral fat' (ranging from 1 to 59 in arbitrary units). As stated by the manufacturer, the intraabdominal adipose tissue or VAT area measured by CT in cm^2 corresponds to the visceral fat arbitrary units (a.u.) obtained by the ViScan multiplied by 10.

2.5. Abdominal and visceral adiposity by computed tomography

All subjects from Cohort 1 underwent CT scanning in the supine position using a 64-slice Multidetector CT (Somatom Sensation 64, Siemens Medical Solutions, Erlangen, Germany) under a standardized protocol. Total abdominal fat (CT-TAT) area and VAT were