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Original Article

The Associations of Body Composition and Fat Distribution With Bone Mineral Density in Elderly Italian Men and Women

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Abstract

This study aimed to investigate the associations of body composition and fat distribution with bone mineral density (BMD) in elderly Italian subjects. In 866 women (age 64.2 ± 6.5 yr) and 168 men (age 65.1 ± 6.1 yr), we measured BMD at lumbar spine, at femur, at the total body, and at the right hand. In all subjects, we also measured sex hormones, 25-hydroxyvitamin D, bone markers, and calcium intake. In both men and women, all body composition parameters had significant positive correlations with BMD at all sites after adjusting for age only; after adjusting also for body weight only lean mass (LM) remained positively associated with BMD at all sites except BMD at lumbar spine. In males, LM was associated with BMD at all sites, whereas android fat was associated with BMD at lumbar spine, at femur, and at whole body. In females, fat mass (FM) was positively and age inversely associated with BMD at all sites, whereas gynoid fat and alkaline phosphatase were inversely associated with BMD at lumbar spine and at femur. In conclusion, the role of LM seems more important in males, whereas in women the role of FM prevails with negative associations between gynoid fat and BMD.

Key Words: Android fat; BMD; gynoid fat; lean mass; sex hormones.

Introduction

Osteoporosis, a systemic skeletal disease characterized by low bone mineral density (BMD) and microarchitectural deterioration of bone tissue leading to increased fragility, is an important public health problem worldwide because of its high morbidity in the aging population *(1)*. BMD by dual-energy X-ray absorptiometry (DXA) is the most important determinant of bone strength and has been accepted as a surrogate measure for the diagnosis of osteopenia and osteoporosis *(2)*.

It follows that knowledge of the factors modulating the behavior of BMD is crucial for preventing and treating osteoporotic disease. Body weight is one of the important determinants of BMD and a positive relationship between body weight or body mass index (BMI) and BMD has been reported *(3−5)*. An inverse relationship between body weight or BMI and the risk of any fracture has also been shown *(6)*.

However, the relative effect of lean mass (LM) and fat mass (FM), the major components of body weight, on BMD still remains controversial. Some studies suggest that in postmenopausal women, the effect of FM on BMD is more important than that of LM *(4,7−9)*. Opposite results have also been reported showing that LM, not FM, is more closely associated with BMD *(10−12)*. Still other studies have found that both LM and FM were significant predictors of BMD, with LM being a more important predictor than FM in premenopausal women, and FM more important than LM in postmenopausal women *(13−15)*. Moreover, Gnudi et al *(14)* found that the relationship between BMD and body composition is different between women with or without osteoporosis. In fact, in osteoporotic women LM and FM were significantly associated with BMD, whereas in women without osteoporosis only

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LM was significantly associated with BMD *(14)*. Similarly, Cui et al *(16)* observed that in postmenopausal women FM was positively associated with BMD at all sites, whereas both LM and FM contributed to hip BMD.

Nevertheless, several recent studies have reported that after adjusting for the mechanical loading effects of body weight, the positive correlation between FM and BMD was no longer present *(17,18)*. Although previous studies have shown that regional fat distribution may also influence BMD independently of total body fat *(19,20)*, the literature data regarding the impact of body FM distribution on BMD still remains controversial. However, several recent studies have suggested an inverse association between visceral adipose tissue and BMD *(18,21–23)*.

In particular, Zillikens et al *(22)* in a large population study showed an inverse relationship between BMD and android fat distribution measured by anthropometry and DXA. The negative effect of visceral fat on bone has been explained by the fact that aromatase activity and adiponectin secretion is lower from visceral fat, whereas inflammatory bone resorption cytokines prevail in visceral fat *(24)*. Other studies yielded opposite findings reporting a protective effect of abdominal fat on BMD and vertebral fracture risk *(25,26)*.

The lack of agreement in the literature regarding the relative contribution of the lean and fat components of body weight on BMD may be explained by the fact that in this field it is not possible to compare the results obtained in study populations, which differ in race, gender, menopausal status, vitamin D levels, nutrition, or physical behavior. Moreover, most of the previous studies addressing body composition have been carried out in women with oriental origin and data taken from South European populations are scarce.

The aim of our single-center cross-sectional study was to investigate the associations of body composition and fat distribution parameters with BMD in elderly Italian men and women. Then, we explored whether body composition, sex hormones, vitamin D, and other variables may be differently associated with BMD at different skeletal sites.

Subjects and Methods

Study Population

Subjects eligible for this single-center study were 1199 consecutive elderly men and women, aged 55 yr or older living in the area of Siena (Italy), who had been participating in a larger epidemiological study between July 2004 and January 2008.

This epidemiological study evaluated the presence of risk factors for metabolic bone diseases in the elderly population of Siena (60,000 inhabitants). Subjects for the epidemiological survey were recruited by general practitioners who, beginning from a specific date requested the first 50 consecutive ambulatory women in menopause for at least 2 yr and the first 25 consecutive men who were 55 yr of age or older, not previously treated with antiosteoporotic drugs and without evidence of cancer or any acute diseases, to participate in the study. The subjects who agreed to participate in the study were consecutively referred to the Center of Prevention, Diagnosis and Therapy of Metabolic Bone Diseases at the University of Siena (Italy). The subjects with hyperthyroidism, pituitary diseases, malabsorption because of gastrointestinal tract disorders, stroke, any history of fractures in the previous 12 mo, or significantly impaired renal or hepatic function were excluded. Other exclusion criteria were history of alcohol abuse and prolonged intake of drugs known to affect bone metabolism such as anticonvulsants, systemic glucocorticoids, gonadic hormones, anabolic steroids, teriparatide, parathyroid hormone (PTH), vitamin D analogs, strontium ranelate, or bisphosphonates. On this basis, 102 subjects were excluded; a further 40 women and 11 men were excluded because of mobility problems, severe obesity, or inadequate quality of DEXA parameters. Of the remainder, 866 postmenopausal women (mean age 64.2 ± 6.5 yr; age range 55–84 yr) and 168 men (mean age 65.1 ± 6.1 yr; age range 55–85 yr) agreed to participate in the study.

Written consent was obtained from all participants, and the study was approved by the Institutional Review Board of Siena University Hospital. For all subjects, a detailed medical history was obtained. The daily dietary calcium intake was assessed by a validated Food-Frequency Questionnaire including foods that account for most of the calcium in the Italian diet *(27)*. In addition, height and weight were measured in a standardized fashion. BMI was calculated as weight in kilograms divided by the square of height in meters. According to the WHO BMI categorization, the subjects were classified in 4 groups: underweight (BMI < 18.5 kg/m^2), normal weight (BMI ≥ 18.5 but < 25 kg/m^2), overweight (BMI ≥ 25 kg/m^2 but < 30 kg/m^2), and obese (BMI ≥ 30 kg/m^2) *(28)*. Physical activity was self-reported by the patients and recorded as the sum of work, home, and leisure activities for the last 12 mo, graded from 1, inactive, to 3 very active.

Methods

In all subjects, we measured BMD at the lumbar spine (LS-BMD), at femoral subregions (femoral neck [FN-BMD] and total hip [TH-BMD]), at the total body (WB-BMD), and at the right hand (Hand-BMD) using a DXA device (Lunar Prodigy; GE Healthcare, Waukesah, WI).

The analysis of the total hand was performed using the manual mode as described by Brownbill and Ilich *(29)*. Osteoporosis and osteopenia were diagnosed according to the World Health Organization (WHO) definition: a T-value lower than −2.5 was diagnosed as osteoporosis and a T-value between −1.0 but higher than −2.5 was diagnosed as low bone density. Sex-matched Italian reference data were used for the calculation of T-score. Body composition parameters (FM, LM, body fat percentage, gynoid fat percentage, and android fat percentage) were determined using the same DXA device (Lunar Prodigy) in conjunction with Encore 2002 software. The ''android'' and ''gynoid'' regions were defined using the software provided by the manufacture. The ''android region'' has a lower boundary at the pelvis cut and the upper boundary above the pelvis cut by 20% of the distance between the pelvis and the neck cuts. The lateral boundaries are the arm cuts. The ''gynoid region'' has an upper boundary