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Original article

The effects of sarcopenia and obesity on femur neck bone mineral density in elderly Korean men and women

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Abstract

Objectives: We aimed to clarify the relationship between fat, muscle, and bone in elderly men and women.
Methods: We analyzed 1373 men and 1803 women who were older than 65 years from the 2008–2010 Korea National Health and Nutritional Examination Surveys. Body composition and femur neck bone mineral density (BMD) were measured by dual-energy X-ray absorptiometry. Sarcopenia was defined as an appendicular skeletal muscle index (SMI) below one standard deviation (SD). Obesity was classified by fat mass index (FMI). Osteoporosis was defined as a BMD of 2.5 SD below that of femur neck BMD.
Results: SMI and FMI were positively correlated with femur neck BMD. In multiple regression analysis, SMI ($\beta = 0.302$ in men, $\beta = 0.154$ in women; $p < 0.001$ each) and FMI ($\beta = 0.079$ in men, $\beta = 0.179$ in women; $p = 0.003$ and $p < 0.001$ respectively) had a positive relationship with femur neck BMD. Men with sarcopenia were 3.89 times more likely to develop osteoporosis. Women with sarcopenia were 1.87 times more likely to develop osteoporosis. Sarcopenia was more clinically significant in the development of osteoporosis in men with a fat deficit and women with excess fat.
Conclusions: Muscle mass and fat mass were identified as determinants of femur neck BMD in men and women. Among them, muscle mass of men and fat mass of women are the most important determinants of femur neck osteoporosis.

Keywords: Obesity; Osteoporosis; Sarcopenia

1. Introduction

A two-component model of body composition is divided into a fat component and a fat-free component (lean body mass), which includes muscles, bones, and internal organs [1]. Advancing age in older adults is accompanied by body composition changes, which are characterized by the loss of lean body mass, especially bone and muscle [2].

Osteoporosis is a systemic skeletal disease, characterized by low bone mass and microarchitectural deterioration of bone tissue, with a consequential increase in bone fragility and susceptibility to fracture [3]. Sarcopenia is the loss of skeletal muscle mass and strength that occurs with advancing age [4]. Osteoporosis and sarcopenia are common diseases in older adults [5,6]. A common etiology may cause both osteoporosis and sarcopenia, and the two diseases may act together in the development of a disability [7]. Some studies reported that sarcopenia was significantly associated with both osteopenia and osteoporosis [8–12].

Extensive epidemiological data show that a higher body weight is associated with a higher bone mineral density (BMD) [13–15]. Body weight is a major determinant of BMD, and adipose tissue mass is regarded as a major contributor to this relationship [15,16]. Some studies suggest that higher levels of total body fat may be associated with a lower BMD in both men and women, after adjusting for

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similar body size [13,17,18]. However, in a recent review article, Reid [16] pointed out that those studies that incorporate weight with lean and fat mass in statistical models would mislead the results. They may not show a true representation of the physiological relationship between fat and bone because these statistical models are confounded by substantial colinearity between variables and yielding [16]. Several studies about regarding sarcopenia and osteoporosis incorporated weight with lean and fat mass in statistical models [9,12]. Therefore, the interrelationships between obesity, sarcopenia, and osteoporosis were not clear in clinical practice.

The aim of this study was to clarify the relationship between fat, muscle, and bone in elderly men and women. More specifically, we aimed to determine the association between sarcopenia and osteoporosis in terms of obesity in elderly Korean men and women using the Korea National Health and Nutrition Examination Survey (KNHANES), a nationally representative cross-sectional survey.

2. Material and methods

This study is based on data acquired from the KNHANES between 2008 and 2010. The KNHANES, initiated in 1998, was designed to assess the health and nutritional status of adults and children living in Korea. The Korea Center for Disease Control and Prevention administers this national representative survey. The KNHANES targets the civilian non-institutionalized Korean population and collects data from interviews, physical examinations, and medical tests every 3 years from approximately 30,000 people. The KNHANES (2008−2010) included dual-energy X-ray absorptiometry (DXA) measurements of the BMD of the spine and hip, and body composition. We analyzed the DXA data of 1373 men and 1803 women who were older than 65 years and had participated in the KNHANES from 2008 to 2010.

2.1. Measurements of bone mineral density and body composition

In the KNHANES, BMD and body composition were measured by DXA methods with a QDR Discovery (formerly the QDR 4500A) fan beam densitometer (Hologic, Inc., Bedford, MA) according to the manufacturer's recommended procedure. All subjects were asked to wear light clothing and to remove any clothing that might interfere with the DXA examination. The DXA results were reviewed and analyzed using industry-standard techniques at The Korean Society of Osteoporosis (Seoul, Republic of Korea). Analysis was performed using Hologic Discovery software (version 12.1) with the default configuration. The KNHANES dataset contains regional (lumbar and femur) DXA measurements of bone mineral content (BMC, g), BMD (g/cm^2), z-score, and t-score, as well as whole-body DXA measurements of bone mineral content (BMC, g), BMD (g/cm^2), fat mass (g), lean mass including BMC (g), and percentage fat (fat mass/total mass × 100), along with demographic information on each subject. Of the DXA data, we used femur BMD, and femur t-score. The derivative values were calculated as follows: fat mass index [FMI; fat mass (kg)/height^2 (cm^2)] and appendicular skeletal muscle mass (four limb fat-free soft tissue; four limb lean mass - four limb BMC; g), appendicular skeletal muscle mass/height^2 (skeletal mass index, SMI) from body composition data.

3. Sarcopenia, osteoporosis and obesity

Sarcopenia was defined as an SMI below one standard deviation (SD) from the sex-specific normal mean of the young reference group. The young reference group is defined as 20−39 year old men (n = 1800) and women (n = 2009). We excluded 1361 of 5170 participants because they had cancer, or liver, kidney, pulmonary, or metabolic disease [19]. The characteristics of the young reference group are shown in Supplement Table 1. The mean SMI was 7.90 ± 0.88 kg/m^2 in men and 5.74 ± 0.74 kg/m^2 in women. Sarcopenia is defined as <7.02 kg/m^2 in men and <5.00 kg/m^2 in women. Osteoporosis is defined as a BMD of 2.5 SD below the peak bone mass of a young, healthy, sex- and race-matched reference population, according to the World Health Organization (WHO) diagnostic classification [3]. In this study, the diagnosis of osteoporosis was established by a measurement of BMD by DXA of the proximal femur neck region. The World Health Organization (WHO) defined overweight and obesity as abnormal or excessive fat accumulation [20]. In this study, overweight and obesity were classified by fat mass index (fat mass/height^2, FMI), which matched classification thresholds of Body Mass Index (BMI) in young adults [21,22].

3.1. Osteoporosis or sarcopenia related factors

In the KNHANES, blood was collected after an 8-h fast. Blood samples were immediately processed, refrigerated, and transported in cold storage to the central testing institute (NeoDin Medical Institute, Seoul, South Korea), where they were analyzed within 24 h. Serum 25(OH) vitamin D concentration was measured with a radioimmunoassay kit (DiaSorin Inc., Stillwater, MN, USA) using a γ-counter (1470Wizard; PerkinElmer, Turku, Finland).

Trained interviewers collected data on demographic factors, health behaviors, and dietary intakes of the participants via personal interviews. Exercise was defined based on how many days per week the participants exercised for more than 30 min with moderate intensity (professional and athletic activities, such as swimming, doubles tennis, volleyball, badminton, and table tennis).

Dietary intake data were obtained by a dietary recall survey asking participants what food and what quantity of food had been consumed during the last 24 h. Consumed nutrients and electrolytes were assessed by the food composition table, which was created and validated by the Rural Development Administration. Dietary variables used in this study included total energy (kcal/day), carbohydrate (% energy), total fat (% energy), protein (% energy), calcium (mg/1000 kcal), and phosphate (mg/1000 kcal) intakes.