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Original Article

Impact of Age, Gender, and Body Composition on Bone Quality in an Adult Population From the Middle Areas of China

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Abstract

Identifying modifiable factors that influence bone status during adulthood to maximize bone quality is a potential primary strategy in the prevention of osteoporosis in later life. We investigated the impact of body height, body weight, body mass index, and body composition on calcaneal bone characteristics as measured with quantitative ultrasound in 441 Chinese adults (238 women) aged 20–55 yr from the middle areas of China. Body composition, including fat-free mass (FFM), muscle mass, and fat mass were obtained by bioelectrical impedance analysis. Bivariate correlation analysis demonstrated a significant negative correlation between age and broadband ultrasound attenuation (BUA), speed of sound (SOS), and stiffness index (SI) both in men ($r = –0.177$, $p < 0.05$; $r = –0.499$, $p < 0.001$; $r = –0.530$, $p < 0.001$, respectively) and women ($r = –0.344$, $p < 0.001$; $r = –0.336$, $p < 0.001$; $r = –0.369$, $p < 0.001$, respectively). Body height, body weight, FFM, and muscle mass had positive correlations with BUA, SOS, and SI in both genders, with FFM having the strongest correlation with BUA, SOS, and SI in men ($r = 0.351$, $p < 0.001$; $r = 0.391$, $p < 0.001$; $r = 0.406$, $p < 0.001$, respectively) and women ($r = 0.331$, $p < 0.001$; $r = 0.288$, $p < 0.001$; $r = 0.324$, $p < 0.001$, respectively). Fat mass had a positive correlation with BUA ($r = 0.331$, $p < 0.001$), SOS ($r = 0.288$, $p < 0.001$), and SI ($r = 0.324$, $p < 0.001$) in women, which was not found in men. Multivariate regression analysis revealed that, in both genders, FFM was a positive predictor for all 3 quantitative ultrasound variables.

Key Words: Age; body composition; fat-free mass; osteoporosis; quantitative ultrasound.

Introduction

Osteoporosis is a classical age-related and gender-specific disease *(1)*. Prevention of osteoporosis has now been recognized as an important aspect in research and health promotion *(2)*. Quantitative ultrasound (QUS) measurement has become an important modality for the assessment of osteoporosis status and the estimate of osteoporotic fracture risk *(3,4)*. The general consensus is that QUS seems to provide structural information in addition to density *(5,6)*. Earlier studies have shown that it could predict fracture as effectively as the bone mineral density (BMD) as measured with dual energy X-ray absorptiometry (DXA) does in both men and women *(7)*.

Body composition is an important determinant of bone status *(8)*. As we know, body composition consists primarily of 2 components, fat-free mass (FFM) and fat mass (FM), and muscle mass (MM) is the most important component of FFM. A variety of previous studies have examined the associations between measures of body composition and bone quality. A higher body weight (BW) leads to greater mechanical load on bone that results in better bone quality *(9)*, and a positive relationship between FFM and BMD has been reported *(10)*. However, the relative effect of FM on bone quality is still controversial. A substantial body of evidence indicates that FM may have beneficial effects on bone *(11)*. Contrasting studies, however, suggest that

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excessive FM may have detrimental effects on bone quality *(12)*. Some researchers reported that greater FM imposed a greater mechanical stress on bone and would be beneficial for bone health *(13)*. In addition, both adipocytes and osteoblasts are derived from a common multipotential mesenchymal stem cell, and the secretion of adipocyte-derived hormones may affect the activation of osteoblasts and osteoclasts *(12)*. The relationships between body composition and QUS parameters would provide useful information for further understanding of bone characteristics *(14)*.

Bone quality in later life depends largely on the peak bone quality achieved in young adulthood, and the subsequent age- and hormone-related bone loss. There is no large literature analyzing the relationships between body composition and QUS parameters in a young adult population separately by gender. Within a cohort of young men and women, the aim of our study was (1) to investigate the impact of age, gender, and body composition on bone quality in a young adult population from the middle areas of China, and (2) to help for screening of subjects at higher risk of fractures, who may need further investigations or targeted interventions, by recognizing the anthropometric parameters more associated with an increased risk of fractures.

Subjects and Methods

Subjects

A sample of 937 individuals, aged 20–55 yr, who were randomly selected from Anhui, Hunan, and Hubei province in the middle areas of China, were initially selected to participate in this study carried out in Anhui National Physical Fitness Monitoring Center in Hefei of Anhui province, China, from February 2015 to May 2015.

All subjects answered a questionnaire regarding lifestyle, medical history, current medication, with menopausal status investigated in women. Individuals with history of fractures in the previous 24 mo or significantly impaired renal or hepatic function, type 1 diabetes, chronic kidney disease, sustained periods of immobilization, amenorrhea (>6 mo), use of cortisone (>6 mo), and hormone replacement therapy (>12 mo) were excluded.

Finally, 441 individuals (238 women) with eligible participants remained for further study from June 2015 to December 2015. The study was approved by appropriate institutional research ethics committee.

Measurements of Anthropometric Characteristics

Body height (BH) was measured to the nearest 0.1 cm using a stadiometer (GMCS-I, XinDongHuaTeng Corp., Beijing, China). Body composition was measured by bioelectrical impedance analyzer (BX-BCA-100, Broshare Technology Corp., Hefei, China); the Reg. No. of BX-BCA-100 in the China Food and Drug Administration is 2210038. In addition to abstinence from diuretics, alcohol, intense exercise, and fluids as detailed earlier, subjects emptied their bladder 30 min before the bioelectric impedance analyses (BIAs) measurement was taken. Subjects stood on bare feet with the heel and toe of each foot in contact with the metal footpads, with arms hanging on each side, lightly holding the analyzer handgrips. Coefficient of variance of the impedance measure was 0.4%. FM, FFM, and MM were estimated by BX-BCA-100, using the equation from Roubenoff et al *(15,16)*. Values obtained from BIA were supported by skinfold measurements using harpenden calipers.

Measurements of Bone Quality

Calcaneal ultrasound measurements were performed using a through-transmission device (BX-BDI-500A, Broshare Technology Corp.), equipped with a couple of broadband transducers (U500, Lanhui ultrasonic device, Wuxi, China) operating at 0.5 MHz. The sampling of frequency of the device was set to 20.0 MHz; the Reg. No. of BX-BDI-500A in the China Food and Drug Administration is 20152230048. Speed of sound (SOS; m/s) and broadband ultrasound attenuation (BUA; dB/MHz) were measured in the right calcaneus with the subject in an upright seated position. The stiffness index (SI), a combination of SOS and BUA, was calculated by the system according to the following formula: $SI = 0.67 \times BUA + 0.28 \times SOS–420$ *(17)*. The measurement took 5 min for each subject. The precision of the QUS measurements was determined using 20 measurements of each of 10 subjects aged between 20 and 55 yr. The mean values for SOS, BUA, and SI varied between 1489 and 1623 m/s, 42 and 133 dB/MHz, and 62 and 130, respectively, and the respective standard deviations were between 4 and 11 m/s, 1 and 5 dB/MHz, and 1 and 4. The calculated coefficients of variation were 0.4%, 2.0%, and 2.5% for SOS, BUA, and SI, respectively.

Statistical Analysis

All statistical analyses were conducted using SPSS for Windows, Version 22.0 (IBM Corp., Armonk, NY). Age, anthropometric characteristics and QUS parameters were expressed as mean ± standard deviation. The level of statistical significance was set at a p value less than 0.05. Student's t test was used for comparison of means and quantitative data, respectively. Variables of BH, BW, body mass index (BMI), FFM, MM, and FM on each of the QUS parameters as dependent variables were determined separately. Bivariate correlation analysis and multiple linear regression analysis were used to further investigate and quantify the relations between BH, BW, BMI, FFM, MM, FM, and QUS parameters.

Results

Table 1 shows the characteristics of subjects, which were divided into 2 gender groups: adult men (20–55 yr) and premenopausal women (20–55 yr). The mean ages of men and women were 36 ± 11.5 yr and 34 ± 9.9 yr, respectively. The BH, BW, BMI, FFM, and MM were significantly higher in