Original Article

Ethnic and Gender Differences in Bone Mineral Density and Bone Turnover in Young Adults: Effect of Bone Size

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Abstract. Generally, the incidence of osteoporotic fracture is lower in black populations and in men. These effects of ethnicity and gender may result from differences in peak bone mineral density (PBMD) and bone turnover (BT), which in turn are affected by bone size. Therefore, the aims of this study were to examine the effects of ethnicity and gender on bone mineral density (BMD) and BT in young African-Caribbean and Caucasian adults, and to adjust for the effect of bone size on BMD and BT. BMD was measured at the lumbar spine, L2–L4 (LS), total body (TB) and femoral neck (FN) by dual-energy X-ray absorptiometry in 44 blacks (16 men, 28 women) and 59 whites (28 men, 31 women) ages 20–37 years. We measured serum bone-specific alkaline phosphatase (BAP) and serum osteocalcin (OC) as markers of bone formation and urinary immuno-reactive free deoxypyridinoline (iDPd) and crosslinked N-telopeptide of type I collagen (NTx) as markers of bone resorption. To adjust the data for any differences in bone size, we calculated: (a) bone mineral apparent density (BMAD), an estimated volumetric bone density which attempts to normalize BMD measurements for bone size; and (b) bone resorption markers as a ratio to total body bone mineral content (TB BMC). Two-way analysis of variance was used to compare the effects of race and gender, and to test for any interaction between these two factors. Blacks had higher BMAD compared with whites at the TB (p < 0.001), LS (p = 0.0001) and FN (p = 0.0005). This increase remained significant at the LS only after calculating BMAD. Men had higher BMAD at all sites (except at the LS). This increase was no longer significant at the FN after calculating BMAD, and LS BMAD was actually greater in women (p < 0.0001). Blacks and whites had similar concentrations of turnover markers, but men had higher bone turnover markers than women (BAP, p < 0.0001; OC, p = 0.002; iDPd, p = 0.03; NTx, p < 0.0001). This increase in bone resorption markers was no longer significant after adjusting for TB BMC (except for NTx in whites). We conclude that the skeletal advantage in blacks during young adulthood is not explained by bone size. However, it seems probable that bone size effects partially explain gender differences in BMD and bone turnover.

Keywords: Bone density; Bone remodeling; Ethnic groups; Sex

Introduction

The risk of osteoporotic fracture in later life is related to gender and ethnicity. The incidence rates of fractures are usually lower in black populations and in men. The lower prevalence of osteoporosis in black populations is partly explained by the higher peak bone mineral density (PBMD) in both black men and women reported in most studies [1–5]. This higher PBMD does not appear to be the same for South-African blacks, in whom bone mineral density (BMD) has been reported to be similar to that in whites or slightly lower [6]. The gender difference in PBMD in blacks and whites has not been well characterized. For example, BMD in young adult twin pairs did not differ by gender except at the radius, where men had a higher BMD than their female twin [7]. However, other work has shown men to have higher BMD at all sites measured [8,9]. Interestingly, it has...
been found that lumbar spine BMD in young premenopausal women tends to be higher compared with that in men [7,8], which contradicts the assumption that men have a higher BMD than women throughout adulthood.

Biochemical markers of bone turnover have been studied in an attempt to understand the etiology of these ethnic and gender differences in BMD during young adulthood. Biochemical markers of bone formation (measured by osteocalcin and bone alkaline phosphatase in serum) may be either lower in blacks [5,10–11] or not different [10,11]. Biochemical markers of bone resorption (measured by urinary deoxypyridinoline, crosslinked N-telopeptides of type I collagen and hydroxyproline) are not different between blacks and whites [5,10,12]. Studies of gender differences in biochemical markers have reported inconsistent findings in whites with higher bone formation markers in men [13–15] and in women [16]. There have been few studies on the effect of gender on markers of bone resorption.

Previous studies have compared calcitropic hormones in Caucasian and African-Caribbean groups in an attempt to examine skeletal metabolism further and to understand the skeletal advantage achieved in black populations. Compared with whites, studies have reported lower 25-hydroxyvitamin D, higher 1,25-dihydroxyvitamin D and higher parathyroid hormone [5,17,18] in blacks. The lower 25-hydroxyvitamin D leads to mild secondary hyperparathyroidism but BMD tends to remain higher in blacks [18]. The reason for this is not fully understood.

When comparing ethnic and gender differences in BMD and bone turnover it is important to consider the effects of body and bone size, because areal BMD is dependent on bone size [19–21]. Skeletal size may also have an effect on bone turnover. Failure to normalize BMD and bone resorption markers for bone size could lead to misinterpretation of results because blacks tend to have a greater skeletal size than whites [5], and men have a greater skeletal size than women [7,8]. BMD as measured by dual-energy X-ray absorptiometry (DXA) is a planar measurement providing information about bone width and height but not bone depth. Therefore BMD is still influenced by bone size. Consequently, various methods have been proposed for normalizing BMD measurements for skeletal size so that BMD becomes a better reflection of true bone density [20,21]. One approach is to correct BMC for a calculated bone volume, resulting in an estimated volumetric bone density (bone mineral apparent density, BMAD) [20,22]. Most studies examining race and gender differences in BMD tend to correct for body size by the use of body mass index (BMI), but this does not consider skeletal size [1–4,7,9]. Quantitative computed tomography (QCT) is the only method which allows a true measurement of volumetric bone density. Thus, the aims of the study were to examine the effects of ethnicity and gender on BMD and bone turnover in young African-Caribbean and Caucasian adults and to adjust BMD and biochemical markers for skeletal size in these groups.

Materials and Methods

Subjects

One hundred and three healthy subjects (44 African-Caribbean and 59 Caucasian) aged 20–37 years were recruited by radio advertisements, word of mouth and posters in the local universities, hospitals, churches and community centers. Recruitment took place between April 1995 and January 1997, and all subjects were measured once. No subjects had any history of bone disease or were taking any drugs known to affect bone metabolism or calcium homeostasis. Volunteers were excluded if they had any past use of steroids, diuretics, heparin, chemotherapy or anticonvulsants. Black and white race was determined by self-declaration and all black subjects were born in the UK with both parents of African-Caribbean descent. Height was measured using a wall-mounted stadiometer (Holtain, Crymych, Dyfed, Wales) to the nearest 0.1 cm. Weight was measured with a set of upright balance scales (Seca, Hallamshire Scales, Sheffield, UK) to the nearest 0.1 kg.

The study was carried out with the approval of the North Sheffield Local Research Ethics Committee. All subjects gave written informed consent.

Dual-Energy X-ray Absorptiometry

Measurements of total body, anteroposterior lumbar spine (L2–L4) and proximal femur (femoral neck) were made in each subject by DXA using a Lunar DPX densitometer (Lunar Radiation, Madison, WI). An aluminum spine phantom was scanned daily to test the longitudinal stability of the machine. The coefficient of variation at the total body lumbar spine and femoral neck was 1% and 3%, respectively.

Biochemical Measurements

Fasting blood samples were taken between 0800 and 1000 hours, and 24 h urine collections were obtained. Three subjects (2 men, 1 woman) failed to complete a 24 h urine collection. We measured serum bone-specific alkaline phosphatase (BAP) and serum osteocalcin (OC) as markers of bone formation. Urinary immunoreactive free deoxypyridinoline (iDPd) and crosslinked N-telopeptides of type I collagen (NTx) were measured as markers of bone resorption. Serum 25-hydroxyvitamin D concentrations were measured as a marker of overall vitamin D status. The intra-assay coefficient of variation (CV) for each analyte was calculated using duplicate measurements. All samples were stored at –80 °C until measured in a single analytical batch.