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Forearm bone geometry and mineral content in UK women of European and South-Asian origin

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Abstract

Ethnic variation in areal bone mineral density (BMD) has been well documented. Such variation may, however, reflects differences in bone geometry rather than volumetric BMD (vBMD). The aim of the study was to compare bone geometry, mineral content (BMC) and vBMD in two ethnic groups, and study the influence of body size, physical activity, reproductive variables, 25 hydroxy-vitamin D (25(OH)D) and parathormone (PTH) status on any observed differences.

The data were from a population-based, cross-sectional survey of peak bone mass in South Asian and European women, the population consisted 230 pre-menopausal South Asian ($n=118$, mean age 28.6±4.6 years) and European ($n=112$, mean age 30±4.3 years) women of UK origin. Women who participated completed an interviewer assisted questionnaire, had blood taken for assessment of 25(OH)D and PTH and had measurements of their distal (4%) and diaphyseal (50%) radius geometry, BMC and vBMD using peripheral quantitative computed tomography.

At the 50% radius, South Asians had lower vBMD ($p<0.001$), BMC ($p<0.001$), cortical area ($p<0.001$), cortical thickness ($p<0.001$), cross-sectional area ($p=0.04$) and increased medullary area ($p<0.04$). Cross-sectional muscle area and stress strain index, however, were not different. Adjustment for age, height and weight attenuated, the difference in cross-section area but did not account for any of the other observed differences. Further adjustment for reproductive variables a physical activity index, 25(OH)D and PTH, attenuated ethnic differences in cortical BMC, area and thickness which became non-significant; however, ethnic differences in cortical vBMD and medullary area persisted. At the 4% site, after adjusting for age, height and weight, there was no difference in total area, total or trabecular vBMD between ethnic groups. After further adjustment for physical activity, reproductive variables, 25(OH)D and PTH, trabecular vBMD was higher in the South Asians.

In conclusion, there are differences in bone geometry, BMC and vBMD at the radial diaphysis between UK South Asians and Europeans which are not explained by differences in body size. Polar stress-strain index was similar, however, suggesting no important differences in bone strength.

Keywords: Ethnicity; 25(OH)D; Bone geometry; Peripheral quantitative computed tomography; Volumetric bone mineral density; Vitamin D

Introduction

Differences in bone mineral density (BMD) between Europeans and South Asians of UK origin have been described, with most reports suggesting that South Asians have lower areal BMD (aBMD) than Europeans [1–7]. However, evidence is often conflicting, and the lower aBMD may be due to smaller body size rather than differences in volumetric BMD (vBMD) [6,8–10]. In the spine, dual energy X-ray absorptiometry (DXA) measured bone mineral apparent density (BMAD), a surrogate for vBMD, has been reported to be the same in both groups [3,11]. Recent data show a greater femoral neck and radial BMAD in South Asians compared to Europeans [1,3]. Therefore, current evidence suggests that bone size and not just vBMD, may contribute to reported differences in aBMD between ethnic groups. Bone geometry is a vital component

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of bone strength, yet there are few studies which have looked at ethnic variation in bone geometry, particularly in South Asian groups.

The aim of this study was to investigate ethnic differences in bone mineral content (BMC), vBMD and bone geometry at the distal and diaphyseal radius, using peripheral quantitative computed tomography (pQCT), in UK pre-menopausal women of European and South Asian descent. We looked also at whether any observed differences could be explained by body size, physical activity, reproductive variables, 25 hydroxy-vitamin D (25(OH)D) and parathormone (PTH) status.

Methods

Participants

The study was a population-based, cross-sectional survey comparing peak bone mass between young women from two ethnic groups; European and South Asian [11]. The South Asian women were resident in Greater Manchester, UK and were either of Pakistani Muslim or Gujarati Hindu descent. Specialized, validated computer software was used to select surnames from primary care registers which conformed to Pakistani Muslim or Gujarati Hindu origin [12]. Participants were aged between 18 and 36 years, premenopausal and were recruited from primary care registers between 2001 and 2003. Recruitment was based in areas which had a high proportion of the two South Asian groups residing within them; these areas were identified from census data. White-Caucasian Europeans were recruited from the same primary care registers as South Asians. Subjects who agreed to participate were invited to attend for an interviewer assisted questionnaire, bone density scan and blood test. Ethnicity was validated when participants attended for bone densitometry scans. Age and ethnicity were the only inclusion criteria for this study. The study received ethical approval from North West Multi-Centre Research Ethics Committee. Written informed consent was obtained from all participants. All outcomes were measured at a single research visit.

Anthropometric measurements

Standing height (m) was measured, to the nearest mm, using a portable stadiometer. Weight (kg) was measured to the nearest 100 g using electronic scales. Body mass index was calculated weight/height^2 (kg/m^2).

Questionnaire

Subjects completed an interviewer assisted questionnaire which included information about female reproductive history including age at menarche, use of the oral contraceptive pill (OCP), whether or not they had been pregnant and if so whether they had breast fed. Habitual physical activity was quantified using a short questionnaire which had been validated in a group of young European men and women [13]. The questionnaire sought information about current habitual levels of activity with no specified time period of recall. Outcome measures were physical activity at work (work index), sport during leisure time (sport index) and physical activity during leisure time excluding sport (leisure index).

25(OH)D, PTH and calcium assessment

Non-fasting blood samples were taken at the same time as bone densitometry measurements to determine total 25(OH)D, PTH and serum calcium levels. Serum 25(OH)D (total of 25 OHD_2 and 25 OHD_3) was measured by high pressure liquid chromatography (Rathburn Chemical Company, Walkerburn, Scotland). Serum calcium was analysed using colorimetric technique (Hitachi UK, Lewes, Sussex) and corrected for changes in serum albumin. Intact PTH was measured using immunoradiometric assay (Nichols Institute, San Juan, California). Normal ranges were defined as: 10–60 pg/ml for PTH, 15–40 ng/ml, total 25(OH)D and calcium 2.15 to 2.65 mmol/l.

Peripheral quantitative computed tomography (pQCT)

Peripheral QCT measurements were made in the radius using a Stratec XCT-2000 scanner (Stratec, Pforzheim, Germany), software version 5.50d. All measurements were made in the non-dominant forearm. Measurements were taken at 4% and 50% of the forearm length (measured with tape measure), proximal to the distal radial joint surface. Total and trabecular vBMD (mg/mm^3) and bone cross sectional area (CSA) (mm^2) were determined at the radius 4% (distal) site. At the 50% (diaphyseal) radius cross-sectional area (mm^2), cortical area (mm^2), cortical vBMD (mg/mm^3), BMC (mg/mm), cortical thickness (mm) and polar stress strain index (SSI—a measure of the bones torsional strength (mm^3) [14,15]) were measured. Medullary area was calculated by subtracting cortical area from bone cross-sectional area for the 50% site. The scans were analysed using contour mode 2 (45%), peel mode 1 (4% site) and separation mode 1, threshold=710 mg/cm^3 (cortical vBMD and geometry), SSI=680 mg/cm^3 for 50% site. Cross-sectional muscle area was measured using contour mode 3, peel mode 1, threshold 40 mg/cm^3 and filter F03F05. Contour mode determines the outer edges of the bone; peel mode is the method of separating cortical and sub-cortical bone from trabecular bone and separation mode analyses cortical bone. The short term precision of repeat measurements in adults (n=22, 2 repeat measurements) in our department is: radius BMD—trabecular 1.27%, total 2.1%, cortical 0.77%, cortical area 2.4%, muscle area 3.7%.

Data analysis

Independent samples t-tests were used to test for differences in subject characteristics, BMC, vBMD and geometric parameters between the Europeans and South Asians. Linear regression was used to look at ethnic differences in vBMD, BMC and geometric parameters after adjusting for age, height and weight, and subsequently after further adjustment for reproductive variables, physical activity, total 25(OH)D and PTH. Variables included in the final model were those which differed between the ethnic groups ($p<0.1$) and which were associated with at least one of the bone outcome variables; these variables were leisure index, age at menarche (years), OCP use (yes/no) and breast feeding (yes/no), 25(OH)D and PTH. Sports and leisure activity were both associated with one or more outcomes though leisure activity was more consistently associated and was therefore included in the model. The results of these analyses are expressed as beta-coefficients and 95% confidence intervals. Data were analysed using SPSS 11.5 for Windows (SPSS Inc. Chicago).

Results

Subject characteristics

Two hundred and thirty participants were included in the analyses, 112 European and 118 South Asian females. There were no differences in any of the bone parameters between the 2 South Asian groups and their data were combined for the analysis. Overall the South Asians were significantly younger, shorter and lighter than the Europeans; body mass index was not different, see Table 1. They were less likely to participate in sports and leisure activity, use the OCP and have a later age at menarche, though were more likely to have breast fed. They had significantly lower total 25(OH)D and higher PTH in comparison to Europeans; serum calcium was not different between groups.

Bone mass and geometry

The mean values for the vBMD, BMC and bone geometric parameters for the South Asians and Europeans are shown in Table 2. At the 50% radius, the South Asians had lower cortical