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Ethnic differences in bone geometry between White, Black and South Asian men in the UK☆

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ABSTRACT

Relatively little is known about the bone health of ethnic groups within the UK and data are largely restricted to women. The aim of this study was to investigate ethnic differences in areal bone mineral density (aBMD), volumetric bone mineral density (vBMD), bone geometry and strength in UK men.

White European, Black Afro-Caribbean and South Asian men aged over 40 years were recruited from Greater Manchester, UK. aBMD at the spine, hip, femoral neck and whole body were measured by DXA. Bone geometry, strength and vBMD were measured at the radius and tibia using pQCT at the metaphysis (4%) and diaphysis (50% radius; 38% tibia) sites. Adjustments were made for age, weight and height.

Black men had higher aBMD at the whole body, total hip and femoral neck compared to White and South Asian men independent of body size adjustments, with no differences between the latter two groups. White men had longer hip axis lengths than both Black and South Asian men. There were fewer differences in vBMD but White men had significantly lower cortical vBMD at the tibial diaphysis than Black and South Asian men ($p < 0.001$). At the tibia and radius diaphysis, Black men had larger bones with thicker cortices and greater bending strength than the other groups. There were fewer differences between White and South Asian men. At the metaphysis, South Asian men had smaller bones ($p = 0.02$) and lower trabecular vBMD at the tibia ($p = 0.003$). At the diaphysis, after size-correction, South Asian men had similar sized bones but thinner cortices than White men; measures of strength were not broadly reduced in the South Asian men.

Combining pQCT and DXA measurements has given insight into differences in bone phenotype in men from different ethnic backgrounds. Understanding such differences is important in understanding the aetiology of male osteoporosis.

1. Introduction

Osteoporosis is an important health problem through its association with age-related fractures and consequent morbidity and mortality. There are important differences in the occurrence of age related fractures between different regions and populations, which are likely due to variation in bone strength and, or trauma – particularly fall risk. Within the UK there is good evidence about bone health among people of White European background, however, relatively little is known about the underlying bone health in the 10% of people with a non-White European background. Recent results from the UK Clinical Practice Research Datalink report the incidence of hip fracture in White men to be 2.7 times greater than in Black men, and approximately double that of South Asian men [1]. However, there are few data concerning bone mass and strength, and the underlying determinants of fracture risk in UK ethnic minority groups, with no data in men.

One of the first studies in the UK addressing ethnic differences in bone health compared areal BMD (aBMD) in women who were White European, Black Afro-Caribbean and South Asian aged 50–55 years using dual energy X-ray absorptiometry (DXA) [2]. This study showed

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that lumbar spine and femoral neck aBMD were higher in Black Afro-Caribbean compared to White European women. Conversely South Asian women were reported to have a lower lumbar spine and femoral neck aBMD compared to White European women, however, after correcting for skeletal size the differences at the lumbar spine were attenuated [2]. Similarly, another study showed that in women aged 24–35 years, South Asian women had lower aBMD compared to White European women, however, after adjustments for body or bone size the difference between the groups were attenuated [3]. These studies illustrate the limitations of DXA when describing population differences [4,5] where body size and habitus differ. Using peripheral quantitative computed tomography (pQCT) has advantages because it measures volumetric BMD (vBMD), cortical and trabecular compartments separately and provides information also about other structural parameters which contribute to bone strength. There are limited data comparing pQCT measurements in different ethnic groups. In the same study reporting no differences in women in size-corrected DXA measurements, the pQCT results showed that South Asian women had lower cortical vBMD, bone mineral content (BMC) and thinner cortices at the radial diaphysis compared to White European women [6]. Despite lower BMC in the South Asian women, bone strength as estimated using the stress strain index (SSI) was similar. Thus, it is possible that bones of pre-menopausal South Asian women may be efficiently adapted to a lower BMC as a result of a different distribution of bone mineral within the periosteal envelope, thereby preserving bone strength [4,6]. Whether these findings are similar in men remains unknown.

The aim of this study was to investigate ethnic differences in aBMD of the spine, hip and whole body and in vBMD, bone geometry and estimates of bending and torsional bone strength (cross-sectional moment of inertia (CSMI) and stress strain index (SSI)) [7–9] at the metaphyseal and diaphyseal radius and tibia, using DXA and pQCT in White European, Black Afro-Caribbean and South Asian men living in the UK. We investigated also whether any observed differences could be explained by body weight and height.

2. Methods

2.1. Participants

Community-dwelling White European men aged 40 years and over were recruited from primary care registers in Manchester (UK) for participation in the European Male Aging Study (EMAS) [10]. Stratified random sampling (by 10 year age band: 40–49 years, 50–59 years, 60–69 years and 70–79 years) was used and subjects were invited by letter of invitation to attend a local clinic for assessment including pQCT and DXA measurements and assessment of height and weight. The men subsequently attended a follow-up assessment of identical measurements a median of 4.3 years later. The results reported here are from the follow-up assessment. During the EMAS follow-up assessment, men aged 40 years and over who were Black and of Afro-Caribbean descent and South Asian men who were of Pakistani, Bangladeshi or Indian descent were invited to attend for the same suite of assessments. Ethnicity was defined by participants' self-report with 3 of 4 grandparents being of identical ethnic origin. Recruitment for these ethnic groups was through a combination of approaches including advertising in community centers and through local media targeted at the relevant ethnic groups. At their clinic visit, participants completed an interviewer-assisted questionnaire which included questions to determine their Physical Activity in the Elderly (PASE) score [11]. Smoking status was assessed by asking whether participants had ever smoked at least 100 cigarettes or been a regular pipe or cigar smoker. Those answering yes to any of the questions were considered as ever smokers. Ethical approval for the study was obtained in accordance with the local ethics review board in Manchester. All participants provided written informed consent.

2.2. Anthropometry

Height was measured to the nearest 1 mm using a stadiometer (Leicester Height Measure, SECA UK Ltd) and body weight was measured to the nearest 0.1 kg using an electronic scale (SECA UK Ltd). Body mass index (BMI) was calculated as weight in kilograms (kg) divided by the square of height (m).

2.3. Dual-energy X-ray absorptiometry

Participants had dual-energy X-ray absorptiometry (DXA) scans performed on QDR 4500A Discovery scanner, software version Apex 4.1 (Hologic Inc., Bedford, MA, USA). Measurements of aBMD at the whole body, total hip, femoral neck and lumbar spine (L1–4) were obtained; the non-dominant proximal femur was scanned. Hip axis length (HAL), whole body fat mass and lean mass were also measured. All scans were reported by an experienced musculoskeletal radiologist (JEA). Standard manufacturer QA and QC procedures were followed using manufacturer (Hologic) provided phantoms. The short term precision (co-efficient of variation (CV%)) in our center for repeat lumbar spine and proximal femur scans in adults ($n = 22$) was 1.1% and 1.3% respectively.

2.4. pQCT

Peripheral QCT (pQCT) measurements were made at the radius and tibia using a Stratec XCT-2000 scanner, software version 6.20 (Stratec, Pforzheim, Germany). All measurements were made in the non-dominant limb. Measurements were taken at 4%, 50% (radius) and 4%, 38%, (tibia) of the limb length which were measured using a wooden ruler (forearm) and segmometer (tibia). Forearm length was defined as the distance from the styloid process of the ulna to the olecranon. Leg length was defined as the distance from the most proximal edge of the medial malleolus to the intercondylar eminence. The scan sites were determined using a planar scout view of the distal radius or tibia and the reference line was placed to bisect the lateral border of the endplate. Total and trabecular vBMD (mg/mm^3) and bone cross sectional area (CSA) (mm^2) were measured at the 4% site (metaphysis). At the 50% radius and 38% tibia (diaphysis): CSA (mm^2), cortical area (mm^2), cortical vBMD (mg/mm^3) were measured and cortical thickness (mm), CSMI (mm^4) and SSI (mm^3) were derived using the standard manufacturer protocol. Medullary area (mm^2), was calculated by total area minus cortical area. CSMI and SSI are measures of bending and torsional strength at the diaphysis and have been related to fracture load [8,9]. The software uses three image processing ‘modes’: contour mode determines the outer edges of the bone; peel mode is the method of separating cortical and sub-cortical bone from trabecular bone at metaphyseal sites and separation mode analyzes cortical bone at the diaphyseal sites. All scans were analyzed using contour mode 2 (manufacturer defined automated threshold of 169 mg/cm^3), peel mode 1 which peels off the outer area of 55% of bone to leave the inner 45% area region of interest containing trabecular bone and marrow only. At the diaphysis, separation mode 1; threshold = 710 mg/cm^3 was used for cortical vBMD and geometry and threshold = 480 mg/cm^3 for SSI. All scans were reported by an experienced musculoskeletal radiologist (JEA). Where significant motion artefact was detected, scans were excluded. The short term precision of two repeat radius measurements with repositioning in adults were ($n = 22$): trabecular BMD 1.27%, 1.42%; cortical BMD 0.77%, 0.71%; cortical area 2.4%, 1.3%. Manufacturer's standard QA and QC procedures were followed using manufacturer supplied phantoms.

2.5. Statistical analysis

Descriptive statistics are presented as mean ± standard deviation (SD). Differences in descriptive characteristics were assessed using