Q J Med 2004; **97**:95–99
doi:10.1093/qjmed/hch017

Bone mineral status in immigrant Indo-Asian women

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Received 14 October 2003 and in revised form 1 December 2003

Summary

Background: Indo-Asian immigrants are known to be at high risk of metabolic bone disease, but the prevalence of osteoporosis in this population is unknown.
Aim: To compare the bone mineral at the lumbar spine and femoral neck of Indo-Asian immigrant women with that of age-matched Caucasian women.
Design: Retrospective analysis.
Methods: Women of Indo-Asian origin referred for bone density scans in the last five years were identified. The skeletal status of each was compared with an age-matched Caucasian control for bone mineral content (BMC), bone mineral density (BMD) and bone mineral apparent density (BMAD) at the lumbar spine and femoral neck, and hip axis length was measured.
Results: At the lumbar spine, Indo-Asians had a significantly lower BMD than Caucasians (0.834 vs. 0.913, $p=0.008$), but there was no significant difference when BMAD values were calculated (0.123 vs. 0.122). At the femoral neck, there was no difference in BMD (0.728 vs. 0.712, $p=0.5$), and BMAD values were significantly higher among Indo-Asians than Caucasians (0.393 vs. 0.319, $p=0.022$). Hip axis length was significantly shorter among Indo-Asian women (10.3 vs. 10.7, $p=0.009$).
Discussion: Although Indo-Asian women appear to have lower spinal BMD than Caucasians, these differences disappear when BMAD values are calculated. While BMD is an areal density, not taking into account the 'depth' of the bone, BMAD is an estimation of volumetric density. Hence lower BMD values in Asians may be a size-related artefact. Longitudinal studies may be required to evaluate the use of BMD as a marker for fracture risk in this population.

Introduction

Immigrants from the Indian sub-continent are at high risk of metabolic bone disease.[1] Until now, however, most studies have focussed upon the predisposition among this population to rickets and osteomalacia.[2] Among Caucasian women, osteoporosis is the most severe and prevalent metabolic bone disease, affecting approximately 1 in 8 women, causing significant morbidity and mortality through its predisposition to fracture.[3] It has recently become clear however, that osteoporosis also poses a threat to other ethnicities: for example, $ 901 million were spent in the US during 1995 for the care of osteoporotic fractures among non-Whites.[4] Unfortunately we currently

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know little of the epidemiology of osteoporosis among the immigrant population.

Although women of Indo-Asian descent have relatively lower skeletal mass at maturity, their rates of hip fracture are lower than those of Caucasians.[5] Differences in hip geometry,[6] or rates of falling,[7] among different ethnic groups have been hypothesized. The only previous study of bone mineral density among British immigrants of Indian origin found lower levels of femoral neck and vertebral bone mineral density (BMD) in this population.[8] However, these 'areal' BMD values have since been shown to be prone to confounding by skeletal size, since adjustment for the area scanned (in g/cm^2) does not completely account for the fact that wider bones are also thicker.[9] Several studies have now shown that adjustment for bone and body size reduces or eliminates apparent differences in bone density between Indo-Asian and White subjects.[10–16] In view of this, we set out to compare bone mineral status of a group of Indian women living in the UK with age-matched Caucasian women.

Methods

Patients

We analysed the database records of women scanned at the Southampton Osteoporosis Centre (UK). The Centre is the sole provider of bone densitometry services for the local population of 500 000 residents, providing 3500 scans annually, and referral is made either by primary care practitioner or hospital physicians, according to local standardized guidelines. For all patients attending the Centre since 1995, information about age, gender and bone mineral have been stored in a confidential database. For this study, women of Indo-Asian origin were identified on the basis of a search of the database for last names of possible Indian origin. The ethnicity of each patient was subsequently confirmed by written communication with their primary-care physician.

Controls

For each Indo-Asian patient, an age-matched (within 5 years) Caucasian control was identified from the database. Where two or more women were eligible as controls, selection was made on the basis of computer-generated random numbers.

Bone densitometry

The bone mineral content (BMC), bone area, bone mineral density (BMD) (g/cm^2) of each patient and each control was measured using dual-energy X-ray absorptiometry (DXA) with a Hologic QDR 2000 instrument (Hologic). Regions of interest for the spine (L1–L4) and right femoral neck were defined according to Hologic guidelines. Hip axis length (defined as the distance from the lateral border of the femur along the central axis of the femoral neck to the medial pelvic wall) was measured using Hologic software. Volumetric bone mineral apparent density of the lumbar spine was estimated according to the method of Carter *et al.*, using the formula (Spine BMAD = BMC/A$^{3/2}$).[17] Bone density and other characteristics of the Indo-Asian patients and their age-matched controls were compared using the two-sample *t*-test.

Results

A total of 41 Indo-Asian women (mean ± SD age 57.7 ± 12.8 years) were included in this study (Table 1). This ethnicity included women of Indian, Pakistani and Bangladeshi descent. Forty-one age-matched controls (mean ± SD age 58.2 ± 13.2 years) were also identified from the database.

Lumbar spine

The measurements of BMC, bone area, BMD and volumetric BMD (BMAD) of the lumbar spine of Indo-Asian cases and Caucasian controls are compared in Table 1. At the lumbar spine,

Table 1 *Bone mineral density, bone mineral apparent density and hip axis length in Indo-Asian women and age-matched Caucasian controls*

	Indo-Asian cases ($n = 41$)	Caucasian controls ($n = 41$)
Age (years)	57.7 (12.8)	58.2 (13.2)
Lumbar spine		
BMC (g)	43.10 (12.77)	51.40 (13.20)
Area (cm^2)	49.47 (7.60)	55.88 (6.67)
BMD (g/cm^2)	0.834 (0.166)	0.913 (0.166)
BMAD (g/cm^3)	0.123 (0.029)	0.122 (0.020)
Femoral neck		
BMC (g)	3.45 (0.64)	3.55 (0.69)
Area (cm^2)	4.44 (0.57)	4.99 (0.40)
BMD (g/cm^2)	0.728 (0.116)	0.712 (0.124)
BMAD (g/cm^3)	0.393 (0.180)	0.319 (0.057)
Hip axis length (cm)	10.27 (0.79)	10.72 (0.69)

Data are means (SD). BMC, bone mineral content; BMD, bone mineral density; BMAD, bone mineral apparent density.

Indo-Asian women had a significantly lower BMD than did Caucasians (mean ± SD 0.834 ± 0.166 vs. 0.913 ± 0.166, $p = 0.008$). However, these differences disappeared when BMAD was calculated, so that the mean volumetric density of the Indo-Asian women was not significantly different from that of the Caucasian women (0.123 ± 0.029 vs. 0.122 ± 0.020, $p = 0.87$).

Femoral neck

At the femoral neck (Table 1), no significant differences in BMD were observed between Indo-Asian women and their age-matched Caucasian counterparts (mean ± SD 0.728 ± 0.116 vs. 0.712 ± 0.124, $p = 0.50$). However, Indo-Asian women had significantly greater mean BMAD at the femoral neck than did Caucasians (0.393 ± 0.180 vs. 0.319 ± 0.057, $p = 0.022$). Mean hip axis length was significantly shorter among the Indo-Asian women than the Caucasian women (10.27 ± 0.79 vs. 10.72 ± 0.69, $p = 0.009$).

Discussion

Although our Indo-Asian women appeared to have lower spinal bone mineral density than age-matched Caucasians, these differences disappeared when BMAD values were calculated. While BMD is an areal density, not taking into account the 'depth' of the bone, BMAD is an estimation of volumetric density. Hence, the results of our study suggest that lower BMD results in Indo-Asians may be artefactual, confounded by differences in bone size. Indo-Asian women have higher volumetric density at the femoral neck and significantly shorter hip axis length than Caucasian women. It is possible that this relatively higher BMAD contributes to the relatively lower rates of hip fracture observed among Indian women. Taken together, these findings suggest that longitudinal data will be required in order to evaluate the use of BMD as a marker of fracture in this population.

The findings of this study must be considered in the context of several limitations. Firstly, these data are from a relatively small number of healthy peri-menopausal British Indo-Asian immigrant women, albeit the largest series of such women studied to date. Unfortunately, data as to other individual risk factors, e.g. use of prednisolone, immobility, previous fractures, etc., are not available. However, the cases and controls for this study were identified from the Southampton Osteoporosis Centre database of individuals referred for bone densitometry by either a local primary care physician or hospital clinician. Guidelines for referral to the service have been in place since 1995, specifying a range of clinical indications for which a bone densitometry measurement might be indicated (clinical osteoporotic fracture; radiographic osteopenia; corticosteroid therapy; incidental finding of vertebral deformity; and the presence of known secondary causes of osteoporosis, such as renal disease), and requests for densitometry that do not specify one of these indications are rejected. As such, the referral for densitometry is relatively standardized and there is no evidence that Indo-Asian women differ in their patterns of referral from Caucasians. Unfortunately, however, we have no information as to the healthcare-seeking behaviour of these immigrant Indo-Asian women, as compared with Caucasians. It is possible that awareness of risk of osteoporosis might be higher among Caucasian women and that therefore, their physicians may be more likely to request densitometry in the presence of risk factors. It is unclear however, that this would result in any systematic bias in the comparison between bone density measurements of cases and controls in this study.

At the femoral neck, standard projectional bone density of the femoral neck did not differ significantly between Indo-Asian and Caucasian women. In contrast, however, the BMAD of Indo-Asian women was significantly greater than that of Caucasian women. Cummings and colleagues have previously shown that BMD and BMAD were both similarly strong predictors of future hip fracture among a cohort of 8000 older Caucasian women; every one SD reduction in either BMD or BMAD was associated with an increased age-adjusted risk of hip fracture 2.6- to 2.7-fold.[18] Rates of hip fracture are lower among women of Indo-Asian descent, and it appears that the ethnic differences in bone size, geometry and BMAD are all contributory in conveying a beneficial effect. As such, the prediction of rates of hip fracture among Indo-Asian women will require the provision of different algorithms of risk assessment from those used among Caucasian women.

The findings of this study are consistent with those of others[8,10–16] in showing that healthy women originating from southern Asia have lower unadjusted bone mineral density at the lumbar spine, but that such differences disappear when adjustment for bone size is made. In their recent comparative study of southeast Asian women and Caucasians, Marquez and colleagues[16] noted some heterogeneity of the effect of correcting for BMAD: the difference in lumbar spine bone density (in southeast Asian women compared to White women) was completely eliminated in pre-menopausal women but persisted in post-menopausal women

(0.133 ± 0.023 vs. 0.143 ± 0.024; $p < 0.0001$). In our study, however, we were unable to explore the influence of menopausal status on this adjustment, since the majority of our cases and controls were probably peri-menopausal.

The comparative differences between spine and hip were noteworthy. One possible explanation for relatively higher bone density of the lumbar spine among Indo-Asian women, as compared with Caucasians, would be a higher prevalence of osteoarthritis. Unfortunately, radiographic information about the prevalence of osteoarthritis in this study sample was not available. Few epidemiological data are available as to the prevalence of osteoarthritis among women of Indo-Asian descent. One study has shown that lumbar spondylosis is less common among Japanese women than Caucasian women,[19] but prevalence data for immigrant Indo-Asian women are currently not available.

In this study, Indo-Asian women did not have significantly different bone mineral density at the femoral neck from that of Caucasian women. This finding contrasts with that of Marquez and colleagues, who found that the femoral neck BMD of southeast Asian women was 4% lower than among Caucasian women.[16] However, the same study also highlighted differences in BMD between those of Vietnamese, Cambodian and Laotian origins. In this light, therefore, it is perhaps unsurprising that the BMD values in another different ethnic group (Indo-Asian) will not be directly comparable. A potential confounder of immigrant population studies is the extent to which the ethnic variations are altered by their new environment. For example, the findings of this study would be influenced by a change in stature if UK-born Indo-Asian women were (e.g.) taller than Indo-Asian-born women. In fact, the majority of the participants in this study were foreign-born and therefore, representative of their native ethnicity. However, in line with the findings of Marquez and colleagues, we found that the BMAD of Indo-Asian women was greater than that among White women. Hip axis length among these women was shorter than their Caucasian peers, in line with the findings of other researchers.[6]

It is well-known that women of Indo-Asian origin are at increased risk of osteomalacia. Our results suggest potential for problems with the interpretation of routine bone densitometry scans of Indo-Asian women. Furthermore, since fracture risk is not dependent solely upon bone density, but also factors such as risk of falling and hip geometry, these results suggest that longitudinal studies will be required in order to define a separate algorithm of risk assessment of future risk of fracture based upon bone density for women of Indo-Asian origin.

References

1. Dunnigan MG, Robertson I. Residence in Britain as a risk factor for Asian rickets and osteomalacia [Letter]. *Lancet* 1980; **1**:770.
2. Solanki T, Hyatt RH, Hughes EA, Cowan RA. Are elderly Asians in Britain at a high risk of vitamin D deficiency and osteomalacia? *Age Ageing* 1995; **24**:103–7.
3. Cooper C. The crippling consequences of fractures and their impact on quality of life. *Am J Med* 1997; **103**:12–17S.
4. Ray NF, Chan JK, Thamer M, Melton LJ III. Medical expenditures for the treatment of osteoporotic fractures in the United States in 1995: report from the National Osteoporosis Foundation. *J Bone Miner Res* 1997; **12**:24–35.
5. Walker-Bone K, Dennison E, Cooper C. Osteoporosis. In: Silman AJ, Hochberg M, eds. *The Epidemiology of Rheumatic Diseases*. Oxford, Oxford University Press, 2002:259–92.
6. Cummings SR, Cauley JA, Palermo L, *et al*. Racial differences in hip axis lengths might explain racial differences in rates of hip fracture. The study of Osteoporotic Fractures group. *Osteoporos Int* 1994; **4**:226–9.
7. Lipsitz LA, Nakajima I, Gagnon M, *et al*. Muscle strength and fall rates among residents of Japanese and American nursing homes: an international cross-sectional study. *J Am Geriatr Soc* 1994; **42**:953–9.
8. Tobias JH, Cook DG, Chambers TJ, Dalzell N. A comparison of bone mineral density between Caucasian, Asian and afro-Caribbean women. *Clin Sci* 1994; **87**:587–91.
9. Seeman E. Growth in bone mass and size: are racial and gender differences in bone mineral density more apparent than real? [Editorial]. *J Clin Endocrinol Metab* 1998; **83**:1414–18.
10. Alekel DL, Peterson CT, Werner RK, Mortillaro E, Ahmed N, Kukreja SC. Frame size, ethnicity, lifestyle, and biological contributors to areal and volumetric lumbar spine bone mineral density in Indian/Pakistani and American Caucasian premenopausal women. *J Clin Densitometry* 2002; **5**: 175–86.
11. Larcos G, Baillon LG. An evaluation of bone mineral density in Australian women of Asian descent. *Australs Radiol* 1998; **42**:341–3.
12. Cundy T, Cornish J, Evans MC, Gamble G, Stapleton J, Reid IR. Sources of interracial variation in bone mineral density. *J Bone Miner Res* 1995; **10**:368–73.
13. Russell-Aulet M, Wang J, Thornton JC, Colt EWD, Pierson RN. Bone mineral density and mass in a cross-sectional study of white and asian women. *J Bone Miner Res* 1993; **8**:575–82.
14. Davis JW, Novotny R, Ross PD, Wasnich RD. Anthropometric, lifestyle and menstrual factors influencing size-adjusted bone mineral content in a multiethnic population of premenopausal women. *J Nutr* 1996; **126**:2968–76.
15. Bhudikanok GS, Wang MC, Eckert K, Matkin C, Marcus R, Bachrach LK. Differences in bone mineral in young Asian and Caucasian Americans may reflect differences in bone size. *J Bone Miner Res* 1996; **11**:1545–6.
16. Marquez MA, Melton LJ III, Muhs JM, Crowson CS, Tosomeen A, O'Connor MK, *et al*. Bone density in an

immigrant population from Southeast Asia. *Osteoporosis Int* 2001; **12**:595–604.

17. Carter DR, Bouxsein ML, Marcus R. New approaches for interpreting projected bone densitometry data. *J Bone Miner Res* 1992; **7**:137–45.
18. Cummings SR, Marcus R, Palermo L, Ensrud KE, Genant HK. Does estimating volumetric bone density of the femoral neck improve the prediction of hip fracture? A prospective study. Sutdy of Osteoporotic Fractures Research Group. *J Bone Miner Res* 1994; **9**:1429–32.
19. Yoshimura N, Dennsion E, Wilman C, Hashimoto T, Cooper C. Epidemiology of chronic disc degeneration and osteoarthritis of the lumbar spine in Britain and Japan: a comparative study. *J Rheumatol* 2000; **27**:429–33.