

Osteoporosis: the shifting scores of BMD

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Abstract

It is imperative to use the correct and accurate reference database when measuring BMD for osteoporosis in the different population groups based on race, to avoid inconsistency in diagnosing osteoporosis and variation in the provision of medical care [1-12].

Keywords: osteoporosis, osteopaenia, bone mineral density, dual energy x-ray absorptiometry, T-scores, Z-scores, ethnicity

Aim

The aim of the study is to emphasise the significance of using the correct ethnic (population groups based on race) matched reference database when measuring bone mineral density (BMD) for osteoporosis in an individual. The researcher is currently working on a study thus this is a work in progress article to highlight the need for suitable BMD values to meet the needs of Indian female groups in the Province of KwaZulu-Natal.

Methodology

Three female participants from the White, Indian and Black race groups were scanned at the spine and hip using the Hologic QDR 4500 bone densitometer to measure their absolute BMD values. These absolute BMD values for the spine and hip were then quantitatively analysed, using the Hologic QDR 4500 software. The diagnostic interpretation for normality, osteopaenia, or osteoporosis is determined using the World Health Organisation (WHO) criteria. Each participant's absolute BMD value for the spine and hip, irrespective of ethnicity, was then measured against the White, Black, and Hispanic population reference databases, supplied by the manufacturer, with respect to reference curves and the calculation of T and Z scores. Asian (Japanese) values were absent on the Hologic QDR 4500 at the local practice but are present on densitometers from other manufacturers. In view of this lack of values at the local practice a diagnosis, using the Asian reference database, could not be determined.

Results

Participant A (White). The absolute BMD values were 0.787 g/cm² at the hip and 1.035 g/cm² at the spine.

Using the White female reference database (Figure 1),

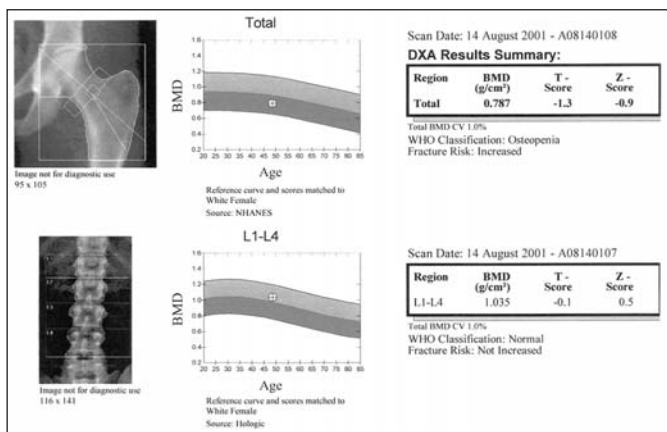


Figure 1: Participant A – White female measured against White female reference database

- The T scores were -1.3 and -0.1 respectively. Using the WHO criteria the results were osteopaenic and normal respectively.
- The Z scores were -0.9 and 0.5 respectively, showing an increase for fracture risk at the hip and no fracture risk at the spine.

Using the Black Female reference database (Figure 2),

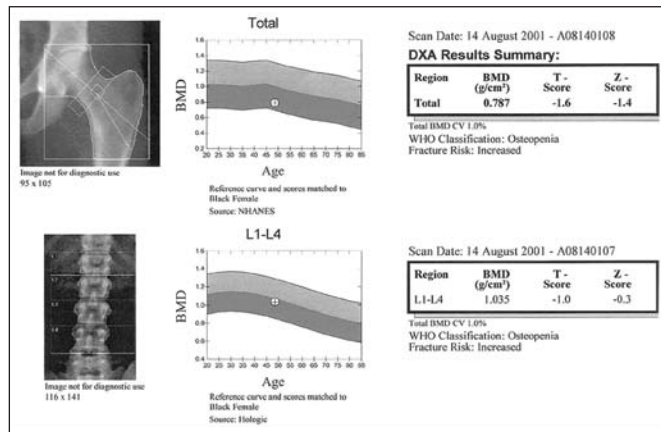


Figure 2: Participant A – White female measured against Black female reference database

- The T and Z scores at the hip were -1.6 and -1.4 respectively. Using the WHO criteria, the diagnosis at the hip did not change although a difference in the T and Z scores were evident.
- The T score at the spine was -1.0 and showed a WHO classification of osteopaenia. The Z score was -0.3 and showed an increased fracture risk.

Participant B (Indian). The absolute BMD values were 0.996 g/cm² at the hip and 0.991 g/cm² at the spine.

Using the White Female reference database: (Figure 3)

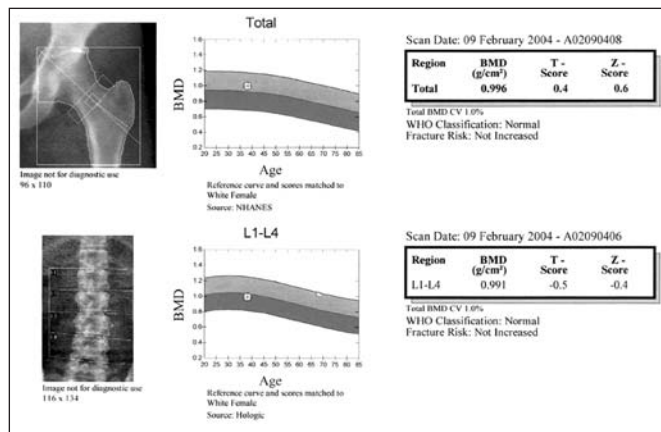


Figure 3: Participant B – Indian female measured against White female reference database

- The T scores were 0.4 and -0.5 respectively. Using the WHO criteria the results were normal.
- The Z scores were 0.6 and -0.4 respectively, showing no increase for fracture risk.

Using the Black Female reference database: (Figure 4)

- The T and Z scores at the hip were -0.2 and -0.1 respectively. Using the WHO criteria, the diagnosis at the hip did not change although a difference in the T and Z scores were evident.
- The T score at the spine was -1.4 and showed a WHO classification of osteopaenia. The Z score was -1.3 and showed an increased fracture risk.

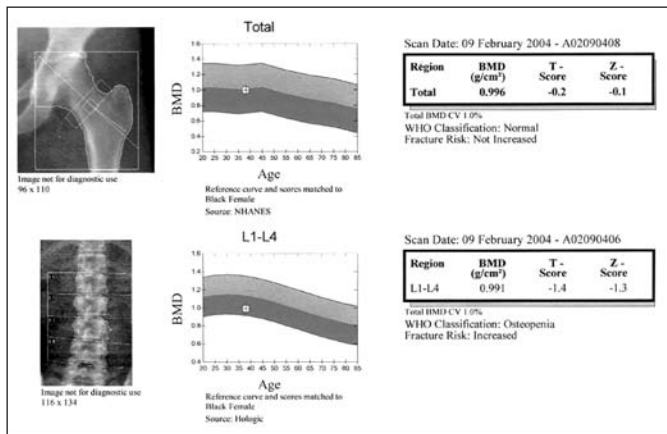


Figure 4: Participant B – Indian female measured against Black female reference database

Participant C (Black). The absolute BMD values were 0.962 g/cm² at the hip and 0.851 g/cm² at the spine.

Using the White Female reference database (Figure 5)

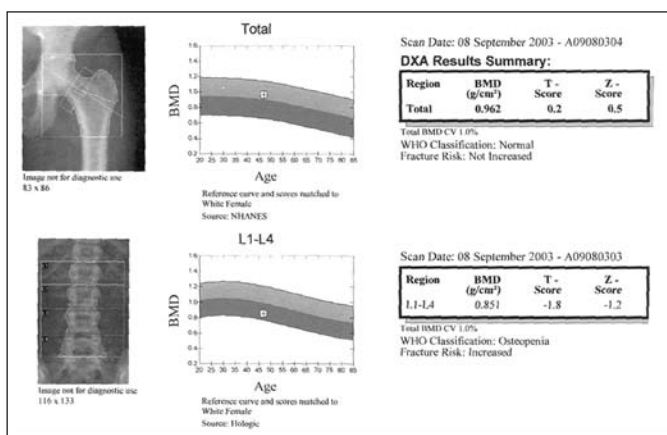


Figure 5: Participant C – Black female measured against White female reference database

- The T scores were 0.2 and -1.8 respectively. Using the WHO criteria the results were normal respectively.
- The Z scores were 0.5 and -1.2 respectively, showing no increase for fracture risk at the hip but an increased fracture risk at the spine.

Using the Black Female reference database (Figure 6)

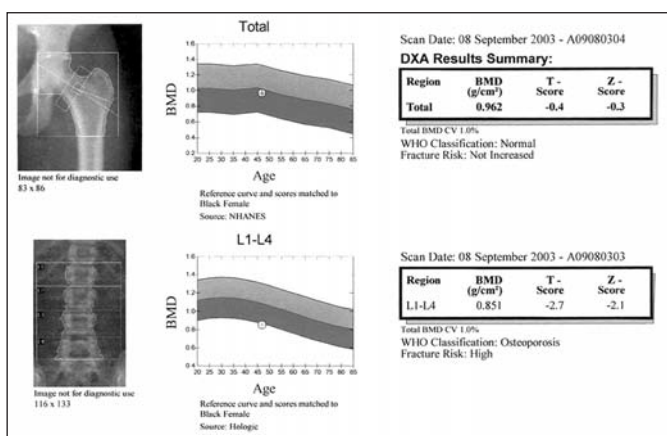


Figure 6: Participant C – Black female measured against Black female reference database

- The T and Z scores at the hip were -0.4 and -0.3 respectively. Using the WHO criteria, the diagnosis at the hip did not change although a difference in the T and Z scores were evident.

- The T score at the spine was -2.7 and showed a WHO classification of osteoporosis. The Z score was - 2.1 and showed that fracture risk was high.

The Hispanic female reference database drew similar results to the White female reference database for all the participants. The results and diagnoses for all three participants changed significantly at the spine but only minimally at the hip, dependent on the reference databases used.

Discussion

According to Kanis, *et al* [1] osteoporosis can be defined as a condition in which the amount of bone tissue is reduced, increasing the likelihood of fracture. The remaining bone is quantitatively deficient, although qualitatively normal. Osteoporosis, as a chronic disease, places a significant burden on society in terms of medical care, deformity and disability. Osteoporotic fractures have come to be recognised as one of the most serious problems in public health, where lifetime risk of suffering a fragility fracture of the hip, spine or forearm is estimated to be 30 - 40%. Figures are comparable with lifetime risk for cardiovascular disease, thus indicating the widespread prevalence of osteoporosis [1].

Osteoporosis is a multifactorial disease with several risks factors that include age, gender, lifestyle factors, body size, fracture history, drug treatments, genetics and other illnesses. Women, generally, are at a greater risk of developing osteoporosis than men. This is due to women experiencing a rapid loss of bone following menopause, which results in a decrease in oestrogen production.

Bone densitometry measurements

There has been significant evolution of radiological techniques for the non-invasive assessment of skeletal integrity. Fogelman and Blake [2] have indicated that this has allowed for the early detection of osteoporosis and the assessment of fracture risk. Currently, the gold standard for predicting fracture risk with bone mineral density measurements is dual energy x-ray absorptiometry (DEXA) scanners. This is due to its advantages of high precision and accuracy, short scan times, and stable calibration in clinical use. Simply, DEXA BMD gives quantitative measurement of BMD. Scanning occurs at two different x-ray photon energies and its principle is based on a subtraction technique, where the attenuation of bone alone is measured and the contributions of the soft tissues are eliminated [1,2]

Bone densitometry provides a measure of fracture risk comparable to the assessment of the risk of stroke by blood pressure readings, or cholesterol readings with regard to developing ischaemic heart disease [1]. Prospective studies by Cummings, *et al* [3] established that as BMD decreases, fracture risk increases. Therefore, BMD should be thought of as a continuous risk factor, the lower the BMD, the higher the risk of fracture.

T-scores and Z-scores

According to Fogelman and Blake [2] BMD measurements are well suited to the study of populations, with the effect of identifying individuals who have a higher than average risk of fracture, assisting in making clinical decisions for therapeutic intervention. Currently, all bone densitometers give results in absolute terms (g/cm²) or in relative terms (T-scores and Z-scores). According to Watts [4] the T score concept was developed to provide a way of using a single set of numbers for all measuring devices and all skeletal sites. The reference population defines T and Z scores. Kanis and Gluer [5] have further reiterated the importance of having the appropriate reference population, when defining T and Z scores.

The T score is a measure of the difference between the patient's BMD and that of a young adult population of the same sex and ethnicity and is calculated using the following formula [4]:

$$\frac{\text{Patient's BMD} - \text{Young Normal Mean}}{1 \text{ SD of Young Normal}}$$

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(continued from page 19)

The Z score is a measure of the difference between the patient's BMD and that of healthy people of the same sex, age and ethnicity and is calculated using the following formula [4]:

$$\frac{\text{Patient's BMD} - \text{Age} - \text{Matched Mean}}{1 \text{ SD of Age} - \text{matched Normal}}$$

The reference database presents the average results as a function of age, sex, and ethnicity for a matched population. The reference curves specify average BMD, and standard deviation (SD) as a function of age. Each curve applies to a specific scan type, analysis type, bone region, patient sex and ethnic group.

These reference curves used on reference database reports provide a graphic display of a patient's results and the calculation of T and Z scores. Each compares a patient's scan or series of scans with the reference database.

Reference ranges

The WHO has established a set of reference criteria for the diagnosis of osteoporosis. Table 1 demonstrates the four general diagnostic categories as defined by WHO [6]. A limitation is that the WHO definition directly applies to Caucasian women. However, osteoporotic fractures are not uncommon in non-Caucasian women, in fact, the National Osteoporosis Foundation of South Africa indicate the osteoporotic fracture rates in the White (Caucasian),

T-score	Relative to Mean BMD	Diagnosis
≥ -1	not more than 1SD below the mean	normal
<- 1 to -2.5 >	more than 1SD below the mean & less than 2.5SD below the mean	osteopaenia/low BMD
≤ -2.5	2.5SD or more below the mean	osteoporosis
< -2.5 + f #	more than 2.5SD below the mean with fragility fractures	severe/established osteoporosis

Table 1: World Health Organisation. WHO Technical Report Series 843. Geneva, 1994.

Asian and "mixed race" populations in this country are similar to those reported from North America and Europe [7]. Furthermore, it is uncertain whether reference ranges supplied by the bone densitometer manufacturers can be applied to all populations, or whether different populations need to establish their own normative data. In contrast, the manufacturer recommendation is that all non-Caucasian South African patients be measured against the Caucasian reference database supplied. However, the International Society for Clinical Densitometry (ISCD) have recommended that these values apply to the United States (US) populations only and that further research is needed for populations outside the US [7].

Several studies [9,10,11,12] have documented interethnic variations in BMD measurements, which in turn has led to over-diagnosis or under-diagnosis for osteoporosis in their respective populations. The findings of these studies indicate an erroneously high diagnosis of osteoporosis when the manufacturers' values (73%) were used compared to 46 % when the populations mean was used.

Both the individual practitioners and medical aids are using BMD as important and paramount criteria for determining which patients to treat [7]. If the WHO criteria are used to determine osteoporosis and fracture risk then it is evident that any errors in the mean BMD and population SD of the reference group might lead to significant differences in the incidence of osteoporosis when applied to other populations [2]. The reference ranges currently used for diagnoses are those supplied by the manufacturers. BMD values at the hip are measured against the NHANES III reference ranges and BMD values at the spine, forearm and whole body are measured against the manufacturer values [Caucasian, Asian, American Black, Hispanic]. Therefore it is of paramount importance that the correct ethnic matched reference database be used for the accurate assessment of osteoporosis for any given individual.

Concluding remarks

The results indicate that diagnostic interpretation varies, depending on the reference database used. If there are variations, then, are there inaccuracies? If so, these inaccuracies can lead to inconsistencies in diagnosing osteoporosis and variation in provision of medical care.

Similarly, the results emphasise the significance of choosing the correct ethnic matched reference database for accurate interpretation for osteoporosis. Given the diverse ethnic groups in South Africa, care should be taken in choosing the appropriate reference database when measuring BMD using DEXA for a given individual.

Furthermore, the recommendation that all non-Caucasian patients be measured against the Caucasian reference database in South Africa needs redress. Similarly, BMD reference values for the local White population need to be evaluated and compared to the Caucasian values supplied by the manufacturers. This implies that research is needed in the local populations to determine any inaccuracies that may be evident [8,12].

Current research is being undertaken, by the author, involving Indian females to determine the average values for BMD as a function of age, sex and ethnicity. This study is 'work in progress' towards further research including the other local population groups.

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