Peak Bone Mineral Density Of Bangladeshi Men And Women

Dilruba Akhter Banu

Abstract: Osteoporosis is a disease that causes bones to become weak and brittle. It affects 55% of Americans aged 50 or above, of which about 80% are women. Millions of fractures occur annually. An effective way of preventing osteoporosis is to maximize the attainment of peak bone mineral density (pBMD). Thus the knowledge of average pBMD that prevails in a nation is very important. Not much study appears to have been done on the subject in Bangladesh. 170 Bangladeshi patients and volunteers were studied at nuclear medicine centers of Comilla and Rajshahi. Bone mineral densities (BMD) at different sites of the skeleton were measured using Dual Energy X-ray Absorptiometer (DXA). Graphs of Age versus BMD were plotted. Data was fitted with the help of polynomials. The best fit was obtained with polynomials of degree 4 in each case. By using bootstrapping method a large number of samples were generated and pBMD was obtained from each of the samples. Mean value of the pBMD was then calculated. pBMD values of the male patients were found to be slightly greater than those of the females. During puberty gender differences become more expressed. After the age of 50 females lose bones more rapidly and quantitatively than males. Bangladeshis seem to belong to the group of nations having low pBMDs.

Index Terms: Bone mineral density (BMD), bootstrapping, DXA, femoral neck, lumbar spine, osteoporosis, peak bone mineral density (pBMD).

1 INTRODUCTION

RESEARCHES on bone mineral density (BMD) are expanding rapidly all over the world but unfortunately people of Bangladesh are not much aware of it yet. Bone is a hard form of connective tissue that constitutes supporting structures or skeletons of vertebrates. Bone serves as a reservoir for calcium and phosphorus, which may, in times, be more urgently needed in other parts of the body. Most of the red and white blood cells are produced by bones. A typical bone such as femur has an outer layer of compact bone and a mesh like network of cancellous bone near the end of the interior of the bone. The solid matter of bone is composed of about two-third mineral substances and approximately one-third organic matter. The minerals are mainly calcium phosphate and calcium carbonate. The organic matter is mostly collagen, a type of protein fiber. Bone is a living tissue which undergoes continuous changes. It increases or decreases in structural strength according to the demands of the body. As a tissue it is subject to deficiencies and disease. Bone takes many years to grow. For most people, bones reach their maximum strength and density by late twenties. Up to 90% of peak bone mass is acquired by age 18 in girls and 20 in boys. Youth is thus the best time for investment in bone health [1]. Bone mineral density (BMD) is a medical term referring to the amount of calcium per square cm of bones [2]. The strength of bones is measured as bone density. Bone mineral content (BMC) is the mass of bone present at a given site. Bone mass and density are two commonly used physical properties that are very similar and share a close mathematical relationship. Calcium is constantly being added and taken away from bones. When calcium is taken away faster than it is added, the bones become lighter, less dense and more porous. These make bones weaker and increase their risk of fracture, thus giving rise to a disease called osteoporosis. Peak bone mineral density (pBMD) or peak bone mass (PBM) is generally defined as the highest level of BMD/BMC achieved as a result of normal growth. Maximizing the attainment of PBM is now considered to be an important component of osteoporosis prevention [3]. There is a large variation in range for pBMD/PBM that is influenced by both genetic and environmental factors. Physical activity and diet may be the most important modifiable factors that can increase PBM /pBMD for both children and adult. Since there are no safe and effective ways to rebuild the osteoporotic skeleton, prevention of osteoporosis by maximizing bone density during skeletal growth emerges as the crucial strategy [2]. It has been suggested that 10% increase in PBM could reduce the risk of fracture by 50% [3]. In this paper we are going to discuss only the bone density aspects of the people of Bangladesh. The topic of bone mineral content will be treated in a subsequent paper.

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2 METHODS

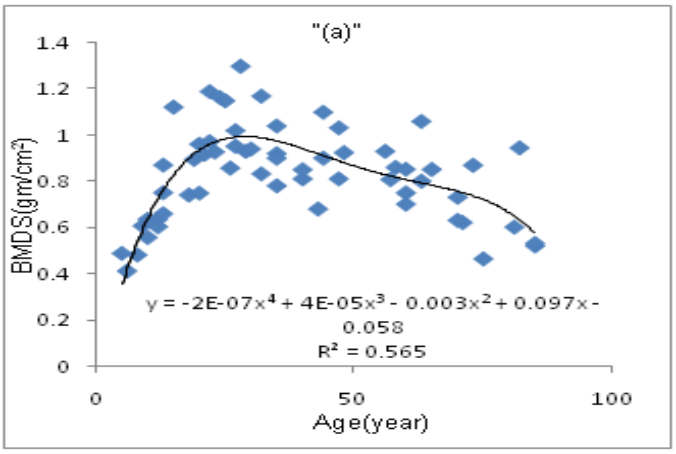
BMD was measured by using Dual Energy X-ray Absorptiometry (DXA) densitometer manufactured by Norland Medical System. In the process of scanning a bone, an X-ray beam is allowed to focus on it. Some of this x-ray is absorbed by the bone and the rest comes out and is detected on the other side. The denser the bone, the more energy is absorbed and less energy is detected. In DXA, X-ray beam of two different energies are used. Two energies allow an estimate to be made for the absorption by soft tissues separately from that by bones. For the measurements of BMD, a patient is allowed to lie on a cushioned table, while a scanner passes over his body. Patients are scanned at lower spine, upper femur, and fore arm. The scan is painless. Calibration is automated in DXA. Analysis of DXA forearm data is totally automated. Software algorithms locate the ulna endplate and search for 10 consecutive lines of distal scout data which contain a minimum bone mineral density. Algorithms direct the scanner to rescan those 10 distal lines at a slower speed with finer resolution. BMD is automatically computed [4]. BMD of 170 patients and volunteers of Bangladesh, aged between 5 and 100 were measured at nuclear medicine centers of Comilla and Rajshahi, situated in the eastern and north- western region of Bangladesh respectively. Skeleton

locations selected were AP spine, femur neck, Ward's triangle, trochanter and forearm (proximal and distal). All patients were clinically assessed by physicians and the relevant information about weight and health was noted. BMD scans were taken in the areas rich in trabecular bone.

3 Results and Discussion

3.1 Trendline Equation

Graphs of Age vs. BMD were plotted. Attempts were made to fit the data with the help of polynomials. It was found that the best fit occurred with n=4. Fig. 1 shows the graphs of Age against BMD for lumbar spine (BMDS) of a sample of male population, where polynomials of degree 3 and 4 have been tried. It would be seen that the value of R^2 is significantly better for degree 4. This has been found to be the case for femoral neck as well for both male and female samples. 4th degree polynomials are not so common in the literature on BMD. Trendlines start from straight line to quadratic, to cubic and in some cases to the highest degree of 4. Makker et al, in their paper on Indian subjects [5], have found the 4- degree polynomial to be suitable for female hips and male femoral necks. Nguyen et al have measured peak bone densities in Vietnamese men and women and fitted the third degree polynomial consistently to lumbar spine, femoral neck and total hip regions [6], [7]. It appears from their statement that they did not try higher than third degree. In the present case all options were tested and the value of R^2 progressively improved for all the set of data obtained for the study. For instance, the value of R^2 for femoral neck of women increased from 0.291 to 0.341 to 0.353 to 0.367 as the regression was continued from straight line, to quadratic, to cubic, to fourth degree respectively.



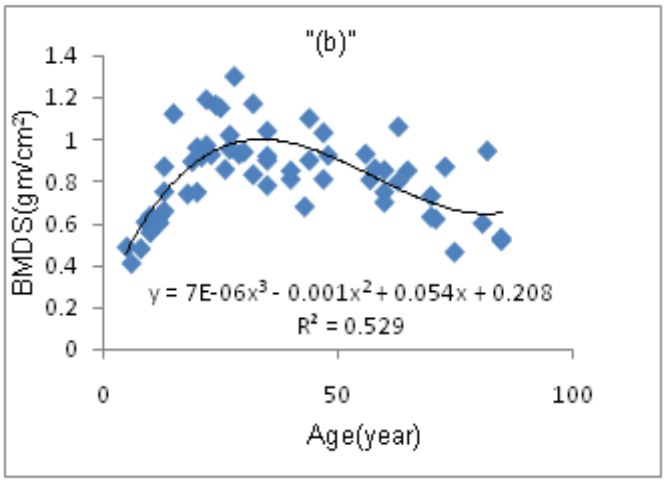


Fig. 1. *Bone mineral density of lumbar spine (BMDS) as a function of age. 4th degree regression is shown in "(a)" and 3rd degree in "(b)".*

3.2 Determination of Peak Bone Mineral Density (pBMD) and the corresponding Age

The usual practice of finding the pBMD is to divide the data into age groups, conventionally into decades. The group, 20-29 years, is taken as the one containing the pBMD and the mean of the BMDs is the pBMD. In fact, WHO recommends the use of mean BMD of Caucasian white women, aged 20-29 years, from the NHANES database as the international reference standard for the calculation of T-scores [8].The method can be subjected to a number of criticisms. Firstly, pBMD has to be present in the group, preferably in the mid-region, which may not necessarily be the case, as will be shown later. Secondly, it is a rather broad range and the errors are likely to be large. Thirdly, the range may be made narrower, but then there should be sufficiently large number of data to make the value representative. Fourthly, the method does not take into account the BMD values of other age groups. Recently a group of Vietnamese scientists [6], [7] have used the bootstrapping method to enormously increase the number of samples based on their original sample. They then calculated the pBMD and the corresponding Age for each of the samples on the basis of the trendline equations obtained for each case. Mean pBMD and Age could then be obtained at the chosen confidence level. In our case, too, we have used the bootstrapping method to generate a large number of samples of the same size as the original sample, keeping the BMD-Age relationship intact. 4th order polynomial regression was then performed on each sample and the results were calculated according to the trendline equation obtained. To pinpoint the pBMD and the Age, BMD values were calculated at half-

year age intervals in the neighborhood of the pBMD. Mean pBMD and mean Age have been calculated at 95% confidence level and the results are shown in Table 1. We believe that this is a better method, because it involves a large number of samples and also because the trendline equation takes the data of all age groups into consideration. The only condition to be satisfied for this method is that the trendline equation should be so chosen that it represents the best fit of the available data.

TABLE 1

Peak Bone Mineral Density (pBMD) with the Corresponding Age along with Standard Deviation for Men and Women at 95% Confidence Level

Site	Gender	pBMD with stand. dev. (gm/cm^2)	Age with stand. dev. (year)
Lumbar Spine	Male	1.0007 ±0.027	29.2 ± 2.5
	Female	0.9115 ± 0.027	32.4 ± 2.2
Femoral Neck	Male	0.9641 ± 0.060	27.4 ± 1.9
	Female	0.8450 ±0.023	24.1 ± 2.8

3.3 Male versus Female BMD

Female pBMD values are usually lower than those of males and that is the reason why women are more vulnerable to osteoporosis than men. This is evident from Table 1. Our results are in agreement with those of USA [9], [10], Canada [11], India [5], China [12], [13], Taiwan [14], Vietnam [7], Indonesia [15], Saudi Arabia [16], Turkey [17] and Korea [18]. Whereas BMD values of women for their femoral neck are distinctly smaller than those of men for all nations without exception, this does not seem to be the case with lumbar spine. For instance, Sweden [19], [20], Iran [21] and Lebanon [22] have nearly the same values for lumbar spine of men and women. If we look at the ages at which pBMDs occur, we find that femoral neck pBMDs for both men and women appear mostly in the age group, 20-29. Once again, exception arises in the case of lumbar spine. The fact that we get 32.5 years as the age for maximum spinal BMD for women is supported by the results in [15], [18], [23], [24]. Berenson et al [25] in their study on white, Hispanic and black women found that white women attained the highest value of spinal BMD at 30 years of age, which continued to increase for black and Hispanic women until 33 years of age.

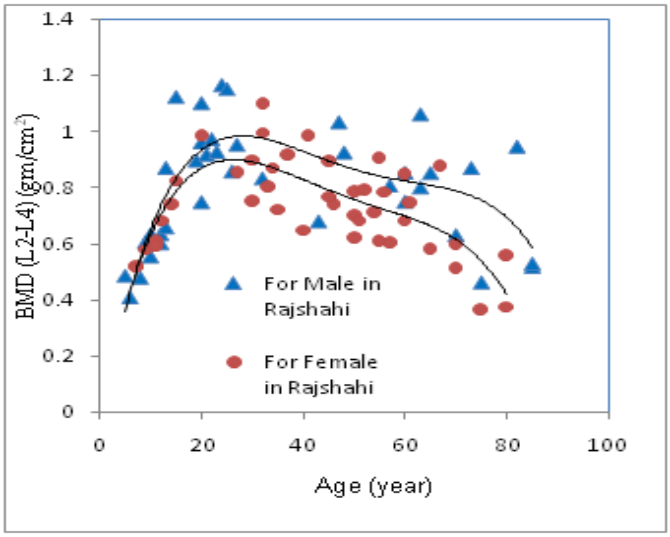


Fig. 2. *BMD of lumbar spine as a function of Age for male and female of Rajshahi.*

To compare how the BMD values for spine vary with age for men and women, we have plotted the data from Rajshahi centre on the same graph (Fig. 2). It is seen that before puberty, boys and girls acquire bone mass at similar rates. During puberty the gender difference in the BMD starts getting more expressed. Then on, the difference grows larger and larger and becomes maximum after 60. Women are thus considered to be at greater risk for developing osteoporosis. But with the increasing number of ageing population, a large number of men too have started suffering from this disease. Calcium deficiency, age related loss of bone strength and physical inactivity, all contribute to osteoporosis. Bones are strongest at about age 30, men then begin to lose bone density. About 30% of hip fractures occur in men and one in eight men older than 50 will have an osteoporotic fracture. Because of their high bone mass, men usually complain about their hip, vertebral body, or distal wrist 10 years later than a woman does. Hip fractures in men result in 30% mortality rate one year after fracture whereas this rate is 17% for women [26]. In age group, 20 to 50, 33% males and 28% females have high risk at the site of lumbar spine. In the age group 51 to 90, 36% males and 70% females have high risk in their lumbar spine. This shows that females lose bones more rapidly and quantitatively than men in lumbar spine, which is also indicated by the graphs in Fig. 2. Trabecular bone is lost sooner and more quickly due to its greater surface area compared to cortical bones [27]. A recent study has demonstrated that post menopausal bone loss occurs at both cortical and trabecular sites. Cortical bone loss may also be due to some diseases such as hyperparathyroidism.

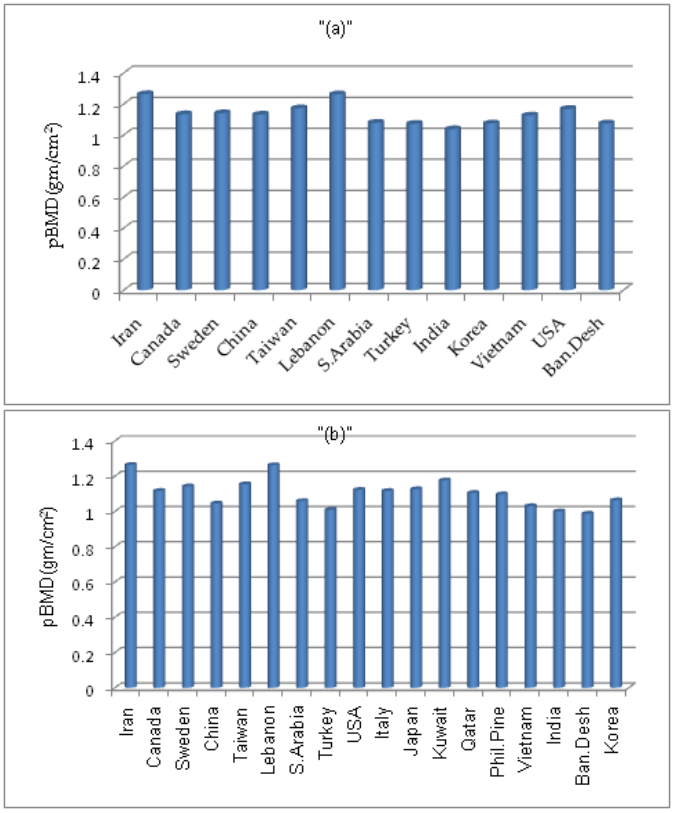


Fig.3. *Country-wise pBMD for males shown in"(a)" and females shown in"(b)"*

3.4 Comparison with other Nations

Comparison amongst pBMD values of different peoples is difficult on many counts. Firstly, densitometers of three different manufacturers give three different values. Attempts have therefore been made to bring these values to standard ones [28], [29]. Secondly, sample size and health condition of the sample may play a part. Thirdly, the method of determining the pBMD may influence its value. For females shown in"(b)" would matter. Despite all these uncertainties, we decided to put some of the available pBMD values on a column chart to get a rough idea about where our results lie in the world context. Larijani et al [21] have tabulated the standardized pBMD values of a number of countries. Some other values including the present ones have been recalculated using the formulae given in [28] and [29]. All these standardized values for the lumbar spines of men and women have been shown in Fig. 3 as columns for comparison. It would be seen that pBMD values for males range from ~1.0 to 1.26. Highest values have been obtained for Iran and Lebanon, while the lowest ones for India, Turkey, Bangladesh, Korea, and Saudi Arabia. USA (Caucasian), Canada, Sweden, China, Taiwan and Vietnam come in the middle range. Bachrach et al [30] have made a comparative study of Asian, Hispanic, Black and Caucasian youth, aged 9-25 years. It appears from their graph that pBMD values for blacks would be even greater than those of Iran and Lebanon. India (South) [31] has the lowest value which is very close to her neighbor, Bangladesh. In the case of women, Iran and Lebanon again come at the top. The bottom group comprises Bangladesh, India, Turkey, Vietnam, China, Saudi Arabia, Korea, and Philippines [32]. To the middle group belong the countries like Qatar [33], USA, Italy [34], Canada, Japan [35], Sweden, Taiwan and Kuwait. Bangladesh has the lowest value which may have to do with the small size and the low health quality of its sample. Even then, it comes within 1.3% of the pBMD of its neighbor, India. Until the very recent time when Bangladesh has been declared as a lower middle-income country, it has been one of the least developed ones. The low value is therefore not unexpected. In developed countries people complaining about bone problems are mostly old whereas in Bangladesh they are middle-aged. Economic and cultural factors have been attributed to this tendency of hiding diseases [36]. The available literature on BMD indicates that the developed countries in the west and even in the east (e.g. Japan) have higher values of BMD than the developing countries of south and south-east Asia. Iran and Lebanon may be treated as exceptions. Henry et al [37] have suggested reference values for the three types of densitometers to be adopted all over Australia. Unfortunately the formula that we have used for standardization does not produce the same result from these three values. This is the reason why we have not shown the Australian BMD on our chart. However, it is almost certain that it would come in the range of the developed countries.

4 CONCLUSION

By using the bootstrapping method of increasing the number of samples, it is possible to obtain reasonable values of pBMD and the corresponding age even with a sample of limited size, as has been shown in the paper. The method has the definite advantage over the usual method of dividing the subjects into various age groups and taking the average of BMDs and Ages. WHO's recommendation of using mean BMD values of Caucasian women of the age group, 20-29, as the reference standard does not seem entirely satisfactory, especially for lumbar spine in which case the maximum value mostly occurs in the 30-39 age group. Time has probably arrived to reconsider these matters in the light of the enormous amount of data that are now available in the literature.

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