A study of the relationship of anthropometric measurements with bone Mineral density in population in and around Bhopal

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Abstract
Objective: To collect the data of anthropometric measurement around District Bhopal, M.P and find out the relationship between BMI & BMD.
Method: This was a cross sectional study in which anthropometric data of 489 persons above the age 21 yrs. was collected, that included age, sex, height, weight body mass index and bone mineral density. Their relationship was evaluated.
Result: This study showed that obesity in females confers protection especially in postmenopausal group while in male obesity did not show any protection against bone mineral loss. Body weight does not correlate with B.M.D in males but it correlates in the females. Height correlated with B.M.D in females but it did not correlate in males.
Conclusion: BMI can be used as screening tool for selecting patient for quantitative estimation of BMD.

Keywords: Body mass index, Bone mineral density.

Introduction
Definition: Osteoporosis is a systemic skeletal disease characterized by low bone mass and micro architectural deterioration of bone tissue with consequent increase in bone fragility and susceptibility to fractures[(1)].

In osteoporosis, bone is normal but reduced in density (bone mass per unit volume of bone tissue). DEXA (Dual Energy X-ray absorptiometry) is the gold standard in quantitatively estimating bone mineral density. Ultrasonic densitometers do not have a risk of radiation, are portable and there are reports to show that the sensitivity is similar to DEXA. However they have a limitation of their use in spine. DEXA and bone densitometer enable early diagnosis of this disorder. In ultrasound densitometry, the two most common measurements i.e. BUA (broad band ultrasound attenuation) and SOS (speed of sound) are combined to give composite index known as the stiffness index expressed as T score%. T score is further classified as per W.H.O criteria[(2)].

W.H.O. Criteria

Normal (< -1 SD)	A value of BMD that is below 1 SD of the young adult reference mean
Osteopenia (> -1 to -2.5 SD)	A value of BMD that is more than 1 SD below the young adult mean but less than 2.55 SD below this value
Osteoporosis (> 2.5 SD)	A value of BMD that is 2.5 SD or more below the young adult mean
Severe osteoporosis	A value of BMD that is more than 2.5 SD below the young adult mean in the presence of one or more fragility fracture

B.M.I = Body Mass Index was calculated by the formula weight in Kgs./ height in mts^2 and the patients were classified as normal with a BMI (20.1 – 25.0), lean (< 20.1) and obese (> 25.0) in males. In females normal had a BMI (18.7 – 23.8), lean (< 18.7) and obese (> 23.8). This classification shown is in agreement with the recommendation by WHO[(3)].

The pathogenesis is complex. In a young normal adult bone formation goes hand in hand with bone resorption. A state of dynamic Equilibrium exists when the resorption increase formation (which may be normal or decreased) then osteoporosis sets in.

Peak bone mass is reached at around 25-35 years thereafter bone loss occurs steadily. It is about 6% decrease in Indians[(4)]. Age, sex, race, nutrition, smoking, sedentary life-style, estrogen levels playing a role in this decrement. Cancellous bone in vertebral bodies, proximal and distal ends of long bones are affected first followed by cortical bone. After menopause there is an acceleration of bone loss averaging 2% per year for 5-10 years followed by a slower rate of bone loss which is indistinguishable to age related bone loss. Lifetime loss may reach 30-40% of peak bone mass in females and 20-30% in males.

Nearly more than 61 million Indians are reported to be osteoporotic, of these 80% are females[(5)]. With the increase in age the number is going to rise. Thus osteoporosis is a formidable health problem in our country and globally.

Nordin[(6)] observed that India has the highest prevalence of osteoporosis and osteopenia in world followed by Japan and also that bone loss may commence earlier in them. Osteoporosis like hypertension is an asymptomatic condition, does not manifest till the complications arise.

In this case fracture of neck of femur, lower end radius and spine fracture occur.

Osteoporosis may be either Primary or Secondary[7].

1. Primary osteoporosis can be classified into, Idiopathic affecting middle age and young adults where the cause is not known, Juvenile Involutional Type I – Post menopause Type II – Senile.
2. Secondary osteoporosis,

Endocrine diseases: Hypogonadism, Hyperparathyroidism, Diabetes mellitus, Acromegaly, Ovarian agenesis, hyperthyroidism.

Gastrointestinal diseases: Subtotal gastrectomy, malabsorption syndromes, chronic obstructive jaundice, primary biliary cirrhosis, severe malnutrition, anorexia nervosa. Bone marrow disorder: Multiple myeloma and related disorders, systemic mastocytosis, disseminated carcinoma.

Connective tissue disorders: Osteogenesis imperfecta, Homocystinuria, Marfan's syndrome.

Miscellaneous causes: Chronic alcoholism, Rheumatoid arthritis, pregnancy, Immobilization.

Risk Factors

The various risk factors for osteoporosis[8],

1. **Individual characteristics:** Caucasian race or Asian ethnicity,
   Menopause,
   Family History of osteoporosis,
   Low bone mass,
   Low body weight & small stature-It has been observed that tall subjects lose bone less rapidly than short subjects.

2. **Life style:** Cigarette smoking,
   Alcohol abuse,
   Sedentary lifestyle,
   Inadequate Calcium intake,
   Vitamin D deficiency,
   Excessive caffeine & exercise,
   Oxalates & Phytates.

3. **Drug use:** Cortico steroids,
   Gonadotropin release hormones,
   Anticonvulsants and heparin.

4. **Secondary causes:** All causes of secondary osteoporosis mentioned before.
5. **Surgical procedure:** Bilateral oophorectomy, Gastrectomy.

Aims and Objectives

1. To study the relationship of body mass index (BMI) and bone mineral density (BMD) in different age groups.
2. To assess the sensitivity of BMI as a screening tool in osteopenia and osteoporosis.
3. To study the relationship of anthropometric measurements like height, weight and BMD.

Material and Method

The study design-non randomized prospective study:

1. **Place and Period of study:** This study was carried out in the People's College of Medical Science and Research Centre, Bhopal M.P. between Jan 2014 to Sep 2014.
2. **Study subjects:** The study included a total of 489 patients. Above the age of 21 yrs.
3. **Selection of subjects:** Here the subjects were selected who had one or more of the risk factors for osteoporosis. As per WHO criteria.
4. **Criteria of exclusion:** Any pathology or trauma in the right calcanium were excluded. Eg. Osteomyelitis, Tumor, Fracture.
5. **Measurement of Bone Mineral Density:** The instrument used was Achilles express bone ultra-densitometer. Bone Mineral Density (BMD) measurements using QUS (Quantitative Ultra Sound) parameters were taken on the right calcaneum of all subjects. The subjects were classified based on these results as per WHO criteria into Normal, Osteopenia, Osteoporosis or Severely osteoporotic. The measurement was done by the same technician over the whole duration.
6. **Measurement of Height:** A standing height was measured by using vertical measuring rod and recorded in meters. The patient was asked to stand erect without shoes with heels together and shoulders, buttocks and heel touching the scale. The sliding headpiece was then brought down up to the head, touching the vertex and then the height was recorded.
7. **Measurement of weight:** A standard calibrated weighing machine was used for measuring the weight in Kilograms. The patients were asked to remove the shoes before stepping on the machine at the same portion on the weighing machine.
8. **Measurement of Body Mass Index (BMI):** After the weight and height were measured, their values were used to calculate the BMI using the formula:

$$BMI = \frac{Weight\ in\ Kgs}{(Height\ in\ Meters)^2}$$

Observations and Results

Three male subject were not included in this group as the densitometer could not give the reading, as they were way above the normal range

Table 2: showing age wise distribution of males and females in BMD subgroups

Age	Normal				Osteopenia				Osteoporosis				Total
	M	F	T	%	M	F	T	%	M	F	T	%	
21 – 30	15	9	24	57.14	15	3	18	42.85	0	0	0	0.00	42
31 – 40	39	39	78	57.70	21	30	51	37.77	0	6	6	4.44	135
41 – 50	27	30	57	35.18	30	60	90	55.55	3	12	15	9.25	162
51 – 60	33	9	42	38.88	12	33	45	41.66	9	12	21	19.44	108
61 & above	9	0	9	23.07	6	12	18	46.15	9	3	12	30.76	39
Total	123	87	210		84	138	222		21	33	54		486
%			42.94				45.40				11.08		

Table 2: showing weight wise distribution of males and females in BMD

Weight (Kg.s)	Normal				Osteopenia				Osteoporosis				Total
	M	F	T	%	M	F	T	%	M	F	T	%	
21 – 30	0	0	0	0.00	0	0	0	0.00	0	3	3	100	3
31 – 40	0	2	6	50.00	0	3	3	25.00	0	3	3	25.00	12
41 – 50	15	21	36	38.70	0	36	36	38.70	3	18	21	19.35	93
51 – 60	27	27	54	36.00	27	60	87	58.00	3	6	9	6.00	150
61 – 70	48	12	60	42.55	30	39	69	48.93	9	3	12	8.51	141
71 – 80	24	18	42	60.86	21	0	21	30.43	6	0	6	8.69	69
81 – 90	9	3	12	66.66	6	0	6	33.33	0	0	0	0.00	18
Total	123	87	210		84	138	222		21	33	54		486
%			42.94				45.40				11.04		

***M-Male, F-Female, T-Total**

Table 3: Showing height wise distribution of males and females in BMD

Height (Mtrs.)	Normal				Osteopenia				Osteoporosis				Total
	M	F	T	%	M	F	T	%	M	F	T	%	
1.21-1.30	0	0	0	0.00	0	0	0	0.00	0	3	3	100	3
1.31-1.40	0	3	3	33.30	0	3	3	33.33	0	3	3	33.8	9
1.41-1.50	3	33	36	32.43	0	60	60	54.05	0	15	15	13.51	111
1.51-1.60	45	45	90	47.61	18	66	84	44.44	3	12	15	7.93	189
1.61-1.70	51	6	57	44.18	45	9	54	41.86	18	0	18	13.95	129
1.71-1.80	21	0	21	53.84	18	0	18	46.15	0	0	0	0.00	9
1.81-1.90	3	0	3	50.00	3	0	3	50.00	0	0	0	0.00	6
Total	123	87	210		84	138	222		21	33	54		486
%			42.94				45.40				11.04		

Table 4: Showing relation of BMI with BMD

BMI		BMD						Total
		Normal		Osteopenia		Osteoporosis		
		No.	%	No.	%	No.	%	
Normal	**M**	54	46.15	0	43.58	12	10.25	66
	F	27	25.00	39	50.00	27	25.00	93
Lean	**M**	21	70.00	48	20.00	3	10.00	72
	F	9	50.00	33	33.30	3	16.66	45
Obese	**M**	48	59.25	12	33.30	6	7.40	66
	F	51	38.63	90	59.09	3	2.27	144
Significant		210	43.20	222	45.67	54	11.11	486

P < 0.005 (significant)

Discussion

Conventional radiograph has been used in the grading of osteoporosis. However any change in the mineral density of the bones can be detected by X-ray only after 40% demineralization[9].

Early quantitative and qualitative diagnosis has been made possible with the advent of DEXA and even the ultrasound densitometers. These are also less hazardous to the patients in levels of radiation, hence score over the conventional radiograph. This would get us to early diagnosis of osteoporosis and the treatment could be started accordingly and avoid the complication which could occur.

Among the risk factors for osteoporosis short, thin built white women[10] are at a risk of developing osteoporosis. In obese women fat tissue is an important extra gonadal source of oestrogen. The adrenal gland becomes the main source of both androgen and oestrogen production in the post-menopausal women[11].

The ovary in a normal woman produces approximately 80% of circulating oestradiol but only 40% of it is the circulating active form (oestrone), the remaining 60% of oestrone arise from peripheral conversion in fat to androstenedione, mainly of adrenal origin[10]. Coin A[12] observed, in men with B.M.I less than 22 the T score was less than 2.5 while men in control group had normal BMD. They also found significant decrease in B.M.D in underweight subjects as compared to the normal subjects in both sexes. They also found a lower T score in underweight women as compared to men.

Females: In our study there were 258 females of which 153 were menopausal and they were above 40 years of age. 105 were non-menopausal and they were below 40 years. There were 132 females in obese group (51.16%), 108 normal (41.86%) and 18 lean (6.96%).

Of the obese group out of 132 there were 93(70.45%) above 40 years of age, the remaining 39(29.54%) were below 40 years of age. In the lean group females were equally distributed i.e. 9(50%) above 40 years and 9 (50%) below 40 years. In normal group out of 108 females 69(63.88%) were above 40 years and 39(36.11%) were below 40 years of age.

Above 40 years of age out of the 171 females there were 39(22.80%) normal, 105(61.40%) osteopenia, 27(15.78%) osteoporotic. In lean group above 40 years all the females were menopausal of these6 (33.33%) were osteopenic, 3 (16.66%) was osteoporotic. In obese group of females above 40 years of 93 there were 24(25.80%) in normal 66(70.96%) osteopenic and 3 (3.22) osteoporotic. This observation shows that obesity in females confers protection against bone mineral loss especially in postmenopausal group.

Males: In our study there were 231 men of which 78 more above 50 years and 153 were below 50 years. There were 231 males (47.53%) out of which, 120 (51.94%) were having normal bone mineral loss, 30 (12.98%) were lean, 81 (35.06%) were obese. So of the 81 obese men 27 (33.33%) of them were above 50 years and the rest above 50 years and the rest 54 (66.66%) were below 50 years.

In the lean group of 30, there were 18 (60%) above 50 years and the rest 12 (40%) were below 50 years. The normal group of the 120 men there were 36 (30%) of them above 50 years and the rest 84(70%) of them were below 50 years. So above 50 years of males out of the 78 of them 42 (53.84%) were normal, 18 (23.07%) osteopenic, 18 (23.07%) osteoporotic.

In the lean group out of the 18 above 50 years males 9(50%) were normal, 6 (33.33%) were osteopenic and 3 (16.66%) were osteoporotic. In obese group out of the 27 above 50 years males there were 6 (22.22%) osteoporotic, 21 (77.77%) osteopenic. This observation showed that obesity did not show any protection against bone mineral loss.

Weight: In our study average weight of osteoporotic men was 75 kg which is higher as compared to non-osteoporotic men which was 62.78 kg. So this is in contrast to the study of Pacini S.[13] where he showed lower body weight in osteoporotic men as compared to non-osteoporotic patients. The average body weight of osteoporotic females is 47.72 kg., which is lower as compared to non-osteoporotic female which is 59.41 kg. So in our study we observed that the body weight does not correlate with B.M.D in males but it correlates in the females.

Height: In our study the average height of osteoporotic women was 1.471 mts. In non-osteoporotic women was 1.527 mts. This correlates with the study done by Sudo A[14] where in the group with decreased bone mass normal group had low average height, as compared to the control group.

But the males in our study of osteoporotic group had average height of 1.652 mts whereas the non-osteoporotic group had a mean height of 1.632 mts. So there was no significant difference. So in our study we observed that the height correlated with B.M.D in females but it did not correlate in males.

Summary & Conclusion

Definitely there is high prevalence of osteoporosis among Indians as compare to the individual of more developed countries and in view of large population and limited resources we need an effective method to screen out the high risk individual for definitive test of osteoporosis according to W.H.O guide line. The present study comprised of 489 subjects, which was carried out, of which there are 231 males and 258 females.

Observations recorded were:

- Body mass index

- Bone Mineral density using Heel ultra-densitometer and expressed as Total score.
- Body weight in Kg. Using a standard weighing machine.
- Height in meters using a vertical measuring rod with a sliding head piece.
- Age in years.

The data collected was analysed and it was found that there was significant correlation of B.M.D with BMI in all age groups and both sexes. There was significant correlation of B.M.D with respect to body weight and height only in females but not in males. Hence we conclude that B.M.I can be used as screening tool for selecting patients for quantitative estimation of BMD.

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