RESEARCH ARTICLE

CONTRIBUTION OF PREDICTED SKELETAL MASS AND FAT MASS BY ANTHROPOMETRIC METHODS IN DETERMINING BONE MINERAL DENSITY IN ELDERLY INDIAN WOMEN

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ABSTRACT
Background: Osteoporosis and obesity are two public health problems that are growing in prevalence worldwide, including in India.
Aims & Objective: The purpose of this study was to investigate the association between fat mass, skeletal mass, and bone mineral density (BMD) in elderly Indian women.
Materials and Methods: A cross-sectional study was conducted in 34 healthy Indian women aged 40–75 years. BMD were measured by ultrasound bone densitometry. Fat mass and skeletal mass were measured by anthropometric methods. To evaluate the associations between fat mass and skeletal mass and BMD, multivariable linear regression models were used to estimate the regression coefficients for fat mass and skeletal mass.
Results: In elderly women, after controlling for age and height, both fat mass and skeletal mass were positively correlated with BMD when they were analyzed independently of each other. When included in the same equation, both fat mass and skeletal mass continued to show a positive effect, but skeletal mass had a significantly greater impact on BMD than fat mass.
Conclusion: This study concludes that anthropometric variables, such as weight, height, Skeletal mass, Fat mass seem to be significant predictors of bone mineral density in elderly women. Skeletal mass had a significant beneficial effect on BMD in elderly women and can be considered as one of the determinants of bone mass.
Key Words: Bone Mineral Density; Fat Mass; Skeletal Mass

Introduction

Osteoporosis and obesity are two public health problems that are growing in prevalence worldwide, including in India. Interestingly, these two body composition disorders, once believed to be unrelated to each other, share several features at both the molecular and clinical levels, and are also correlated with similar environmental factors.[1] Several studies have investigated the influence of anthropometrical parameters such as body height, body mass, skeletal mass, and body mass index (BMI) to the BMC and BMD. Low body mass has been declared to be a significant risk factor in the development of osteoporosis; on the other hand, obesity has been mentioned as a significant confounder of BMD.[2]

The influences of anthropometric parameters with their more or less global effects on bone have been studied in some investigations. The results of these studies most often revealed a positive influence of total body weight, body mass index (BMI), lean body mass (LBM), body fat, and height on BMD, with, however, a large variation in correlation coefficients.[3] The correlations between anthropometric parameters and BMD might partly be explained by their mechanical effects on bone.[4] Body weight, for instance, provides resistance that muscles must overcome for work and play.[5] It remains unclear, however, whether BMD is determined by body weight per se or by single components of anthropometric variables.

Assessment of bone mineral density (BMD) is not possible everywhere and needs to special tool and equipment, for instance DEXA, etc. and these are not portable, also this is very costly and this study wants to find a cheap, simple and accessible method to prediction of bone mineral density (BMD) everywhere by anthropometric characteristics and without need to special and expensive tools. Therefore the main purposes of the present investigation were to estimate the relationship of anthropometric parameters on bone mineral density and predict BMD based on anthropometric variables.

Materials and Methods

Anthropometric Measurements

Participants' body weight, height, humerus breadth, wrist breadth, femur breadth, ankle breadth, limb circumferences (upper arm, thigh, and calf), and skin fold thickness (triceps, thigh, and calf) were measured by trained testers. All the measurements were conducted on the right side of the body. Height was measured in the upright position to the nearest millimetre (0.1cm) with a stadiometer. Body mass (weight), was measured to the nearest 0.1kg using digital scale. Humerus breadth (bi-epicondylar) was measured the distance between medial and lateral epicondyles of the humerus when the arm is raised forward to the horizontal and the forearm is flexed to a right angle at the elbow. Wrist breadth (bistyloid) was measured when the right forearm is resting on the subject's thigh and the hand flexed at the wrist to an angle of about 90^0. Femur breadth: (bi-epicondylar) was measured the distance between medial and lateral epicondyles of the femur when the subject is seated and the leg is flexed at the knee to form a right angle with the thigh. Ankle breadth was measured the distance between the maximum protrusion of the medial tibia malleolus and the lateral fibular malleolus. All the measurements were taken at the nearest 0.1 cm by using Breadth calliper. Triceps skin fold thickness was measured at midway between the lateral projection of the acromion process of the scapular and the inferior margin of the olecranon process of the ulna. The thigh skin fold site was located in the midline of the anterior aspect of the thigh, midway between the inguinal crease and the proximal border of the patella. Upper arm and thigh circumference were measured via measuring tape horizontally around at the same level as the triceps and thigh skin folds. Calf circumference was measured by a measuring tape horizontally around at the level of the maximum circumference. The calf skin fold was measured at the point on the medial surface of the calf, at the same level as the calf circumference. BMD was assessed with ultrasound bone densitometry instrument. BMD was measured at calcaneal site.

Following formulas were used to calculate Skeletal Mass, % body fat:

- *Skeletal Mass as per Drinkwater et al. (1986) equation:*
  $S (kg) = [(HB+WB=FB=AB)/4]^2 \times ht \times 0.92kg \times 0.001$
  Where, HB: biepicondylar humerus breadth; WB: bistyloideus breadth; FB: biepicondylar femur breadth; AB: bimalleolus breadth; ht: height in cm.
- *Body density as per Jackson et al. (1980) equation:*
  $\text{Body density} = 1.099421 - 0.0009929(\sum 3skf) + 0.0000023(\sum 3skf)^2 - (0.0001392(X_2)$
  Where, $\sum 3skf$ = sum of 3 skinfolds in mm i.e. Suprailiac, Triceps and Midthigh. X_2 = Age in years.
- *% Body Fat as per Siri Equation (1956):*
  % Body Fat = [(4.95 ÷ Body Density) - 4.5] × 100

Protocol

All tests were conducted after a medical investigation; a standardized questionnaire assessing information regarding the personal and family history about bone fractures, exercise training and nutrition history was applied to eliminate risk factors that might interfere with bone metabolism. All anthropometrical parameters were measured according to the protocol recommended by the International Society for the Advancement of Kinanthropometry (ISAK). Anthropometric variables were conducted after a light breakfast and without exercise for 12 hours. Those were measured in the Health & Sport Clinic in the Faculty of physical Education & Sports Sciences in Visva Bharati University, Santiniketan, India. The study was conducted according to the ethical principles for clinical research involving human subjects in accordance to the Declaration of Helsinki.

Statistics

Descriptive statistics for and Regression - stepwise - multiple was used to predict bone mineral density via anthropometric variables in elderly women. Significance was set at $p<0.05$ for all tests. Analyses were carried out using SPSS v18.0 (SPSS, 2009).

Results

Mean and standard deviations and standard error for all the variables of elderly women are presented in Table 1.

Correlation Coefficients between Anthropometric variables and BMD

Positive significant correlations were detected between anthropometric variables and BMD (Table 2). The results of this study were showed a significant correlation between bone mineral density and age (r = -0.587, p <0.002), height (r = 0.518, p <0.008) weight (r = 0.516, p <0.008), BMI (r = 0.412, p <0.041), SM (r = 0.647, p <0.000), and % Fat (r = 0.423, p <0.044).

Stepwise Multiple Regression Prediction of BMD

Results of step-wise multiple regression analysis for anthropometric variables (age, body height, weight, BMI, SM, % Fat), best predict bone mineral density (BMD) in elderly women are shown in Table 3. From all the variables, entered into the equation using stepwise multiple regression analysis, BMD as dependent, following results were obtained. Out of 6 variables entered into equation, 3 variables best predicted the

BMD. The first and foremost variable to predict Bone Mineral Density (BMD) was Age with the correlation coefficient of R=.693 with the contribution of 45.8% (F = 21.295, p <0.000). Thereafter other variables Skeletal Mass (SM) 25.8% (F = 31.26, p <0.000), % Fat 14.9% (F = 52.296, p <0.000) were predicted the Bone Mineral Density (BMD), respectively. Other Anthropometric variables did not predict the Bone Mineral Density (BMD) in elderly women.

Table-1: Baseline characteristics of the variables

Variables	Mean	Std. Deviation	Std. Error
Age (yrs.)	53.50	1.44	8.15
Height (cm)	152.02	0.88	4.99
Weight (kg)	60.92	1.73	9.81
BMI	26.34	0.70	3.98
BMD (T-score)	-2.51	0.19	1.09
SM (kg)	5.41	0.09	0.54
% Fat	32.46	1.06	5.99

Table-2: Correlations between BMD and other variables

Variables	BMD (T-score)	
	Correlation	Sig
Age (yrs.)	-0.587**	0.002
Height (cm)	0.518**	0.008
Weight (kg)	0.516**	0.008
BMI	0.412*	0.041
SM (kg)	0.647**	0.000
% Fat	0.423*	0.044

* Correlation is significant at the 0.05 level (2 tailed); ** Correlation is significant at the 0.01 level (2- tailed); BMD: bone mineral density; BMI: body mass index; % Fat: percent fat mass; SM: skeletal mass.

Table-3: multiple regression analysis to predict BMD

Model	Variables Entered	Variables Removed	R	R Square	Adjusted R Square
1	Age	-	0.693	0.481	0.458
2	SM	-	0.860	0.740	0.716
3	%Fat	-	0.939	0.882	0.865

Discussion

This study found Positive significant correlations were detected between anthropometric variables and BMD in elderly women. The results of this study were showed a significant correlation between bone mineral density and age, height, weight, BMI, Skeletal mass, and % Fat.

From all Anthropometric variables, entered into the equation using stepwise multiple regression analysis, Bone mineral density as dependent, following results were obtained. Out of 6 Anthropometric variables entered into equation, the first and foremost variable to predict Bone Mineral Density (BMD) was Age. Skeletal mass and % Fat were the second and third variables for prediction BMD in the elderly women.

Most studies on the relationships between anthropometric characteristics, bone mineral densities, and bone mass in elderly women revealed positive correlations between BMD values and anthropometric characteristics.[6,7] The limitation of the study was its small sample size. Further studies may be conducted with larger samples to contribute to generalization of the results.

Conclusion

Both the skeletal mass and fat mass positively affect BMD, and both the component is the main determinant of bone mineral density. However, greater quantities of skeletal and fatty masses have a protective effect against this reduction of BMD. These results show that slimmer women, especially those with less muscular mass, present higher risk for developing osteoporosis during the postmenopausal period. Furthermore this method can help those where there are no facilities to take a BMD test with sophisticated instruments.

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