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ORIGINAL ARTICLE
ORİJİNAL ARAŞTIRMA

Relation of age, body weight and BMI with bone mineral density (BMD) at spine, proximal femur and total body BMD in postmenopausal Kashmiri women: a study of 165 cases.

Postmenopozal Kaşmirli Kadınlarda Yaş, Vücut Ağırlığı ve VKİ ile Omurga, Proksimal Femur ve Toplam Vücut Kemik Mineral Yoğunluğu (KMY) arasındaki ilişki: 165 Olgu Üzerinde Yapılan Bir Çalışma.

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ÖZ

Amaç: Postmenapozal Kaşmirili kadınlarda osteoporoz prevalansını ve yaş, vücut ağırlığı ve Vücut Kitle İndeksi (VKİ) ile Kemik Mineral Yoğunluğu (KMY) arasındaki ilişkiyi araştırmak.

Yöntem: Poliklinik başvurusunda bulunan ve yazılı bir aydınlatılmış onam alınan Postmenopozal kadınlar çalışmaya alındı. Her bir özne için yaş, boy ve ağırlık kaydedildi ve BMI, kg / m2 olarak hesaplandı. Dual Enerji X-ray Absorptiometri (DEXA) kullanılarak lumbar omurga, proksimal femur ve tüm vücutta BMD (t-skoru) elde edildi. Olgular yaş, kilo, VKİ ve KMY'ye (t-skoru) göre gruplara ayrıldı. Sonuçlar, SPSS istatistiksel paket program kullanılarak analiz edilmiştir.

Bulgular: Ortalama yaşları 58.9 ± 9.7 yıl olan, ortalama ağırlığı 56.5 ± 11.7 kg ve ortalama BMI 24.1 ± 4.3 kg / m2 olan 165 postmenopozal Kaşmirli kadın analiz edildi. Lumbar omurga, proksimal femur ve total vücutta düşük kemik kitlesi (osteopeni ve osteoporoz) sırasıyla% 96.4,% 64.3 ve% 68.5 idi. Tüm bölgelerde osteoporoz prevalansı ileri yaş gruplarında istatistiksel olarak daha anlamlıydı (P <0.05). Hem vücut ağırlığı, hem de VKİ açısında daha yüksek bir tarafta bulunma, osteoporoza karşı koruyucu bir etkiye sahipti ki bunlar bel omurundaki VKİ ve KMY hariç istatiksel olarak anlamlıydı (p <0.05) (P = 0.276). Yaş, tüm ölçülen yerlerde KMY ile negatif korelasyon (P <0.00001), vücut ağırlığı ve VKİ ise pozitif korelasyon gösterdi (P <0.00001).

Sonuç: Kaşmirli postmenopozal kadınların yaklaşık% 80'i bel omurunda osteoporotiktir. Sadece dörtte birinin total vücut KMY'sine göre osteoporotik olduğu ve proksimal femur KMY'sine göre beşte birinin osteoporotik olduğu görülüyor. Artan yaş ile KMY tüm bölgelerde azalmaktadır. BMI'nun koruyucu olmadığı lomber omurga haricinde, vücut ağırlığındaki ve VKİ'nin osteoporoza karşı koruyucu bir rolü vardır. Vücut ağırlığı, tüm bölgelerdeki KMY açısından VKİ'den daha iyi bir öngörücüdür.

Anahtar Kelimeler: Osteoporoz, Osteopeni, Kemik Mineral Yoğunluğu, Vücut Kitle İndeksi, Menapoz

ABSTRACT

Aim: To find prevalence of osteoporosis and relation of age, body weight and Body Mass Index (BMI) with Bone Mineral Density (BMD) in postmenopausal Kashmiri women.

Methods: Postmenopausal women, attending the outpatient department, were registered for the study after taking a written informed consent. Age, height and weight were recorded for each subject and BMI calculated as kg/m^2. BMD (t-score) was obtained at lumbar spine, proximal femur and whole body using Dual Energy X-ray Absorptiometry (DEXA). The subjects were divided into groups based on age, weight, BMI, and BMD (t-score). The results were analyzed using statistical package for social sciences.

Results: 165 postmenopausal Kashmiri women with a mean age of 58.9 ± 9.7 years, mean weight of 56.5 ± 11.7 kg and mean BMI of 24.1 ±4.3 kg/m^2 were analyzed. 96.4 %, 64.3% and 68.5 % subjects had low bone mass (osteopenia and osteoporosis) at lumbar spine, proximal femur and total body respectively. Prevalence of osteoporosis at all the sites was more in advanced age groups which was statistically significant (P < 0.05). Both body weight and BMI on a higher side had a protective influence against osteoporosis which was statistically significant (P < 0.05) except for BMI and BMD at lumbar spine (P = 0.276). Age had a negative correlation with BMD at all the measured sites (P < 0.00001) while as body weight and BMI had a positive correlation (P < 0.00001).

Conclusion: Nearly 80 % of Kashmiri postmenopausal women are osteoporotic at the lumbar spine. While as only one fourth's are osteoporotic with respect to total body BMD and only one fifth's with respect to proximal femur BMD. With increasing age BMD decreases at all the sites. Increase in body weight and BMI have a protective role against osteoporosis with exception of lumbar spine where BMI is not protective. Body weight is a better predictor of BMD than BMI at all the sites.

Keywords: Osteoporosis, Osteopenia, Bone Mineral Density, Body Mass Index, Menopause

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Introduction

Osteoporosis is the most common metabolic bone disease having multi-factorial association. (1, 2) It is characterised by a decrease in the bone mineral density (BMD), predisposing to risk of fragility fractures. (3- 5) Osteoporosis is a worldwide public health problem primarily associated with aging and its prevalence is expected to increase with increase in life expectancy of the population. (6-8)

The human skeleton undergoes continuous remodelling throughout life to maintain its strength. The plateau of peak bone mass is reached in the middle of third decade of life and thereafter bone re-sorption exceeds new bone formation at the rate of about 0.3 to 0.5 % per year. In women, this rate of bone loss increases tenfold for five to seven years after the onset of the menopause, which makes postmenopausal women more susceptible to develop osteoporosis than male counterparts.(7)

Fragility fractures in the elderly population and their consequent morbidity, mortality and socioeconomic burden can be prevented if osteoporosis is diagnosed and treated early. (9) Postmenopausal women who are having risk factors for development of osteoporosis need to be screened for osteoporosis. It is a well established fact that body mass index (BMI) and body weight have a positive correlation with BMD while as advancing age has a negative impact on BMD. (1, 9-13) So these parameters should be analysed to know about the at risk postmenopausal women. We here study the relation of age, body weight and BMI with BMD in postmenopausal women of Kashmir province of India to know about the parameters which are better predictors of osteoporosis in this population.

MATERIAL AND METHODS

The study was conducted on postmenopausal women (not experienced any menstrual bleeding for a minimum of one year despite presence of an intact uterus and absence of pregnancy and lactation) attending the outpatient clinic of a tertiary care centre of Kashmir province of India from January 2015 to August 2016. Postmenopausal women with thyroid disorders, parathyroid disorders, diabetes mellitus, chronic renal disease, chronic liver disease, chronic obstructive lung disease, bronchial asthma, malignancy, rheumatoid arthritis and other chronic arthritis, other metabolic bone disease, mal-absorption syndrome, compression fractures of the spine, or with history of smoking, alcoholism, long term immobilization, hysterectomy, surgical menopause, hormone replacement therapy, use of drugs causing osteoporosis, and bisphosphonate therapy were excluded from the study.

A total number of 165 postmenopausal women with age ranging from 42 to 85 years were enrolled for the study. Informed written consent was obtained from each subject. Subjects were dressed in light clothes and without wearing shoes, weight in kilograms and height in meters was recorded and BMI calculated as weight (kg)/ [Height (m)] ^{2}, after which Bone Mineral Density (t-score) was obtained at lumbar spine (L-1 to L-4 vertebra), proximal femur and total body using Dual Energy X-ray Absorptiometry (DEXA) scan. As per World Health Organization (WHO) criteria and definition, a t-score of $\geq$ -1 is normal bone mass; t- score $\leq$ -1 but > -2.5 is categorised as osteopenia and; a t-score of $\geq$ -2.5 is labelled at osteoporosis. (5, 14)

The subjects were divided into groups on the basis of age, weight and BMI. On the basis of age we had three groups (Age $\leq$ 55 years; 55 to 65 years and > 65 years), and two groups on the basis of weight (weight $\leq$ 55kg and; > 55 kg). BMI was categorised into four groups based on the guidelines from Centre for Disease Control (CDC) (underweight: BMI < 18.5 kg/m^2; normal weight: BMI 18.5 to 24.9

kg/m^2; overweight: BMI 25 to 29.9 kg/m^2; and obese: BMI ≥ 30 kg/m^2). 15 In each of these groups, BMD (t-score) was analysed at lumbar spine, proximal femur and total body.

The date collected was analyzed using statistical package for social sciences (SPSS) software and expressed as mean ± SD. The association between variables (age, weight and BMI) and BMD was analysed using Chi-square test. The correlations and trend between variables and BMD was calculated using Pearson's correlation coefficient test. P-value < 0.05 was considered statistically significant.

RESULTS

The study population included 165 postmenopausal Kashmiri women with an average age of 58.9 ± 9.7 years. The various anthropometric parameters and the bone mineral density (t- score) at lumbar spine, proximal femur and total body BMD of the study population have been summarized in Table I.

Only 3.6 % of the subjects had normal bone mass and the remaining 96.4 % had low bone mass (osteopenia and osteoporosis) at the lumbar spine. On the other hand 64.3 % had low bone mass, at the proximal femur. On the basis of total body BMD 31.5 % subjects had a normal bone mass (Table II).

All the subjects > 65 years of age had low bone mass (osteopenia and osteoporosis) at the lumbar spine. 66.1 %, 83.6 % and 94.4 % of the subjects of the age groups ≤ 55 years, 55 – 65 years and > 65 years, respectively, were osteoporotic at the lumbar spine. At proximal femur, 4.8 %, 20.9 % and 47.22 % and as per total body BMD 9.7 %, 26.9 % and 47.22 % of the subjects of the age groups ≤ 55 years, 55 – 65 years and > 65 years were osteoporotic respectively. Incidence of osteoporosis at lumbar spine, proximal femur and as per total body BMD was more in advanced age groups which was statistically significant (Table II). Pearson's correlation test demonstrated a negative statistically significant correlation between age and BMD at lumbar spine, proximal femur and for total body BMD. However, this correlation was moderate for lumbar spine (R = -0.4) and strong for proximal femur (R = -0.5) and total body BMD (R = -0.5) (Table III, Figure 1).

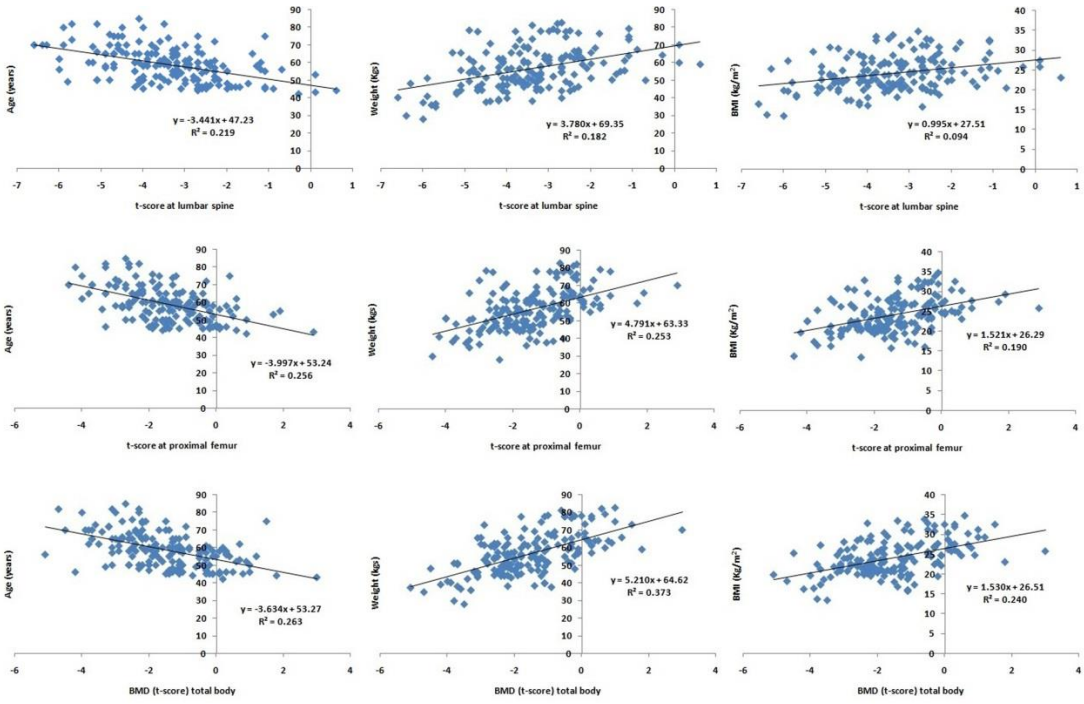

Figure 1: Scatter diagram with trend line depicting correlation of age, weight and BMI with BMD (t-score) at lumbar spine, proximal femur and total body BMD.

Table I: Anthropometric variables and Bone Mineral Density (T-Score) of the study population.

Variable	Mean ± SD	Range
Age (years)	58.9 ± 9.7	42 - 85
Weight (Kg)	56.5 ± 11.7	27.9 – 82.8
Height (cm)	152.7 ± 7.5	128 - 172
BMI (kg/m²)*	24.1 ± 4.3	13.5 – 34.7
Lumbar Spine L1 to L4 (t – score)	-3.4 ± 1.3	-6.6 – 0.6
Proximal Femur (t – score)	-1.4 ± 1.2	-4.4 – 2.9
Total Body (t – score)	-1.6 ± 1.4	-5.1 - 3

*BMI: Body Mass Index

Weight had a statistically significant impact on BMD at lumbar spine (χ^2 = 11.33; P = 0.0034), at proximal femur (χ^2 = 32.97; P > 0.00001) and for total body BMD (χ^2 = 44.03; P > 0.00001) (Table II). 90.1 %, 32.1 % and 37.0 % of the participants' ≤ 55 kg in weight were osteoporotic at lumbar spine, proximal femur and for total body BMD respectively, where as only 65.5 %, 9.5 % and 13.1 % of the participants > 55 kg in weight were osteoporotic at these respective sites of BMD measurement. The correlation of weight with BMD was significantly positive which was moderate for the lumbar spine (R = +0.4) and strong for proximal femur (R = +0.5) and total body BMD (R = +0.6) (Table III, Figure 1).

7.3 % of the study population were underweight and 38.8 % were overweight and obese as per CDC guidelines for categorization of the BMI (Table II). 96.6 % of normal BMI group and 95.3 % of overweight and obese BMI groups had low bone mass at spine which was not statistically significant (P < 0.05) (Table III). However, 77.1 % of the normal BMI group and 46.8 % of the overweight and obese groups had low bone mass at the proximal femur which was statistically significant. Similar relation was also found between total body BMD and BMI (Table III). Pearson's correlation test had a positive relation between BMI and BMD at lumbar spine, however, the relation was weak (R = +0.3). While as this correlation was found to be moderate at proximal femur (R = +0.4) and for the total body BMD (R = +0.4).

Weight and BMI both had positive correlation with BMD at all the measured sites, but weight had stronger correlation as compared to BMI (Table III).

DISCUSSION

Osteoporosis is a worldwide problem characterized by decrease in bone mass and structural degeneration of the bone. (6, 16) Symptomless loss of bone mass makes it a 'silent disorder'. (16) Prevalence of osteoporosis is on increase due to increase in aging population. In India population aged above 50 years constitutes 10 % of the total population and is likely to constitute 34 % of total population by year 1950. And life expectancy of 67 years at present is expected to increase to 77 years by 1950. (8, 16)

Osteoporosis can afflict any sex, but postmenopausal women are the most vulnerable group. After menopause, women loose bone mass at the rate of 1 – 2 % per year for about 5 to 10 years. After 5 years of onset of menopause mean fall in BMD is 7 – 10 % in vertebral column and 5 to 7 % in the pelvic bones. (17, 18)

Table II: Distribution of BMD at lumbar spine, proximal femur and total body according to independent variables (age, weight and BMI)**

Distribution of BMD* at Lumbar Spine according to independent variables (age, weight and BMI**)							
Variable		Normal Bone Mass	Osteopenia	Osteoporosis	Total	Chi Square X^2	P-value
		No. (%)	No. (%)	No. (%)	No. (%)		
Age (yrs)	≤55	5 (3.0)	16 (9.7)	41 (24.9)	62 (37.6)	13.83	0.0078
	55 - 65	1 (0.6)	10 (6.1)	56 (33.9)	67 (40.6)		
	>65	0 (0)	2 (1.2)	34 (20.6)	36 (21.8)		
Total		6 (3.6)	28 (17.0)	131 (79.4)	165 (100)		
Weight (kg)	≤55	1 (0.6)	7 (4.2)	73 (44.2)	81 (49.0)	11.33	0.0034
	>55	5 (3.0)	21 (12.8)	58 (35.2)	84 (51.0)		
Total		6 (3.6)	28 (17.0)	131 (79.4)	165 (100)		
BMI** (kg/m^2)	Underweight	0 (0)	0 (0)	12 (7.3)	12 (7.3)	7.50	0.276
	Normal	3 (1.8)	13 (7.9)	73 (44.2)	89 (53.9)		
	Overweight	3 (1.8)	10 (6.1)	32 (19.4)	45 (27.3)		
	Obese	0 (0)	5 (3.0)	14 (8.5)	19 (11.5)		
Total		6 (3.6)	28 (17.0)	131 (79.4)	165 (100)		
Distribution of BMD* at Proximal Femur according to independent variables (age, weight and BMI**)							
Variable		Normal Bone Mass	Osteopenia	Osteoporosis	Total	Chi Square X^2	P-value
		No. (%)	No. (%)	No. (%)	No. (%)		
Age (yrs)	≤55	34 (20.6)	25 (15.2)	3 (1.8)	62 (37.6)	34.17	<0.00001
	55 - 65	22 (13.3)	31 (18.8)	14 (8.5)	67 (40.6)		
	>65	3 (1.8)	16 (9.7)	17 (10.3)	36 (21.8)		
Total		59 (35.7)	72 (43.7)	34 (20.6)	165 (100)		
Weight (kg)	≤55	12 (7.3)	43 (26.0)	26 (15.8)	81 (49.1)	32.97	<0.00001
	>55	47 (28.5)	29 (17.6)	8 (4.8)	84 (50.9)		
Total		59 (35.8)	72 (43.6)	34 (20.6)	165 (100)		
BMI** (kg/m^2)	Underweight	3 (1.8)	4 (2.4)	5 (3.1)	12 (7.3)	22.08	0.0011
	Normal	22 (13.3)	46 (27.9)	21 (12.7)	89 (53.9)		
	Overweight	20 (12.1)	19 (11.6)	6 (3.6)	45 (27.3)		
	Obese	14 (8.5)	3 (1.8)	2 (1.2)	19 (11.5)		
Total		59 (35.7)	72 (43.7)	34 (20.6)	165 (100)		
Distribution of BMD* Total Body according to independent variables (age, weight and BMI**)							
Variable		Normal Bone Mass	Osteopenia	Osteoporosis	Total	Chi Square X^2	P-value
		No. (%)	No. (%)	No. (%)	No. (%)		
Age (yrs)	≤55	32 (19.4)	24 (14.5)	6 (3.6)	62 (37.6)	28.60	<0.00001
	55 - 65	17 (10.3)	32 (19.4)	18 (10.9)	67 (40.6)		
	>65	3 (1.8)	16 (9.7)	17 (10.3)	36 (21.8)		
Total		52 (31.5)	72 (43.7)	41 (24.8)	165 (100)		
Weight (kg)	≤55	6 (3.6)	45 (27.3)	30 (18.2)	81 (49.1)	44.03	<0.00001
	>55	46 (27.9)	27 (16.4)	11 (6.6)	84 (50.9)		
Total		52 (31.5)	72 (43.7)	41 (24.8)	165 (100)		
BMI** (kg/m^2)	Underweight	1 (0.6)	5 (3.1)	6 (3.6)	12 (7.3)	37.03	<0.00001
	Normal	15 (9.1)	47 (28.5)	27 (16.4)	89 (53.9)		
	Overweight	22 (13.3)	15 (9.1)	8 (4.8)	45 (27.3)		
	Obese	14 (8.5)	5 (3.0)	0 (0)	19 (11.5)		
Total		52 (31.5)	72 (43.7)	41 (24.8)	165 (100)		

BMI: Body Mass Index

The prevalence of osteoporosis in Indian women ranges from 8 to 62 % in different studies. (19) Jain V et al (2013) in their study in Bhopal (India) using quantitative Ultrasound at calcaneum had 33.5 % and 43.5 % of postmenopausal women osteoporotic and osteopenic respectively. (9)Unni J et al (2010) had 31.4 % of women, more than 40 years of age in Pune (India), osteopenic and 14.3 % had osteoporosis. (13) In our study, 20.6% postmenopausal women were osteoporotic and 43.7 % were osteopenic at the proximal femur,

which is comparable to other studies.

Table III: Correlation between Anthropometric variables and Bone Mineral Density

Variable	BMD* (T-score) at lumbar spine		BMD* (T-score) at proximal femur		BMD* (T-score) Total body	
	R***	P-value	R***	P-value	R***	P-value
Age (years)	- 0.468	<0.00001	-0.506	<0.00001	-0.514	<0.00001
Weight (kg)	+0.427	<0.00001	+0.504	<0.00001	+0.611	<0.00001
BMI** (kg/m²)	+0.307	<0.00001	+0.437	<0.00001	+0.490	<0.00001

*BMD: Bone Mineral Density; **BMI: Body Mass Index;
***R: Paerson Correlation cofficient

However, at lumbar spine 79.4 % of the subjects had osteoporosis and 17 % had osteopenia. Such discordance in BMD at different sites of measurement in same study population has been seen before as well. Chhibber G et al (2007) in their study in Delhi and rural Haryana of India had 58.4 % of postmenopausal women osteoporotic at the lumbar spine, but only 24.4 % were osteoporotic at the proximal femur. (20) Lu YC et al (2016) found 50 % discordance between osteoporosis classification based on t-score measured at lumbar spine and proximal femur. Using lowest t-score from multiple sites significantly increases prevalence of osteoporosis in postmenopausal women from 4.03 % to 10.75 %. (21) There are different reasons for such discordance. Woodson proposed physiological factors, pathophysiological factors, anatomic factors, artifacts, technical problems as reasons for such discordance. (22) Weight bearing increases BMD at hip which explains high BMI (obesity) as a risk factor for such discordance. (21, 23) In a retrospective study on postmenopausal women in India, 34.7 % had minor discordance and 16.67 % had major discordance in t-score at hip and spine. (24)

Aging has detrimental effect on bone mass especially in the postmenopausal women, where bone loss is accelerated secondary to loss of ovarian function. (25, 26) BMD decreases at a faster rate in elderly women than elderly men. (27) In our study 50 % of the postmenopausal women, osteoporotic at the proximal femur, were > 65 years of age and 41.2 % were of the age group 55 to 65 years. 94.4 % of the subjects aged > 65 years were osteoporotic at the lumbar spine. There was a negative correlation between age and BMD at all the measured sites. These observations are consistent with the studies of Douchin T et al (2000), Chanprasertyothin S et al (2006), Montazerifar F et al (2014), Sharmin S et al (2014) and Petroudia SR et al (2016). (1, 8, 28-30)

Even though there are studies which have revealed that obesity has a negative influence on BMD, majority of the studies show both body weight and BMI have a positive impact on bone mass. This has been explained by whether obesity is defined in terms of body weight and BMI or on the basis of amount of total body fat expressed as percentage of body weight. (31, 32) In our study both body weight and BMI had a statistically significant role in protection against osteoporosis except at spine where relation of BMI and BMD was not statistically significant ($p = 0.276$). BMD at all the measured sites, in our study, had a positive significant correlation with body weight as well as BMI. However, the correlation was more for the body weight than BMI at all the measured sites (Table III). Petroudia SR et al (2016) in their study had similar results as ours and concluded body weight is a better predictor of BMD than BMI. (8) It is proposed body weight is the better predictor of BMD than BMI as square of height in the formula for calculating BMI underestimates BMD in tall and overestimates BMD in short statured

subjects. (33, 34) Montazerifar F et al (2014) had positive correlation of weight and BMI with BMD at lumbar spine as well as femoral neck but it was statistically significant for only lumbar spine. (1) Increased soft tissue mass in obese and overweight leads to mechanical loading of the bone which stimulates differentiation of osteoblasts. Besides the adipose tissue in obese postmenopausal women is a source of estrogens from aromatization, resulting in increase in BMD. (28, 31, 35)

CONCLUSION

Around one third of Kashmiri postmenopausal women have normal total body and proximal femur BMD. One fourth of women have osteoporosis with regard to total body BMD and one fifth have osteoporosis at proximal femur. With regard to lumbar spine majority (around 80 %) are osteoporotic. With increasing age of postmenopausal women BMD decreases at all the skeletal sites. There is a significant negative correlation between age and BMD at all the sites. Higher body weights as well as obesity (higher BMI) have a protective effect on BMD in postmenopausal Kashmiri women, except at lumbar spine, where increase in BMI may not protect against osteoporosis, even though BMI of the subjects and BMD at their lumbar spine have a positive correlation. Body weight is a better predictor of BMD at all the sites than BMI; both in terms of Chi Square test as well Paerson's correlation coefficient. Thus, postmenopausal women with lower body weights constitute a high risk group for development of osteoporosis.

Besides age, weight and BMI, BMD after menopause is influenced by multiple factors such as, age at menarche, parity, duration of lactation of children, dietary habits, level of physical activity and lifestyle, socioeconomic status, educational level, status of vitamin D, truncal obesity, total body fat mass, total body lean mass and genetic predisposition, all of which have not been taken into consideration in this study. The premenopausal BMD status of the Kashmiri women has not been studied, so there is a need of a study which compares BMD status in both premenopausal as well as postmenopausal women. These are the limitations of our study and need to be addressed in future studies on postmenopausal women from Kashmir.

REFERENCES

1. Montazerifar F, Karajibani M, Alamian S, Sandoughi M, Zakeri, Z, Dashipour AR. Age, Weight and Body Mass Index Effect on Bone Mineral Density in Postmenopausal Women. *Health scope* 2014;3(2):e14075.
2. Lurati A, Laria A. Relationship between Lumbar Bone Mineral Density (BMD) and Body Mass Index (BMI) in Pre-Menopausal Population. A Large Cohort Study. *Rheumatology (Sunnyvale)* 2015;5(4):181.
3. Johnell O, Kanis JA, Oden A, Johansson H, De Laet C, Delmas P. et al. Predictive value of BMD for hip and other fractures. J Bone Miner Res 2005;20(7):1185-94.
4. Marshall D, Johnell O, Wedel H. Meta-analysis of how well measures of bone mineral density predict occurrence of osteoporotic fractures. *BMJ* 1996;312(7041):1254-9.
5. Kanis JA, Melton LJ, Christiansen C, Johnston CC, Khaltaev N. The diagnosis of osteoporosis. *J Bone Miner Res* 1994;9(8):1137-41.
6. Mishra AK, Gajjar K, Patel K. Association between Body Mass Index and Bone Mineral Density among healthy women in India. Int *J Med Res Health Sci* 2016;5(4):156-60.
7. Simon LS. Osteoporosis 2005. *Clin Geriatr Med* 2005;2(3)1:603-29.
8. Petroudia SR, Ziaei S, Ardekani AE. Body weight is a Better Predictor of Bone Mineral Density than Body Mass Index in Postmenopausal Women. *Int J Musculoskelet Pain Prevent* 2016; 1(1):41-5.
9. Jain V, Agrawal BK, Varshney A, Biswas SS. Prediction of bone mineral density by age, body mass index and menopausal status in middle socioeconomic status women of urban Kolar region of Bhopal. *IOSR-JDMS* 2013; 12(3):17-21.
10. Gupta U, Sharma S, Gupta NK. Changes in Bone Mineral Density in Indian Women: A Cross-Sectional Study. *Sch J App Med Sci* 2014;2(3A):917-21.
11. Ahlborg HG, Johnell O, Turner CH, Rannevic G, Karlsson MK. Bone loss and bone size after menopause. *N Engl J Med* 2003;349(4):327-34.
12. Ensurd KE, Palermo L, Black DM, Cauley J, Jergas M, Orwoll ES, et al. Hip and calcaneous bone loss increase with advancing age: longitudinal results from the study of osteoporotic fractures. *J bone Miner Res* 1995;10(11):1778-87.
13. Unni J, Garg R, Pawar R. Bone mineral density in women above 40 years. *J Midlife Health* 2010;1(1):19-22.
14. Asessment of fracture risk and its application to screening for postmenopausal osteoporosis. Report of a WHO Study Group. *World Health Organ Tech Rep Ser* 1994;843:1-29.
15. Centers for Disease Control and Prevention. Credible health information, 2009, http://www.cdc.gov/healthyweight/assessing/bmi/adult BMI/index.html.
16. Meiyanti. Epidemiology of osteoporosis in postmenopausal women aged 47 to 60 years. *Univ Med* 2010;29:169-76.
17. Uusi-Rasi K, Sievanen H, Pasanen M, Kannus P. Age-related decline in trabecular and cortical density: a 5-year peripheral quantitative computed tomography follow-up study of pre- and postmenopausal women. *Calcif Tissue Int* 2007;81(4):249-53.
18. Khosla S, Melton LJ 3rd, Achenbach SJ, Oberg AL, Riggs BL. Hormonal and biochemical determinants of trabecular microstructure at the ultradistal radius in women and men. *J Clin Endocrinol Metab* 2006;91(3):885-91.

19. Khadilkar AV, Mandlik RM. Epidemiology and treatment of osteoporosis in women: an Indian perspective. *Int J Womens Health* 2015;7:841-50.

20. Chhibber G, Roy R, Eunice M, Srivastava M, Ammini AC. Prevalence of osteoporosis among elderly women living in Delhi andrural Haryana. *IJEM* 2007;11(1):11-4.

21. Lu YC, Lin YC, Lin YK, Liu YJ, Chang KH, Chieng PU, et al. Prevalence of Osteoporosis and Low Bone Mass in Older Chinese Population Based on Bone Mineral Density at Multiple Skeletal Sites. *Sci Rep* 2016;6:25206.

22. Woodson G. Dual X-ray absorptiometry T-score concordance and discordance between the hip and spine measurement sites. *J Clin Densitom* 2000;3:319-24.

23. Kohrt WM, Snead DB, Slatopolsky E, Birge SJ. Additive effects of weight-bearing exercise and estrogen on bone mineral density in older women. *J Bone Miner Res* 1995;10:1303-11.

24. Singh M, Magon N, Singh T. Major and minor discordance in the diagnosis of potmenopausal osteoporosis among Indian women using hip and spine dual-energy X-ray absorptiometry. *J Midlife Health* 2012;3:76-80.

25. Reginster JY, Burlet N. Osteoporosis: a still increasing prevalence. *Bone* 2006;32:S4-9.

26. Lane NE. Epidemiology, etiology, and, diagnosis of osteoporosis. *Am J Obstet Gynecol* 2006;194:S3-11.

27. Daly RM, Rosengren BE, Alwis G, Ahlborg HG, Sernbo I, Karlsson MK. Gennder specific age-related changes in bone density, muscle strength and functional performance in the elderly: a 10-year prospective population-based study. *BMC Geriatr* 2013;13:71.

28. Douchi T, Yamamoto S, Oki T, Maruta K, Kuwahata R, Nagata Y. Relationship between body fat distribution and bone mineral density in premenopausal Japanese women. *Obstet Gynecol* 2000;95(5):722-5.

29. Chanprasertyothin S, Saetung S, Payattikul P, Rajatanavin R, Ongphiphadhanakul B. Relationship of body composition and circulatory adiponectin to bone mineral density in young premenopausal women. *J Med Assoc Thai* 2006;89(10):1579-83.

30. Sharmin S, Haque M, Miah SR, Rahman MM, Haque JA,Rahman HA, et al.BMD status of Postmenopausal Women in relation with BMI: A study with 93 cases. *Bangladesh J Nucl Med* 2014;17(2):138-41.

31. Kim KC, Shin DH, Lee SY, Im JA, Lee DC. Relation between obesity and bone mineral density and vertebral fractures in Korean postmenopausal women. *Yonsei Med J* 2010;51(6):857-63.

32. Silva HG, Mendonca LM, Conceicao FL, Zahar SE, Farias ML. Influence of obesity on bone density in postmenopausal women. *Arg Bras Endocrinol Metabol* 2007;51(6):943-9.

33. Ooms ME, Lips P, Van Lingen A, Valkenburg HA. Determinants of bone mineral density and risk factors for osteoporosis in health elderly women. J *Bone Miner Res* 1993;8(6):669-75.

34. Robbins J, Schott AM, Azari R, Kronmal R. Body mass index is not a good predictor of bone density: result from WHI, CHS, and EPIDOS. *J Clin Densitom* 2006;9:329-34.

35. Oros S, Ianas O, Valdoius S, Giurcaneanu M, Ionescu L, Neacsu E, et al. Does obesity protect postmenopausal women against osteoporosis? *Acta Endo (Buc)* 2012;8(1):67-76.