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Prevalence and risk factors of low bone mineral density among premenopausal women aged 40 to 45 years of Bikaner

Shikatoli Wotsa and Vimla Dunkwal

Abstract
To assess the prevalence of osteoporosis and osteopenia among premenopausal women aged 40 to 45 years of age attending the free orthopedic care camps in Bikaner district of Rajasthan. A total of 760 premenopausal women were included in the study. All subjects underwent bone mineral density measurement through dual-energy X-ray absorptiomentry (DEXA) scan. The overall prevalence of osteoporosis and osteopenia was 13.8 and 61.1 per cent, respectively. A pattern of level of physical activity, exercise, exposure to sunlight, supplementation of calcium and vitamin D, cigarette smoking, alcohol consumption and caffeine intake through tea/coffee were taken in consideration to know the behavioral risk factors of the respondents. Essential steps are needed for better public education and a wider dissemination of knowledge and awareness regarding osteoporosis and its prevention.

Keywords: Prevalence, osteoporosis, osteopenia, dual energy x-ray absorptiometry

Introduction
Strong bones are important for health and a bone mineral density test is the best way to analyze the bone health. It compares the bone density or mass to that of a healthy person of same age and gender (Shokri *et al.*, 2019) [31]. The bone mineral density shows whether an individual is normal, osteopenic or osteoporotic (WHO, 2004) [34]. Usually, causes of low bone mass include family history, undeveloped good bone mass during young age and certain physiological conditions or medicines. People having low bone mass are at higher risk of osteoporosis due to a decrease in bone strength and increase in bone fragility (Pouresmaeili *et al.*, 2018) [27].

The data concerned with India indicates that 1 out of 3 females suffered from osteoporosis, which makes India one of the largest affected countries in World (Jaipal and Gora, 2015) [14]. In the Indian scenario, increasing life expectancy and issues like low calcium, vitamin D and micro nutrient intake, gender inequality, genetic predisposition have contributed to a high incidence of osteoporosis and morbidity among women. Therefore, it is important to optimize bone health by creating awareness regarding healthy lifestyle not only during the peri and post-menopausal age group but throughout a woman's life (Sharma *et. al.* 2017) [29].

Measurement of bone mineral density (BMD) is a major tool for the diagnosis of osteoporosis. Dual- energy x-ray absorptiometry (DEXA) densitometer is a specialized x-ray device that quantifies bone mineral density at the spine, femur and other skeletal sites. This scan is non-invasive and comfortable procedure for patients with minimum radiation. Clinically, osteoporosis is defined as the lower bone density than -2.5 standard deviation while, osteopenia is the condition of low bone density within the range of -1 and -2.5 (Fonseca, *et. al.*, 2014) [10].

The term "osteoporosis" should be used with restraint in pre menopausal women, particularly when the diagnosis is based on bone mineral density alone, when the bone mineral density is at the low end of or just below the normal range, and there is no history of fracture (Dickinson, 2014). In certain clinical contexts, when bone mineral density is below expected range for age and the individual has a known secondary cause of osteoporosis such as steroid use or premenopausal estrogen deficiency, its diagnosis can be considered in the absence of history of fractures. The diagnosis of "osteopenia" based on bone density should not be applied to premenopausal women (Cohen and Shane, 2008) [6].

Risk factors for osteoporosis are categorized as modifiable and non modifiable. Weight, smoking, alcohol consumption, physical inactivity, dietary calcium deficiency and long term

use of glucocorticoids are among the modifiable risk factors while gender, age, race and genetic features are associated to non-modifiable factors. These factors can be more widespread in women with respect to gender (Pouresmaeili *et al*., 2018) [27]. Premature menopause and loss of ovarian function before menopause are other risk factors for developing osteoporosis (Okeke *et al.,* 2013) [25]. Other risk factors include poor nutrition i.e. low dietary calcium intake and deficiency of vitamin D. When insufficient calcium is absorbed from dietary sources, the body produces more parathyroid hormone (PTH) which boosts bone remodeling by mobilizing osteoclasts in the bone to break down and to sacrifice bone calcium to supply required minerals to nerves and muscles (Godos *et al.,* 2022) [11]. Since vitamin D helps in calcium absorption from the intestines into the blood so it is necessary to fulfill the requirements of vitamin D. Sun exposure is very limited in India due to darker skin pigmentation. Recent modernization of nation has resulted into working indoors and reduced physical activity. The Indian women are less exposed to the sun light due as their dressing pattern covers most of their body parts and they mostly work indoors (Mitra *et al.,* 2006) [21].

Prevention is an important approach for minimizing the risk of any disease. Osteoporosis is preventable as well as treatable by leading a bone healthy lifestyle at all stages of life. Simple and most important elements of prevention include diet and exercise as they help in achieving highest possible peak bone mass in children as a result an individual will have more bone mass in adulthood and less prone to have weak and breakable bones at older age. Diet is essential for maintaining bone formation as well as density and should contain adequate calories, protein, optimum calcium & vitamin D (Sozen *et al*., 2017). Exercise should be performed at least 30 minutes a day and 3 times a week. Exercise not only improves agility, strength, posture and balance but they may also increase bone density. Osteoporosis can be managed by thorough history and assessment of risk factors, physical examination and investigation to know the secondary causes, diagnosis and classification of the condition after estimating bone mineral density, estimation of ten year fracture risk using fracture risk algorithm (FRAX), lifestyle and diet modification and by performing pharmacological therapy. There are certain medicines that help in treating osteoporosis (Shoback *et al.,* 2020) [30]. The medications include bisphosphonates, denosumab, calcitonin, SERMs, estrogen & progesterone that inhibit bone resorption, parathyroid hormones and teriparatide stimulate bone formation while, vitamin D and strontium ranelate give mixed results (Pai, 2017) [26].

Methodology

Selection of location

The study was conducted in the department of Food & Nutrition, College of Community Science, SKRAU, Bikaner along with the collaboration of two associated groups comprising government hospital and private orthopedic care centres.

Selection of subjects

Pre-menopausal women aged between 40 to 45 years, who visited the hospitals for any type of care and attended the free bone mineral density check-up camp were selected. Relatively all healthy women aged between 40-45 years who came to the referral hospital outpatient department during the free bone mineral density check-up camps were approached to participate in the study. P-DEXA examination was conducted consecutively on those who volunteered to participate.

Occurrence of low bone mineral density

Selection of human subjects was the most important task for this study on occurrence of low bone mineral density. Screening was done in order to find out the prevalence of low bone mineral density in women. Difficulty was faced as it was a population based study so free health check-up camps were opted to assemble the subjects at one common platform for performing the screening procedure for analyzing the bone mineral density. Prior permission was obtained from authorities. P-DEXA scan machine was used for screening in the presence of a radiologist and a technician. Overall, eight camps were attended in Bikaner district to cover the selected number of subjects (760). The bone mineral density was measured by P-DEXA scan and WHO guidelines were used for the diagnosis of osteoporosis and osteopenia in the selected respondents (WHO, 1994) [35].

Table 1: WHO guidelines (1994) [35] for the diagnosis of osteoporosis

Bone mineral density value (T-score)	Classification
>-1	Normal
-1 to -2.5	Osteopenia
<-2.5 or lower	Osteoporosis

Collection of data

General information

The general information about the subjects such as name, age, address, contact numbers, educational qualification, type of family, occupation, family income (annually), parity, food habits and type of meal pattern were collected and was recorded in the pretested interview schedule.

Age: Women who attained age 40 to 45 years and still menstruating were selected for the study.

Educational status: The educational status of each respondent was categorized as Illiterate, primary education, high school, intermediate, graduate and post-graduate.

Type of family: The selected respondents were categorized according to their family type i.e. nuclear family and joint family. Nuclear family was considered when a family consisted of only husband, wife and their children and any other family member who is/are dependent on this unit and living with them. Joint family is the collection of more than one primary unit, on the basis of close blood ties and common residence.

Occupation: The selected respondents were grouped according to their occupation and categorized into professional worker, business women and housewives.

Income: Income was assessed for the subject's family as total earning in terms of money during a specific period of time. Subjects were classified into different groups on the basis of their total income, as given by the Rajasthan Housing Board Jaipur, Raj. (2014).

Parity: Parity is the number of pregnancies carried out by a woman for at least 20 weeks (duration varies from region to

region, 20 - 28 weeks, depending upon age of viability).

Assessment of risk factors associated to osteoporosis

Several behavioral risk factors increase the odds of developing osteoporosis by accelerating bone loss or by reducing intestinal calcium absorption efficiency (Krall *et al*., 1999) [18].

A pattern of level of physical activity, exercise, exposure to sunlight, supplementation of calcium and vitamin D, cigarette smoking, alcohol consumption and caffeine intake through tea/coffee were taken in consideration to know the behavioral risk factors of the respondents.

Ethical approval

There is a statutory obligation to obtain the prior approval of Ethics committee. Synopsis and ICF (Informed Consent Form) were submitted to the Ethics Committee, S.P. Medical College and Associate Group of Hospital, Bikaner. The Ethics Committee granted its approval after examining and discussing the documents.

Results and Discussions

Personal particulars like age, educational status, occupation, income status, type of family and parity of respondents obtained through a structured interview schedule. The pertinent information have been summarized and presented in table 2 and discussed below:

Table 2: Distribution of subjects according to general information

Sl No	General information		Per cent of subjects
1	Age	40-45	760 (100)
		Mean±SD	42.48±2.12
2	Educational status	a) Literate	27 (3.5)
		b) High School	101 (13.2)
		c) Intermediate	140 (18.4)
		d) Graduate	408 (53.6)
		e) Postgraduate & above	84 (11.1)
3	Occupation	a) Professional worker	116 (15.2)
		b) Self-employed	303 (39.9)
		c) Home-maker	341 (44.9)
4	Income status	a) LIG (Below 2.5)	153 (20.1)
		b) MIG (2.5-6)	487 (64.1)
		c) HIG (6 & above)	120 (15.8)
5	Type of family	a) Joint	472 (62.1)
		b) Nuclear	288 (37.9)
6	Parity	a) 0	68 (8.9)
		b) 1-3	500 (65.8)
		c) 4-6	178 (23.5)
		d) Above 6	14 (1.8)

Note: Values in parenthesis indicate the percentage of the subjects

It is evident from the table 2 that the age of the subjects ranged from 40 to 45 years with mean age presented as 42.48±2.12 years. Among all the respondents, very few were literate (3.5%), 13.2 per cent were educated up to high school, 18.4 per cent studied up to intermediate level, more than half of the respondents were graduates (53.6%) and 11.1 per cent were qualified up to post graduate and above. Further observation reveals that educated subjects were in higher number among the study group. The occupation of subjects in different fields and their distribution according to it reveals that 15.2 per cent were working as professionals (doctors, professors, lecturers, teachers, librarians & administrative officers), 39.9 per cent were self-employed such as bakers, tailors, shop owners, shop keepers & vendors and 44.9 per cent were home makers. Distribution of subjects according to their income status recorded that 20.1 per cent respondents belonged to low income group, 64.1 per cent were marked under middle income group and 15.8 per cent belonged to high income group. Data regarding the distribution of subjects according to the type of family to which they belong to describes that majority of the subjects were from joint families (62.1%) whereas remaining respondents were from nuclear families (37.9%). The status of parity of the women reveals that 8.9 per cent subjects had no parity, 65.8 per cent had parity of one to three children, 23.5 per cent had four to six children and 1.8 per cent had more than 6 children.

Occurrence of low bone mineral density

Low bone mineral density is a considerable public health problem as it leads to osteoporosis and fractures after minimal trauma is the most serious consequence of osteoporosis. World Health Organization defined osteoporosis as bone mineral density being more than 2.5 standard deviations below the mean for young healthy adult women at any site (WHO, 1994) [35]. Bone mineral density is a tool for the assessment of prevalence of osteoporosis as well as early identification of individual at high risk of a fracture related to osteoporosis (Marshall *et al*., 1996) [19].

Table 3: Occurrence of low bone mineral density in premenopausal women

BMD	No of subjects	Percentage
T-score (>-1) Normal	191	25.1
T-score (-1 to -2.5) Osteopenia	464	61.1
T-score (>-2.5) Osteoporosis	105	13.8

The finding after the screening of bone mineral density of selected women by using P-DEXA scan machine is presented in the table 3. The results of the study show that 25.1 percent subjects among the respondents were normal while 61.1 per cent had osteopenia and 13.8 per cent had osteoporosis. It is found that the percentage of osteopenic subjects was higher. Comparatively, Kadam *et al*. (2010) reported that the prevalence of osteopenia and osteoporosis in urban pre and post menopausal women aged 40-75 years was 48.4 per cent and 25.8 per cent respectively. The present results are similar to several other studies in which the percentage of osteopenic subjects was higher i.e 62.2 per cent (Das *et al*., 2016), 65.7 per cent (Gupta *et al*., 2014) [12], 46.2 per cent (Singh and Paul, 2017) [31] and 43.33 per cent (Chaudhary *et al*., 2019) [4].

Assessment of associated risk factors of osteoporosis

Several behavioral risk factors increase the odds of developing osteoporosis by accelerating bone loss or by reducing intestinal calcium absorption efficiency (Krall *et al*., 1999) [18].

Table 4: Distribution of subjects according to associated risk factors

Particulars	Normal (n=191)	Osteopenia (n=464)	Osteoporosis (n=105)	Total subjects (N=760)	
1. Physical exercise					
Walking	98 (51.3)	164 (35.3)	35(33.3)	297 (39.0)	X^2 (cal)= 97.57 ** X^2 (tab)= 15.05 df=8
Running	5 (2.6)	6 (1.3)	1 (1.0)	12 (1.6)	
Jogging	3 (1.6)	4 (0.9)	1 (1.0)	8 (1.1)	
Yoga	65 (34.0)	76 (16.4)	8 (7.6)	149 (19.6)	
No exercise	20 (10.5)	214 (46.1)	60 (57.1)	294 (38.7)	
2. Sunlight exposure (on daily basis)					
No exposure	23 (12.1)	195 (42.1)	51 (48.6)	269 (35.4)	X^2 (cal)= 80.27 ** X^2 (tab)= 12.59 df=6
5 to 10 minutes	43 (22.5)	98 (21.1)	21 (20.0)	162 (21.3)	
10 to 15 minutes	56 (29.3)	105 (22.6)	19 (18.1)	180 (23.7)	
More than 15 minutes	69 (36.1)	66 (14.2)	14 (13.3)	149 (19.6)	
3. Supplementation					
Yes	45 (23.6)	105 (22.6)	11 (10.5)	161 (21.2)	X^2 (cal)=8.43 * X^2 (tab)= 5.99 df=2
No	146 (76.4)	359 (77.4)	94(89.5))	599 (78.8)	
If Yes,					
Tablet	1 (2.2)	105 (100)	11 (47.8)	117 (72.7)	
Capsules	1 (2.2)	-	-	1 (0.6)	
Extract & powder	43 (95.6)	-	-	43 (26.7)	
4. Addiction					
Yes	21 (10.9)	46 (9.9)	10 (9.5)	77 (10.1)	X^2 (cal)= 0.22 NS X^2 (tab)= 5.99 df=2
No	170 (89.1)	418 (90.1)	95 (90.5)	683 (89.9)	
If Yes,					
Cigarette smoking	0	0	0	0	
Alcohol consumption	0	0	0	0	
Any other (*gutkha*)	21 (100.0)	46 (100.0)	10 (100.0)	77 (100.0)	
5. Intake of tea/coffee					
2-4 cups/ day	98 (51.3)	302 (65.1)	68 (64.8)	468 (61.6)	X^2 (cal)= 24.69 * X^2 (tab)= 9.48 df=4
More than 6 cups/ day	68 (35.6)	83 (17.9)	23 (21.9)	174 (22.9)	
Never	25 (13.1)	79 (17.0)	14 (13.3)	118 (15.5)	
6. History of fracture					
Yes	14 (7.3)	68 (14.6)	19 (18.1)	101 (13.3)	X^2 (cal)= 8.74 ** X^2 (tab)= 5.99, df=2
No	177 (92.7)	396 (85.4)	86 (81.9)	659 (86.7)	
Maternal history of fracture					
Yes	16 (8.4)	79 (17.1)	23 (21.9)	118 (15.5)	X^2 (cal)= 11.49 ** X^2 (tab)= 5.99, df=2
No	175 (91.6)	385 (82.9)	82 (78.1)	642 (84.5)	

Note: Values in parenthesis indicate the percentage of the subjects
P values **p<0.01, *p<0.05, NS- non-significant

Physical exercise has a great impact on the prevalence of low bone mineral density. It is indicated in table 4 that 51.3 per cent respondents preferred walking, 2.6 per cent running, 1.6 per cent jogging and 34 per cent *yoga* among all normal subjects (191). Majority of the osteopenic (46.1%) and osteoprotic subjects (57.1%) did not perform any exercise followed by walking (35.3 & 33.3%), *yoga* (16.4 & 7.6%), running (1.3 & 1.0%) and jogging (0.9 & 1.0%) respectively. Result shows strong positive association between normal, osteopenic & osteoporotic and pattern of the respondents' physical activity.

Exposure to sun has a good relationship with healthy bones. It is recommended to have at least 10 to 30 minutes sun exposure during the middle of the day with more body surface area exposed to sun for the formation of recommended level of vitamin D in the body (Nair and Maseeh, 2012) [23]. Majority of normal subjects (36.1%) had more than 15 minutes sunlight exposure on daily basis followed by subjects who used to get sunlight for 10 to 15 minutes (29.3%) and 5 to 10 minutes (22.5%). Percentage of osteopenic subjects who used to spend 10 to 15 minutes per day under sunlight was 22.6 per cent followed by exposure for 5 to 10 minutes (21.1%) and more than 15 minutes of sunlight contact (14.2%). Maximum number of osteoporotic subjects (48.6%) had no sunlight exposure followed by 5 to 10 minutes exposure (20.0%), 10 to 15 minutes (18.1%) and 13.3 per cent respondents used to stay for more than 15 minutes under sunlight. Overall, it was found that majority of the respondents (35.4%) were not exposing themselves to sunlight on daily basis. Result revealed that there is a strong positive correlation between duration of sunlight exposure and occurrence of osteoporosis and osteopenia. Similarly, Munshi *et al*. (2014) [22] observed that nearly 75 per cent women were not exposing themselves to sunlight on daily basis because of increasing concern for skin disorders caused due to excessive sun exposure.

Calcium and vitamin D supplementation has a positive effect on the bone mineral density as it reduces the rate of bone loss and risk of fractures (Chapuy *et al*., 2002) [3]. A correlated meta-analysis also confirmed that supplementation of vitamin D improved the lower extremity muscle performance and reduced risk of falling (Bischoff-Ferrari *et al.*, 2009) [2]. Therefore, normal calcium balance together with normal vitamin D status is important for maintaining well balanced bone metabolism as both the nutrients are considered crucial for preventing and treating osteoporosis (Chiodini and Bolland, 2018) [5]. The details observed regarding intake of supplements by respondents in table 3 show that 23.6 per cent were normal, 22.6 per cent had osteopenia and 10.5 per cent had osteoporosis among the subjects who consumed calcium and vitamin D supplements (n=161). While 76.4 percent were normal followed by those with osteopenia (77.4%) and

osteoporosis (89.5%) among the women who were not taking any type of supplement (n=599). The data also illustrated that majority (78.8%) of women had no consumption of calcium and vitamin D supplements required for healthy bones. The supplements taken by subjects (161) was in the form of tablets (72.7%), capsules (0.6%) and extract & powders (26.7%).

The statistical interpretations indicate that the subjects are prevalent to osetopenia and osteoporosis as majority were not taking supplements and there is a highly significant difference ($p< 0.01$) between the intake of supplements and incidence of osteopenia and osteoporosis.

Substance abuse has significantly been found to increase the risk of bone loss in both men and women. Chronic heavy drinking, nicotine in cigarettes and using drugs have been found to affect bone length and bone mineral content as well as density (Chaudhary *et al.*, 2019) [4]. The data showed that overall, 10.1 per cent subjects found to be addicted to *gutkha*/tobacoo chewing which include normal (10.9%), osteopenic (9.9%) and osteoporotic (9.5%) while the remaining 89.9 per cent were not found to be addicted to cigarette, alcohol or any other substances. Addiction to various substances such as alcohol, smoking and tobacco can have many different effects on osteoporosis, including inhibiting proper vitamin absorption, impairing hormone regulation, preventing bone development and speeding up bone deterioration (Heydari *et al*., 2017) [13]. However, the present result shows insignificant relation between the level of addiction and frequency of osteopenia and osteoporosis.

Tea is the most popular beverage in the world. Several kinds of antioxidants including flavanoids exist in tea which shows some positive effect on some degenerative diseases. However, tea is a beverage which contains caffeine as well. It is reported that the caffeine could decrease the bone mineral density and subsequently increase the hazard of fracture (Kara *et al*., 2007) [17]. The information regarding intake of number of tea/coffee by the respondents presented in table 4 unfurls that normal (51.3%), osteopenic (65.1%) and osteoporotic (64.8%) respondents used to consume 2 to 4 cups tea/coffee per day. The consumption of more than 6 cup tea/coffee on daily basis found to be higher in normal (35.6%) respondents followed by osteoporotic (21.9%) and osteopenic (21.9%), respectively whereas 15.5 per cent respondents of total subjects comprised of 13.1 per cent normal, 17.0 per cent osteopenic and 13.3 per cent osteoporotic never consumed tea/coffee. Findings state that intake of 2 to 4 cups tea/coffee daily which is quite enough for a person in case of low bone mineral density is highly significant to osteoporosis. A related investigation done on elderly post-menopausal women reveals bone loss due to higher consumption of caffeine (tea/coffee). Another study also showed alike results that high caffeine intake is positively associated with osteoporotic fractures.

According to the studies, high caffeine intake inhibits the calcium absorption in the body but after analyzing the observed data, it is stated that high caffeine intake is not significantly associated with the prevalence of osteoporosis. Some studies reported that high consumption of caffeine in the form of coffee and tea accelerated the bone loss at the spine in the elderly post-menopausal women (Rapuri *et al*., 2001) [27]. On the contrary, some other studies stated that high caffeine intake has been proposed as a risk factor for osteoporotic fractures (Avila *et al*., 1991) [1] but the evidence associating the high caffeine intake with low bone density is inconsistent (Cooper *et al*., 1992) [7].

History of previous fracture is a well-documented risk factor for future fracture risk but its relation with bone mineral density and prevalence of osteoporosis is still not well established (Kanis *et al*., 2004) [16]. But some studies reported that non-traumatic fractures in women are significantly associated with the osteoporosis at the femoral neck and the site of previous fractures impacts on future osteoporotic fractures independent of bone mineral density (Morin *et al*., 2014) [21]. The dispersal of respondents according to the history of their past fractures at different sites shows that maximum number of osteoporotic subjects had prior fractures followed by osteopenic (14.6%) and normal (7.3%) while, 86.7 per cent of total subjects comprised of 92.7per cent normal, 85.4 per cent osteopenia and 81.9 per cent osteoporosis did not report any history of fracture. Overall, very less number of subjects (13.3%) was found to have history of previous fracture at different sites while maximum subjects (86.7%) reported history of fracture.

The statistical analysis shows a significant association ($p<0.05$) between history of former fractures and occurrence of osteoporosis & osteopenia.

Maternal history of fracture especially hip fracture is a well-documented genetic risk factor for the osteoporotic fractures that is independent of bone mineral density among the women (Kanis *et al*., 2004) [16]. Furthermore, the effect of family history is not a general but site specific predisposition to fractures. But the data on effect of family history on the prevalence of low bone mineral density is still not a well-documented risk factor for osteoporosis. It is given that 21.9 per cent osteoporotic respondents had maternal history of fractures followed by osteopenic (17.1%) and normal (21.9) which counted up as 15.5 per cent. Overall, 84.5 per cent subjects did not have any maternal history of fracture which include normal (91.6%), osteopenic (82.9%) and osteoporotic (78.1%). The statistical analysis shows highly significant correlation between maternal history of fractures and prevalence of osteoporosis and osteopenia.

Conclusion

There is a high incidence of low bone mineral density of among premenopausal women in Bikaner manifesting to condition such as osteopenia and osteoporosis. Further, there is a need to intensify public health education to improve women's knowledge and practices regarding osteoporosis and its prevention with special recommendations on adequate calcium, vitamin D, and other nutrients which are responsible for bone health. Encouragement to do physical activity as well as imparting knowledge regarding preventable risk factors for developing osteoporosis is also the need of the hour.

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