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Prevalence and Association of Hypertension and Bone Mineral Density among Postmenopausal Women of North India

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Abstract
The present cross-sectional study aimed to evaluate prevalence and association of hypertension and bone mineral density among postmenopausal women living in various parts of north India. A sample of 250 postmenopausal women ranging in age between 45 to 80 years was selected by purposive sampling from various parts of north India (Haryana, Punjab, and Chandigarh). Anthropometric parameters (height, weight), physiological variables (systolic and diastolic blood pressure, pulse rate), hypertension (as per JNC VII criteria) and bone mineral density (using dual Energy X-ray Absorptiometry at lumbar spine L1-L4) of all the participants were recorded. Findings indicated that 40.4% women were identified with hypertension, out of which 12.8% had normal bone mineral density, 16.4% and 11.2% were osteopenic and osteoporotic respectively. Comparative analysis revealed that hypertensive osteoporotic subjects had significantly higher mean values for systolic blood pressure (142.71 vs 127.22, $p<0.001$), diastolic blood pressure (92.68 vs 82.39, $p<0.001$) and pulse rate (71.79 vs 68.81, $p<0.01$) as compared to their normotensive osteoporotic counterparts. Results from binary logistic regression analysis revealed that in osteoporotic subjects odds of having systolic blood pressure was 2.32 (CI=1.05-5.13), for diastolic blood pressure 1.48 (CI=0.96-2.31), and for pulse rate 1.31 (CI=0.64-2.68). The results demonstrated that high blood pressure is negatively associated with bone mineral density among elderly population.

1. Introduction

Osteoporosis and hypertension are age associated non-communicable public health problems having an immense burden on aging population. A number of previous studies have established that higher blood pressure level leads to abnormalities of calcium metabolism as well as secondary activation of the parathyroid gland, resulting an increased movement of calcium from bone [1-4]. Most of the published data in this domain [5-7] have highlighted that increased angiotensin II levels enhances bone resorption as well as inhibits mineralization thereby causing adverse effects among hypertensive patients. Recent research conducted by IIic et al., [8] observed negative effect of treatment of hypertension on bone mineral density can further worsen osteoporosis. The World Health Report [9] pointed out that blood pressure as one of the five important risk factors for non-communicable disease all over the world. Most of the available literature on hypertension and osteoporosis focused on their age related changes [10, 11] as well as their prevalence and risk factors [12, 13], but so far studies

on the association of these two diseases has received very little attention. Since osteoporosis (low bone mineral density) and hypertension are manifested more severely among aging population thereby affecting their quality of life in general and bone health in particular. So the present study is an attempt to examine prevalence as well as magnitude of association between two age associated silent diseases (i. e high blood pressure and osteoporosis) having enhanced burden on elderly population.

2. Material and Methods

The present cross-sectional study involved two hundred and fifty postmenopausal females between 45 to 80 years of age selected by purposive sampling method from various parts of North India i. e Punjab, Chandigarh, and Haryana. Punjab and Haryana are two adjoining states of North India with a common capital Chandigarh (Figure 1).

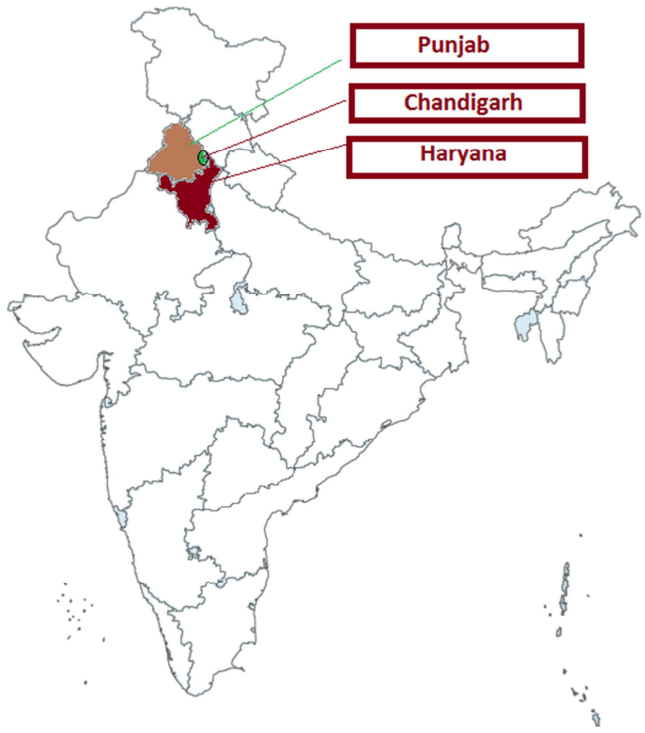

Figure 1. *Area of Study.*

The predominant geographical features of north India are the Indo-Gangetic plain which spans the states of Punjab, Haryana, Uttar Pradesh and Bihar. Data collection was carried out from March 2011 to September 2011 on the participants who matched the following inclusion criteria of present study. The subjects who were having any chronic or long term disease, and undergoing hormone replacement therapy were excluded from the study. Detailed information of all the subjects about their age, education, occupation, dietary habits, marital status and menopausal status was obtained through personal interview based on schedule. Besides this, additional information regarding their awareness on osteoporosis and hypertension was also collected. All the subjects were explained about the nature of the study, thereafter they gave their consent for participation and ethical guidelines were followed accordingly. The ethical committee of Kurukshetra University, Kurukshetra, Haryana (India) approved the study.

Height (cm) and weight (kg) of all postmenopausal women were taken following the standard techniques described by Weiner and Lourie [14] and calculated for body mass index (kg/m^2). Systolic and diastolic blood pressure (mm of Hg) was taken on left arm using manual mercury Sphygmomanometer, after the rest of at least 15-20 minutes for each subject. Three readings were recorded on each female and out of which the lowest value has been included in the study. Diagnosis of hypertension was based as per the criteria given by Seventh Report of Joint National Committee [15]. Hypertension was defined as a systolic blood pressure (SBP) ≥140 mmHg and/or a diastolic blood pressure (DBP) ≥90 mmHg. All the participants were further grouped in following different categories: Normal (<120/<80), pre hypertensive (120-139 / 80-89), Stage I hypertensive (140-159/ 90-99), Stage II hypertensive (>_160/ or_>100). Subjects who were on antihypertensive medication at least two weeks prior to the study were also designated as hypertensive.

All the subjects were screened for osteoporosis, osteopenia and normal categories by using dual Energy X-ray Absorptiometry (DXA) for assessing their bone mineral density at lumbar spine (L1-L4) (GE Healthcare Lunar enCORE, Madison, USA). Osteoporosis was defined on the basis of T scores [16] of the each participant; T scores <-2.5 SD was used as the cut off value in the diagnosis of osteoporosis, T scores between -2.5 SD and -1 SD was for low bone mass (osteopenia), and T scores >-1 SD was considered as normal. For comparisons normal and osteopenic subjects were grouped together because their bone mineral density was >-2.5 SD and osteoporotic subjects (BMD <-2.5 SD) were taken as separate group. Mean and standard deviation values were computed using the Statistical Package for Social Sciences (SPSS) version 22. Student's t-test was employed to ascertain the statistical significance of differences ($p<0.05$(*), $p<0.01$(**), $p<0.001$(***) between normal and osteoporotic groups. Binary logistic regression analysis was used to estimate odds ratio (OR) with 95% confidence interval (95%CI).

3. Results

Table 1presents socio-demographic profile of the subjects. Mean age of postmenopausal women of present study was 62.11 $\pm$ 5.2 years. Out of the total 250 female, 43.6% were highly qualified (graduate and post graduate). Thirty two percent females were working, whereas 58.8% and 9.2% females were housewives and pensioners respectively. Seventy two percent females were married, 11.2%, 16% and 0.8% were divorcee, widowed and single respectively. Most of the subjects (81.6%) were vegetarian, while rest of the

females (18.4%) were non vegetarian. Very few subjects (19.2%) had awareness about meaning, causes and consequences of osteoporosis, whereas 54.4% participants were aware about hypertension.

Table 1. *Socio- demographic profile of the subjects.*

Parameters	No of subjects (N)	Percent (%)
Education		
Up to 5th standard	96	38.4%
Matric	45	18%
Graduate	50	20%
Post graduate	59	23.6%
Occupation		
Working	80	32%
House wives	147	58.8%
Pensioner	23	9.2%
Marital status		
Married	180	72%
Divorcee	28	11.2%
Widowed	40	16%
Single	2	0.8%
Diet		
Vegetarian	204	81.6%
Non vegetarian	46	18.4%
Awareness about osteoporosis		
Yes	48	19.2%
No	202	80.8%
Awareness about hypertension		
Yes	136	54.4%
No	114	45.6%

Table 2. *Frequency distribution of different categories of hypertension (as per JNC-VII criteria) with respect to bone mineral density.*

Subjects	Hypertension			
	Normal	Prehypertensive	Stage I	Stage II
	< 80 /<120	80-89 /120-139	90-99/140-159	>=100. DBP/>=160. SBP
	N (%)	N (%)	N (%)	N (%)
Normal (N=83)	18 (7.2%)	33 (13.2%)	27(10.8%)	5 (2%)
Osteopenia (N=103)	19 (7.6%)	43 (17.2%)	37 (14.8%)	4 (1.6%)
Osteoporosis (N=64)	8 (3.2%)	28 (11.2%)	28 (11.2%)	-
Total (N=250)	45 (18%)	104 (41.6%)	92 (36.8%)	9 (3.6%)

Distribution of subjects in different categories of hypertension (as per JNC-VII criteria) on the basis of their bone mineral density is summarized in Table 2. Out of total eighty three normal subjects (T scores >-1 SD), 13.2% were in prehypertensive category and 10.8%, 2% in stage I and stage II of hypertension respectively. Whereas out of total 103 osteopenic subjects (T scores between -2.5 SD and -1 SD), 14.8% and 1.6% were in stage I and stage II of hypertension. Among osteoporotic participants (T scores <-2.5 SD), 11.2% were in Stage I of hypertension. No osteoporotic subject was reported in the stage II of hypertension.

Mean and standard deviation values of various morpho-physiological variables of normotensive and hypertensive subjects classified on the basis of their bone mineral density (i. e non-osteoporotic and osteoporotic) are presented in Table 3. Among Normotensive women mean values of systolic (127.22 vs 125.59), diastolic blood pressure (82.39 vs 82.04) and pulse rate (68.81 vs 68.65) was higher in osteoporotic females than their non-osteoporotic counterparts, although differences were statistically nonsignificant. Non osteoporotic normotensive women were taller and heavier than their osteoporotic normotensive counterparts. Similarly among hypertensive subjects non osteoporotic hypertensive women were taller, heavier and less body mass index than their osteoporotic hypertensive counterparts. Whereas non osteoporotic hypertensive women revealed greater mean values of systolic (147.72 vs 142.71), diastolic blood pressure (96.87 vs 92.68) and pulse rate (71.97 vs 71.79) than their osteoporotic hypertensive counterparts, although differences were statistically non significant.

Binary logistic regression analysis (Table 4) demonstrated that odds of having hypertension was 1.03 (0.96-1.11) for height, 1.01 (0.94-1.08) for weight and 0.94(0.82-1.06) for body mass index among osteoporotic subjects. Strongest predictor of hypertension was systolic blood pressure 2.32 (1.05-5.13), diastolic blood pressure 1.48 (0.96-2.38) and pulse rate 1.31 (0.64-2.68) among osteoporotic females.

Table 3. *Mean, standard deviation and t-value of various morpho-physiological variables of normotensive (Nonosteoporotic-Osteoporotic) and hypertensive (Nonosteoporotic- Osteoporotic) postmenopausal females.*

Variables	Normotensive				Hypertensive			
	Non-osteoporotic		Osteoporotic		Non-osteoporotic		osteoporotic	
	Mean	S. D	Mean	S. D	Mean	S. D	Mean	S. D
	(N=118)		(N=36)		(N=68)		(N=28)	
Systolic blood pressure (mm of Hg)	125.59	7.93	127.22	6.77	147.72	10.03	142.71	6.01*
Diastolic blood pressure (mm of Hg)	82.04	5.06	82.39	5.47	96.87	6.65	92.68	8.59*
Pulse rate(beats per minute)	68.65	2.79	68.81	3.51	71.22	3.49	71.79	3.54
Height (cm)	157.84	7.21	154.25	9.63*	157.10	6.23	156.36	7.38
Weight (kg)	63.99	11.62	54.58	11.72***	63.91	10.04	56.68	9.27**
Body mass index (kg/m^2)	24.93	4.52	26.09	4.51	24.84	4.35	25.08	4.52

Student's t-test = $p<0.05$(*), $p<0.01$(**), $p<0.001$(***).

Table 4. *Mean, standard deviation, t-value and odds ratio of various morpho-physiological variables of normotensive osteoporotic and hypertensive osteoporotic postmenopausal females.*

Variables	Normotensive osteoporotic		Hypertensive osteoporotic		odds ratio(95% CI)
	Mean	S. D	Mean	S. D	
	(N=36)		(N=28)		
Systolic blood pressure (mm of Hg)	127.22	6.77	142.71	6.01***	2.32(1.05-5.13)*
Diastolic blood pressure (mm of Hg)	82.39	5.47	92.68	8.59***	1.48 (0.96-2.31)*
Pulse rate(beats per minute)	68.84	3.51	71.79	3.54**	1.31 (0.64-2.68)*
Height (cm)	154.25	9.63	156.36	7.38	1.01(0.94-1.08)
Weight (kg)	54.28	11.72	56.68	9.27**	1.03(0.96-1.11)
Body mass index (kg/m^2)	26.09	4.51	25.08	4.52	0.94 (0.82-1.06)

Student's t-test = p<0.05(*), p<0.01(**), p<0.001(***).

4. Discussion

Osteoporosis (Low Bone mineral density) and hypertension (high blood pressure) are non-communicable "silent diseases" particularly more prevalent among elderly population. The present study demonstrated that total prevalence of hypertension was 40.4% and prevalence of osteoporosis was 25.6% among postmenopausal women of north India. Out of which, prevalence of hypertension was found to be highest in the osteopenic women (16.4%) followed by normal (12.8%) and least in osteoporotic subjects (11.2%). It was further observed that no osteoporotic subject fall in stage II of hypertension, this might be due to hypertensive osteoporotic subjects have lowered longevity. Supporting above mentioned findings Cappuccio et al., [17] observed that women who rapidly lost bone mass and were hypertensive would be less likely to survive, and therefore an association would be harder to detect.

Findings of present study revealed that among normotensive women mean values of systolic (127.22 vs 125.59), diastolic blood pressure (82.39 vs 82.04) and pulse rate (68.65 vs 68.81) was higher in osteoporotic females than their non-osteoporotic counterparts, thereby suggesting an inverse correlation between bone mineral density and blood pressure. Comparing the hypertensive osteoporotic subjects with their normotensive osteoporotic counterparts revealed that former had significantly higher mean values for systolic blood pressure (142.71 vs 127.22), diastolic blood pressure (92.68 vs 82.39) and pulse rate (71.79 vs 68.81) as compared to their normotensive osteoporotic counterparts. Binary logistic regression analysis (Table 4) demonstrated that odds of having systolic blood pressure was 2.32 (1.05-5.13), diastolic blood pressure 1.48 (0.96-2.38) and 1.31 (0.64-2.68) for pulse rate among osteoporotic females. These findings are in agreement with those reported by Tsuda et al., [18] that bone mineral density was inversely correlated with systolic blood pressure, suggesting that high blood pressure might be associated with the decrease in bone mineral density among elderly women. A study conducted by Popovic and Tasic [19] observed that a rise in the values of systolic blood pressure and diastolic blood pressure by one unit caused a significant decrease in the bone mineral density by 0.005 g/cm^2 (0.005 to 0.006 g/cm^2) in case of SBP and by 0.008 g/cm^2 (0.007 to 0.010 g/cm^2) in case of DBP. Recent studies on elderly women [20, 21, 18] highlighted a potential contribution of estrogen in the regulation of bone mineral density and various cardiovascular functions and advocated that estrogen deficiency associated with menopause might accelerate abnormalities in the calcium metabolism at both the cellular and systemic levels, which would explain, in part, osteoporosis and hypertension in elderly women.

In the present study both normotensive and hypertensive non osteoporotic females were significantly taller, heavier and had lesser body mass index than their osteoporotic counterparts in both the groups. Morin et al. [22] has discussed the negative impact of low body weight on bone health. Recent study of Kaur [23] observed that bone mineral density was highest in women with BMI between 18.5-24.9 kg/m^2 and also documented that underweight and overweight has negative effect on bone mineral density.

Hence it is clear from the above discussion that high blood pressure is negatively associated with bone mineral density among elderly population. Results from previous research [24, 25] have also shown higher blood pressure and hypertension were significantly and positively correlated with osteoporosis postmenopausal women. The findings lend further emphasis that burden of osteoporosis and hypertension is likely to increase with increasing age because elderly females have limited knowledge and awareness about meaning causes and consequences of these diseases as well as because of social and economic reasons they have poor access to treatment and control of these age associated silent disease. Hence a holistic approach is needed to control burden of these growing public health problems among postmenopausal women.

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