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CORRELATES OF OSTEOPENIA AND OSTEOPOROSIS IN WOMEN WITH OBESITY

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ABSTRACT

Aims: To determine the prevalence of osteopenia and osteoporosis in postmenopausal women with obesity, and to assess the correlation of age, duration of menopause, BMI, body fat and lipids with T-scores. **Settings and Design:** Cross sectional study at a tertiary care hospital in North India. **Materials and Methods:** A total of 86 women with BMI ≥25 kg/m² underwent dual energy X ray absorptiometry, and the 42 postmenopausal women among them were analysed. Bone status was classified by WHO T-score criteria at each site and overall, using the lower of the hip and lumbar spine T-scores. **Results:** Overall, 16 women (38.1%) had normal bone status, 14 (33.3%) had osteopenia and 12 (28.6%) had osteoporosis. Osteoporosis was identified in 26.2% at the lumbar spine and 14.3% at the hip. Women with osteoporosis were older than women with normal bone status (59.42 ± 8.94 vs 50.00 ± 7.40 years). BMI was lower in the osteopenia and osteoporosis groups than in the normal group (median 27.95 and 27.80 vs 33.05 kg/m²). The lowest T-score correlated negatively with age ($\rho = -0.49$, $P < 0.001$) and duration of menopause ($\rho = -0.50$, $P < 0.001$), and positively with BMI ($\rho = 0.41$, $P = 0.008$). Body fat percentage and lipids neither differed across groups nor correlated with T-scores. **Conclusions:** Nearly two in three postmenopausal women with obesity had osteopenia or osteoporosis, and the lumbar spine identified more osteoporosis than the hip. Age, duration of menopause and BMI were related to bone status, whereas body fat and lipids were not. Assessing both sites may be useful in this group.

KEYWORDS: Body mass index, obesity, osteopenia, osteoporosis, post-menopause.

INTRODUCTION

Osteoporosis is an important cause of skeletal fragility in women, and its burden increases after menopause. In India, the reported prevalence of osteoporosis among women ranges widely, from 8% to 62%.[1] A meta-analysis of Indian postmenopausal women estimated a pooled prevalence of osteoporosis of 29% at the lumbar spine and femoral neck, while osteopenia affected 37% of women at these sites.[2] Studies from North India have similarly shown a substantial burden of low bone mass among postmenopausal women, with osteoporosis and osteopenia reported in 30.5% and 44.2% of women in Punjab,[3] and in 37.5% and 44.7% in another North Indian study.[4] These findings highlight the importance of identifying factors related to skeletal health in postmenopausal Indian women.

Menopause is a major physiological transition in this regard. The decline in estrogen after menopause increases bone turnover and accelerates bone loss.[5,6] Bone health, however, is influenced not only by age and hormonal status but also by body size and body composition. In Punjab, a BMI above 30 kg/m² was associated with a lower likelihood of both osteoporosis and osteopenia.[3] The relationship between adiposity and skeletal health is more complex than BMI alone may suggest, because BMI does not distinguish between fat and lean tissue. The contribution of these compartments to bone may also differ with overall body size. In a

Brazilian cohort of postmenopausal women, lean mass was associated with higher bone mineral density (BMD) in women with BMI ≥25 kg/m², whereas fat mass was associated with higher BMD in women with normal BMI.[7] Studies of serum lipids and BMD have also produced inconsistent findings.[8]

This complexity is particularly relevant in postmenopausal women with obesity. Greater body weight increases mechanical loading on bone, which has been linked with higher BMD.[5] At the same time, visceral adipose tissue has been reported to promote osteoclast activation and to reduce insulin like growth factor I, which may lower bone formation.[6] Much of the existing literature has examined women across a broad range of BMI categories,[3,7] so it is unclear whether BMI, body fat and lipids continue to relate to bone status when obesity is already present. Bone health in postmenopausal women with obesity therefore remains less well characterised, particularly in Indian women.

The present study examined bone health in postmenopausal women with obesity, with emphasis on the relation of bone status with anthropometric, body composition and metabolic characteristics. We first determined the prevalence of osteopenia and osteoporosis at the hip and lumbar spine. We then compared age, BMI, body fat percentage and lipid parameters across women with normal bone status, osteopenia and osteoporosis. Finally, we assessed the correlation of age, duration of menopause, BMI, body fat percentage and lipid parameters with hip, lumbar spine and lowest T-scores.

MATERIALS AND METHODS

Study design and participants

This cross-sectional study was conducted at a tertiary care hospital in North India between August 2025 and March 2026. A total of 86 women with BMI ≥25 kg/m² were enrolled, the cutoff for obesity used by the Endocrine Society of India.[9] Of these, 42 were postmenopausal and were included in the present analysis. Women with chronic kidney disease, chronic liver disease, stroke, diabetes mellitus, thyroid disorders, tuberculosis, chronic malnutrition or malignancy were excluded. Duration of menopause was recorded by structured interview.

Measurements

Height and weight were measured by standard methods, and BMI was calculated. T-scores at the hip and lumbar spine, together with total body fat percentage, were obtained by dual energy X ray absorptiometry (DXA) on a Hologic Discovery Wi system. Serum total cholesterol, triglycerides, LDL and HDL were measured.

Classification of bone status

Bone status was classified using the WHO T-score criteria.[10] A T-score of −1.0 or higher was classified as normal, a T-score below −1.0 and above −2.5 as osteopenia, and a T-score of −2.5 or lower as osteoporosis. The WHO densitometric classification is applicable to postmenopausal women.[11] Each site was classified separately. Overall status was based on the lower of the hip and lumbar spine T-scores (lowest T-score), and discordance was defined as different categories at the two sites.[6]

Statistical analysis

Categorical data were presented as n (%), and confidence intervals (CI) for proportions were calculated by the Wilson score method. Normality of continuous variables was checked with the Shapiro–Wilk test. Normally distributed variables were presented as mean ± SD and compared across the three bone status groups by Welch ANOVA with Games–Howell pairwise tests, with ω^2 as the effect size. Other continuous variables were presented as median (IQR) and compared by the Kruskal–Wallis test with Dunn pairwise tests and Bonferroni correction, with ε^2 as the effect size. Spearman rank correlation was used to relate age, duration of menopause, BMI, body fat and lipids to the lowest, hip and lumbar spine T-scores, because several variables were not normally distributed. The 95% CIs for correlation coefficients were calculated by the Fisher z transformation. For the statistical analysis, the Statistical Package for the Social Sciences software version 29.0.2 (Chicago, Illinois, USA) was used. A P value below 0.05 was taken as significant.

Ethics

The Institutional Ethics Committee, Jawaharlal Nehru Medical College, Aligarh Muslim University, approved the study (IECJNMC/2139). Informed consent was obtained from all participants.

RESULTS

Participant characteristics

The mean age of the post-menopausal women was 54.9 ± 9.2 years, and 17 (40.5%) were aged 50 to 59 years (Table 1). Mean duration of menopause was 8.7 ± 8.2 years, and 19 women (45.2%) were within 5 years of menopause. Mean BMI was 30.01 ± 3.72 kg/m², and 18 women (42.9%) had BMI ≥30 kg/m². Hypertension was present in 36 women (85.7%), dyslipidemia in 33 (78.6%), and both in 27 (64.3%).

Table 1: Demographic and clinical characteristics of postmenopausal women (n = 42)

Parameter	Value
Age (years), mean ± SD (range)	54.9 ± 9.2 (40–75)
Age group, n (%)	
<50 years	13 (31.0)
50–59 years	17 (40.5)

≥60 years	12 (28.6)
Duration of menopause (years), mean ± SD (range)	8.7 ± 8.2 (0–35)
Duration of menopause group, n (%)	
≤5 years	19 (45.2)
6–10 years	7 (16.7)
11–15 years	11 (26.2)
>15 years	5 (11.9)
BMI (kg/m²), mean ± SD (range)	30.01 ± 3.72 (25.00–38.00)
BMI group, n (%)	
25.0–29.9 kg/m²	24 (57.1)
≥30.0 kg/m²	18 (42.9)
Hypertension, n (%)	36 (85.7)
Dyslipidemia, n (%)	33 (78.6)
Both hypertension and dyslipidemia, n (%)	27 (64.3)

BMI: body mass index.

Distribution of bone status

Overall, 16 women (38.1%) had normal bone status, 14 (33.3%) had osteopenia and 12 (28.6%) had osteoporosis (Table 2). Osteopenia or osteoporosis was therefore present in 26 women (61.9%). Osteoporosis was identified in 11 women (26.2%) at the lumbar spine and 6 (14.3%) at the hip. The two sites gave different categories in 11 women; in 9 of them the lumbar spine gave the lower category, and in 2 the hip did.

Table 2: Distribution of bone status in postmenopausal women (n = 42)

Bone status	Lumbar spine, n (%) [95% CI]	Hip, n (%) [95% CI]	Overall (lowest T-score), n (%) [95% CI]
Normal (T ≥ −1.0)	17 (40.5) [27.0–55.5]	20 (47.6) [33.4–62.3]	16 (38.1) [25.0–53.2]
Osteopenia (−2.5 < T < −1.0)	14 (33.3) [21.0–48.4]	16 (38.1) [25.0–53.2]	14 (33.3) [21.0–48.4]
Osteoporosis (T ≤ −2.5)	11 (26.2) [15.3–41.1]	6 (14.3) [6.7–27.8]	12 (28.6) [17.2–43.6]

Overall bone status was based on the lowest T-score of the hip and lumbar spine, using WHO categories.[10] CI: confidence interval, calculated by the Wilson score method.

Comparison across bone status groups

Age differed across the groups (P = 0.016), and women with osteoporosis were older than women with normal bone status (59.42 ± 8.94 vs 50.00 ± 7.40 years). BMI also differed (P = 0.015), being lower in both the osteopenia group (median 27.95 kg/m²) and the osteoporosis group (27.80 kg/m²) than in the normal group (33.05 kg/m²). Total body fat percentage was almost identical in the three groups (P = 0.998), and total cholesterol, triglycerides, LDL and HDL did not differ (all P > 0.35) (Table 3).

Table 3: Comparison of age, body mass index, body fat and lipid profile across bone status groups in postmenopausal women

Parameter	Normal (n = 16)	Osteopenia (n = 14)	Osteoporosis (n = 12)	P value	Effect size
Age (years)	50.00 ± 7.40	56.57 ± 9.14	59.42 ± 8.94*	0.016	$\omega^2 = 0.15$
BMI (kg/m²)	33.05 (29.25, 35.45)	27.95 (27.07, 29.93)*	27.80 (26.90, 29.40)*	0.015	$\varepsilon^2 = 0.21$
Total body fat (%)	47.58 ± 4.28	47.51 ± 3.91	47.51 ± 2.80	0.998	$\omega^2 = 0.00$
Hip T-score§	0.45 (0.02, 0.70)	−1.20 (−1.60, −1.10)*	−2.30 (−2.70, −1.50)*	<0.001	$\varepsilon^2 = 0.69$
Lumbar spine T-score§	−0.60 (−0.70, −0.18)	−1.80 (−1.90, −1.50)*	−3.00 (−3.23, −2.85)*#	<0.001	$\varepsilon^2 = 0.83$
Total cholesterol (mg/dL)	185.20 ± 41.27	187.86 ± 35.23	171.64 ± 53.52	0.675	$\omega^2 = 0.00$
Triglycerides	158.00 (115.25,	190.00 (138.00,	169.50 (120.59,	0.775	$\varepsilon^2 = 0.01$

(mg/dL)	198.80)	212.75)	194.75)		
LDL (mg/dL)	115.50 (93.50, 123.62)	97.23 (87.56, 126.77)	100.22 (88.25, 107.50)	0.382	$\varepsilon^2 = 0.05$
HDL (mg/dL)	44.50 (40.75, 47.17)	46.00 (42.00, 53.50)	42.50 (38.45, 48.11)	0.439	$\varepsilon^2 = 0.04$

Mean ± SD values were compared by Welch ANOVA with Games–Howell pairwise tests (effect size ω^2). Median (IQR) values were compared by the Kruskal–Wallis test with Dunn pairwise tests and Bonferroni correction (effect size ε^2). *Differs from normal ($P < 0.05$); #differs from osteopenia ($P < 0.05$). §Variables used to define the groups. BMI: body mass index; LDL: low density lipoprotein; HDL: high density lipoprotein.

Correlation with T-scores

Age correlated negatively with the lowest T-score ($\rho = -0.49$, $P < 0.001$), the hip T-score ($\rho = -0.36$, $P = 0.018$) and the lumbar spine T-score ($\rho = -0.48$, $P = 0.001$). Duration of menopause showed a similar pattern, with ρ values of −0.50, −0.36 and −0.45 for the lowest, hip and lumbar spine T-scores (Table 4). BMI correlated positively with the lowest T-score ($\rho = 0.41$, $P = 0.008$), the hip T-score ($\rho = 0.40$, $P = 0.009$) and the lumbar spine T-score ($\rho = 0.31$, $P = 0.043$). Body fat percentage and lipids showed no correlation with T-scores at either site.

Table 4: Correlation of clinical and metabolic variables with T-scores in postmenopausal women (n = 42)

Variable	Lowest T-score, ρ (95% CI)	P value	Hip T-score, ρ (95% CI)	P value	Lumbar spine T-score, ρ (95% CI)	P value
Age (years)	−0.49 (−0.70 to −0.21)	<0.001	−0.36 (−0.61 to −0.06)	0.018	−0.48 (−0.69 to −0.19)	0.001
Duration of menopause (years)	−0.50 (−0.71 to −0.23)	<0.001	−0.36 (−0.61 to −0.06)	0.018	−0.45 (−0.67 to −0.16)	0.003
BMI (kg/m²)	0.41 (0.11 to 0.64)	0.008	0.40 (0.10 to 0.63)	0.009	0.31 (0.00 to 0.57)	0.043
Total body fat (%)	0.02 (−0.30 to 0.33)	0.920	−0.07 (−0.37 to 0.25)	0.655	0.06 (−0.25 to 0.37)	0.693
Total cholesterol (mg/dL)	0.06 (−0.26 to 0.37)	0.700	0.05 (−0.27 to 0.36)	0.750	0.01 (−0.30 to 0.32)	0.931
Triglycerides (mg/dL)	−0.04 (−0.35 to 0.27)	0.783	−0.11 (−0.41 to 0.21)	0.492	−0.03 (−0.33 to 0.29)	0.874
LDL (mg/dL)	0.23 (−0.09 to 0.50)	0.150	0.20 (−0.12 to 0.48)	0.212	0.17 (−0.15 to 0.46)	0.284
HDL (mg/dL)	0.00 (−0.32 to 0.31)	0.977	0.07 (−0.25 to 0.37)	0.677	−0.08 (−0.38 to 0.24)	0.633

ρ: Spearman rank correlation coefficient, with 95% CI calculated by the Fisher z transformation. Lowest T-score: the lower of the hip and lumbar spine T-scores for each participant. A negative ρ indicates that higher values of the variable go with lower T-scores. BMI: body mass index; CI: confidence interval; LDL: low density lipoprotein; HDL: high density lipoprotein.

DISCUSSION

This study examined bone status and its correlates in postmenopausal women with obesity. Osteopenia or osteoporosis was present in 26 of the 42 women. Older age, longer duration of menopause and lower BMI were related to poorer bone status, whereas body fat percentage and lipid levels were not, and the lumbar spine identified more osteoporosis than the hip.

Nearly two in three had osteopenia or osteoporosis. Within this group of women who all had obesity, bone status was related to age, duration of menopause and BMI, but not to body fat percentage or lipid levels. The site of measurement also mattered, because the lumbar spine identified osteoporosis in almost twice as many women as the hip.

Higher BMI has been linked with lower risk of osteoporosis and osteopenia in postmenopausal women from Punjab.[3] Even so, the proportion of women with osteoporosis in our sample (28.6%) was close to the 30.5% and 37.5% reported in two North Indian studies of postmenopausal women.[3,4] Osteopenia was less frequent in our sample (33.3%) than in those studies (44.2% and 44.7%).[3,4] Reported prevalence of osteoporosis in Indian women ranges from 8% to 62%,[1] and studies differ in skeletal sites, sampling and body size. Our sample was also small, so these figures are not directly comparable. Even so, the proportion of women with osteoporosis in our sample was in a similar range to that reported in these studies.

How many women were identified depended on the skeletal site. Osteoporosis was found in 26.2% at the lumbar spine but in only 14.3% at the hip. An Indian

meta-analysis showed the same pattern, with pooled osteoporosis prevalence of 29% at the lumbar spine and 6% at the hip.[2] The two sites placed about one in four of our participants in different categories, and in most of these women the spine gave the lower category. Discordance between hip and lumbar spine T-scores is common. In a Taiwanese study, 40% of patients with osteoporosis had minor discordance and 5% had major discordance.[6] Discordance may have physiological, pathological, anatomical, artefactual or technical causes, and vertebral osteophytes, end plate and facet sclerosis, and aortic calcification can affect T-scores.[6] Spine images were not reviewed in our study, so the reason for discordance in our participants cannot be established. What the finding does show is that assessment of a single site would have missed some women with low bone mass. This is why overall status was based on the lower of the two T-scores.

Age and duration of menopause were the factors most clearly related to poorer bone status. Women with osteoporosis were older than women with normal bone status, and both age and duration of menopause correlated negatively with T-scores. This is consistent with the acceleration of bone loss that follows the decline in estrogen after menopause.[5] In a nationwide Korean study, adults with osteopenia and osteoporosis were likewise older and had lower BMI than those with normal BMD.[8] Among Iranian postmenopausal women, bone density correlated with age and BMI.[12] Because age and duration of menopause increase together, this cross sectional study cannot separate their effects.

BMI continued to relate to bone status even though every participant had obesity. Women with osteopenia and osteoporosis had lower BMI, and BMI correlated positively with T-scores at both sites, in agreement with the Korean findings.[8] One explanation offered in the literature is that greater body weight increases mechanical loading on bone, which has been linked with higher BMD.[5]

Body fat percentage, however, showed no relation with bone status. A study of 102 Indian postmenopausal women found that lean body mass correlated more strongly with lumbar spine BMD ($r = 0.48$) than body fat percentage did ($r = 0.29$).[13] In a Brazilian cohort, lean mass rather than fat mass was associated with higher BMD in postmenopausal women with BMI ≥ 25 kg/m².[7] Our findings are consistent with these reports, which suggest that in women with higher BMI, fat mass is not the part of body weight most closely related to bone. Lean mass was not examined in the present analysis, however, so we cannot say whether the relation of BMI with T-scores reflects lean mass. Body fat was also uniformly high in our participants, with a mean of about 47.5% and little spread in every group, which may have limited the ability to detect a correlation.

Lipid levels were not related to bone status either, and the published evidence on this question is mixed. In the Punjab study, triglyceride level was independently associated with the risk of osteoporosis and osteopenia.[3] In the Korean study, triglycerides were inversely associated with whole body BMD, while total cholesterol and HDL showed no significant correlation with BMD when men and women were analysed separately.[8] Dyslipidemia was present in most of our participants and the sample was small, so our data do not allow a firm conclusion about lipids and bone.

Taken together, low bone mass was common in these postmenopausal women with obesity. Older age, longer duration of menopause and lower BMI were related to poorer bone status, and assessing both the hip and the lumbar spine gave a more complete picture than either site alone.

Limitations

Some of the limitations of this study are discussed. The sample was small and drawn from a single centre, and the cross-sectional design does not allow conclusions about cause and effect. Because all women had obesity, no comparison could be made with women of normal BMI. Vitamin D, calcium intake, physical activity, sex hormones, lean mass and fracture history were not analysed, and spine images were not reviewed for degenerative changes. Several comparisons were made, and the findings should therefore be considered exploratory.

CONCLUSION

Nearly two in three postmenopausal women with obesity in this study had osteopenia or osteoporosis. The lumbar spine identified more osteoporosis than the hip, and the two sites often disagreed. Older age, longer duration of menopause and lower BMI were related to poorer bone status, whereas body fat and lipid profile were not. Obesity did not rule out low bone mass, and assessing both the hip and lumbar spine may be useful in postmenopausal women with obesity.

Declarations

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Conflicts of interest: None

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