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Research Article

# The Effect of Body Mass Index, Age, Weight, and Psychosocial Status on Bone Mineral Density in Postmenopausal Women on Hemodialysis

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## Abstract

**Background:** Decreased bone mass, often measured using bone mineral density (BMD) is frequently seen in patients with end-stage renal disease (ESRD) undergoing hemodialysis. It may cause serious bone health problems such as fractures. Several risk factors of low bone mass in the patients on hemodialysis have been proposed including age and body mass index (BMI). Our current study explored the relationship between BMI, age, sociodemographic status, and BMD among postmenopausal women on hemodialysis.
**Methods:** This study enrolled postmenopausal women on hemodialysis whose bone densitometry was checked and assessed with the age, BMI, and social status. Statistical analysis was performed in SPSS software.
**Results:** Sixty participants with a mean ± standard deviation (SD) of age of 57.00 ± 10.63 years were enrolled. After adjustment of sex and age, normal-weight women had 2 times the prevalence of low bone density compared to the obese women [prevalence ratio (PR) = 2, 95% confidence interval (CI): 1.4–2.8]. For osteoporosis, the PR was also twice higher for the women with normal BMI (PR = 2, 95% CI: 1.3-2.8) and 1.6 times higher for the overweight group than the women in the obese group (PR = 1.6, 95% CI: 1.3-2.4).
**Conclusion:** Among the women on hemodialysis, obese women have lower prevalence of osteoporosis than normal-weight cases.

*Keywords:* Osteoporosis; Hemodialysis; Body Mass Index; Bone Mineral Density; Postmenopause

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## Background

Chronic kidney disease (CKD) outcomes consist of not only headway to end-stage renal disease (ESRD) but also complications of reduced function of kidney and high risk of cardiovascular disease (CVD) (1). ESRD needs modalities of renal replacement therapy (RRT) including kidney transplantation or dialysis. The incidence of ESRD in Iran has been increased in the last twenty years and reached 507 per million (2). Patients with ESRD usually have an accelerated bone mass loss due to abnormal bone turnover which results in a high prevalence of bone health problems, especially low bone density and osteoporosis (3-10).

Osteoporosis is a metabolic bone disorder described by decreased bone mineral density (BMD) with weakening of bone micro-architecture, resulting in increased bone fragility and fracture risk (11-14). Osteoporosis is the most common human bone disease and major public health problem worldwide. The prevalence is increasing due to an increase in life expectancy. Osteoporosis is associated with a high rate of morbidity and mortality related to fractures, especially hip fractures (12-18).

Patients with ESRD are at high risk of fractures due to increased bone loss, low BMD, and high prevalence of osteoporosis. Dual-energy x-ray absorptiometry (DEXA) is a commonly-used method to determine BMD due to its high accuracy, a short scan time, and a low radiation dose.

The relationship between BMD and body mass index (BMI) among women with ESRD has not been examined in Iran. Therefore, because of diverse racial and ethnic mixture and variable climate, this study was designed to examine the relationship between BMI and BMD in postmenopausal Iranian women.

## Methods

This cross-sectional study enrolled 60 postmenopausal women, undergoing hemodialysis at academic hospitals of Golestan University of Medical Sciences, Gorgan, Iran, who conducted bone densitometry in a rheumatology clinic in Gorgan. Informed consent was obtained from all participants.

We collected demographic data (age, occupation, educational level, and marital status) and risk factors for low BMD [sedentary lifestyle, hypertension (HTN), smoking, and consumption of certain kinds of foods like cheese, yogurt, milk, alcohol, and coffee] using a standardized questionnaire. Patients were excluded if they had coronary artery disease (CAD), chronic lung disease with dyspnea on exertion, orthopedic disorders exacerbated by activity, a history of cerebrovascular disease, inability to communicate, blindness or other major disabilities, or chronic use of corticosteroids, heparin, and antiepileptic agents. Subjects with fracture of the lumbar spine or fracture of right hip were also excluded. Of the 77 eligible patients approached for the study, 17 patients refused to

participate. Women who did not exercise regularly, 3 times a week for 25 minutes each time based on self-reports, were classified as sedentary subjects.

We measured anthropometric parameters such as weight, height, and BMI based on the World Health Organization (WHO) protocols. For the classification of nutritional status, the WHO's guideline was applied (18, 19).

BMD (g/cm$^2$) was recorded by DEXA. The densitometry measurements of total femur, lumbar spine, and femoral neck were done by Hologic QDR 4500 device (USA). The DEXA results were categorized as T-score ≤ -2.5 as osteoporosis and T-score between -1.01 and -2.49 as low bone density (19).

Data were analyzed by SPSS software (version 16, SPSS Inc., Chicago, IL, USA). Quantitative variables were expressed as mean ± standard deviation (SD), and categorical variables were labeled as frequencies and percentages. Prevalence ratios (PRs) with 95% confidence intervals (CIs) for the adjusted factors like age, sex, BMI were computed; a $P < 0.05$ was considered significant. This study was permitted as undergraduate general practitioner thesis by the local Institutional Research Board and the Ethics Committee of Golestan University of Medical Sciences, Gorgan (no: 1397/816).

## Results

The mean ± SD of age of 60 postmenopausal patients with ESRD included in this study was 57.00 ± 10.63 years. Of our study population, 63% were women with a partner, 53% had 5 to 8 years of education, and 30% were retired. Further, 55% were sedentary, 3.3% were active smokers, 1.6% consumed alcohol, and 46.6% were regular coffee drinkers. Dairy consumption was common with 40.5% of women consuming yogurt and/or milk (190 ± 30 g) at least weekly, 29.4% consuming twice weekly, and 39.7% consuming cheese daily, with no significant difference among BMD groups. The prevalence of low bone density was 50% (n = 30), osteoporosis prevalence was also 50% (n = 30), and no participant had normal BMD. The PR for low bone density in eutrophic women was significantly higher than obese women. Women with normal weight had 2 times the prevalence of low bone density of obese women after the adjustment for age and sex. We found that advancing age significantly increased the prevalence of low bone density. Women aged above 60 years had a prevalence of low bone density 1.9 times more than women less than 60 years ($P < 0.05$).

Osteoporosis Relationship with BMI, age, marital status, and smoking status:

The osteoporosis PR in group of women with normal weight was 2 times the PR for obese women. Similarly, the PR was 1.6 times higher in overweight compared with the obese category. The PR for osteoporosis was also much higher in the age group ≥60 years, being twice the PR for patients in the category of 50-59 years. Having no partner also had a higher PR for osteoporosis than women with a partner. No significant relation for smoking and alcohol consumption was detected ($P > 0.05$).

PR for osteoporosis related to HTN was also assessed which no significant relation was detected.

Table 1 indicates the T-score values and BMD for femoral neck, total hip and vertebral bodies in eutrophic, overweight, and obese women. All values were considerably different ($P < 0.01$), but no significant relation was found regarding vertebral bodies although the bone mass was increased ($P = 0.06$).

## Discussion

Our study assessed the correlation between BMI and low bone density and osteoporosis in Iranian population. PR for low bone density and osteoporosis was lower in obese women. Older age also showed a correlation with higher prevalence of low bone density and osteoporosis as well as BMI. Osteoporosis and HTN had no significant relationship. Those without a partner had a higher frequency of osteoporosis. Evaluating the relationship of BMI with BMD, it was obtained that obese women had less value of low bone density and osteoporosis, verifying the results of other studies in which the presence of a high BMI had a positive improving influence on BMD (20). A large cross-sectional study proved the impact of BMI on BMD and showed the lower prevalence of osteoporosis in the obese group (15). A previous case-control study detected that the group of patients with fractures had lower BMI versus those without fractures (16); moreover, other studies showed the protective effect of a high BMI (21, 22). The correlation between osteoporosis and body weight is still under debate (20), but this topic has not yet been fully clarified although several clarifications have been offered: a higher body weight enforces a more mechanical load on bone with an increase of bone mass to house this load (23) and body fat appears to exert a protective factor for fractures; besides, body fat may interrupt assessing the BMD by false detection of soft tissue as increased bone mass in DEXA (20). Additionally, adipocytes are key estrogen production sources, causing an increase in this hormone serum levels and also of other related hormones like insulin and leptin; it may act directly and/or indirectly on osteoblast/osteoclast activity, leading to the improvement of bone mass (20).

In spite of a lower osteoporosis prevalence in obesity detected in the current study, it is important to consider that not all types of fat are beneficial for bone mass. Subcutaneous fat and visceral fat have opposite impacts on the bone structure. Visceral fat induces systemic inflammation, which can result in bone mass decrease (24) as well as having a link with increased levels of pro-inflammatory cytokines such as tumor necrosis factor (TNF) and interleukin 6 (IL-6), which increase bone resorption and progress osteoporosis (25). Hypercortisolic state, which may decrease bone mass, showed a relationship with increasing visceral fat as well (26).

**Table 1.** T-score and bone mineral density (BMD) values in body mass index (BMI) categories of 60 postmenopausal Iranian women

| Variable | Normal | Overweight | Obese | P-value |
|---|---|---|---|---|
| **T-score** | | | | |
| **Femoral neck** | -2.580 ± 0.870 | -2.300 ± 0.750 | 1.910 ± 0.800 | < 0.001 |
| **Total hip** | -1.700 ± 0.930 | -1.600 ± 0.900 | -1.430 ± 0.900 | < 0.001 |
| **Vertebral body** | -0.910 ± 1.000 | -0.650 ± 1.000 | -0.250 ± 0.850 | 0.060 |
| **BMD (g/cm$^2$)** | | | | |
| **Femoral neck** | 0.611 ± 0.138 | 0.633 ± 0.113 | 0.686 ± 0.252 | < 0.001 |
| **Total hip** | 0.665 ± 0.141 | 0.754 ± 0.132 | 0.890 ± 0.242 | < 0.001 |
| **Vertebral body** | 0.836 ± 0.165 | 8.716 ± 0.174 | 0.773 ± 0.190 | 0.060 |

Data are presented as mean ± standard deviation (SD)
BMD: Bone mineral density

However, subcutaneous fat came out to be positive for developing bone mass, considering that potentially protective proteins against osteoporosis development (e.g., adiponectin) existed more in subcutaneous than visceral fat tissue (25). Obesity is coupled with some diseases, including HTN, type II diabetes mellitus (DM), CVDs, metabolic syndromes, and some cancers which could all be against bone health (23, 27-32). Current data revealed that extra fat tissue was the reason for uninhibited inflammatory factors secretion, possibly inducing metabolic and cardiovascular events (33).

The dairy products consumption demonstrated no significant relation with BMD, probably owing to our small sample size. It is known that an adequate intake of calcium could be helpful to avoid bone loss (34). We noticed no significant relationship between coffee and BMD, as a previous large study (35).

Moreover, another study indicated that a caffeine intake of > 300 mg/day augmented vertebral bone loss. We also found advanced age to be a significant factor for reduced bone mass (17, 36-38).

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The bone mass, after a peak at 35 years old, goes steady until beginning of menopausal age. After menopause, there is a fast bone loss phase over five to ten years, followed by a rather slower phase encouraged by age (11, 39, 40). In the elderly, the crucial goal of prevention is to reduce bone loss. Menopause is also a risk factor that is linked with a disturbance in bone metabolism, and the first 5 to 10 postmenopausal years make up the time in which the major amount of bone loss occurs. About one out of three postmenopausal women with low BMD are at augmented risk for osteoporosis and fractures over their living time (15). The decrease in estrogen production is the key to such disturbance, overlapping with many other factors which may contribute including a reduced level of calcium absorbed by the intestine, owing the low calcitonin production, a hormone inhibiting bone demineralization (15, 41). Lack of estrogen is a significant cause of bone loss during menopause, especially in the elderly (41).

Osteoporosis did not reveal a significant association with hypertensive condition in our current study; however, in previous studies (42, 43) they were correlated significantly and even HTN was set as a risk factor for bone mineral loss (15). This discrepancy seen in our investigation versus previous studies could be attributed to a very low frequency of HTN-positive cases among our study participants.

We found that those cases having no partner had higher osteoporosis. There are some data linking marriage with decreased risk of osteoporosis fractures (44, 45). There could be two points: one is that marriage might have a protecting impact on individuals' lives, second is that single people might be less healthy (46). The marital disruption such as divorce can induce psychosocial tension affecting bone health. Conversely, marriage is usually related with better economic safety for the woman, yielding reduced psychosocial pressure which may develop the general bone health (47).

Relation between BMD and consumption of dairy products was not significant in our study perhaps due to low sample size.

In addition to our mentioned findings, we noticed an interesting finding that unlike general population, PR of osteoporosis in vertebral region among patients with ESRD was lower according to our results; osteosclerosis is frequently found in patients with renal osteodystrophy and secondary hyperparathyroidism. Bone sclerosis in renal osteodystrophy could influence different skeletal elements, but it frequently outweighed in the axial skeleton. One of the classic findings comprises broad osteosclerosis localized below the endplates of the vertebral bodies with normal density of the middle parts known as rugger jersey spine (48).

Our current study has some limitations. We did not gather data of menopausal and menarche age, previous fractures history, temporary corticosteroids intake, hormone replacement therapy (HRT), level of physical activity, calcium, and vitamin D, exposure to sunlight, and other nutrients supplementation.

*Conclusion*

In our study, obese women had a lower prevalence of low bone density versus normal-weight cases; furthermore, obese cases revealed a lower prevalence of osteoporosis as compared to normal-weight and overweight participants. As the age increased, low bone density increased in relation; osteoporosis was significantly higher in those over 60 years and women having no partner. No significant relationship was detected between osteoporosis and HTN.

## Conflict of Interest

The authors declare no conflict of interest in this study.

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