Original Article

Relation between Biochemical Parameters and Bone Density in Postmenopausal Women with Osteoporosis

Mohammad Reza Salamat[1], Shokouh Momeni[2], Ali Asghar Rastegari[2]

[1]Department of Medical Physics, School of Medicine, Isfahan University of Medical Sciences, Isfahan, Iran, [2]Department of Molecular and Cell Biochemistry, Falavarjan Branch, Islamic Azad University, Isfahan, Iran

Abstract

Background: Osteoporosis is the most prevalent metabolic bone disease in postmenopausal women associated with reduced bone mass and increased bone fracture. Measuring bone density in the lumbar spine and hip is a reliable measure of bone mass and can therefore specify the risk of fracture. Dual-energy X-ray absorptiometry (DXA) is an accurate non-invasive system measuring bone density, with a low margin of error and no complications. The present study aimed to investigate the relationship between biochemical parameters with bone density in postmenopausal women.

Materials and Methods: This cross-sectional study was conducted on 87 postmenopausal women referred to osteoporosis centers in Isfahan. Bone density was measured in the spine and hip area using the DXA system. Serum levels of calcium, phosphorus, alkaline phosphatase, and magnesium were measured by an autoanalyzer, and serum levels of vitamin D were measured by high-performance liquid chromatography (HPLC).

Results: The mean parameters of calcium, phosphorus, alkaline phosphatase, vitamin D, and magnesium did not show a significant difference between the two groups (P-value > 0.05). In the control group, the relationship between alkaline phosphatase and bone mineral content (BMC) and bony area (BA) in the spine was significant with a correlation coefficient of − 0.402 and 0.258, respectively (P-value < 0.05) and BMD and T-score in the femoral neck area showed a direct and significant relationship with phosphorus (correlation = 0.368; P value = 0.038). There was a significant relationship between the Z-score with calcium (correlation = 0.358; P value = 0.044).

Conclusion: There was no significant relationship between the values of calcium, phosphorus, alkaline phosphatase, vitamin D, and magnesium parameters and bone density (spine and hip) in postmenopausal women with osteopenia or osteoporosis.

Keywords: Alkaline phosphatase, bone mineral density, calcium, magnesium, menopause, osteoporosis, phosphorus, vitamin D

Address for correspondence: Mrs. Shokouh Momeni, Department of Molecular and Cell Biochemistry, Falavarjan Branch, Islamic Azad University, Isfahan, Iran.
E-mail: momenishokouh@gmail.com
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Introduction

Osteoporosis is a systemic skeletal disease with reduced bone mass and microscopic changes in the bone tissue with a risk of fracture.[1,2] The World Health Organization named the years 2000 to 2010 as the decade of bone and joint disorders, including osteoporosis, and reported this disease as the fourth main human enemy after a heart attack, stroke, and cancer, and the leading cause of fracture in the world.[3] One of the most important goals of measuring bone density is to identify individuals at risk of osteoporosis before the occurrence of fracture. Especially hip fracture is one of the leading causes of death in the elderly, mostly in women.[4] Decreased age-related bone mass occurs in both sexes, but osteoporosis is less common in men due to more bone mass and lack of hormonal changes that occur during menopause.[5]

Furthermore, the major component for bone formation is calcium, and vitamin D is necessary for its absorption. In addition to its role in calcium balance, vitamin D has receptors

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in various tissues, including the pancreas, stomach, gonads, brain, skin, and breast; therefore, different functions can be attributed to vitamin D.[6] Alkaline phosphatase is a group of enzymes that hydrolyze ester phosphates. Osteoblasts are a great source of alkaline phosphatase. This enzyme plays a key role in calcium deposition, which is significantly activated after bone fracture.[7]

In contrast, approximately 60% of the total magnesium is stored in the bone. According to epidemiological experiments and investigations, both the increase and decrease in magnesium have adverse impacts on bones. Magnesium depletion leads to osteoporosis directly by affecting the formation of crystals and bone cells and indirectly by suppressing the parathyroid hormone.[8]

In the past few years, several biochemical markers of bone formation, such as osteocalcin, the bone-specific isoenzyme of alkaline phosphatase, and magnesium and bone resorption have been described and successfully applied to clinical research.[9]

Because there is a physiological relationship between the amounts of blood biochemical parameters and bone density and metabolism, and changes in some of them, such as calcium and vitamin D, are known as risk factors for reduced bone mineral density (BMD), the present study was conducted to determine the biochemical parameters and bone density in postmenopausal women with osteoporosis.

Materials and Methods

This cross-sectional study was conducted on 100 postmenopausal women referred to osteoporosis centers in Isfahan during 2018–2019.

Inclusion criteria were passing 1 year of menopause onset and no menopause at the ages below 45 years. Patients with kidney and liver disease, as well as patients taking osteoporosis pills, were excluded from the research.

Written consent from eligible subjects who were referred by specialist doctors for a bone density scan, suspicious of suffering from osteopenia/osteoporosis, and explaining to the referred subjects that research is being conducted to investigate some causes of developing low bone density was acquired. Their demographic information, including age, height, weight, body mass index (BMI), duration of menopause, history of underlying diseases, family history of osteoporosis, history of bone fractures, used drug, and its type were recorded.

Measurement of bone density

Bone density in the spine and hip areas was assessed using the Norland XR-800 (made in the USA), by dual-energy X-ray absorptiometry (DXA method). To this end, bone density status was determined in two areas, and postmenopausal women were divided into two healthy (control) and unhealthy (osteopenia or osteoporosis) groups.

A bone density scan gives a person a Z-score and a T-score. T-scores compare the bone density with that of a healthy person, whereas Z-scores use the average bone density of people of the same age, sex as a comparator.

To perform the above division, healthy samples (control group) were selected based on the T-score of the lumbar spine and hip vertebrae. That is, those were selected as the control group who had T-score ≥ -1 in both the lumbar spine and hip areas according to the World Health Organization classification. Besides, women with T-score <-1 in one area (lumbar spine or hip) were considered an unhealthy group (having osteopenia or osteoporosis). A low Z-score (below −2.0) is a warning sign that a person has low bone density mass for age and sex (and/or may be losing bone at a faster rate).

Measurement of blood biochemical parameters

After assessing the bone density, 10 mL of blood was taken from each participant using normal syringes. Around 7 mL of it was transferred to the clot tube to measure the calcium, phosphorus, alkaline phosphatase, and magnesium parameters. The remaining blood was transferred to a K2EDTA tube for a 25-hydroxy vitamin D (25OHD) test.

Clot tubes contained a clot activator and a polymer gel. The tubes were placed in a Universal 320 centrifuge at 2500 to 3000 rpm for 5 min to separate the serum. The tubes were centrifuged twice under the above conditions. The obtained serum was transferred to the desired tubes by a blue-tip sampler. Then, the serum level of the mentioned parameters was measured using Pars Azmoon kits and BT3000 autoanalyzer. Calcium was measured photometrically by ARSENAZO III, phosphorus was measured photometrically by UV test, and alkaline phosphatase was measured by DGKC (standard of the German Society for Biochemistry and Molecular Biology), and magnesium was measured photometrically using Xylidyl blue.

25 hydroxy vitamin D measurement

To measure 25 OHD, 3 mm of blood was transferred from each individual to K2EDTA tubes containing anticoagulant ethylenediaminetetraacetic acid (EDTA) and K2 salt. The tubes were then centrifuged at 2500 to 3000 rpm for 5 min to separate the serum. The tubes were centrifuged twice under the above conditions. In the next step, the plasma was mixed with certain solutions, and the resulting mixture was centrifuged at 12000 to 14000 rpm for 5 min, and 25OHD was measured by high-performance liquid chromatography (HPLC).

Statistical analysis

Finally, the collected data were entered into the SPSS software (Ver. 26). Data are presented as frequency (percentage) or mean ± standard deviation (SD). At the level of inferential statistics, tests such as independent sample *t*-test, Chi-square test, and Pearson's correlation coefficient were used. In all analyses, a significance level of less than 0.05 was considered.

Results

In the present study, out of 100 patients, 13 were excluded due to the lack of referral for the evaluation of biochemical

parameters or measurement of bone density. Of the remaining 87 patients in the study, 32 cases were in the control group (with normal bone mineral density) and 55 in the case group (with abnormal density) with osteopenia or osteoporosis. The age of individuals in the control group with a mean of 56.56 ± 0.90 years was significantly lower than the case group with a mean of 60.36 ± 0.80 years (*P*-value = 0.003). The weight and BMI of patients in the control group were also significantly higher than the case group (*P*-value <0.05). Moreover, in the case group, physical activity was significantly lower than in the control group (*P*-value = 0.041). Also, the duration of menopause in the case group with a mean of 8.96 ± 0.87 years was significantly longer than the control group with a mean of 5.16 ± 0.84 years (*P*-value = 0.002) [Table 1].

In the assessment of BMD and bone mineral content (BMC), it was determined that the mean BMD, BMC, T-score, and Z-score in different areas of the body (vertebrae, femoral neck, trochanter, and hip) were significantly lower in postmenopausal women in the patient group compared with the control group (*P*-value < 0.05). However, in the bony area (BA) variable, only in the L1 vertebral region of the spine, a significant difference was found between the two groups (*P*-value < 0.05). No significant difference was observed in other areas (*P*-value > 0.05) [Table 2].

In addition, the mean biochemical parameters, including calcium, phosphorus, alkaline phosphatase, magnesium, and vitamin D in patients with osteoporosis and osteopenia were not significantly different from the control group (*P*-value > 0.05) [Table 3].

In the evaluation of the relationship between bone density in the spine (mean vertebrae) and biochemical parameters, it was observed that in the control group, the relationship between alkaline phosphatase and BMC and BA variables was significant with a correlation coefficient of − 0.402 and 0.258, respectively (*P*-value = 0.023 and 0.002). In other cases, no significant relationship was found between the variables and biochemical parameters of the spinal area in the two groups (*P*-value > 0.05) [Table 4].

Finally, in the evaluation of the relationship between bone density in the hip (femoral neck, trochanter, ward triangle, and total hip) and biochemical parameters, it was found that in the control group, two variables of BMD and T-score in the femoral neck showed a direct and significant relationship with phosphorus (correlation = 0.368; *P* value = 0.038). Also, the Z-score variable showed a significant relationship with calcium with a correlation coefficient of 0.358 (*P*-value = 0.044). In the wards triangle area, BMD, BMC, and T-score variables showed a direct and significant relationship with phosphorus (correlation = 0.371; *P* value = 0.037) [Table 5]. It should be noted that in the case group, none of the variables of bone density in the hip area showed a significant relationship with biochemical parameters (*P*-value > 0.05) [Table 6].

Table 1: Demographic information of the two groups

Characteristics	Control group (*n*=32)	Case group (*n*=55)	*P*
Age; year	56.56±0.90	60.36±0.80	0.003
Height; cm	156.22±1.11	154.71±0.75	0.248
Weight; kg	75.84±1.70	66.40±1.34	<0.001
BMI; kg/m^2	31.17±0.76	27.83±0.62	0.001
Duration of menopause; year	5.16±0.84	8.96±0.87	0.002
Family history of osteoporosis	4 (12.5%)	2 (3.6%)	0.129
Previous fracture history	1 (3.1%)	2 (3.6%)	0.969
Low physical activity*	17 (53.1%)	41 (74.5%)	0.041
Taking medication			
Calcium	2 (6.3%)	1 (1.8%)	
Cortone	1 (3.1%)	1 (1.8%)	
Past medical history			
Thyroid disorders	6 (18.8%)	10 (18.2%)	0.796
High blood pressure	10 (31.3%)	17 (30.9%)	
Cardiovascular disease	0 (0%)	4 (7.3%)	
Backache	17 (53.1%)	23 (41.8%)	

BMI: Body mass index. *Walking below half an hour a day

Discussion

According to the results of the current study, the BMI of postmenopausal women in the case group was significantly lower than that in the control group. Consistent with the present study, Jiang *et al*.[10] also indicated that BMI less than 28 kg/m^2 in white postmenopausal women aged 46–50 years is a potential indicator for osteoporosis.

Various studies have estimated that between 20 and 50% of changes in bone density are affected by lifestyle and, above all, nutrition. Nutrition plays an essential role in the formation of the highest bone density during growth. Adequate calcium intake is essential at the age of growth and reaching maximum bone mass, as well as in adulthood and old age to cope with bone loss. Also, in postmenopausal women, the reduction in bone mass is accelerated and the calcium balance becomes negative.[11-13]

Furthermore, with deficiency of vitamin D, in addition to reduced calcium absorption, parathyroid hormone is increased, which in turn results in calcium reabsorption from bone and reduced bone mass.[14] Thus, the status of vitamin D is considered a vital factor that determines bone health. However, there is debate on the relationship between 25OHD and bone density.

In this regard, in the current study, no significant relationship was found between vitamin D levels and the amount and density of bone minerals in the lumbar vertebrae (L1-L4) and hip in two groups of healthy women and women with osteopenia and osteoporosis. Consistent with the present study, Deng *et al*.,[15] also concluded that postmenopausal Chinese women with serum 25OHD levels less than 30 ng/mL showed lower bone density in the femoral neck but this relationship was not observed in the lumbar spine.

Table 2: Evaluation of bone density at different points between the two groups

Variables		Control group ($n=32$)	Case group ($n=55$)	*P*
BMD; g/cm^2				
Spine	L1 vertebra	1.05±0.02	0.76±0.02	0.003
	L2 vertebra	1.09±0.02	0.81±0.01	<0.001
	L3 vertebra	1.11±0.02	0.83±0.01	<0.001
	L4 vertebra	1.12±0.02	0.84±0.02	0.004
	Mean	1.17±0.02	0.87±0.02	<0.001
Hip	Femoral neck	0.89±0.02	0.72±0.01	<0.001
	Trochanter	0.71±0.01	0.56±0.01	<0.001
	Wards tri	0.66±0.02	0.50±0.01	0.003
	Hip Ts BMD	0.96±0.02	0.78±0.01	<0.001
T-Score				
Spine	L1 vertebra	0.05±0.14	-1.76±0.11	0.001
	L2 vertebra	-0.08±0.11	-1.77±0.09	<0.001
	L3 vertebra	0.02±0.13	-1.63±0.09	<0.001
	L4 vertebra	0.07±0.13	-1.52±0.09	0.001
	Mean	-0.01±0.12	-1.77±0.09	<0.001
Hip	Femoral neck	-0.84±0.15	-2.29±0.10	<0.001
	Trochanter	-0.72±0.14	-2.07±0.10	<0.001
	Wards tri	-1.53±0.13	-2.77±0.10	0.002
	Hip Ts BMD	0.07±0.14	-1.43±0.10	<0.001
BMC; g				
Spine	L1 vertebra	14.47±0.45	11.99±0.36	0.003
	L2 vertebra	15.16±0.40	11.62±0.24	<0.001
	L3 vertebra	16.56±0.52	12.52±0.23	<0.001
	L4 vertebra	25.37±2.82	17.03±1.35	0.011
	Mean	64.35±1.95	50.72±1.09	<0.001
Hip	Femoral neck	4.10±0.09	3.37±0.06	<0.001
	Trochanter	8.45±0.28	6.91±0.18	0.005
	Wards tri	0.66±0.02	0.50±0.01	<0.001
	Hip Ts BMD	30.54±0.71	25.04±0.45	<0.001
Z-Score				
Spine	L1 vertebra	0.38±0.16	-1.24±0.12	0.001
	L2 vertebra	0.28±0.13	-1.22±0.09	<0.001
	L3 vertebra	0.35±0.15	-1.17±0.09	<0.001
	L4 vertebra	0.42±0.14	-1.06±0.10	0.001
	Mean	0.37±0.14	-1.22±0.10	<0.001
Hip	Femoral neck	0.54±0.15	-0.71±0.11	0.001
	Trochanter	0.36±0.15	-0.84±0.11	<0.001
	Wards tri	0.29±0.14	-0.75±0.11	0.003
	Hip Ts BMD	0.81±0.15	-0.50±0.11	<0.001
BA; cm^2				
Spine	L1 vertebra	13.79±0.34	15.98±0.57	0.001
	L2 vertebra	13.93±0.28	14.43±0.24	0.195
	L3 vertebra	14.86±0.30	15.10±0.18	0.466
	L4 vertebra	22.04±2.07	19.71±1.41	0.341
	Mean	55.08±1.47	58.79±1.12	0.041
Hip	Femoral neck	4.61±0.06	4.70±0.04	0.229
	Trochanter	11.88±0.22	12.31±0.20	0.162
	Hip Ts BMD	31.63±0.33	32.11±0.29	0.296

BMD: Bone mineral density, BMC: Bone mineral content; BA: Bone area

In contrast, Ohta *et al*.,[16] demonstrated that low levels of 25OHD in postmenopausal women with osteoporosis older than 70 years can be a determining factor in the quality of life. The findings by Garnero *et al*.,[17] also suggested that 25OHD levels were not associated with hip bone mineral density in postmenopausal women with a mean age of 62.2 years. This study, consistent with our study, confirms the lack of a connection between vitamin D and bone density.

Another study indicated the significant association between 25OHD levels and bone density in the femoral neck area in postmenopausal women.[18] Also, Nakamura *et al*.[19] concluded that there is a significant association between the higher serum levels of 25OHD and increased bone density in the femoral neck, which is not in agreement with our study.

Furthermore, the results of the present study suggested that calcium only in the control group showed a significant relationship with Z-score in the femoral neck area, and no relationship was seen between calcium and bone density in the patient group. In contrast to our study, in a study by Quesada-Gómez *et al*.[20] conducted for the assessment of calcium and vitamin D intake by the 25OHD measurement in treated and untreated osteoporotic postmenopausal women, it was found that 25OHD and inadequate calcium intake were very common in both groups.

In fact, menopause is one of the most important causes of osteoporosis because it is affected by estrogen deficiency, which increases bone regeneration resulting in a high loss of bone mass. After menopause, women lose an average of 30% of their bone mineral density, which leads to osteopenia, and eventually osteoporosis. Hence, in women, there is a rapid phase of bone loss after menopause due to estrogen deficiency. Bone formation is the process that controls the deposition of minerals by the organic component of the bone matrix. The mineral phase is made of calcium and phosphorus. Concentrations of these ions in the plasma and extracellular fluid (ECF) influence the rate of mineral formation.

When bone is absorbed, calcium and phosphorus are released into the extracellular fluid, and the organic component of the bone matrix is absorbed. Furthermore, a reduction in calcium intake or impaired absorption of calcium from the intestine decreases the calcium serum level. This reduction may be because of a decrease in active calcium transport or diffusion of the calcium absorption system.[21,22]

Prabha *et al*.[23] studied bone markers (serum levels of calcium, phosphorus, and alkaline phosphatase) in Indian postmenopausal women and concluded that there was a significant decrease in the serum levels of calcium in the patient group compared with the control group. There was also a significant increase in serum levels of phosphorus and alkaline phosphatase in the patient group compared with the control group, which is inconsistent with our findings. Because in our study, serum levels of calcium, phosphorus, and alkaline phosphatase were assessed by autoanalyzer in both the control and case groups and there was no significant relationship between the two groups.

Khatake and Jadhav[24] also investigated the relationship between serum calcium levels and bone density in Indian women before and after menopause and indicated a significant relationship between serum calcium levels and bone density in postmenopausal women.

Contrary to our study, Milenković *et al*.[25] found that vitamin D deficiency in postmenopausal women with osteoporosis is a significant risk factor for bone fractures and reduced bone density.

In contrast to the present study, Hosseinpanah *et al*.[26] examined the relationship between vitamin D levels and bone mineral density in postmenopausal women. No association was found between vitamin D and bone mineral density in different areas. Other studies in France and China did not find any association between femoral bone density and bone markers with 25OHD levels and parathyroid hormone.[27,28] In the study by Sigurdsson in Iceland, where the average intake of calcium and vitamin D was high in women over 70 years, no significant relationship was observed between vitamin D and bone density.[29] The above studies, consistent with our work, confirm the lack of association between vitamin D levels and bone density.

In addition, our findings indicated that the relationship between serum level of 25OHD and bone mineral density in the spine and hip area in healthy postmenopausal women and postmenopausal women with osteoporosis was not significant. Consistent with this result, in the study of Khashayar *et al*.[30] on a healthy Iranian population, it was shown that the 25OHD level has a significant inverse relationship with bone mineral density in the total hip and spine.

Magnesium, in contrast, is the fourth most abundant cation in the body and the second most important intracellular cation and is required for many enzymatic reactions. Accurate control of magnesium homeostasis appears to be critical for bone health. According to laboratory and epidemiological studies, both high and low magnesium levels contribute to osteoporosis directly by acting on the formation of crystals on bone cells, indirectly by affecting the secretion and activity of the parathyroid hormone, and by increasing low-grade inflammation.[31]

In this regard, the results of the present study exhibited that the relationship between magnesium and bone mineral density in the hip and spine was insignificant.

In the study by Brodowski, serum magnesium levels in women with osteoporosis were reported as significantly lower than normal. A hemostatic system has not been identified to regulate serum magnesium, and this concentration is constant at most times. Maintaining serum magnesium concentrations in the

Table 3: Mean biochemical parameters in the two study groups

Biochemical Parameters	Control group ($n=32$)	Case group ($n=55$)	*P*
Vitamin D; ng/mL	37.02±2.90	37.05±2.55	0.986
Calcium; mg/dL	9.11±0.04	9.19±0.05	0.212
Phosphorus; mg/dL	3.32±0.07	3.39±0.06	0.474
Alkaline phosphatase; IU/L	209.41±10.38	222.67±8.38	0.330
Magnesium; mg/dL	2.01±0.03	1.99±0.02	0.756

Table 4: Relationship between biochemical parameters and bone density in the spine in the two groups

Spine		Vitamin D	Calcium	Phosphorus	Alkaline phosphatase	Magnesium
Control group						
BMD; g/cm^2	Correlation	-0.173	-0.027	0.232	-0.111	-0.053
	P	0.344	0.884	0.201	0.547	0.774
BMC; g	Correlation	-0.157	-0.207	0.091	0.402	0.019
	P	0.392	0.255	0.622	0.023	0.920
T-score	Correlation	-0.178	-0.041	0.240	-0.093	-0.059
	P	0.329	0.823	0.186	0.611	0.747
Z-score	Correlation	-0.192	0.017	0.098	-0.115	-0.067
	P	0.291	0.926	0.592	0.530	0.716
BA; cm^2	Correlation	-0.051	-0.220	-0.101	0.528	0.064
	P	0.783	0.227	0.584	0.002	0.730
Case group						
BMD; g/cm^2	Correlation	0.044	-0.074	0.162	-0.263	0.219
	P	0.747	0.590	0.236	0.052	0.109
BMC; g	Correlation	0.066	-0.02	0.081	-0.213	0.222
	P	0.634	0.887	0.556	0.118	0.104
T-score	Correlation	0.030	-0.080	0.161	-0.262	0.222
	P	0.830	0.561	0.240	0.053	0.103
Z-score	Correlation	0.200	-0.118	0.143	-0.269	0.113
	P	0.886	0.392	0.298	0.050	0.411
BA; cm^2	Correlation	0.046	0.072	-0.089	0.003	0.031
	P	0.739	0.603	0.517	0.984	0.820

BMD: Bone mineral density, BMC: Bone mineral content; BA: Bone area

Table 5: Relationship between biochemical parameters and bone density in the pelvic region in the control group

Hip/Control group		Vitamin D	Calcium	Phosphorus	Alkaline phosphatase	Magnesium
Femoral neck						
BMD; g/cm^2	Correlation	-0.027	0.285	0.368	-0.192	0.320
	P	0.885	0.114	0.038	0.292	0.074
BMC; g	Correlation	-0.011	0.233	0.321	-0.092	0.334
	P	0.954	0.200	0.074	0.615	0.062
T-score	Correlation	-0.026	0.285	0.368	-0.192	0.320
	P	0.889	0.114	0.038	0.292	0.074
Z-score	Correlation	-0.073	0.358	0.235	-0.242	0.307
	P	0.690	0.044	0.195	0.182	0.087
BA; cm^2	Correlation	0.011	-0.047	-0.008	0.142	0.094
	P	0.951	0.799	0.966	0.437	0.608
Wards tri						
BMD; g/cm^2	Correlation	0.110	0.291	0.371	-0.167	0.042
	P	0.548	0.107	0.037	0.361	0.820
BMC; g	Correlation	0.110	0.291	0.371	-0.167	0.042
	P	0.548	0.107	0.037	0.361	0.820
T-score	Correlation	0.109	0.291	0.370	-0.167	0.041
	P	0.552	0.106	0.037	0.367	0.822
Z-score	Correlation	0.054	0.346	0.194	-0.209	0.019
	P	0.768	0.052	0.287	0.252	0.916
Hip Ts BMD						
BMD; g/cm^2	Correlation	0.037	0.169	0.258	-0.251	0.061
	P	0.840	0.356	0.153	0.166	0.740
BMC; g	Correlation	0.020	0.194	0.137	-0.144	0.124
	P	0.914	0.288	0.455	0.431	0.498
T-score	Correlation	0.036	0.168	0.258	-0.251	0.061
	P	0.845	0.357	0.155	0.166	0.738
Z-score	Correlation	-0.007	0.211	0.128	-0.271	0.041
	P	0.970	0.247	0.485	0.134	0.824
BA; cm^2	Correlation	-0.024	0.132	-0.138	0.111	0.150
	P	0.896	0.472	0.451	0.544	0.414

BMD: Bone mineral density, BMC: Bone mineral content; BA: Bone area

normal range depends on the uptake, excretion, and passage of cations through the membrane, and there is no hormonal regulation in this case. The main control of magnesium balance is mainly done by the kidneys, which keep serum magnesium in the normal range, especially its low intake. Low-magnesium diets reduce the urinary excretion of magnesium, thereby preventing a decrease in serum magnesium levels.[32] Other previous studies have revealed that the concentration of magnesium in red blood cells decreases significantly in postmenopausal women and people with osteoporosis; however, the concentration of serum or plasma magnesium does not decrease significantly,[33] which is consistent with our study.

Sharma *et al*.[34] also concluded that a reduction in deficiency in postmenopausal women may lead to inflammatory disorders along with bone loss. Saito *et al*.[35] demonstrated that reduced magnesium concentrations may be a risk factor for osteoporosis in the elderly, especially women. Additionally, another study in support of this work found lower magnesium levels in blood cells in postmenopausal women with osteoporosis and concluded that the magnesium transport mechanism could influence patients with osteoporosis.[36] On the contrary, Wang *et al*.[37] reported higher magnesium concentrations in Chinese women with osteopenia and osteoporosis compared to healthy women, which is in contrast to our findings.

Although many studies have been conducted on osteoporosis and osteopenia and bone mineral density measurements, the present study can be significant and novel in terms of the investigation of the relationship between bone markers and bone mineral density and content. Besides, a comparative study of this relationship before and after menopause in women can be interesting and present the physiological changes in a period of women's lives, which is suggested to be considered in future works.

Conclusion

Based on the results of the current study, the mean serum levels of calcium, phosphorus, alkaline phosphatase, vitamin D, and magnesium did not show a significant difference

Table 6: Relationship between biochemical parameters and bone density in the pelvic area in the case group

Hip/case group		Vitamin D	Calcium	Phosphorus	Alkaline phosphatase	Magnesium
Femoral neck						
BMD; g/cm^2	Correlation	0.221	-0.034	-0.001	-0.182	0.127
	P	0.105	0.805	0.992	0.184	0.355
BMC; g	Correlation	0.203	-0.042	0.027	-0.089	0.164
	P	0.137	0.761	0.847	0.520	0.231
T-score	Correlation	0.222	-0.034	-0.001	-0.181	0.126
	P	0.104	0.804	0.991	0.185	0.358
Z-score	Correlation	0.193	-0.084	-0.017	-0.176	-0.007
	P	0.157	0.540	0.900	0.200	0.959
BA; cm^2	Correlation	-0.033	-0.039	0.059	0.159	0.081
	P	0.810	0.779	0.667	0.246	0.558
Wards tri						
BMD; g/cm^2	Correlation	0.065	-0.060	-0.085	-0.083	-0.077
	P	0.635	0.662	0.536	0.549	0.578
BMC; g	Correlation	0.065	-0.060	-0.085	-0.083	-0.077
	P	0.635	0.662	0.536	0.549	0.578
T-score	Correlation	0.065	-0.060	-0.085	-0.083	-0.077
	P	0.638	0.662	0.538	0.547	0.576
Z-score	Correlation	0.055	-0.113	-0.096	-0.086	-0.197
	P	0.691	0.412	0.486	0.532	0.150
Hip Ts BMD						
BMD; g/cm^2	Correlation	0.168	-0.062	-0.004	-0.257	0.007
	P	0.221	0.653	0.977	0.058	0.958
BMC; g	Correlation	0.122	-0.001	0.038	-0.172	-0.020
	P	0.373	0.997	0.783	0.211	0.887
T-score	Correlation	0.167	-0.062	-0.004	-0.257	0.008
	P	0.223	0.653	0.977	0.058	0.954
Z-score	Correlation	0.147	-0.110	-0.015	-0.253	-0.097
	P	0.284	0.425	0.912	0.062	0.481
BA; cm^2	Correlation	-0.046	0.115	0.091	0.113	-0.042
	P	0.39	0.401	0.509	0.413	0.763

BMD: Bone mineral density, BMC: Bone mineral content; BA: Bone area

between the control and case groups (patients with osteopenia or osteoporosis). Also, alkaline phosphatase showed a direct and significant relationship with BMC and BA in the spine in the control group. The phosphorus parameter also showed a direct and significant relationship with bone density in the femoral neck. In contrast, no significant relationship was observed between any of the biochemical parameters and hip area bone density in the case group.

Ethics approval and consent to participate

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed. This study was approved by the ethic committee of Falavarjan Branch, Islamic Azad University on 19th January 2015 (No:17230520931006).

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Conflicts of interest

There are no conflicts of interest.

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