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Trabajo Original

Valoración nutricional

Post-menopausal osteoporosis: do body composition, nutritional habits, and physical activity affect bone mineral density?

Osteoporosis posmenopáusica: ¿afectan a la densidad mineral ósea la composición corporal, los hábitos nutricionales y la actividad física?

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Abstract

Objective: to evaluate the effect of body composition, nutritional habits (NH), and physical activity (PA) levels on bone mineral density (BMD) in osteoporotic postmenopausal women (OPW).

Subjects and method: the demographic characteristics, anthropometric measurements, PA status, information on NH, some biochemical findings, and BMD measurements of 100 OPWs were evaluated.

Results: in this study, 48 % of the women were classified as obese. The obese women were found to have lower vitamin D levels and higher parathyroid hormone levels than those of the over-weight women. A positive correlation was found between body mass index and L_1L_4, L_2L_4, and femur BMD ($r = 0.268$, $p < 0.001$; $r = 0.241$, $p < 0.01$; $r = 0.369$, $p < 0.001$, respectively). There was a significant decrease in L_1L_4 and femur BMD with increasing age ($r = -0.224$, $p < 0.05$; $r = -0.366$, $p < 0.001$, respectively). Femur BMD showed a positive correlation with duration (hours/week) and frequency of PA (days/week). According to the logistic regression analysis, body weight, daily tea consumption, and PA were positively associated with femur BMD, while advanced age, the age of menarche, salt and coffee consumption, and postmenopausal fracture status were negatively associated.

Conclusion: we observed that body weight, some nutritional factors, and active lifestyle have seemed to effect BMD in OPWs. An adequate, balanced nutrition maintaining the ideal weight, and regular physical activity may improve bone health in OPWs.

Keywords:

Osteoporosis. Post-menopause. Nutritional habits. Bone mineral density. Physical activity.

Resumen

Objetivo: evaluar el efecto de la composición corporal, los hábitos nutricionales (NH) y los niveles de actividad física (PA) sobre la densidad mineral ósea (BMD) en mujeres posmenopáusicas osteoporóticas (OPW).

Sujetos y método: se evaluaron las características demográficas, mediciones antropométricas, estado de PA, información sobre NH, algunos hallazgos bioquímicos y datos de BMD de 100 OPW.

Resultados: en este estudio, el 48 % de las mujeres se clasificaron como obesas. Se encontró que las mujeres obesas tenían niveles más bajos de vitamina D y niveles más altos de hormona paratiroidea que los de las pacientes con sobrepeso. Se encontró una correlación positiva entre el índice de masa corporal y L_1L_4, L_2L_4 y la BMD del fémur ($r = 0{,}268$, $p < 0{,}001$; $r = 0{,}241$, $p < 0{,}01$; $r = 0{,}369$, $p < 0{,}001$, respectivamente). Hubo una disminución significativa de los valores de L_1L_4 y BMD femoral con el aumento de la edad ($r = -0{,}224$, $p < 0{,}05$; $r = -0{,}366$, $p < 0{,}001$, respectivamente). La BMD del fémur mostró una correlación positiva con la duración (horas/semana) y la frecuencia (días/semana) de la PA. Según el análisis de regresión logística, el peso corporal, el consumo diario de té y la PA se asociaron positivamente con la BMD del fémur, mientras que la edad avanzada, la edad de la menarquia, el consumo de sal y café, y la presencia o no de fracturas posmenopáusicas se asociaron negativamente.

Conclusión: observamos que el peso corporal, algunos factores nutricionales y el estilo de vida activo parecen haber afectado la BMD en las OPW. Una nutrición adecuada y equilibrada, el mantenimiento del peso ideal y la actividad física regular pueden mejorar la salud ósea de las OPW.

Palabras clave:

Osteoporosis. Posmenopausia. Hábitos nutricionales. Densidad mineral ósea. Actividad física.

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INTRODUCTION

Bone loss and osteoporosis are considered to be among the most important complications of the postmenopausal period (1). Osteoporosis is defined by the World Health Organization (WHO) as a progressive systemic skeletal disease characterized by decreased bone mass and bone tissue degradation, resulting in increased bone brittleness and fracture susceptibility (2). The decrease in bone mass, which is the physiological result of aging, continues with a 0.3 %-0.5 % loss of cortical bone in the slow phase, and 2 %-3 % in the fast phase after the age of 40. While the slow phase takes place in the first 6-10 post-menopausal years, the transition to the fast phase is proportional to sedentary life (3). It is estimated that 40 % of post-menopausal women have osteoporosis, more than 15 % have hip fractures, and 50 % have osteoporosis fractures in their lifetime (4).

Post-menopausal osteoporosis primarily stems from three main causes: deficiency of estrogen hormone, lack of physical activity, and poor nutrition (3).

A healthy lifestyle, staying physically active, maintaining the ideal body weight, and especially keeping a balanced nutrition play an important role in preventing chronic diseases such as osteoporosis (5). However, it is difficult to assess the effect of nutrition on bone health because diet is a combination of nutrients and the impact of individual nutrients is difficult to assess (5,6). The effect of nutritional status on bone mineral density in women with post-menopausal osteoporosis remains unknown (6). It has been suggested that healthy eating habits with high vegetable/fruit content may prevent osteoporosis, and an unbalanced diet, rich in processed foods, may cause a decrease in bone mineral density (BMD) (5). It has also been suggested in several studies that calcium intake is important for skeletal development and bone mass development. On the other hand, only few studies have investigated the effect of other nutrients on bone mass. The effects of protein, sodium, and caffeine on calcium metabolism are known, but their effects on bone mineral density have not been reported (6).

The aim of this study was to evaluate the effects of body composition, nutritional habits (NH), and physical activity (PA) levels on BMD in post-menopausal osteoporotic women (OPWs).

SUBJECTS AND METHOD

This study was conducted in Mersin City Hospital, between November 2019 and January 2020, in 100 Turkish women who were 40-75 years old, had been diagnosed with osteoporosis (BMD measurement, T score < -2.5), and were determined to be in the post-menopausal period (amenorrhea over one year). Exclusion criteria included: pregnancy or lactation, chronic kidney or liver disease, bowel disease (Crohn's disease, irritable bowel syndrome, short bowel syndrome), age outside the 40-75 year range, rejection to participate in the study. Data were collected using a questionnaire via face-to-face interviews.

The women's demographic characteristics, namely health status (menopause status and medication used, etc.), anthropometric measurements (height, weight, body mass index (BMI)), PA status, information about NH, biochemical data (serum calcium, phosphorus, parathyroid hormone levels), and BMD measurements were evaluated.

BMD measurements of the women were performed using the dual energy X-ray absorptiometry (DEXA) technique. Vertebral DEXA examinations were performed in the posterior-anterior direction, including the L_1L_4 and L_2L_4 vertebrae. Bone mineral density was recorded for vertebrae, femoral neck, and whole body. Body weights were measured and recorded by a dietician using a weighing instrument with ± 0.1 kg precision. Women´s height was measured and recorded by the dietician with a stadiometer. During height measurements, the women stood with both feet side by side, touching each other, and on the Frankfurt plane (a plane passing through the eyes and the upper margin of the auricle) (7). BMI was calculated with the formula of body weight (kg)/height $(m)^2$. BMI values are classified by WHO as underweight for those below 18.5 kg/m^2, normal for those between 18.5 and 24.9 kg/m^2, overweight for those between 25 and 29.9 kg/m^2, and obese for those over 30 kg/m^2 (8). In order to determine food consumption status in participants, daily food consumption and daily dietary energy and nutrient intake records were obtained via the 24-hour recall method, and the data were then analyzed by the "Computer Aided Nutrition Program, Nutrition Information Systems Package Program (BeBIS)", which was developed to be used in Turkey. In order to determine the NH of women, the Food Frequency Questionnaire (FFQ) form was administered (9).

In order to establish PA levels, information about exercise type (walking, running, swimming, yoga, Pilates, etc.), frequency (weekly, day), and duration was obtained.

This study was approved by the Ethics Committee, Scientific Research and Publication Board of Toros University (#80706068.02-050/22 and date: 25/09/2019/37).

STATISTICAL ANALYSIS

The data obtained in the study were evaluated with the SPSS 15.0 package program. Appropriate descriptive values are presented for qualitative and quantitative variables. Qualitative variables are presented as number (n) and percentage (%), and quantitative variables are presented as mean and standard deviation ($\overline{X}$ ± SD).

The suitability of the variables to normal distribution was examined using visual (histogram and probability graphs) and analytical methods (Kolmogorov-Smirnov/Shapiro-Wilk tests). For continuous variables, the difference between two means test (Student-t test or non-parametric test) was used between two independent groups, and a one-way variance analysis or non-parametric Kruskal-Wallis analysis test was used in groups of 3 or more. A logistic regression analysis test was used to evaluate the variables considered to have an effect on femur BMD measurements. Any p value less than 0.05 was considered statistically significant.

Table I. Demographic characteristics, anthropometric measurements, physical activity status, and clinical features of osteoporotic postmenopausal women

Variable	Value
Age, ($\overline{X}$ ± SD), year	54.73 ± 6.14
Body mass index, $\overline{X}$ ± SD) kg/m²	30.36 ± 4.73 (20.20-44.12)
Body mass index category, kg/m² (%)	
Underweight (< 18.5 kg/m²)	-
Normal (18.5 - < 24.99 kg/m²)	11
Overweight (25 - < 29.99 kg/m²)	41
Obese (≥ 30 kg/m²)	48
Current smokers, (%)	18
Duration of smoking ($\overline{X}$ ± SD), year	18.76 ± 10.10
Frequency of smoking ($\overline{X}$ ± SD), piece/day	14.83 ± 10.07
Physically active, (%)	16
Duration of activity, ($\overline{X}$ ± SD), hour/week	5.88 ± 1.45
Frequency of activity, ($\overline{X}$ ± SD), day/week	1.28 ± 1.34
Age of amenorrhea onset, ($\overline{X}$ ± SD), year	44.99 ± 5.24
Age of menopause onset, ($\overline{X}$ ± SD), year	45.16 ± 5.21
Number of pregnancies, ($\overline{X}$ ± SD)	5.25 ± 3.26
Prescription medication use, (%)	60
Vitamin-mineral supplementation, (%)	73
Postmenopausal fracture	24
Chronic diseases at baseline	
Diabetes mellitus	13
Hypertension	27
Cardiac disease	60
Other	8

Values are presented as mean ± SD or number (%).

RESULTS

In this study, 48 % of post-menopausal women who were diagnosed with osteoporosis were obese. The demographic and clinical features of these women are shown in table I.

According to the BMI classification, mean femoral BMD values in obese women were higher than those of overweight women ($p = 0.004$) (Table II).

Mean vitamin D levels were lower in obese women than in overweight women ($p = 0.04$), and mean PTH levels were higher in obese women than in overweight women ($p = 0.01$). In order to evaluate the relationship of low vitamin D and high PTH levels with NH in obese women, the differences in 24-hour food consumption were assessed. According to the BMI classification, there was a difference between daily energy (kcal/day) ($p = 0.002$), CHO (g/day) ($p = 0.007$) and fat (g/day) ($p = 0.003$) intakes, and there was no difference in terms of ingestion of the other nutrients (fat and water-soluble vitamins, minerals, pulp, and cholesterol). According to the post-hoc analysis, energy (kcal/day) ($p = 0.002$), CHO (g/day) ($p = 0.004$) and fat (gr/day) ($p = 0.004$) intakes in obese women were higher than in overweight women (Table II).

A positive correlation was found between BMI values and L_1L_4, L_2L_4 and femur BMD measurements ($r = 0.268$, $p < 0,001$; $r = 0.241$, $p < 0.01$; $r = 0.369$, $p < 0.001$, respectively) (Fig. 1). There was a significant decrease in L_1L_4 and femur BMD with increasing age ($r = -0.224$, $p < 0.05$; $r = -0.366$, $p < 0.001$, respectively). Femur BMD showed a positive correlation with PA duration (hours/week) and frequency (days/week) ($r = 0.214$, $p = 0.03$; $r = 0.231$, $p = 0.02$, respectively). There was no correlation between biochemical parameter measurements (serum calcium, vitamin D, and PTH) and BMD measurements (femur, L_1L_4 and L_2L_4) ($p > 0.05$).

According to the logistic regression analysis, body weight, daily tea consumption, and PA were positively associated with femur BMD, while advanced age, age at menarche, salt and coffee consumption, and post-menopausal fracture status were negatively associated (Table III).

DISCUSSION

As a result of this study, it was observed that body composition was associated with lumbar vertebrae and total femoral BMD in OPWs, and BMD increased as BMI increased. Głogowska-Szeląg (10) found a positive correlation between BMI and BMD in post-menopausal women diagnosed with osteoporosis, which is in accordance with the results of the present study. Barrera et al. (11) confirmed that high BMI values had a protective effect on the femoral neck bone BMD values of 845 healthy elderly individuals with low socioeconomic level.

Many studies in recent years have suggested that high BMI values may be protective for osteoporosis and fracture risk in men and in pre- and post-menopausal women (12-15). This dilemma between bone metabolism and obesity is a complex relationship known as the obesity paradox—the higher the values in bone mineral density, the less the risk for fractures in obese individuals (16). As reported in the NHANES 2005-2008 (The National Health and Nutrition Examination Survey conducted in the USA) after evaluating 3,296 adults, aged 50 years and over, the BMD value increased by 0.0082 g/cm² for each one-unit increase in BMI value (17). In contrast, some studies have shown a negative effect of obesity on BMD (18,19). It has been reported that the different results obtained in these studies may be due to differences between men, pre-menopausal women, and post-menopausal women in terms of lifestyle, obesity, and fat distribution. It has been reported that high levels of estrogen, leptin, and adiponectin contained in the subcutaneous adipose tissue, which are found in women more often than in men, may be protective for osteoporosis in women (16). Researchers have

Table II. Biochemical parameters and BMD measurements evaluated according to the BMI classification of osteoporotic postmenopausal women

BMD measurement values and Biochemical parameters	Values			
BMI (kg/m²)	18.5 - < 24.99 (n = 11)	25 - < 29.99 (n = 41)	≥ 30 (n = 48)	p
L_1-L_4 BMD	0.88 ± 0.07	0.89 ± 008	0.92 ± 0.07	> 0.05
$L_{2-}L_4$ BMD	0.88 ± 0.06	0.91 ± 0.08	0.93 ± 0.07	> 0.05
Femur BMD	0.83 ± 0.11	0.84 ± 0.09^c	0.90 ± 0.08^c	0.004†
Serum calcium	9.70 ± 0.34	9.66 ± 0.42	9.60 ± 0.46	> 0.05
Serum phosphor	4.33 ± 0.72	3.97 ± 0.82	3.85 ± 0.53	> 0.05
Serum PTH	64.2 ± 36.83	53.04 ± 23.63^a	71.09 ± 30.65^a	0.01*
Serum vitamin D	26.59 ± 20.21	27.08 ± 14.03^b	19.80 ± 12.36^b	0.04*
Daily food consumption, calculated via 24-hour food consumption	**Values**			
BMI (kg/m²)	18.5 - < 24.99 (n = 11)	25 - < 29.99 (n = 41)	≥ 30 (n = 48)	p
Energy (kcal/day)	*1543.75 ± 248.32*	*1493.99 ± 374.95^c*	*1774.98 ± 390.84^c*	*0.002†*
Protein (g/day)	*57.40 ± 13.35*	*59.44 ± 16.41*	*63.06 ± 17.35*	*> 0.05*
CHO (g/day)	*192.93 ± 42.28*	*177.17 ± 43.15^c*	*210.23 ± 52.47^c*	*0.007†*
Fat (g/day)	*57.22 ± 17.73*	*58.25 ± 21.37^c*	*72.72 ± 20.96^c*	*0.003†*

**Differences were tested with one-way ANOVA or Kruskal-Wallis analysis for continuous variables. Significant difference was set at *$p < 0.05$, $^†p < 0.01$. Mann-Whitney U-test or post hoc test was used for the analysis of further differences; $^ap < 0.01$, $^bp < 0.05$, $^cp < 0.005$.*

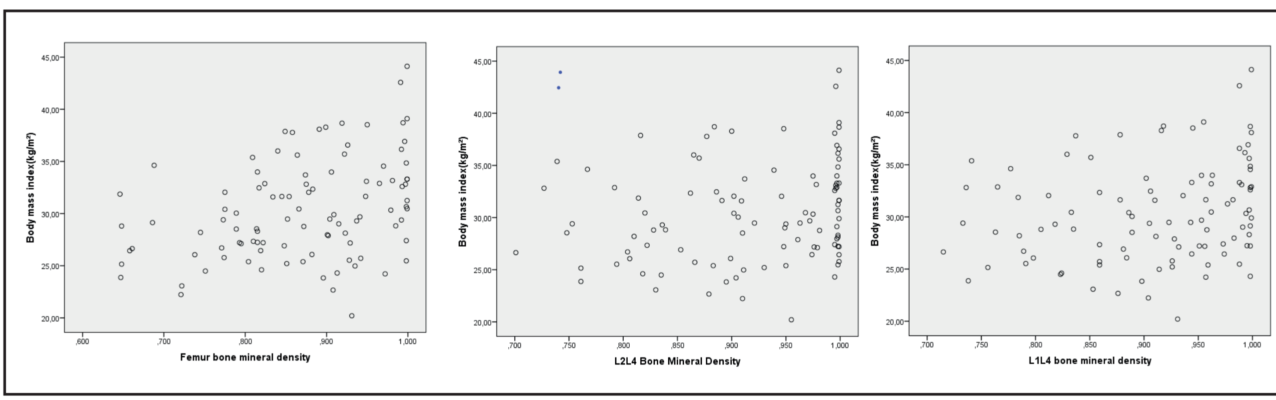

Figure 1.

Correlations between total femur and lumbar vertebrae bone mineral density and body mass index (kg/m2) in postmenopausal osteoporotic women.

reported that, despite the harmful effects of obesity on the body, the increase in BMI can prevent the reduction of BMD with advancing age, but there are no clear data regarding what is the ideal weight to prevent systemic diseases caused by osteoporosis and obesity in post-menopausal women (16). Skrzek et al. (20) reported the appropriate BMI value as 26.0-27.9 kg/m^2 for the lowest risk of osteoporosis in post-menopausal women. In contrast, in another study, it was reported that the optimal BMI interval value was 23.0-24.9 kg/m^2 for Korean men over 50 years of age and post-menopausal women to minimize the risk of osteoporosis and type-2 diabetes simultaneously (21).

In this study, we observed that obese women had higher femoral BMD values than overweight women. When the nutritional status of the women and the distribution of the nutrients they received were evaluated, it was found that the energy, CHO, and fat consumption of these obese women was significantly higher.

Table III. Regression analysis between bone mineral density and other determinants of postmenopausal osteoporotic women

Determinants	Regression analysis (Adjusted R2 value = 0.465, p = 0.001†)		
	Coeff.	95 % CI	p
Age, (year)	-0.004	-0.006 to -0.001	0.002†
Weight (kg)	0.003	0.002 to 0.004	0.001†
Age of menarche, (year)	-0.011	-0.020 to -0.002	0.01*
Salt consumption behavior, n No (19) Yes (81)	-0.023	-0.041 to -0.005	0.01*
Coffee consumption behavior, n No (48) Yes (52)	0.048	0.016 to 0.079	0.003†
Tea consumption behavior (count/day), n None (5) 1-4 cups of tea (47) 5-10 cups of tea (34) ≥ 10 cups of tea (14)	0.019	0.008 to 0.030	0.001†
Postmenopausal fracture, n No (76) Yes (24)	0.041	0.004 to 0.078	0.02*
Physical activity, n No (84) Yes (16)	0.109	0.018 to 0.200	0.01*
Duration of physical activity (n), None (84) ≥ 5 hours/ week (16)	-0.015	-0.033 to 0.002	0.08

*Significant difference was set at *p < 0.05, †p < 0.01.*

However, there was no relationship between calcium and vitamin D intakes (as obtained from FFQ data) and BMD, which could explain the high BMD in obese women. In contrast, obese women had lower levels of vitamin D and higher levels of PTH than those of overweight women. It is known that vitamin D deficiency causes osteopenia and osteomalacia, and negatively affects the prognosis of osteoporosis (22). In our study, vitamin D deficiency (plasma levels < 20 ng/mL) was found especially in obese women. Lee et al. (22) studied vitamin D deficiency in post-menopausal women, and found that the vitamin D deficiency rate in post-menopausal women with similar BMI values was 61.8 %. In the present study, higher femoral BMD measurements in obese women suggested that obesity had a protective effect on osteoporosis. However, this situation is complicated by low vitamin D and high PTH levels in these obese women.

According to the logistic regression analysis, body weight, daily tea consumption, and PA were positively associated with femur BMD, while advanced age, age of menarche, salt and coffee consumption, and post-menopausal fracture status were negatively associated. Cavkaytar et al. (23) studied 170 osteopenic and 224 osteoporotic post-menopausal women and reported that BMI values higher than 32 kg/m^2 were protective for post-menopausal osteoporosis according to the logistic regression analysis, and that advanced age is an independent risk factor for post-menopausal osteoporosis.

Caffeine is a naturally occurring plant xanthine alkaloid that is widely consumed worldwide and found in many beverages, including tea, coffee, and cocoa. Although moderate caffeine intake is generally thought to have positive effects on human health, its effect on bone metabolism is controversial (24). In rats with osteoporosis due to ovariectomy, medium or high doses of caffeine have been shown to have no detrimental effect on the skeletal system (24). In a study conducted in post-menopausal women in China, it was shown that the frequency of osteoporosis was higher in women who did not consume coffee regularly (25). In the 4th and 5th Korean National Health and Nutrition Survey (2008-2011), moderate coffee consumption in post-menopausal women was reported to have protective benefits on bone health (26). However, in accordance with our data, epidemiological studies have found that caffeine might contribute to loss of bone by increased urinary calcium excretion and decreased efficiency in calcium intestinal absorption (27,28). In post-menopausal women, caffeine intake can lead to a decrease in calcium absorption, and high doses of caffeine (> 300 mg/g or ≥ 4 cups/day) can speed up bone loss in the lumbar vertebrae (29). Because the conceivable effect of high coffee consumption on fracture risk and bone density is probably modest, large, long-term studies are needed to assess this (28). The increase in sodium intake due to increased salt consumption is associated with increased urinary calcium in men and women of all ages (30). However, there is no evidence that increased salt intake may result in any consistent effect on bone health or irreversible changes in bone loss when considering lifestyle, dietary habits, and hormonal factors (30). In our study, salt consumption was found to be an independent variable that affected BMD negatively.

Studies in recent years have shown that tea consumption can be a promising approach to reducing bone loss and reducing the risk for osteoporotic fractures in older adults (31). Tea polyphenols increase osteoblast genesis and suppress in vitro osteoclast genesis. Bone is resorbed by osteoclast cells and then new bone is formed by osteoblast cells. During bone remodeling, excessive osteoclastic activity and inadequate osteoblastic activity are the main reasons for osteoporosis development (31). Animal studies have shown that the intake of tea polyphenols has a positive effect on bone. This effect is manifested by increased bone mass and trabecular bone volume, number, and thickness, and lower trabecular separation, which results in stronger bones (32).

It is extremely important to exercise regularly and to be physically active by avoiding a sedentary lifestyle for healthy bones. In physically inactive individuals, mechanical receptors (osteocytes) cannot receive signals pertaining to the need for repairing/remodeling the damaged bone, or the need for synthesis of new bone. Thus, a gradual decrease in the total BMD occurs (33). In a study that investigated the risk factors of osteoporosis in post-menopausal women, regular PA was reported to be protective for osteoporosis, as in our study (34). The current study has several limitations. First, we have only analyzed OPWs and did not have corresponding data for a pre-menopausal younger population. Second, we had a small and heterogeneous study population. For further investigations, larger sample sizes including pre- and post-menopausal women are required, preferably using a longitudinal design.

In summary, our data show that weight, daily tea consumption, and PA levels may have a positive influence on BMD in OPWs, whereas age, age at menarche, salt and coffee consumption, and post-menopausal fracture status were observed to have negative effects on BMD. An active lifestyle and nutritional factors should not be ignored in the prevention of osteoporosis during the post-menopausal period. The importance of adequate, balanced nutrition throughout life is a known fact. As a result, it is thought that in order to increase the quality of life of women in the post-menopausal period more randomized studies should be conducted about PA, maintenance of ideal weight, avoidance of excessive salty foods, and consumption of coffee and tea.

REFERENCES

1. Atik Ş. Osteoporoz, Türkiye Eklem Hastalıkları Tedavi Vakfı Yayımı, Birinci Baskı, Ankara; 1998.
2. Kanis JA, Melton LJ, Christiansen C, Johnston CC, Khaltaev N. The diagnosis of osteoporosis. J Bone Miner Res 1994;9:1137-41. DOI: 10.1002/jbmr.5650090802
3. Tang G, Ma HK. Menopausal Osteoporosis. Int J Gynecol Obstet 1994;46:203-7. DOI: 10.1016/0020-7292(94)90236-4
4. Black DM, Rosen CJ. Clinical Practice Postmenopausal Osteoporosis. N Engl J Med 2016;374:254-62. DOI: 10.1056/NEJMcp1513724
5. Lanyan A, Marques-Vidal P, Gonzalez-Rodriguez E, Hans D, Lamy O. Postmenopausal women with osteoporosis consume high amounts of vegetables but insufficient dairy products and calcium to benefit from their virtues: the CoLaus/OsteoLaus cohort. Osteoporos Int 2020;31:875-86. DOI: 10.1007/s00198-019-05225-x
6. New SA, Bolton-Smith C, Grubb DA, Reid DM. Nutritional influences on bone mineral density: a cross-sectional study in premenopausal women. Am J Clin Nutr 1997;65:1831-9. DOI: 10.1093/ajcn/65.6.1831
7. Baysal A, Aksoy M, Besler HT, Bozkurt N, Keçecioğlu S, Merdol TK, et al. Diyet el kitabı, 5. Baskı, Ankara, Hatiboğlu yayınevi; 2008.
8. WHO. [Accessed April 27, 2016]. Avaliable at: http://apps.who.int/bmi/index.jsp?introPage=intro_3.html
9. Gunes FE, Imeryuz N, Akalin A, Bekiroglu N, Alphan E, Oguz A, et al. Development and validation of a semi-quantitative food frequency questionnaire to assess dietary intake in Turkish adults. J Pak Med Assoc 2015;65(7):756-63.
10. Głogowska-Szeląg J. Assessment of the relationship between bmd and body mass index bmi in women with postmenopausal osteoporosis. Wiad Lek 2018;71(9):1714-8.
11. Barrera G, Bunout D, Gattás V, de la Maza MP, Leiva L, Hirsch S. A high body mass index protects against femoral neck osteoporosis in healthy elderly subjects. Nutrition 2004;20(9):769-71. DOI: 10.1016/j.nut.2004.05.014
12. Fawzy T, Muttappallymyalil J, Sreedharan J, Ahmed A, Alshamsi SO, Al Ali MS, et al. Association between body mass index and bone mineral density in patients referred for dual-energy X-ray absorptiometry scan in Ajman, UAE. J Osteoporos 2011;2011:876309. DOI: 10.4061/2011/876309
13. Wee J, Sng BY, Shen L, Lim CT, Singh G, Das De S. The relationship between body mass index and physical activity levels in relation to bone mineral density in premenopausal and postmenopausal women. Arch Osteoporos 2013;8:162. DOI: 10.1007/s11657-013-0162-z
14. Montazerifar F, Karajibani M, Alamian S, Sandoughi M, Zakeri Z, Dashipour AR. Age, weight and body mass index effect on bone mineral density in postmenopausal women. Health scope 2014;3(2). DOI: 10.17795/jhealthscope-14075
15. Shayganfar A, Ebrahimian S, Masjedi M, Daryaei S. A study on bone mass density using dual energy X-ray absorptiometry: Does high body mass index have protective effect on bone density in obese patients? J Res Med Sci 2020;25:4. DOI: 10.4103/jrms.JRMS_1066_18
16. Fassio A, Idolazzi L, Rossini M, Gatti D, Adami G, Giollo A, et al. The obesity paradox and osteoporosis. Eat Weight Disord 2018;23(3):293-302. DOI: 10.1007/s40519-018-0505-2
17. Lloyd JT, Alley DE, Hawkes WG, Hochberg MC, Waldstein SR, Orwig DL. Body mass index is positively associated with bone mineral density in US older adults. Arch Osteoporos 2014;9:175. DOI: 10.1007/s11657-014-0175-2
18. Gnudi S, Sitta E, Lisi L. Relationship of body mass index with main limb fragility fractures in postmenopausal women. J Bone Miner Metab 2009;27:479-84. DOI: 10.1007/s00774-009-0056-8
19. Greco EA, Fornari R, Rossi F, Santiemma V, Prossomariti G, Annoscia C, et al. Is obesity protective for osteoporosis? Evaluation of bone mineral density in individuals with high body mass index. Int J Clin Pract 2010;64:817-20. DOI: 10.1111/j.1742-1241.2009.02301.x
20. Skrzek A, Koziel S, Ignasiak Z. The optimal value of BMI for the lowest risk of osteoporosis in postmenopausal women aged 40-88 years. Homo 2014;65:232-9. DOI: 10.1016/j.jchb.2014.01.003
21. Hyun LJ, Kim JH, Hong AR, Kim SW, Shin CS. Optimal body mass index for minimizing the risk for osteoporosis and type 2 diabetes. Korean J Intern Med 2019. doi: 10.3904/kjim.2018.223. [Epub ahead of print]
22. Lee JS, Kim JW. Prevalence of vitamin D deficiency in postmenopausal high- and low-energy fracture patient. Arch Osteoporos 2018;10;13(1):109. DOI: 10.1007/s11657-018-0524-7
23. Cavkaytar S, Seval MM, Atak Z, Findik RB, Ture S, Kokanali D. Effect of reproductive history, lactation, first pregnancy age and dietary habits on bone mineral density in natural postmenopausal women. Aging Clin Exp Res 2015;27(5):689-94. DOI: 10.1007/s40520-015-0333-4

24. Xu H, Liu T, Hu L, Li J, Gan C, Xu J, et al. Effect of caffeine on ovariectomy-induced osteoporosis in rats. Biomed Pharmacother 2019;112:108650. DOI: 10.1016/j.biopha.2019.108650
25. Yang P, Zhang XZ, Zhang K, Tang Z. Associations between frequency of coffee consumption and osteoporosis in Chinese postmenopausal women. Int J Clin Exp Med 2015;8(9):15958-66.
26. Choi E, Choi KH, Park SM, Shin D, Joh HK, Cho E. The Benefit of Bone Health by Drinking Coffee among Korean Postmenopausal Women: A Cross-Sectional Analysis of the Fourth & Fifth Korea National Health and Nutrition Examination Surveys. PLoS One 2016;27:11(1):e0147762. DOI: 10.1371/journal.pone.0147762
27. Rapuri PB, Gallagher JC, Kinyamu HK, Ryschon KL. Caffeine intake increases the rate of bone loss in elderly women and interacts with vitamin D receptor genotypes. Am J Clin Nutr 2001;74(5):694-700.
28. Wolk A, Glynn A, Warensjö E, Byberg L, Michaëlsson K. Coffee consumption in relation to osteoporotic fracture risk and bone mineral density: a prospective longitudinal cohort study. Bone 2012;50:S36.
29. Shuai L, Zhipeng D, Qiang W. Effect of coffee intake on hip fracture: a meta-analysis of prospective cohort. Nutr J 2015;14:38.
30. Cohen AJ, Roe FJ. Review of risk factors for osteoporosis with particular reference to a possible aetiological role of dietary salt. Food Chem Toxicol 2000;38(2-3):237-53.
31. Shen CL, Chyu MC, Wang JS. Tea and bone health: steps forward in translational nutrition. Am J Clin Nutr 2013 98(Suppl 6):1694S-9S. DOI: 10.3945/ajcn.113.058255
32. Das AS, Mukherjee M, Mitra C. Evidence for a prospective anti-osteoporosis effect of black tea (Camellia Sinensis) extract in a bilaterally ovariectomized rat model. Asia Pac J Clin Nutr 2004;13:210-6.
33. Branković S, Vukojević P, Vujasinović-Stupar N, Palić- Obradović S. Role of exercise program on bone mass in matients with osteoporosis. Acta Rheuma Belgrade 2009;30:34-8.
34. Bijelic R, Milicevic S, Balaban J. Risk Factors for Osteoporosis in Postmenopausal Women. Med Arch 2017;71(1):25-8. DOI: 10.5455/medarh.2017.71.25-28.