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Relation between bone density and certain parameters of lipid status in postmenopausal women

Research Article

Aleksandar Dimic[1]*, Marina Rašic Popovic[2], Ivan Tasic[1], Dragan Djordjevic[1], Sonja Stojanovic[1], Bojana Stamenkovic[1], Dejan Popovic[2], Saša Milenkovic[1], Milena Dimic[3], Jovan Nedovic[1]

1 Institute for Therapy & Rehabilitation, Niska Banja, Serbia, Faculty of Medicine, University of Nis, Bul. Dr Zorana Djindjica 81, 18000 Nis, Serbia

2 Health Center Vranje, J. J. Lunge 1, 17500 Vranje, Serbia

3 Faculty of Medicine, University of Nis, Bul. Dr Zorana Djindjica 81, 18000 Nis, Serbia

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Abstract: The aim of the paper was to examine the relation between bone density and certain parameters of lipid status in postmenopausal women. The research involved 300 women referred to densitometric examination as they belonged to the risk group of postmenopausal women. All the examinees had the following biochemical parameters determined: total cholesterol, triglycerides, HDL cholesterol, LDL cholesterol, glycemia, serum Ca and P. Univariate logistic regression analyses showed that each year of age, menopause duration, AH are significantly connected to risk increase for the appearance of osteopenia or osteoporosis. Increase in values of SBP, DBP, cholesterol, LDL and triglyceride are connected with significant risk increase for the appearance of osteopenia or osteoporosis. Patients with AH are connected to 11 times elevated risk for the appearance of osteopenia or osteoporosis, cigarette smoking increased the risk by seven times, physical inactivity even by 52 times, CVD in the family anamnesis by eight times, and osteoporosis in the family anamnesis is connected to the risk by four times. In our research, atherogenic lipoproteins negatively correlate with lumbar bone density. Disturbed lipide status is a risk factor for cardiovascular diseases, but also a risk factor for the appearance of osteoporosis.

Keywords: *Bone mineral density • Cardiovascular risk • Postmenopausal women • Lipid status*

1. Introduction

Cardiovascular diseases (CVDs) are problematic because of their prevalence, early disability, frequent hospitalizations and early death. Osteoporosis (OP) carries with it an increased risk of bone fracture, consequent disability and hospital mortality, as well as the high cost to manage its complications [1].

Osteoporosis and atherosclerosis greatly influence personal health, especially among the aging population and postmenopausal women. These chronic diseases have similar risk factors (physical inactivity, smoking, age profile, hyperhomocysteinemia, inflammation, oxidative stress). Elevated LDL cholesterol levels and low HDL cholesterol levels are associated with a decrease in bone density and with bone remodeling and the atherosclerotic process. Oxidized serum lipids, besides their already determined role in atherogenesis, have been shown, under experimental conditions, to affect both osteoblasts and osteoclasts. Estrogens also play a role in both CVD and OP through their effects on cytokines, such as IL-1, IL-6, TNF-alpha and osteoprotegerin.

Study results have shown that bisphosphonates administered as therapy for osteoporosis have a positive effect on lipid parameters, and that hypolipemic drugs—statins—have a beneficial effect on bones in that they also retard osteoporosis and atherosclerosis [2-4].

Estrogens are natural cardioprotective and vasoprotective agents; besides their influence on the lipid profile, they affect the hemopath system by acting on the endo-

* *E-mail: aleksandardimi@yahoo.com*

thelium of blood vessels, modulating the effect of nitric oxide (NO), vasoactive substances and cytokines [5]. Also, they have a protective role for bone tissue through receptors on osteoblasts and the modulating effect on cytokines, growth factors and hormones. Loss of ovarian function with ensuing estrogen deficiency leads to sleep disorders, mood disorders, depression and also to an increased risk for some chronic diseases, including cardiovascular diseases and osteoporosis [6,7].

Several studies, however, indicate that atherosclerosis and osteoporosis are associated. Calcification is a common feature of atherosclerotic plaques and is regulated in a way similar to bone mineralization. Vascular calcification is similar to bone formation, and both are regulated by estrogen. Moreover, calcified plaque has been shown to have numerous cellular and molecular elements that participate in bone formation including (but not exclusive to) bone morphogenetic protein-2, collagen 1, osteonectin, osteopontin, matrix Gla proteins, osteocalcin and osteoprotegerin [8-11].

1.1 Aim

The aim of the paper is to examine the relationship between bone density and certain parameters of lipid status in postmenopausal women.

2. Examinees

The research involved 300 women referred for densitometric examination because they were postmenopausal women at risk for osteoporosis; the examination was undertaken in the Bone Densitometry Unit in the Institute for Treatment and Rehabilitation "Niška Banja", Niš. All examinees were postmenopausal (menopause defined by absence of menstrual periods for twelve months). The research excluded examinees with documented cardiovascular disease, diabetes, secondary osteoporosis caused by a number of endocrine disorders, systemic diseases, as well as examinees who took drugs known to influence the bone metabolism (glucocorticoids and anticonvulsants).

Characteristics of examined groups

Based on the measured bone densities, the examinees were divided into three groups:

Group I - 84 examinees had osteoporosis, i.e., T-score ≤ - 2.5;

Group II - 115 examinees had osteopenia, i.e., T-score from -1 to -2.5;

Group III - 101 examinees had normal bone density, T-score ≥ -1.

Average age of postmenopausal women was 56.96 years (SD±4.78).

In the research, the following parameters were used:

1. Clinical patient processing included taking personal anamnesis, as proscribed by the protocol.
2. Densitometry determination of bone density.

Bone density measurements were made in the lumbar spine using the DXA Densitometer Choplogic Discovery QDR-C; the results were presented as absolute values (gr/cm^2) and T- score. According to WHO recommendations, the gold standard for bone density measurement is a dual energy x-ray absorptiometry (DEXA) scan that measures bone density in the spine and left hip [12]. According to the WHO definition, normal bone mineral density is present when the T-score is -1.0 or above; in osteopenia, the T-score is between -1 and -2.5; in osteoporosis, the T-score is 2.5 standard deviations below the mean for young, healthy female population. Severe osteoporosis, with the T-score ≤ -2.5, is accompanied by fractures [13].

3. Anthropometric measurement included the measurements of body mass (BM) and body height (BH). Based on these measurements, the body mass index (BMI) was calculated according to the following formula:

$$BMI\ (kg/m^2) = BM\ (kg)/BH2\ (m^2)$$

Obesity was defined as BMI>30 kg/m^2. Waist circumference was measured by positioning the measuring tape midway between the top of the hip bone and the bottom of the rib cage; values were estimated according to the WHO criteria. The normal value for women is <88 cm.

4. Arterial blood pressure (BP) measurement was performed on both arms in a sitting position half an hour after rest, by the auscultatory Korotkoff technique, using a sphygmomanometer. Arterial hypertension (AH) is defined when the systolic blood pressure (SBP) is higher than 140 mmHg, and diastolic blood pressure (DBP) is higher than 90 mmHg.
5. Lifestyle, in the sense of physical activity, smoking and alcohol use, was analyzed. The examinees who reported to be physically active every day (fast walking, bicycle driving, swimming, doing aerobic exercises) in duration of 30–45 min, 4–6 times a week were regarded as physically active; this intensity amounted to 60%–75% of the corresponding heart frequency [14]. Smokers were defined as individuals who reported everyday smoking. The non-smokers included ex-smokers (who had not smoked for more than the past two years) and individuals who had never smoked.
6. Biochemical parameters

All examinees had the following biochemical parameters determined: total cholesterol, triglycerides, HDL cholesterol, LDL cholesterol, glycemia, serum Ca and P.

• Total cholesterol (TC) was determined by enzymatic colorimetric method (PAP); reference laboratory values 3.9–5.5 mmol/L.
• Triglycerides (TG) were determined by enzymatic colorimetric method; reference laboratory values 0.70–2.0 mmol/L.
• HDL cholesterol (HDL-C) was determined by enzymatic colorimetric method (PAP); reference laboratory values1.0–1.7 mmol/L for women.
• LDL cholesterol (LDL-C) was indirectly determined, using the following formula: LDL-C=Hol – Tg/2.2-HDL-C; reference laboratory values 2.8–3.9 mmol/L.
• Glucose (Gly) was determined by GOD-PAP method; reference laboratory values 3.6–6.1 mmol/L.
• Serum Ca was determined by spectrophotometric method; reference laboratory values 2.20–2.65 mmol/L.
• Serum phosphorus (P) was determined by spectrophotometric method; reference laboratory values 0.81–1.45 mmol/L.

7. Determination of the total ten-year risk for the occurrence of fatal cardiovascular event.

The total 10-year risk was calculated for all examinees by using the SCORE system charts for the countries with high cardiovascular risk.

4. Statistical methods

Quantitative statistical analysis was performed using Microsoft Office Excel 2003 for registration, rating, grouping, and tabular and graphical data presentation. Calculations were done using SPSS 10.0.

The following statistical parameters were presented: arithmetic mean (Xsr), standard deviation (SD), minimum and maximum values, structure index (%), and 95% confidence interval (95% CI).

To compare the means of the two examinee groups, Student's t-test and Mann-Whitney U-test were used when the distribution of values did not meet the requirements of normal distribution. Comparison of values among the three groups of examinees was done using a simple univariate analysis of variance (ANOVA with Dunnett post hoc test).

To compare the frequency of certain features, the Mantel-Haenszel chi-square test and Fisher's exact probability test were used when some of the expected frequencies were below 5.

Estimate of factor-of-interest influence on the values of bone density was performed using linear regression analysis. Regression coefficients (B) and 95% confidence intervals were calculated. The statistical significance of regression coefficients was checked using the t-test. The factors proved by univariate regression to significantly influence the values of dependent variables were included in multivariate regression models. By applying the backwards stepwise method, the model excluded all factors where the influence was not statistically significant in a multivariate analysis. The values of coefficients represent changes in the values of dependent variables caused by changes in the values of independent variables by one measuring unit. For independent variables, the regression coefficient represents a change in the value of dependent variable in one modality compared to the other.

Estimate of significant predictors of osteopenia and osteoporosis was done by logistic regression analysis. We calculated the values of approximate risk (odds ratio, OR) for the occurrence of osteopenia and osteoporosis under the influence of the score factors for the total cardiovascular risk, as well as traditional risk factors for cardiovascular diseases. Statistical significance of the calculated OR values was checked by the Wald test based on chi square distribution. After univariate regression analysis, multivariate analysis was performed following the same principles as those in the linear regression analysis.

In all analyses, the error estimate lower than 5% ($p<0.05$) was taken as borderline statistical significance. The results of statistical analysis are presented in tables and graphs.

5. Results

The average cholesterol level in patients with normal bone density was 5.23±0.60 mmol/L, in the group with osteopenia 6.00±1.16 mmol/L, and in women with osteoporosis, 6.64±0.78 mmol/L. ANOVA and Dunnett's test show that the differences between all those values are highly statistically significant ($p<0.001$) (Table 1).

Table 1. Cholesterol level in patients by group (mmol/L).

Parameter	Group			Total
	Control	Osteopenia	Osteoporosis	
Xsr	5.23	6.00	6.64	5.92
SD	0.60	1.16	0.78	1.06
Median	5.13	5.82	6.47	5.75
Minimum	3.90	3.71	5.08	3.71
Maximum	7.02	10.57	9.80	10.57

The average HDL level in the control group was 1.28±0.25 mmol/L, in the group with osteopenia it was 1.23±0.21 mmol/L, in women with osteoporosis 1.22±0.40 mmol/L. Differences between those values are not statistically significant (Table 2).

Table 2. HDL level in patients by group (mmol/L).

Parameter	Group			Total
	Control	Osteopenia	Osteoporosis	
Xsr	1.28	1.23	1.22	1.24
SD	0.25	0.21	0.40	0.29
Median	1.25	1.25	1.25	1.25
Minimum	0.80	0.93	0.61	0.61
Maximum	2.01	2.06	2.28	2.28

The average LDL level in the control group was 3.09±0.58 mmol/L; it was statistically significantly lower (ANOVA and post hoc test: p<0.001) than in the groups with osteopenia (3.87±1.68 mmol/L) and osteoporosis (4.26±0.81 mmol/L) (Figure 1).

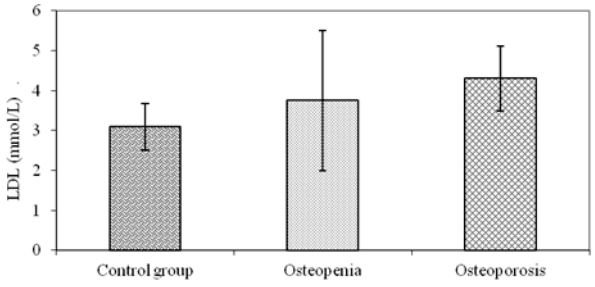

Figure 1. LDL level in patients presented by groups (mmol/L).

The average triglyceride level in patients with normal bone density was 1.24±0.45 mmol/L, in the group with osteopenia it was 1.54±0.58 mmol/L, and in women with osteoporosis it was 1.83±0.95 mmol/L. Differences between all those values are highly statistically significant (ANOVA and post hoc test: p<0.001) (Table 3).

Table 3. Triglyceride level in patients by group (mmol/L).

Parameter	Group			Total
	Control	Osteopenia	Osteoporosis	
Xsr	1.24	1.54	1.83	1.52
SD	0.45	0.58	0.95	0.71
Median	1.15	1.43	1.61	1.43
Minimum	0.57	0.60	0.71	0.57
Maximum	3.00	3.33	8.02	8.02

The average BMI value in patients with normal bone density was 26.54±3.36 kg/m^2, in the group with osteopenia it was 26.64±3.89 kg/m^2, and in women with osteoporosis it was 26.05 ±3.73 kg/m^2; differences between those values are not statistically significant (p>0.05) (Table 4). Univariate linear regression analysis showed a significant negative correlation between age and menopause duration on the one side and bone density on the other, in the following way: age by 0.012 g/cm^2 (0.009–0.015 g/cm^2) and menopause by 0.012 g/cm^2 as well (0.010–0.014 g/cm^2).

Values of systolic BP (SBP), diastolic BP (DBP), cholesterol, LDL and triglycerides showed a significant negative correlation with bone density: SBP by 0.005 g/cm^2 (0.005–0.006 g/cm^2), DBP by 0.008 g/cm^2 (0.007–0.010 g/cm^2), cholesterol by 0.060 g/cm^2 (0.047–0.072 g/cm^2), LDL by 0.038 g/cm^2 (0.027–0.049), and triglycerides by 0.056 g/cm^2 (0.036–0.077 g/cm^2).

Table 4. BMI values in patients by group (kg/m^2).

Parameter	Group			Total
	Control	Osteopenia	Osteoporosis	
Xsr	26.54	26.64	26.05	26.44
SD	3.36	3.89	3.73	3.67
Median	26.57	26.03	26.03	26.28
Minimum	18.29	17.99	18.37	17.99
Maximum	42.42	40.51	36.44	42.42

Examinees with arterial hypertension (AH) had decreased bone density by 0.318 g/cm^2 (0.11–0.164 g/cm^2), examinees who smoked had decreased bone density by 0.128 g/cm^2 (0.101–0.155 g/cm^2), examinees with increased total cardiovascular risk by 0.196 g/cm^2 (0.174–0.218), physically inactive examinees by 0.171 g/cm^2 (0.146–0.195 g/cm^2), existence of CVD in family anamnesis by 0.113 g/cm^2 (0.086–0.140), and osteoporosis in the family anamnesis decreased bone density by 0.084 (0.084–0.120).

The HDL level showed a significant positive correlation with bone density by 0.057 g/cm^2 (0.005–0.109); examinees who had given birth to children showed increased bone density by 0.078 g/cm^2 (0.020–0.136 g/cm^2) compared with women who had not. Values of BMI, glycemia, level of phosphorus and alcohol consumption did not significantly influence the values of bone density (Table 5).

Univariate logistic regression analyses showed that for each year of age and menopause duration AH is significantly connected to increased risk for osteopenia or osteoporosis: age by 25% (17%–33%), menopause by 42% (30%–54%), AH by 62% (41%–86%). Increase in values of SBP, DBP, cholesterol, LDL and triglyceride for a single measurement unit are connected with significant risk increase for the appearance of osteopenia or osteoporosis: SBP by 15% (12%–19%), DBP–20% (14%–25%), cholesterol by 5 times (3–8 times), and LDL and triglyceride by 4.5 times. Patients with AH have an 11-fold elevated risk for osteopenia or osteoporosis; cigarette smoking increased the risk by 7-fold, physical inactivity as much as 52-fold, CVD in the family anamnesis by 8-fold, and osteoporosis in the family anamnesis is connected to a 4-fold increase in risk.

Values of BMI, HDL, glucose, calcium and phosphorus levels, alcohol consumption and previously having given birth did not show a significant influence on the risk for either of osteopenia or osteoporosis (Table 6) (Figure 2).

Table 5. Influence of risk factors on bone density; results of univariate linear regression analysis.

Factor	B	t	p	Limits of 95% IP for B	
				Lower	Upper
Age (years)	-0.012	8.28	<0.001	-0.015	-0.009
Menopause duration (years)	-0.012	12.56	<0.001	-0.014	-0.010
Arterial hypertension (years)	-0.138	10.18	<0.001	-0.164	-0.111
Body mass index (kg/m^2)	0.003	1.34	0.183	-0.001	0.007
Systolic BP (mmHg)	-0.005	15.16	<0.001	-0.006	-0.005
Diastolic BP (mmHg)	-0.008	11.32	<0.001	-0.010	-0.007
Smoking	-0.128	9.36	<0.001	-0.155	-0.101
Cholesterol (mmol/L)	-0.060	9.46	<0.001	-0.072	-0.047
HDL – cholesterol (mmol/L)	0.057	2.16	0.032	0.005	0.109
LDL-cholesterol (mmol/L)	-0.038	6.81	<0.001	-0.049	-0.027
Triglycerides (mmol/L)	-0.056	5.49	<0.001	-0.077	-0.036
Glycemia (mmol/L)	-0.012	0.77	0.442	-0.043	0.019
Total CV risk	-0.033	18.04	<0.001	-0.036	-0.029
Increased total CV risk	-0.196	17.48	<0.001	-0.218	-0.174
Ca (mmol/L)	0.100	2.08	0.039	0.005	0.195
P (mmol/L)	0.076	1.61	0.109	-0.017	0.168
Physical inactivity	-0.171	13.54	<0.001	-0.195	-0.146
Genetics of CVD	-0.113	8.17	<0.001	-0.140	-0.086
Genetics of osteoporosis	-0.084	4.63	<0.001	-0.120	-0.048
Alcohol consumption	0.012	0.31	0.761	-0.067	0.092
Childbirth	0.078	2.64	0.009	0.020	0.136

Table 6. OR values for the assessment of the connection of lower bone density (osteopenia and osteoporosis) and risk factors: results of the univariate logistic regression analyses.

Factor	OR	Wald	p	Limits of 95% IP for B	
				Lower	Upper
Age (years)	1.25	46.94	<0.001	1.17	1.33
Menopause duration (years)	1.42	67.37	<0.001	1.30	1.54
Arterial hypertension (years)	10.89	69.69	<0.001	6.22	19.09
Duration of hypertension	1.62	47.26	<0.001	1.41	1.86
Body mass index (kg/m^2)	0.99	0.11	0.739	0.93	1.06
Systolic BP (mmHg)	1.15	84.38	<0.001	1.12	1.19
Diastolic BP (mmHg)	1.20	57.32	<0.001	1.14	1.25
Smoking	7.08	37.17	<0.001	3.78	13.29
Cholesterol (mmol/l)	4.98	53.26	<0.001	3.24	7.67
HDL – cholesterol (mmol/L)	0.40	3.73	0.054	0.16	1.01
LDL-cholesterol (mmol/L)	4.55	49.72	<0.001	2.98	6.92
Triglycerides (mmol/L)	4.52	25.94	<0.001	2.53	8.07
Glycemia (mmol/L)	1.29	1.01	0.314	0.79	2.12
Total CV risk	7.14	46.07	<0.001	4.05	12.61
Increased total CV risk	2.12	35.12	<0.001	1.83	2.45
Ca (mmol/L)	0.32	1.28	0.257	0.04	2.31
P (mmol/L)	0.65	0.19	0.663	0.09	4.55
Physical inactivity	51.97	29.48	<0.001	12.49	216.33
Genetics of CVD	8.07	45.77	<0.001	4.41	14.78
Genetics of osteoporosis	4.33	13.31	<0.001	1.97	9.50
Alcohol consumption	1.37	0.21	0.649	0.36	5.27
Childbirth	0.44	2.06	0.151	0.15	1.35

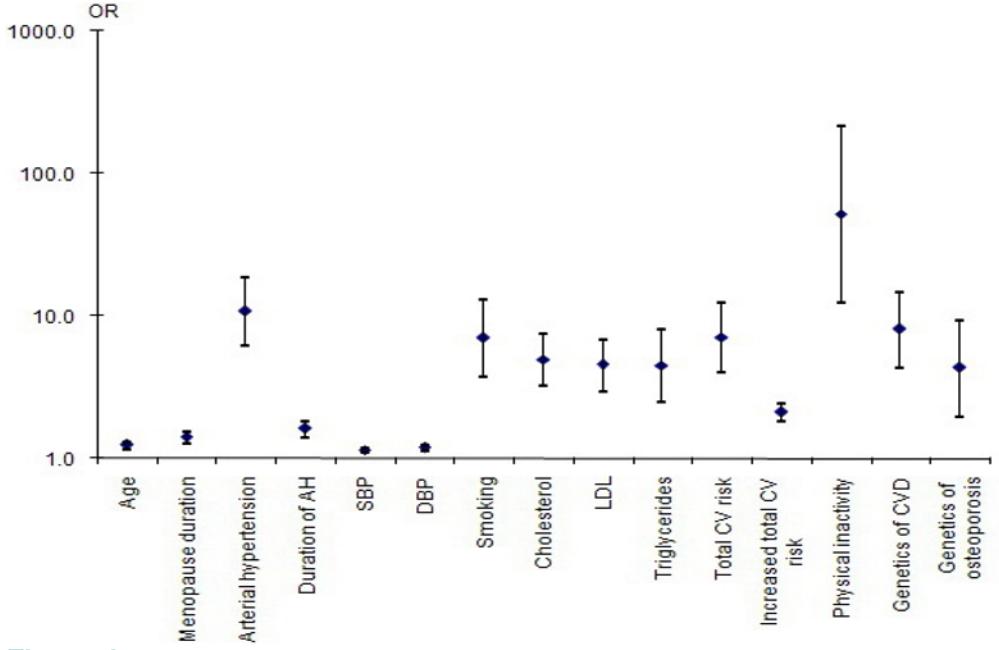

Figure 2. Values of OR and their 95% CI for the estimation of significant factors' influence on bone density – results of univariate logistic regression analysis.

6. Discussion

Many studies have shown conflicting results regarding the relationship between lipid status and bone density. Numerous authors have established the correlation between lipid status and bone mass; however, there are also reports that show that changes in lipid status do not show a significant connection to bone mass.

Solomon et al. included 13,592 persons in their investigation based on the NHANES III study (The National Health and Nutritional Examination Survey, U.S.), who had certain values of bone density and lipid levels. Patients who were on lipid-lowering therapy were excluded from that investigation. Comparing bone density to the total cholesterol, LDL cholesterol and HDL cholesterol, data from that extensive study suggest that elevated total cholesterol and LDL cholesterol are associated with reduced bone density values, whereas positive HDL cholesterol values are associated with higher bone density values [15].

In a study of 52 obese women in early menopause, Orozco suggested that cardiovascular risk factors such as hyperlipidemia may be associated with low bone density. His data also suggest that 81% of women with hyperlipidemia have osteopenia, which implies that women with atherogenic lipid status have a strong association with osteopenia and osteoporosis. In other words, postmenopausal women with LDL cholesterol higher than 4,1 mmol/L have a reduced spinal and femur BMD in comparison with women who have normal values of lipid parameters [16].

Yamaguchi et al., in a study involving 214 Japanese women, established that LDL cholesterol was significantly inversely correlated with BMD of the lumbar spine, and that HDL cholesterol was significantly positively correlated with BMD of the lumbar spine [17].

Analyzing our results from univariate logistic regression analyses and the values of lipid parameters in the groups of the present study, it is apparent that total cholesterol values, LDL cholesterol and triglyceride ($p<0.001$) have an influence on bone density, whereas HDL cholesterol values have a less significant influence on bone density.

Stulc et al. established a negative correlation between BMD of the lumbar spine and cholesterol and triglyceride plasma values in postmenopausal women [18]. Similarly, Makovey et al., in a univariate regression analyses, showed an inverse correlation of total cholesterol and LDL cholesterol with bone density in postmenopausal women in all localizations [19].

The afore-mentioned results correspond to our results by one measurement unit. Cholesterol, LDL and triglyceride values showed significant negative correlation with bone density: cholesterol by 0.060 g/cm^2 (0.047–0.072 g/cm^2), LDL by 0.038 g/cm^2 (0.027–0.049 g/cm^2), triglyceride by 0.056 g/cm^2 (0.036–0.077 g/cm^2). The HDL level showed a significant positive correlation with bone density by 0.057 g/cm^2 (0.005–0.109 g/cm^2).

An extensive study by Semelsone et al. (the Framingham Osteoporosis Prospective Study) did not find any correlation between total cholesterol level and bone density [20]. Likewise, Begger et al. also suggest the absence of any correlation between lipid parameters and bone density. However, comparing women with or without vertebral fracture, the serum triglycerides showed significant differences. In their investigation, those authors emphasize that serum lipids do not affect bone density directly, but rather indirectly through promotion of atherosclerosis that in its turn affects local bone metabolism [21].

The results of Cui et al. suggest that total cholesterol and LDL levels inversely correlate with BMD in premenopausal and postmenopausal women. In postmenopausal women, inverse correlation of total cholesterol and LDL cholesterol with hip BMD is established, whereas triglyceride levels show a positive correlation with trochanter bone density, unlike the already mentioned high triglycerides, which in premenopausal women show an inverse correlation with spinal bone density [22].

In the investigation by Tanko et al. including 340 postmenopausal women of average age 59 years (50–75 years) followed up for 8 years, showed that at the beginning, serum cholesterol showed a negative correlation with BMD; however, after adjusting for age and BMI after the 8-year follow-up period, no correlation appeared. However, it was shown that patients with the highest increase of serum cholesterol had the greatest decrease in spinal BMD apart from BMI [23].

The impact of hyperlipidemia, according to data from the literature, and higher on the lumbar spine than on the proximal femur, there is a higher prevalence of lumbar osteoporosis and osteopenia in women with hypercholesterolemia, defined as total cholesterol values higher than 5.7 mmol/L, in comparison with patients who have normal lipid status, and that women with lumbar osteoporosis have higher cholesterol levels in comparison with patients with normal bone density divided according to the age of the patient.

The results of Hsu et al. in a large number of men and in premenopausal and postmenopausal women showed a significant negative correlation of total cholesterol, LDL cholesterol, the HDL/LDL cholesterol relationship and bone density in all mentioned groups. They have also shown that the risk for osteoporosis increases depending on the body fat percentage [24].

Shilbayer et al. showed a strong independent association of LDL cholesterol and BMD [25].

Poli et al., based on study results that included 1303 postmenopausal women, suggest that an increased LDL cholesterol level should be considered an additional risk factor for the reduction of bone mineral density [26].

The Hertfordshire Cohort Study study, which investigated problems of lipid status, obesity and bone density in 465 men and 448 women, established that bone density correlates with triglyceride, HDL cholesterol values, even after setup relationship waist-hip, age, social status and lifestyle, but not with total cholesterol and LDL cholesterol [27].

Adami et al., by univariant analysis in older postmenopausal women, established a positive correlation of bone density with all lipid parameters, except with HDL cholesterol where there was a negative correlation [28]. D'Amelio et al. also established a negative connection between HDL cholesterol and bone density. Poli et al., and Cui, also suggest the absence of any correlation between HDL cholesterol and bone density [24].

In their study, Brownbill and Ilich showed that glyceride serum positively correlates with femoral bone density, and total cholesterol with total bone density. Postmenopausal women with serum triglyceride above the median value had significantly higher hip BMD than those whose triglyceride was below the median. Patients with total cholesterol values above 240 mg/dl had significantly higher bone density [29]. The investigation of Kim et al., including 907 postmenopausal women age 60 to 79, showed that HDL cholesterol positively correlates with femoral bone density; waist circumference correlates negatively with BMD, whereas the BMI positively correlates with BMD [30].

7. Limitations

Because of the small study population (300 patients), conclusions should be drawn with caution. The research should be continued with the inclusion of male patients, and the definite importance of the results obtained will be demonstrated after the follow-up of the examinees.

8. Conclusion

In our research, atherogenic lipoproteins negatively correlate with lumbar bone density. The connection between lipid status and bone density is more pronounced in persons with osteoporosis than in patients with osteopenia and those with normal bone density. Disturbed lipid status is a risk factor for cardiovascular diseases, but also a risk factor for the development of osteoporosis.

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