Serum calcium, magnesium, phosphorous and lipid profile in healthy Iranian premenopausal women

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Abstract

Introduction: Recent epidemiological evidence suggests that alteration in calcium, phosphorous or magnesium metabolism may have direct cardiovascular consequences. However, it is unknown whether variations in serum values of these minerals are in relationship with lipid profile and adiposity as metabolic risk factors of cardiovascular events in premenopausal women independent of confounders. The aim of this study was to investigate the relationship between serum calcium, magnesium and phosphorous with lipid profile in healthy premenopausal women.

Materials and methods: This study was performed on 82 reproductive age women aged 17-50 who were randomly selected from general population of Tabriz, Iran. They were assigned into obese and none-obese groups. Weight and height for BMI calculation were measured using a calibrated Seca scale and cotton ruler which was attached to the wall. Body composition was analyzed by bioelectrical impedance analysis (BIA). Serum magnesium, calcium and phosphorous were measured colorimetrically; fasting blood glucose (FBG) and serum lipids were assessed by enzymatic methods.

Results: Obese woman had significantly lower serum magnesium ($P = 0.035$) and significantly higher fasting blood glucose ($P = 0.028$), total cholesterol ($P = 0.035$), triglyceride ($P = 0.019$), low density lipoprotein ($P=0.003$) and parathyroid hormone concentrations ($P = 0.031$) compared to non obese women. In correlation coefficient analysis, serum calcium concentrations had a positive weak relationship with total cholesterol ($r = 0.267$, $P = 0.013$) and triglyceride ($r = 0.301$, $P = 0.005$) concentrations in all participants; whereas in separate analysis of subjects as obese and non obese groups, these relationships lost their significance. Serum phosphorous had a weak positive relationship with total cholesterol ($r = 0.31$, $P = 0.002$) and an inverse weak relationship with parathyroid hormone ($r = - 0.32$, $P = 0.002$). After adjusting for confounding variables by multiple regression analysis, the positive relationship between serum calcium, triglyceride, high density lipoprotein and low density lipoprotein cholesterol were significant.

Conclusion: Our results indicate that abnormality in serum calcium and phosphorous is significantly correlated with serum lipids. Further studies are warranted for interpretation of these associations and understanding the underlying mechanisms.

Key words: calcium; phosphorous; magnesium; obesity; body composition; lipid profile

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Introduction

Calcium as an essential regulator in many homeostatic systems plays an important role in controlling diverse biological process such as hormone secretion, intermediary metabolism, and bone structure (1-3). Recently it has been suggested that some of metabolic disorders, hypertension and cardiovascular disease are linked by common defects in metabolism of some divalent cations such as calcium and magnesium (4,5). The positive relationship between serum calcium and cardiovascu-

lar disease (6) metabolic syndrome (1) or myocardial infarction (7) has been reported in previous studies. On a parallel note, several studies have reported an inverse relationship between serum magnesium concentrations and lipid profile (8,9). Low serum magnesium is associated with cardiovascular events and metabolic syndrome (10). Although the exact mechanisms underlying these relationships are not fully understood, potential mechanisms is the basic role of these cations in metabolic pathways (11). It can be concluded from the above introduction that serum calcium and magnesium are considered as good predictors of lipid abnormality; however one important unanswered question is that whether this relationship can be happened in healthy normal individuals without cardiovascular disease and other morbidities. Previous studies were carried out in diabetes (12), hypothyroidism (13) or metabolic syndrome (1) and not in normal subjects; therefore the aim of this study is to investigate the relationship of serum calcium, magnesium and phosphorus with lipid profile in healthy Iranian premenopausal women.

Methods and materials

Subjects

The study was conducted at Nutritional research center, Tabriz University of medical science between January and July 2008. Subjects were recruited through advertisement with letters which were sent to randomly selected homes in eastern region of Tabriz city. These letters included information about general inclusion criteria of the study. A total of 82 healthy volunteer women were participated in our study. Subjects were divided into obese (N = 40) and non obese (N = 42) groups based on their body mass index. The inclusion criteria of study were 17-50 years of age, BMI 30-34.9 kg/m^2 for obese and 18.5-24.9 kg/m^2 for non obese group. The exclusion criteria included a history of hepatic or renal disease, cardiovascular disease, diabetes, hypertension, treatment with estrogen and contraceptives (OCP), loop diuretics or corticosteroids. Subjects in the two groups were pair matched for age. Matching limit for age was ± 3 years. The study protocol was approved by ethics committee at Tabriz University of medical sciences and all subjects gave their written informed consent to participate in this study.

Biochemical measurements

Venous blood samples were collected from all subjects between 7 and 9 a.m. after an overnight fasting in tubes without additives. These samples were centrifuged; the serum was obtained and stored at -70°C until the assay. Serum concentrations of calcium, magnesium and inorganic phosphate were measured using standard colorimetric methods (kits from Darman- Kave Co., Esfahan, Iran; Ziest Chem Co., Tehran-Iran and Cheme Enzyme Co., Tehran-Iran respectively). Serum parathyroid hormone (PTH) was measured with ELISA (Bio source Europe S.A, Nivelles, Belgium). The sensitivity of this test was 2 ng/L and means inter and intra assay coefficients of variation (CV) were 7.1 and 1.1% respectively (14). Serum 25-hydroxy vitamin D was measured by Chemiluminescence Immuno Assay (DiaSorin Inc., Stillwater, MN, USA). Sensitivity of this test was 17.5 nmol/l and means inter and intra assay coefficient of variation was 13.2% and 10.5% respectively. We also categorized subjects into three groups according to their serum calcium or phosphorous levels: groups with low, medium and high serum calcium or phosphorous levels.

Fasting blood glucose (FBG), total cholesterol (TC), triglyceride (TG) and high density lipoprotein cholesterol (HDL-C) levels were analyzed using enzymatic colorimetric method. The TG level in all subjects was lower than 4.52 mmol/L (400 mg/dL); therefore we used Friedwald formula for estimation of Low Density Lipoprotein Cholesterol (LDL-C) concentrations based on serum TC, TG and HDL levels (15). Mean inter and intra assay CV were 1.14, 0.061 for TC; 1.60, 1.53 for TG and < 4 for HDL respectively.

Anthropometric and dietary assessments

Weight was measured to the nearest 0.1 kg using a calibrated Seca scale (Itin Scale Co., Inc. Germany) while subjects had light clothes and no shoes. Height was measured using a cotton ruler which was attached to wall. Body mass index was calculated

as weight (kg) / height (m) ^{2}. Waist circumference (WC) was obtained by measuring the smallest area below the rib cage and above the ambilicus. Standing hip circumference (HC) was measured at the inter trochantric level (16) Waist to hip ratio (WHR) was obtained by dividing the mean WC by the mean HC. Each participant had a body composition analysis with Bioelectrical Impedance Analysis (BIA) method (Human-IM Plus; DS Dietosystem, Milan, Italy). Demographic characteristics of subjects were determined using a screening questionnaire to provide information on general personal characteristics, health status, medication history and a history of previous medical disease. To assure that there is no difference between dietary calcium, magnesium and vitamin D intake between obese and non obese subjects, a three day diet record was obtained from participants. Average daily nutrient intakes were calculated by Nutritionist Ш software (N-Squared analytical software computing, Ore., USA). Intake of magnesium, calcium and vitamin D that are correlated with total energy intake was adjusted for total energy intake with residual method (17).

Statistical analysis

SPSS software (version 17, SPSS Inc., Chicago, IL, USA) was used for all analysis. The Kolmogorov-Smirnov test was used to verify the hypothesis of normal distribution, followed by the independent Student's-t test supposing normal distribution, and the Mann-Whitney U test was used, when the supposition of normal distribution was not accepted. The association between serum calcium, magnesium and phosphorous with fasting blood glucose and lipid profile was examined by using the Pearson's correlation test or by Spearman's rank correlation test.

Since BMI, WHR, PTH and 25-hydroxy vitamin D influence the calcium metabolism, the above mentioned association was reassessed by multiple regression analysis with excluding the confounding effect of these variables. In addition, subjects were categorized by tertiles into three groups according to serum calcium or phosphorous concentrations: groups with low, medium and high serum calcium or phosphorous concentrations. Kruskal-Wallis test was used to analyze the differences in serum lipids among three groups with Bonferroni corrections for multiple comparisons (18). Continuous variables are expressed as mean ± SD if they had normal distribution or median and Interquartile range (Q1-Q3) if not. Age was presented as median and range (maximum-minimum). P values less than 0.05 is considered significant.

Results

Profile of obese and non obese groups are shown in table 1. All general characteristics are significantly different between groups except for age and dietary intake of calcium, magnesium and vitamin D. Comparison of biochemical parameters between obese and non obese women (table 2) shows that serum FBG, TC, TG, LDL-C and PTH concentrations is higher and serum magnesium is lower in obese group. There is no significant difference between serum calcium, phosphorous, HDL-C and 25-hydroxy vitamin D concentrations between groups. In correlation coefficient analysis (table 3) serum calcium concentrations had a positive weak correlation with TC ($r = 0.267$, $P = 0.013$), TG ($r = 0.301$, $P = 0.005$), and 25-hydroxy vitamin D concentrations ($r = 0.303$, $P = 0.034$) in all participants; whereas in separate analysis of subjects as obese and non obese groups, these relationships were not significant. Correlation coefficient is also significant for the inverse weak relationship between serum magnesium concentrations and BMI, weight, WC, fat mass and for positive relationship between serum magnesium and fat free mass.

Serum phosphorous had a weak positive relationship with total cholesterol ($r = 0.310$, $P = 0.002$) and a weak negative relationship with parathyroid hormone ($r = - 0.342$, $P = 0.002$). After controlling for confounding variables in multiple regression analysis serum calcium had a positive relationship with TG, LDL-C and HDL-C (table 4).

Subjects with higher serum calcium concentrations had significantly higher levels of TC, TG and LDL-C compared with the corresponding levels in the subjects with low and medium calcium concentrations ($P = 0.028$, 0.045 and 0.038 respective-

Table 1. Characteristics of study participants

Characteristic	Obese (N = 42)	Non obese (N = 40)	P
Age (years)	30 (17-51)	31 (19-45)	0.474
Weight (kg)	81.07 ± 10.13	58.19 ± 6.40	**<0.001**
Height (m)	1.57 ± 0.05	1.60 ± 0.05	**0.036**
BMI (kg/m^2)	32.95 ± 3.35	23.40 ± 4.12	**<0.001**
Fat mass (%)	41.64 ± 4.85	27.36 ± 5.34	**<0.001**
Fat free mass (%)	58.06 ± 5.21	72.64 ± 5.34	**<0.001**
WHR	0.81 ± 0.05	0.74 ± 0.05	**<0.001**
WC (cm)	95.75 ± 8.0	74.68 ± 6.97	**<0.001**
Dietary calcium intake (mg/d)	511.03 ± 222.5	546.14 ± 319.78	0.673
Dietary magnesium intake (mg/d)	89.29 ± 56.92	103.14 ± 75.81	0.492
Dietary vitamin D (IU/d)	43.61 ± 8.03	47.03 ± 16.13	0.210

BMI - body mass index; WHR - waist to hip ratio, WC - waist circumference.
Data are presented as mean ± SD or median ± IQR (Interquartile range).

Table 2. Biochemical characteristics of study participants

Characteristics	Obese (N = 42)	Non obese (N = 40)	P
FBG (mmol/L)	4.26 ± 0.82	3.96 ± 0.61	**0.028**
Calcium (mmol/L)	2.22 ± 0.18	2.20 ± 0.17	0.459
Phosphorous (mmol/L)	1.11 ± 0.24	1.10 ± 0.24	0.561
Magnesium (mmol/L)	0.87 ± 0.11	0.97 ± 0.27	**0.035**
TC (mmol/L)	4.20 ± 0.95	3.85 ± 0.55	**0.035**
Triglycerides (mmol/L)	0.93 ± 0.26	0.81 ± 0.18	**0.019**
LDL-C (mmol/L)	2.84 ± 0.73	2.44 ± 0.48	**0.003**
HDL-C (mmol/L)	0.99 ± 0.13	0.98 ± 0.17	0.998
25 hydroxy vitamin D (nmol/L)	40.26 ± 19.12	41.42 ± 25.52	0.861
PTH (ng/L)	83.25 ± 39.84	65.53 ± 32.92	**0.031**

FBG - fasting blood glucose; TC - total cholesterol; LDL-C - low density lipoprotein cholesterol; HDL-C - high density lipoprotein cholesterol; PTH - parathyroid hormone. Data are presented as mean ± SD or median ± IQR (Interquartile ranges).

ly; Table 5). *Post- hoc* analysis has revealed that the mean level of TC in high calcium group was higher than in low and medium calcium groups (P = 0.032 and 0.026 respectively). TG and LDL-C in this group was also higher than low calcium group (P = 0.044 and 0.024 respectively). In comparison of subjects classified by serum phosphorous levels, subjects with higher levels of serum phosphorus had significantly higher fasting blood glucose and lower triglycerides (P = 0.034, 0.049 respectively; Table 6). According to *post-hoc* analysis results, the differences between FBG and TG among groups, were significant between medium and high phosphorous groups (P= 0.002 and 0.025 respectively).

Discussion

This study demonstrates that serum calcium is positively associated with lipid profile in premenopausal women. This association remained significant

Table 3. Correlation coefficient (with P values in brackets) for serum calcium, magnesium, phosphorous in relation to lipid profile and body composition in total participants

Characteristics	Calcium r (P)	Magnesium r (P)	Phosphorous r (P)
FBG (mmol/L)	0.08 (0.444)	0.03 (0.979)	- 0.12 (0.242)
TC (mmol/L)	0.27 (**0.013**)	-0.01 (0.991)	0.31 (**0.002**)
Triglycerides (mmol/L)	0.30 (**0.005**)	0.02 (0.864)	0.18 (0.078)
LDL-C (mmol/L)	0.24 (**0.027**)	-0.04 (0.718)	0.21 (**0.042**)
HDL-C (mmol/L)	0.08 (0.481)	0.01 (0.946)	0.02 (0.828)
25 hydroxy vitamin D (nmol/L)	0.30 (**0.034**)	0.13 (0.377)	-0.06 (0.661)
PTH (ng/L)	-0.01 (0.898)	-0.13 (0.235)	-0.32 (**0.002**)
BMI (kg/m^2)	0.06 (0.563)	-0.27 (**0.014**)	0.09 (0.405)
Weight (kg)	0.11 (0.331)	-0.25 (**0.020**)	0.17 (0.110)
WC (cm)	0.10 (0.377)	-0.26 (**0.015**)	0.15 (0.151)
WHR	0.14 (0.197)	-0.20 (0.067)	-0.17 (0.093)
Fat Mass (%)	0.08 (0.486)	-0.28 (**0.008**)	0.02 (0.822)
Fat Free Mass (%)	-0.11 (0.312)	0.29 (**0.006**)	-0.01 (0.894)

FBG - fasting blood glucose; TC - total cholesterol; LDL-C - low density lipoprotein cholesterol; HDL-C - high density lipoprotein cholesterol; PTH - parathyroid hormone; BMI – body mass index; WC – waist circumference; WHR - waist to hip ratio.

Table 4. Multiple regression analysis between serum calcium, fasting blood glucose and lipid profile (adjusted for 25-hydroxy vitamin D, PTH, BMI and WHR).

Characteristics	Calcium β (P)
FBG (mmol/L)	0.258 (0.145)
TC (mmol/L)	-0.786 (0.260)
Triglycerides (mmol/L)	0.448 (**0.050**)
HDL-C (mmol/L)	1.275 (**0.049**)
LDL-C (mmol/L)	0.460 (**0.038**)

FBG - fasting blood glucose; TC - total cholesterol; LDL-C - low density lipoprotein cholesterol; HDL-C - high density lipoprotein cholesterol.

Table 5. Fasting blood glucose and serum lipids of study subjects base on blood calcium tertiles.

Characteristics	Low Calcium < 2.15 mmol/L (N = 27)	Medium Calcium 2.15-2.27 mmol/L (N = 27)	High Calcium > 2.27 mmol/L (N = 28)	P
FBG (mmol/L)	3.95 ± 0.55	4.15 ± 0.82	4.19 ± 0.86	0.590
TC (mmol/L)	3.82 ± 0.50	3.81 ± 0.83	4.36 ± 0.90	**0.028**
Triglycerides (mmol/L)	0.77 ± 0.156	0.91 ± 0.23	0.92 ± 0.28	**0.045**
HDL-C (mmol/L)	0.99 ± 0.14	0.99 ± 0.18	1.01 ± 0.15	0.829
LDL-C (mmol/L)	2.46 ± 0.46	2.51 ± 0.45	2.92 ± 0.87	**0.038**

FBG - fasting blood glucose; TC - total cholesterol; LDL-C - low density lipoprotein cholesterol; HDL-C - high density lipoprotein cholesterol.

Table 6. Fasting blood glucose and serum lipids of study subjects base on blood phosphorous tertiles.

Characteristics	Low > 0.96 mmol/L (N = 25)	Medium 0.96-1.21 mmol/L (N = 30)	High > 1.21 mmol/L (N = 27)	P
FBG (mmol/L)	4.33 ± 0.75	3.93 ± 0.80	4.04 ± 0.61	**0.034**
TC (mmol/L)	3.73 ± 0.85	3.96 ± 0.56	4.29 ± 0.85	0.271
Triglycerides (mmol/L)	0.82 ± 0.22	0.88 ± 0.20	0.90 ± 0.27	**0.049**
HDL-C (mmol/L)	0.98 ± 0.14	0.99 ± 0.16	1.03 ± 0.16	0.629
LDL-C (mmol/L)	2.49 ± 0.46	2.57 ± 0.56	2.85 ± 0.82	0.099

high density lip FBG - fasting blood glucose; TC - total cholesterol; LDL-C - low density lipoprotein cholesterol; HDL-C - high density lipoprotein cholesterol.

after adjusting for potential confounders (BMI, WHR, PTH and 25-hydroxy vitamin D). Subjects with higher serum calcium levels had higher serum TC, TG, and LDL-C. Since the menopausal status has significant influence in lipid and calcium metabolism (19,20), the study groups were selected from premenopausal women. The first report of association between serum calcium and lipid profile (TC, HDL-C) was in De Bacquer *et al*. (21) study; although, the effect of potential confounding variables was not regarded in this report. Lars Lind and colleagues (1) found positive relations between blood pressure, serum glucose and cholesterol with serum calcium concentrations by including only BMI, age and BUN as confounding variables. In a cohort of males aged 50 serum calcium was also defined as an independent prospective risk factor for myocardial infarction (7). There are several potential mechanisms that may explain the association of serum calcium and lipid profile. The average concentrations of serum PTH in our study sample was 76.2 ± 39.01 ng/L, whereas the normal range for serum PTH concentrations is 10-65 ng/L (22), this elevated PTH concentrations leads to excessive calcium accumulation in cytosol, PTH induced calcium entry into cells inhibits mitochondrial oxidation and ATP production and ultimately increasing intracellular calcium (23); Increased cytosolic calcium is responsible for disturbance in lipid metabolism and inducing hyperlipidemia (24-28). Calcium ions are necessary for insulin production by islet cells of pancreas and increased intracellular calcium concentrations may also induce insulin resistance and lipid abnormality (29). High serum PTH level has also suppressive effect on the lipoprotein lipase activity (24). Abnormality of this enzyme may result in increased triglyceride, low density lipoprotein cholesterol and decreased high density lipoprotein cholesterol (23). These mechanisms can somewhat explain the relationship between serum calcium and lipid profile, however due to the case - control design of the study, we are not able to clarify the causal nature of these relationships.

Subjects with higher serum phosphorous levels had significantly higher levels of triglyceride concentrations than their controls. Other anthropometric or biochemical variables were not different between serum phosphorous groups except in the case of PTH (In low, medium and high phosphorous groups: 89.91 ± 43.03, 76.17 ± 39.16 and 63.88 ± 31.45 ng/L respectively; P = 0.040). This finding is in consistent with other researchers work such as Dhingra R *et al*. (30) and Park W. *et al*. (31). The biological mechanisms of the phosphate and triglyceride relationship are not fully understood. A possible mechanism which has been explained by Park W. (31) is that serum phosphate affect phospholipids metabolism in the liver. Another mechanism is diminishing lipoprotein lipase activity due to higher parathyroid hormone concentrations which consequently leads to abnormal lipid metabolism (24).

Another observation of our study is the significant difference between serum magnesium concentrations between obese and non obese women. This finding agree with that of Huetra *et al*. (5), as pro-

posed by this authors lower dietary magnesium intake in obese individuals may be the main reason for magnesium deficiency in obese group, however as shown in table 1 magnesium intake in obese and non obese groups was not significantly different; the link between obesity and magnesium deficiency can partially be explained by inflammatory markers. Rodriguez (32) and Hauner (33) found a strong relationship between low serum magnesium and high tumor necrosis factor α (TNF-α) in obese subjects. Guerrero (34) and Laimer (35) in similar studies reported negative relation between serum magnesium and C-reactive protein in obesity. Production of inflammatory cytokines by adipose tissue is the cause of increased inflammatory markers in obesity. Cytokines such as TNFα and Interleukine-6 (IL-6) are secreted by adipose tissue (36,37). The cause and effect relationship between serum magnesium and inflammatory markers in obesity is poorly known. One possible mechanism is that inflammatory factors especially tumor necrosis factors increase renal 1-α-hydroxylase activity and 1,25-$(OH)_2$ vitamin D (38). This active metabolite enhances renal calcium reabsorption and so higher magnesium urinary excretion (39). In addition, low serum magnesium can promote weight gain by increasing intracellular calcium (40). Increased calcium in adipocytes enhances lipogenesis (41). It also activates phosphodiesterase 3B and decrease lipolysis (42).

Similarly elevated serum PTH concentrations in obese group of the present study which has also been reported previously by other investigations (42-44) can be attributed to elevation in calcium influx in to adipocytes due to elevation of 1,25-$(OH)_2$ vitamin D production by PTH; this can promote lipid storage in adipose tissue (44). Another possible cause of increased PTH in obese individuals is altered mineral metabolism; according to previous report of T. Anderson et al changed complex binding of plasma calcium could lead to secondary increase of parathyroid hormone in obesity (45).

Some potential limitations of our study are as follows: first, only women and not men were enrolled in this study, therefore we cannot generalize the results to the total population, second, insulin resistance and inflammatory cytokines were not evaluated, whereas these markers have physiological relations with both mineral metabolism and lipid abnormalities, finally, an interventional study rather than case-control one could better explain the causal relationship between variables. Despite these limitations one important clinical considerations of our study is that calcium and phosphorous levels should be controlled as risk factors of lipid abnormality and consequently metabolic syndrome or cardiovascular disease.

In conclusion, this study showed a significant association between serum calcium and lipid profile even after adjusting for potential confounders (BMI, WHR, serum PTH, serum 25-hydroxy vitamin D,) in a group of premenopausal women. Additional research is warranted to confirm or possibly reject the potential links between these variables and clarifying the underlying mechanisms.

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Potential conflict of interest

None declared.

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Koncentracija kalcija, magnezija, fosfora i lipidni status u serumu kod zdravih Iranki u reproduktivnoj dobi

Sažetak

Uvod: Noviji epidemiološki dokazi upućuju na zaključak da promjena metabolizma kalcija, fosfora ili magnezija može imati izravnih kardiovaskularnih posljedica. Međutim, nepoznato je jesu li varijacije u koncentraciji tih minerala u serumu povezane s lipidnim statusom i pretilošću kao metaboličkim rizičnim čimbenicima od kardiovaskularnih događaja kod žena u reproduktivnoj dobi nezavisno o zbunjujućim čimbenicima. Cilj ovog istraživanja bio je istražiti povezanost između koncentracije kalcija, magnezija i fosfora u serumu i lipidnog statusa kod zdravih žena u reproduktivnoj dobi.

Materijali i metode: Ovo je istraživanje provedeno na 82 žene u reproduktivnoj dobi od 17-50 godina koje su nasumično odabrane iz populacije grada Tabriza u Iranu. Težina i visina ispitanica izmjerene su umjerenom Seca vagom i pamučnom mjernom trakom pričvršćenom na zid. Postotak masnog tkiva određen je metodom bioelektrične impendancije (engl. *bioelectrical impedance analysis*, BIA). Koncentracija magnezija, kalcija i fosfora u serumu određena je kolometrijskom metodom; koncentracije glukoze natašte (FBG) i lipida u serumu određene su enzimskim metodama.

Rezultati: Koncentracije magnezija u serumu bile su statistički značajno niže (P = 0,035), a koncentracije glukoze natašte (P = 0,028), ukupnog kolesterola (P = 0,035), triglicerida (P = 0,019), lipoproteina niske gustoće (P = 0,003) i paratiroidnog hormona (P = 0,031) više kod pretilih ispitanica u usporedbi s ispitanicama s normalnom tjelesnom težinom. Koncentracije kalcija u serumu bile su u slaboj pozitivnoj korelaciji s koncentracijama ukupnog kolesterola (r = 0,267, P = 0,013) i triglicerida (r = 0,301, P = 0,005) kod svih ispitanica; dok je u podskupinama prema statusu pretilosti korelacija izgubila statističku značajnost. Koncentracija fosfora u serumu bila je u slaboj pozitivnoj korelaciji s koncentracijom ukupnog kolesterola (r = 0,31, P = 0,002) i inverznoj slaboj korelaciji s koncentracijom paratiroidnog hormona (r = - 0,32, P = 0,002). Višestruka regresijska analiza, nakon prilagodbe zbunjujućih čimbenika, pokazala je značajnu pozitivnu povezanost između koncentracije kalcija, triglicerida, lipoproteina visoke gustoće i lipoproteina niske gustoće.

Zaključak: Naši rezultati upućuju na zaključak da su patološke vrijednosti koncentracije kalcija i fosfora u serumu u značajnoj korelaciji s koncentracijom lipida u serumu. Potrebna su daljnja istraživanja kako bi se objasnila ta povezanost i razumjeli mehanizmi koji leže u podlozi.

Ključne riječi: kalcij; fosfor; magnezij; pretilost; postotak masnog tkiva; lipidni status