Original Article

Serum calcium and phosphorus in postmenopausal women with and without hypertension or cardiovascular disease: A comparative cross-sectional study

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ABSTRACT

Objective: To compare serum calcium and phosphorus concentrations in postmenopausal women with and without documented hypertension or cardiovascular disease and examine their associations with blood pressure and lipid parameters.

Material and Methods: This comparative cross-sectional study was conducted at Liaquat University of Medical and Health Sciences, Jamshoro, Pakistan, from July to December 2025. Through purposive sampling, 226 postmenopausal women aged 45–70 years were recruited. Group A included 113 women without documented hypertension or cardiovascular disease. Group B included 113 women with documented hypertension, established cardiovascular disease (myocardial infarction, angina or stroke), or both. Welch's t tests compared group means. Pearson correlations were calculated within each group. Separate linear models adjusted mineral differences for age, body mass index and time since menopause.

Results: Group B had lower mean (standard deviation [SD]) total calcium than Group A [7.60 (0.56) vs 9.10 (0.24) mg/dL] and higher phosphorus [4.30 (0.24) vs 3.76 (0.24) mg/dL]. Adjusted mean differences (B − A) were −1.48 mg/dL (95% confidence interval [CI] −1.64, −1.33) for calcium and 0.55 mg/dL (95% CI 0.46, 0.64) for phosphorus. Fisher tests found no evidence of between-group differences in correlations.

Conclusion: Lower total calcium and higher phosphorus were associated with documented hypertension or cardiovascular disease in this cross-sectional sample after adjustment for the measured covariates.

Keywords: Blood Pressure, Calcium, Hypertension, Phosphorus, Postmenopause.

This article can be cited as: **Rind RS, Memon BG, Chandio S, Asif M, Memon F, Memon E. Serum calcium and phosphorus in postmenopausal women with and without hypertension or cardiovascular disease: A comparative cross-sectional study. 196-202. DOI: https://doi.org/10.55629/pakjpathol.v37i3.1056**

INTRODUCTION

Cardiovascular disease (CVD) is a leading cause of morbidity and mortality in women. Menopause transition is an important period for cardiovascular evaluation as it is a time of reproductive hormone changes along with alterations in lipid metabolism, body composition and vascular function. This change is also a time for earlier detection and control of cardiovascular risk factors, according to the American Heart Association [1]. Cardiovascular health after menopause is also a result of chronological ageing and existing metabolic conditions.

Alterations in adiposity, insulin sensitivity and circulating lipids may lead to an unfavorable cardiovascular profile. This is important when considering biochemical measurements that change with age, nutritional status and underlying disease [2]. Laboratory parameters that can be obtained easily may be useful in defining the clinical profile of postmenopausal women. They need to be evaluated in a prospective way to determine their value in predicting future events.

The burden of known cardiovascular risk factors is also applicable to women in Pakistan and the rest of South Asia. A preventive cardiology clinic in Karachi reported known hypertension in 73.2% of female participants, diabetes in 26.8% and a body mass index of at least 30 kg/m² in 50.5% [3]. The prevalence of hypertension in the community-based Second National Diabetes Survey of Pakistan (2016-2017) was 46.2% among adults, age adjusted and weighted, across four provinces [4], while the prevalence in the Karachi study was in a selected clinic population.

Calcium and Phosphorus are important for skeletal metabolism and for a number of cellular processes. Parathyroid hormone, vitamin D and fibroblast growth factor 23 (FGF-23) help regulate their serum concentrations. These pathways offer a biological

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Receiving Date: **03 Mar 2026** Revision Date: **01 Jun 2026** Acceptance Date: **14 Sep 2026**

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explanation for studying serum calcium and phosphorus in conjunction with cardiovascular parameters [5]. Direct measurement of these regulators would be necessary to determine the contribution of each to any difference observed.

Population-based studies demonstrate that age, sex and menopausal status are important factors to consider when interpreting serum mineral concentrations. In the Rotterdam Study, women older than 45 years had higher serum calcium and phosphate concentrations than men of similar age, and sex hormone concentrations were associated with these differences [6]. A subsequent study reported higher serum phosphate around menopause and proposed sex-specific reference intervals for adults older than 45 years [7]. The clinical significance of a difference between two groups will depend on the size of the difference and the laboratory reference interval. Individual concentrations may fall within that interval even when the difference is statistically significant.

The association between serum phosphorus and cardiovascular outcomes has now been observed beyond the chronic kidney disease population. A 2024 systematic review and meta-analysis of general-population studies found that higher serum phosphate was associated with cardiovascular mortality and subclinical coronary atherosclerosis [8]. Important considerations when interpreting whether these findings are applicable to postmenopausal women recruited from a clinical setting include participant characteristics, renal function and other determinants of mineral metabolism.

Results of serum calcium are inconsistent between populations and outcomes. In a study of 7,259 postmenopausal women with osteoporosis, there was an independent association between higher baseline calcium and subsequent cardiovascular events [9]. A population-based prospective study of US adults reported an L-shaped association between serum calcium and cardiovascular mortality [10]. The variation in reported associations may be due to differences in baseline health, outcome definitions and measured confounders. Blood pressure and serum calcium were compared in postmenopausal and reproductive-age women in a study in Bangladesh [11].

There is limited evidence from Pakistan comparing serum calcium and phosphorus in postmenopausal women with and without documented hypertension or established CVD. The present study aimed to compare serum calcium and phosphorus levels among these groups and to investigate the relationship of each mineral with the systolic and diastolic blood pressure and lipid parameters in each group.

MATERIAL AND METHODS

This comparative cross-sectional study was conducted in the Department of Biochemistry, Liaquat University of Medical and Health Sciences (LUMHS), Jamshoro, Pakistan, in collaboration with the Diagnostic and Research Laboratory, LUMHS, from 01 July to 30 December 2025. Ethical approval was obtained from the Research Ethics Committee, LUMHS, before recruitment commenced (reference LUMHS/REC/808, dated 04 June 2025). The protocol was also approved by the Advanced Studies and Research Board, LUMHS. Informed consent was obtained from participants, and their information was kept confidential.

Sample size was estimated using the single-proportion module of OpenEpi version 3.01. The calculation assumed a prevalence of 18%, a 95% confidence level and a margin of error of 5 percentage points [12]. The study met its recorded target by recruiting 226 postmenopausal women aged 45–70 years through non-probability purposive sampling from the Cardiology Outpatient Department, LUMHS, Jamshoro. Postmenopausal status was defined as at least 12 consecutive months of amenorrhea without another physiological or pathological cause. Participants were divided into two groups of 113 women each. Group A included women without documented hypertension, myocardial infarction, angina or stroke. Group B included women with documented hypertension, established cardiovascular disease (myocardial infarction, angina or stroke), or both, identified through medical history and hospital records. Group classification reflected documented clinical diagnoses rather than a validated cardiovascular risk score.

Women with a documented history of chronic kidney disease, thyroid or parathyroid disorders, chronic inflammatory disease, hepatic disease, malignancy or severe systemic illness were excluded. Women receiving calcium or vitamin D supplementation were also excluded.

Age, body mass index and time since menopause were recorded. Blood pressure was measured using a mercury sphygmomanometer after participants had rested in a seated position for 10 minutes. Two readings were obtained five minutes apart, and their average was used for analysis. Because

hypertension contributed to group classification, between-group blood pressure differences were considered descriptive findings.

Venous blood samples were collected after an overnight fast of 8–12 hours. Serum was separated and analysed for total calcium, inorganic phosphorus, total cholesterol, low-density lipoprotein (LDL) cholesterol, high-density lipoprotein (HDL) cholesterol and triglycerides. Biochemical testing was performed at the Diagnostic and Research Laboratory, LUMHS. Total serum calcium and inorganic phosphorus were measured using a Roche Cobas C311 automated clinical chemistry analyser (Roche Diagnostics, Mannheim, Germany). Calcium was estimated using the Calcium Gen.2 assay (CA2; catalogue no. 05061482190), based on the 5-nitro-5′-methyl-BAPTA colorimetric principle. Inorganic phosphorus was determined using the Phosphate (Inorganic) ver.2 assay (PHOS2; catalogue no. 03183793122), based on the UV phosphomolybdate method, according to the manufacturer's instructions. Calcium was reported as measured total serum calcium; albumin-adjusted and ionized calcium were not assessed.

Data were analysed in IBM SPSS version 23 and Python. Continuous variables were summarised as mean (standard deviation) and categorical variables as n (%). Welch's two-sample t tests compared age, body mass index (BMI), time since menopause, systolic and diastolic blood pressure, total, LDL and HDL cholesterol, triglycerides, total serum calcium and serum phosphorus between groups. Mean differences were expressed as Group B minus Group A with 95% confidence intervals (CIs). Pearson correlations between each mineral and each blood pressure and lipid measure were calculated within each group. Fisher's r-to-z tests compared the corresponding correlations between groups. Separate linear regression models estimated mean group differences in calcium and phosphorus, adjusting for age, BMI and time since menopause. The regression CIs were based on HC3 robust standard errors. Negative values for time since menopause were treated as missing for that variable only. Fully adjusted models used complete cases. Sensitivity analyses adjusted for age and BMI in the full sample and repeated the fully adjusted models in women with a recorded time since menopause of at least one year. All tests were two-sided with a nominal significance threshold of $p < 0.05$. Correlation analyses were exploratory.

RESULTS

The study included 226 postmenopausal women, with 113 (50.0%) in each group.

Women in Group B were older and had a higher mean body mass index and a longer mean time since menopause (all $p < 0.05$, Table-I). After treating 14 negative entries as missing, duration was available for 111 women in Group A and 101 in Group B.

Group B had higher mean systolic and diastolic blood pressure, total cholesterol, LDL cholesterol and triglycerides, and lower mean HDL cholesterol (lipids all $p < 0.05$, Table-II). Blood pressure differences were reported descriptively because hypertension contributed to group classification.

Group B had lower mean total serum calcium and higher mean serum phosphorus (both $p < 0.05$, Table-III). Both differences persisted after adjustment for age, body mass index and time since menopause. The estimates were similar in the sensitivity analyses.

Within-group correlations met the nominal $p < 0.05$ threshold for 7 of 12 pairs in Group A and 12 of 12 in Group B (Table-IV). The Fisher tests found no evidence that any correlation differed between groups (smallest $p = 0.151$).

Table-I: Participant characteristics.

Variable	Group A n = 113	Group B n = 113	B − A (95% CI)	t (df)	p-value
Age (years)	53.20 (2.90)	55.20 (3.40)	2.00 (1.17, 2.83)	4.76 (218.6)	3.56×10^{-6}
Body mass index (kg/m²)	27.90 (2.24)	31.20 (2.60)	3.30 (2.66, 3.94)	10.22 (219.2)	2.63×10^{-20}
Time since menopause (years)	5.24 (2.19)	8.48 (4.43)	3.24 (2.28, 4.21)	6.65 (143.1)	5.86×10^{-10}

Group values are mean (SD). SD, standard deviation. Unadjusted p-values are from two-sided Welch t tests. CI, confidence interval. df, degrees of freedom. Time since menopause used 111 observations in Group A and 101 in Group B.

Table-II: Blood pressure and lipids.

Variable	Group A n = 113	Group B n = 113	B − A (95% CI)	t (df)	p-value
Systolic BP (mmHg)	114.77 (8.50)	142.40 (5.40)	27.63 (25.76, 29.50)	29.17 (189.7)	4.92×10^{-72}
Diastolic BP (mmHg)	74.40 (8.00)	90.40 (4.00)	16.00 (14.34, 17.66)	19.02 (164.7)	2.11×10^{-43}
Total cholesterol (mg/dL)	184.64 (6.40)	228.70 (13.30)	44.06 (41.32, 46.80)	31.73 (161.2)	3.13×10^{-71}
LDL cholesterol (mg/dL)	107.70 (10.20)	132.60 (9.80)	24.90 (22.28, 27.52)	18.71 (223.6)	1.19×10^{-47}
HDL cholesterol (mg/dL)	49.00 (5.07)	39.40 (4.80)	−9.60 (−10.89, −8.31)	−14.62 (223.3)	2.13×10^{-34}
Triglycerides (mg/dL)	135.00 (7.50)	157.00 (8.00)	22.00 (19.97, 24.03)	21.33 (223.1)	9.39×10^{-56}

Group values are mean (SD). SD, standard deviation. Unadjusted p-values are from two-sided Welch t tests. CI, confidence interval. df, degrees of freedom. BP, blood pressure. LDL, low-density lipoprotein. HDL, high-density lipoprotein.

Table-III: Unadjusted and adjusted serum mineral differences.

Variable	Group A n = 113	Group B n = 113	B − A (95% CI)	t (df)	p-value
Total serum calcium (mg/dL)	9.10 (0.24)	7.60 (0.56)	−1.50 (−1.61, −1.39)	−26.17 (151.8)	3.87×10^{-58}
Serum phosphorus (mg/dL)	3.76 (0.24)	4.30 (0.24)	0.54 (0.48, 0.60)	16.91 (224.0)	6.72×10^{-42}
Mineral	Adjusted model n		Adjusted B – A (95% CI)	HC3 t (df)	p-value
Total serum calcium (mg/dL)	212		−1.48 (−1.64, −1.33)	−18.63 (207)	3.90×10^{-46}
Serum phosphorus (mg/dL)	212		0.55 (0.46, 0.64)	11.94 (207)	2.40×10^{-25}

Group values are mean (SD). SD, standard deviation. Unadjusted p-values are from two-sided Welch t tests. CI, confidence interval. df, degrees of freedom. Models adjusted for age, body mass index and time since menopause using HC3 standard errors.

Table-IV: Correlations of serum minerals with blood pressure and lipids.

Mineral	Correlate	Group A r (p)	Group B r (p)	Fishe r z	Between-group p-value
Phosphorus	Systolic BP	0.24 (0.0105)*	0.38 (3.30×10^{-5})*	1.15	0.249
	Diastolic BP	0.18 (0.0564)	0.31 (8.34×10^{-4})*	1.03	0.304
	Total cholesterol	0.28 (0.00267)*	0.40 (1.14×10^{-5})*	1.01	0.313
	LDL cholesterol	0.17 (0.0718)	0.29 (0.00184)*	0.94	0.347
	HDL cholesterol	−0.16 (0.0905)	−0.27 (0.00383)*	−0.86	0.392
	Triglycerides	0.23 (0.0143)*	0.33 (3.58×10^{-4})*	0.81	0.42
Total calcium	Systolic BP	−0.26 (0.00542)*	−0.42 (3.64×10^{-6})*	−1.35	0.178
	Diastolic BP	−0.17 (0.0718)	−0.35 (1.45×10^{-4})*	−1.44	0.151
	Total cholesterol	−0.29 (0.00184)*	−0.43 (2.00×10^{-6})*	−1.20	0.232
	LDL cholesterol	−0.22 (0.0192)*	−0.34 (2.29×10^{-4})*	−0.97	0.333
	HDL cholesterol	0.18 (0.0564)	0.30 (0.00125)*	0.95	0.344
	Triglycerides	−0.24 (0.0105)*	−0.37 (5.49×10^{-5})*	−1.07	0.287

n = 113 per group. BP, blood pressure. LDL, low-density lipoprotein. HDL, high-density lipoprotein. Within-group p-values are from two-sided Pearson correlation tests. Fisher's r-to-z tests compared groups. * Nominal two-sided $p < 0.05$ within groups.

DISCUSSION

The relationship between mineral metabolism and cardiovascular health remains incompletely understood in postmenopausal women. This study examined serum calcium and phosphorus alongside blood pressure and lipid parameters in women attending a tertiary care outpatient setting in Pakistan. It compared women with documented hypertension or cardiovascular disease with women without these diagnoses to characterize differences in their biochemical profiles.

Women with hypertension or cardiovascular disease had higher serum phosphorus and lower total serum calcium. Both differences persisted after adjustment for age, body mass index and time since menopause. They were also older, had a higher body mass index and had experienced a longer duration since menopause. These accompanying differences are relevant because mineral concentrations and cardiovascular characteristics may share demographic and metabolic determinants. The findings therefore describe associations between clinical status and mineral concentrations; they do not establish an independent contribution of either mineral to cardiovascular disease.

The phosphorus finding agrees with evidence from community-based investigations. Dhingra *et al*. demonstrated an association between higher serum phosphorus and incident cardiovascular disease in the Framingham Offspring cohort, including participants without established chronic kidney disease [13]. Foley *et al*. similarly associated phosphorus with coronary artery calcification in young adults participating in CARDIA [14]. The Rotterdam Study subsequently supported a relationship between phosphate and coronary calcification through observational and genetic analyses [15]. These studies extend interest in phosphate metabolism beyond advanced renal disease. However, their prospective and imaging

outcomes differ from the clinical comparison undertaken here.

Clinical classification of individual phosphorus results requires the study laboratory's assay-specific reference interval. Bosman *et al*. demonstrated sex-related differences in serum minerals and an increase in phosphate during menopause, supporting interpretation within an appropriate physiological context [6,7]. McGovern *et al*. examined phosphate-related cardiovascular outcomes across categories of kidney function, further highlighting the importance of renal status [16].

The lower calcium concentration in Group B contrasts with studies associating higher calcium with cardiovascular events. Slinin *et al*. identified an association between higher baseline calcium and subsequent cardiovascular events in postmenopausal women with osteoporosis.9 Research among Saudi women also examined relationships between calcium and lipid profiles [17]. Conversely, Hou *et al*. demonstrated an L-shaped association between calcium and cardiovascular mortality.10 These findings indicate that calcium–cardiovascular relationships vary across populations and outcomes. Differences in baseline health, participant selection and calcium distribution may contribute to the contrasting patterns.

Total calcium includes both protein-bound and ionized fractions; therefore, a lower total concentration does not necessarily indicate a corresponding reduction in biologically active calcium. Desgagnés *et al*. demonstrated that albumin-adjustment formulas could misclassify calcium status, highlighting the limitations of estimating ionized calcium from total concentrations [18]. Findings in hypoparathyroidism further illustrate the importance of the underlying clinical context when interpreting calcium–phosphate associations [19]. The absence of albumin and ionized calcium measurements consequently limits interpretation of the calcium difference in this study. It also prevents determining whether differences in protein binding contributed to the lower total concentration.

The greater adiposity and longer duration since menopause in Group B provide additional context. Kamińska *et al*. examined cardiovascular risk characteristics in relation to menopause, while Uddenberg *et al*. described accompanying changes in body composition, blood pressure and lipoproteins [20, 21]. Anagnostis *et al*. likewise emphasized the broader cardiovascular implications of menopause [22]. These findings support interpreting mineral concentrations alongside established clinical factors. Adjustment for age, body mass index and time since menopause addressed measured differences in these characteristics. Medication use and other unmeasured factors could still contribute to the associations.

Higher blood pressure in Group B partly reflected the recruitment definition because hypertension was a qualifying diagnosis. This difference therefore represented a characteristic of the selected groups rather than independent evidence of a mineral-related mechanism. Kim *et al*. associated higher calcium with arterial stiffness progression after adjustment for several cardiovascular factors, contrasting with the lower calcium observed here [23]. Their findings highlight the distinction between serum mineral measurements, blood pressure and directly assessed vascular outcomes. The present study did not measure arterial stiffness or coronary calcification.

Calcium and phosphorus homeostasis is regulated through coordinated intestinal absorption, bone turnover and renal excretion, involving parathyroid hormone, vitamin D and FGF-23.5 Alterations in these pathways offer a possible explanation for differences in serum mineral concentrations. The association between higher phosphate and cardiovascular outcomes described in previous studies supports the relevance of mineral metabolism to cardiovascular health [8]. However, these regulatory pathways were not assessed here, and their contribution remains uncertain. Medication exposure, dietary intake and previously unrecognized renal impairment are additional possible influences that the available measurements could not adequately characterize.

Purposive recruitment from one centre limits generalisability, and the cross-sectional design limits inference about temporal relationships. Missing duration measurements were more frequent in Group B and limited the fully adjusted analyses to complete cases. Sensitivity analyses gave similar mineral estimates. Albumin, ionized calcium and hormonal regulators of mineral metabolism were unavailable. Medication use, lifestyle and laboratory measures of kidney function were not systematically assessed. Excluding women with known kidney disease leaves the possibility of unrecognised renal impairment. The multiple exploratory correlations are susceptible to chance findings. Future studies should characterise mineral status, medication exposure and renal

function, account for these covariates and assess prospective cardiovascular outcomes.

CONCLUSION

Postmenopausal women with documented hypertension or cardiovascular disease had lower total serum calcium and higher serum phosphorus after adjustment for age, body mass index and time since menopause. These associations were observed at a single time point.

CONFLICT OF INTEREST

None

GRANT SUPPORT & FINANCIAL DISCLOSURE

Declared none

Disclosure

None

AUTHORS CONTRIBUTION

Rehana Sarwar Rind: Substantial contributions to study design, acquisition of data, manuscript drafting or reviewing it critical for important intellectual Content, final approval, responsible for every aspect of the research

Beenish Ghaffar Memon: Substantial contributions to study design, acquisition of data, Manuscript drafting or reviewing it critical for important intellectual content, final approval, responsible for every aspect of the research

Sofia Chandio: Substantial contributions to concept, study design, critical review, final approval, responsible for every aspect of the research

Maria Asif: Substantial contributions to concept, study design, critical review, final approval, responsible for every aspect of the research

Faryal Memon and Emaan Memon: Substantial contributions to concept, study design, critical review, final approval, responsible for every aspect of the research

REFERENCES

1. El Khoudary SR, Aggarwal B, Beckie TM, Hodis HN, Johnson AE, Langer RD, *et al*. Menopause transition and cardiovascular disease risk: implications for timing of early prevention: a scientific statement from the American Heart Association. Circulation. 2020;142(25):e506-e532. DOI:https://doi.org/10.1161/CIR.0000000000000912
2. Ryczkowska K, Adach W, Janikowski K, Banach M, Bielecka-Dabrowa A. Menopause and women's cardiovascular health: Is it really an obvious relationship? Arch Med Sci. 2023;19(2):458-466. DOI: https://doi.org/10.5114/aoms/157308
3. Rauf R, Khan MN, Sial JA, Qamar N, Saghir T, Kazmi KA. Primary prevention of cardiovascular diseases among women in a South Asian population: a descriptive study of modifiable risk factors. BMJ Open. 2024; 14(11): e089149. DOI: https://doi.org/10.1136/bmjopen-2024-089149
4. Basit A, Tanveer S, Fawwad A, Naeem N; NDSP Members. Prevalence and contributing risk factors for hypertension in urban and rural areas of Pakistan; a study from second National Diabetes Survey of Pakistan (NDSP) 2016-2017. Clin Exp Hypertens. 2020; 42(3): 218-24. DOI: https://doi.org/10.1080/10641963.2019.1619753
5. Kurpas A, Supeł K, Idzikowska K, Zielińska M. FGF23: a review of its role in mineral metabolism and renal and cardiovascular disease. Dis Markers. 2021; 2021: 8821292. DOI: https://doi.org/10.1155/2021/8821292
6. Bosman A, Koek WNH, Campos-Obando N, van der Eerden BCJ, Ikram MA, Uitterlinden AG, *et al*. Sexual dimorphisms in serum calcium and phosphate concentrations in the Rotterdam Study. Sci Rep. 2023; 13(1): 8310. DOI: https://doi.org/10.1038/s41598-023-34800-w
7. Bosman A, Campos-Obando N, Ramakers C, Zillikens MC. Serum phosphate in the general population: a need for sex-specific reference intervals. J Clin Endocrinol Metab. 2025; 110(6): e1885-e1891. DOI: https://doi.org/10.1210/clinem/dgae633
8. Torrijo-Belanche C, Moreno-Franco B, Muñoz-Cabrejas A, Calvo-Galiano N, Casasnovas JA, Sayón-Orea C, *et al*. High serum phosphate is associated with cardiovascular mortality and subclinical coronary atherosclerosis: systematic review and meta-analysis. Nutrients. 2024; 16(11): 1599. DOI: https://doi.org/10.3390/nu16111599
9. Slinin Y, Blackwell T, Ishani A, Cummings SR, Ensrud KE. Serum calcium, phosphorus and cardiovascular events in post-menopausal women. Int J Cardiol. 2011; 149(3): 335-40. DOI: https://doi.org/10.1016/j.ijcard.2010.02.013
10. Hou X, Hu J, Liu Z, Wang E, Guo Q, Zhang Z, *et al*. L-shaped association of serum calcium with all-cause and CVD mortality in the US adults: a population-based prospective cohort study. Front Nutr. 2023; 9: 1097488. DOI: https://doi.org/10.3389/fnut.2022.1097488
11. Dipa MI, Nessa A, Firoz S, Aktar N, Israt S, Sharmin A. Evaluation of the changes of blood pressure and serum calcium level in postmenopausal women. Mymensingh Med J. 2020; 34(4): 1045-49. DOI: https://pubmed.ncbi.nlm.nih.gov/32844787/
12. Zhang Y, Li X, Liu Y, Zhao Y. Association of serum calcium levels with cardiovascular risk factors in postmenopausal women. Menopause. 2022;29(5):587-594. https://doi.org/10.1097/GME.0000000000001945
13. Dhingra R, Sullivan LM, Fox CS, Wang TJ, D'Agostino RB Sr, Gaziano JM, *et al*. Relations of serum phosphorus and calcium levels to the incidence of cardiovascular disease in the community. Arch Intern Med. 2007;167(9):879-885. https://doi.org/10.1001/archinte.167.9.879

14. Foley RN, Collins AJ, Herzog CA, Ishani A, Kalra PA. Serum phosphorus levels associate with coronary atherosclerosis in young adults. J Am Soc Nephrol. 2009;20(2):397-404. https://doi.org/10.1681/ASN.2008020141
15. Campos-Obando N, Bosman A, Kavousi M, Medina-Gomez C, van der Eerden BCJ, Bos D, *et al*. Genetic evidence for a causal role of serum phosphate in coronary artery calcification: the Rotterdam Study. J Am Heart Assoc. 2022; 11(15): e023024. DOI: https://doi.org/10.1161/JAHA.121.023024
16. McGovern AP, de Lusignan S, van Vlymen J, Liyanage H, Tomson CR, Gallagher H, *et al*. Serum phosphate as a risk factor for cardiovascular events in people with and without chronic kidney disease: a large community-based cohort study. PLoS One. 2013;8(9):e74996. DOI: https://doi.org/10.1371/journal.pone.0074996
17. Mohammedsaeed W, Surrati AMQ, Alshanqiti A. Cross-sectional analysis of the association between serum calcium levels and lipid profiles and the risk of cardiovascular disease in Saudi women. Medicine (Baltimore). 2025; 104(42): e44947. DOI:https://doi.org/10.1097/MD.0000000000044947
18. Desgagnés N, King JA, Kline GA, Seiden-Long I, Leung AA. Use of albumin-adjusted calcium measurements in clinical practice. JAMA Netw Open. 2025; 8(1): e2455251. DOI: https://doi.org/10.1001/jamanetworkopen.2024.55251
19. Kaul S, Ayodele O, Chen K, Cook EE, Swallow E, Rejnmark L, *et al*. Association of serum calcium and phosphate with incident cardiovascular disease in patients with hypoparathyroidism. Am J Cardiol. 2023; 194: 60-70. DOI:https://doi.org/10.1016/j.amjcard.2023.01.029
20. Kamińska MS, Schneider-Matyka D, Rachubińska K, Panczyk M, Grochans E, Cybulska AM. Menopause predisposes women to increased risk of cardiovascular disease. J Clin Med. 2023; 12(22): 7058. DOI: https://doi.org/10.3390/jcm12227058
21. Uddenberg ER, Safwan N, Saadedine M, Hurtado MD, Faubion SS, Shufelt CL. Menopause transition and cardiovascular disease risk. Maturitas. 2024; 185: 107974. DOI: https://doi.org/10.1016/j.maturitas.2024.107974
22. Anagnostis P, Lambrinoudaki I, Stevenson JC, Goulis DG. Menopause-associated risk of cardiovascular disease. Endocr Connect. 2022; 11(4): e210537. DOI: https://doi.org/10.1530/EC-21-0537
23. Kim KA, Jung HO, Kim MJ, Lee SY, Lee DH, Han D, *et al*. The role of serum calcium levels in the progression of arterial stiffness: cross-sectional and longitudinal analyses in a multicenter cohort. J Clin Hypertens (Greenwich). 2025;27(4):e70055. DOI: https://doi.org/10.1111/jch.70055