Open Access
ORIGINAL ARTICLE
Journal of Biomedical Sciences
DOI: https://doi.org/10.3126/jbs.v11i2.74364

Comparative analysis of serum calcium, phosphorus, and vitamin D levels in pre- and postmenopausal women: A nutritional correlation study

Dhungana A[1]*, Tamang JM[2], Chaudhary NK[3], Tiwari K[4]

Corresponding author:
Dr. Arun Dhungana, Associate Professor, Department of Biochemistry, Kathmandu Medical College Teaching Hospital, Duwakot, Bhaktapur, Nepal
Email: a_dhungana1@yahoo.com ORCID

Information about the article:

Received: Oct. 10, 2024
Accepted: Dec. 09, 2024
Published online: Jan. 20, 2025

Cite this article:

Dhungana A, Tamang JM, Chaudhary NK, Tiwari K. Comparative analysis of serum calcium, phosphorus, and vitamin D levels in pre- and postmenopausal women: A nutritional correlation study. Journal of Biomedical Sciences. 2024;11(2):19-27

Publisher
Nepal Health Research Society, Bahundhara -6, Gokarnesowor Municipality, Kathmandu, Nepal
eISSN 2382-5545, ISSN 2676-1343 (Print)

ABSTRACT

Background

Serum calcium and vitamin D deficiencies are common among post-menopausal women, which can lead to osteoporotic fractures. Early detection of imbalances in serum calcium, phosphorus, and vitamin D can aid in providing proper treatment. This study compares serum calcium, phosphorus, and vitamin D levels between pre-menopausal and post-menopausal women and assesses their relationship with dietary calcium and sunlight exposure.

Material and methods

A cross-sectional study was conducted at Kathmandu Medical College between February and April 2024. Using consecutive sampling, participants' serum samples were analyzed with an automated analyzer, and Pearson's correlation was calculated using SPSS version 21.

Results

BMI was significantly higher in post-menopausal women (24.28 ± 0.49 kg/m^2) than in pre-menopausal women (23.25 ± 1.722 kg/m^2). Pre-menopausal women had higher serum calcium (9.18 ± 0.47 mg/dl) and vitamin D levels (23.03 ± 6.01ng/ml) than post-menopausal women (8.91 ± 0.43 mg/dl and 21.75 ± 5.86 ng/ml, respectively). Serum phosphorus was higher in post-menopausal women (4.19 ± 0.66 mg/dl) compared to pre-menopausal women (4.01 ± 0.54 mg/dl). Vitamin D levels in post-menopausal women positively correlated with calcium and dietary calcium intake but had an insignificant correlation with sunlight exposure and a negative correlation with phosphorus.

Conclusion

The study concludes that post-menopausal women have higher BMIs and lower serum calcium and vitamin D levels. Regular monitoring of bone markers, dietary calcium and vitamin D intake, and increased sunlight exposure are recommended to enhance bone health in pre-menopausal and postmenopausal women.

Keywords
Phosphorous, pre-menopausal, post-menopausal, serum calcium, vitamin D

Background

Menopause is defined as the permanent end of the menstrual cycle [1]. In this phase, physical, mental, and hormonal changes are associated with the cessation of the menstrual cycle in females [2]. The mean age for menopause ranges from 45 to 55 years and varies for diverse groups [3]. It is estimated that there will be 1.2 billion women worldwide who will be in menopause by 2030. [4]. It results from the exhaustion of the ovarian follicles, which leads to diminished synthesis of estradiol and some other hormones [5].

During menopause, the development of osteoporosis, cardiovascular diseases (CVD), arterial hypertension, glucose metabolism issues, reproductive cancers, and cognitive degenerative diseases increases [6]. Additionally, nutritional disturbances, especially deficiencies in trace elements and vitamins, are more likely during this time. Every vitamin, mineral, and trace element is crucial for maintaining health and well-being in menopausal women [7]. Among these, calcium is the most vital mineral for the human body, essential for maintaining the skeletal system throughout life. The reduction in ovarian estrogen production leads to an increased rate of bone resorption and a consequent decline in bone mass [2].

Dietary calcium is essential for maintaining normal calcium balance and preventing bone loss caused by nutritional deficiencies [8, 9]. Calcium absorption is reduced due to the lack of vitamin D, resulting from the age-related deterioration of organ functions. Deterioration in ovarian function during menopause is accompanied by a decrease in bone mass, altered calcium and vitamin D metabolism, and phosphorus. A reduction in calcium absorption is due to a drop in the circulating vitamin D levels [2].

Since several Nepalese populations are deficient in vitamin D and calcium [10], the prevalence of vitamin D deficiency in the population ranges from 32.0% to 73.6%, with a higher incidence observed in females [11]. Early detection of an imbalance in vitamin D, calcium, and phosphorus serum levels in menopausal women can be a valuable therapeutic and follow-up tool. From this viewpoint, serum calcium, phosphorus, and vitamin D levels were studied in pre-menopausal and post-menopausal women.

Material and methods

Study design and the participants

A present quantitative cross-sectional study was conducted at Kathmandu Medical College, Sinamangal, from February 2024 to April 2024, after obtaining ethical approval from the institutional review committee (IRC). Orthopaedic in- and outpatient departments were chosen as the study site for this study. The study was conducted among 354 women, where the samples were divided equally into two groups, of which 177 were pre-menopausal and the rest were post-menopausal women. Study groups were enrolled based on selection criteria, and patients were informed regarding the nature of the study. Subjects who wished to participate in this study provided written consent. We administered a structured questionnaire and 24-hour diet recall to gather information on demographics, medical, and dietary habits. Participants were enrolled in groups using non-probability sampling methods with consecutive sampling techniques.

Experimental procedure and data collection

Biochemical test regarding serum calcium, phosphorous and vitamin D. Under aseptic conditions, a venous blood sample was obtained by venipuncture from the cubital vein and was collected in a vial. Serum was separated after centrifugation. The specific biochemical test was performed on the sample using an automated analyzer, and the obtained value was recorded. The reference ranges of the parameters used in this study are as follows: serum calcium: 8.4–10.4 mg/dL [12], serum phosphorus: 3.5–5.5 mg/dL [13, 14], vitamin D deficiency = ≤20 ng/ml, insufficient = 21-29 ng/ml, and sufficient = >30 ng/ml [15, 16].

Inclusion criteria

Pre-menopausal Group: Women in the reproductive age group of 30–45 years with regular menstrual cycle.

Postmenopausal Group: Women 46–60 years of age, with one year of amenorrhea, who were not receiving any hormonal replacement therapy.

Exclusion criteria

Women had menstrual disorders, e.g., irregular menses and menorrhagia, with bone fractures in the previous year. Similarly, women on hormonal replacement therapy, oral contraceptives, smokers, alcoholics, and those under any estrogen therapy or any supportive treatment for menopausal symptoms for at least 6 months before the study.

Ethical committee approval and informed consent

The permission for the research was obtained from the institutional review committee (IRC). Consent was taken from the participants prior to the study. This study was done according to the declaration of Helsinki.

Sample size calculation

The prevalence of vitamin D deficiency observed was 66.4% in a study conducted by Sinha AK *et al*. [17]. The sample size was calculated by using the formula, $n = z^2pq / e^2$

[z = 1.96 at 95% Confidence Interval (CI), P = prevalence of Vitamin D deficiency = 66.4%, q = (1 - p), e = permissible error at 5% with a degree of assurance as a 95% confidence level. So, the sample size is for this study was $(1.96)^2$ x 0.664 x 0.336 / 0.0025 = 342.83. Assuming a non-response rate of 3%, 342.83 X 3 = 10.28; 342.83 + 10.28 = 353.11, the required sample size for this study was 354.

Data interpretation and statistical analysis

Data was analyzed using SPSS (Statistical Package for Social Science) version 21. Descriptive statistics were represented as mean ± standard deviation (S.D.) with 95% confidence intervals for continuous data (age, height, weight, body mass index (BMI), serum calcium, phosphorous, and vitamin D) and categorical data (religion, education, occupation, etc.) for the pre- and post-menopausal groups, as frequency number. Analytical statistical analysis was done to compare serum calcium, phosphorous, and vitamin D levels, which were evaluated using an independent T-test. Assessment of correlation test done by Pearson's correlation coefficient- analyze the relation between calcium, phosphorus, and vitamin D in pre-menopausal and post-menopausal women with statistical significance assumed at $p < 0.05$.

Results

Table 1: Socio-demographic characteristics of the respondents (N=354)

Variables	Pre-menopausal		Post-menopausal	
	n	(%)	n	(%)
	177	100	177	100
Age	37.76 ± 4.37		52.75 ± 4.00	
Menopausal age			48.05 ± 1.89	
Religion				
Hindu	146	82	142	80.2
Buddhist	16	9	26	14.6
Christian	10	6	6	3.5
Muslim	5	3	1	0.6
Other	-		2	1.1
Education				
Illiterate	9	5	3	1.7
Primary education	23	23	18	10.2
Secondary education	99	56	70	39.6
Higher education	45	25.5	73	41.2
Graduate	1	0.5	11	6.2
Postgraduate	-	-	2	1.1
Marital status				
Married	166	94	154	87
Unmarried	7	4	1	0.5
Divorced	4	2	3	1.5
Widowed	-	-	19	11
Occupation				
Employed	84	47.5	33	18.5
Housewife	92	52	143	81
Other	1	0.5	1	0.5

The average age of pre-menopausal and post-menopausal women was 37.76 and 52.75 years, respectively, while the average menopause age was 48.05 years. Most participants, 82% and 80.2%, were Hindu, while 9% and 14.6% were Buddhist, representing the pre-menopausal and post-menopausal groups, respectively. 56% and 41.2% of participants completed their higher education level, 25.5% were graduates, and 39.6% had completed secondary education in the pre- and post-menopausal groups, respectively. Most respondents were married (94% and 87%), 52% and 81% were housewives, whereas 47.5% and 18.5% were employed in pre- and post-menopausal women, respectively. (Table 1)

Table 2: Anthropometric measurement of respondents

Variables	Pre-menopause (n=177) (Mean±SD)		Post-menopause (n=177) (Mean ± SD)	p-value
Weight (Kg)	55.87 ± 4.82		57.40 ± 4.41	0.002*
Height (cm)	154.91 ± 4.77		153.77 ± 5.02	0.029*
BMI (kg/m^2)	23.25 ± 1.72		24.28 ±0.49	<0.001*
BMI classification	**n**	**(%)**	**n**	**(%)**
Normal	155	87.5	127	71.5
Overweight	22	12.5	47	26.5
Grade I obesity	-	-	3	2

×p>0.05, statistically not significant, *p<0.05, statistically significant

A significantly higher height ($P < 0.05$), weight, and BMI were observed amongst post-menopausal women ($p < 0.01$). The respondents in the pre-menopausal group had 87.5% with normal BMI while 12.5% were overweight, and the post-menopausal group had 71.5% normal, 26.5% were overweight, and 2% obese, as shown in table 2

65.3% of respondents were non-vegetarian, while 55% were vegetarian in pre- and post-menopausal women. Most respondents took three meals a day, 81.4% and 56%, while consumption of calcium-rich food was 80.2% and 79% in pre- and post-menopausal groups, respectively. The calcium intake frequency observed was once a day, in 43.5% and 58%, while once every two days, it was 40.1% and 36%, respectively, in pre- and post-menopausal women. Most respondents (70.7% and 80.8%) did not consume fish; 48.6% and 45.8% of the pre- and post-menopausal women took eggs once in two days, respectively. In this study, 83.6% and 91.5% of respondents were exposed to sunlight, while 36.7% and 38% were exposed to 1-30 min per day, while 16.9% and 31% were exposed to 31-60 min in a day in pre- and post-menopausal women, respectively. 89.8% and 60% of respondents knew the importance of calcium and vitamin D for bone health. In comparison, 86.4% and 59% received guidance from healthcare professionals regarding calcium and vitamin D supplements in pre-menopausal and post-menopausal women, respectively. (Table 3)

Table 3: Food habit, frequency and sunlight exposure among pre- and post-menopausal women

Variables	Pre-menopausal (n=177)	(%)	Post-menopausal (n=177)	(%)
Dietary Habit				
Vegetarian	65	36.7	97	55
Non-vegetarian	112	63.3	80	45
Meal Frequency				
Twice a day	31	17.5	72	40.5
Thrice a day	144)	81.4	99	56
Four times a day	2	1.1	6	3.5
Calcium Rich food				
Milk and milk product	26	14.7	31	17.5
Green leafy vegetable	9	5.1	6	3.5
Both	142	80.2	140	79
Calcium Frequency				
Once a day	77	43.5	103	58
Twice a day	28	15.8	11	6
Once in two days	71	40.1	63	36
Once a week	1	0.6		
Fish intake				
No	125	70.7	143	80.8
Once in 2 days	2	1.1	1	0.6
Once a week	8	4.5	-	-
Once in 15 days	19	10.7	11	6.2
once in a month	23	13	22	12.4
Egg intake				
No	54	30.5	7	43
Once a day	11	6.2	5	2.8
Twice a day	-	-	1	0.5
Once in 2 days	86	48.6	81	45.8
Once a week	26	14.7	14	7.9
Sunlight Exposure				
Yes	148	83.6	162	91.5
No	29	16.4	15	8.5
Sunlight exposure in min				
No exposure	29	16.4	15	8.5
1-30	65	36.7	67	38
31-60	30	16.9	55	31
61-120	47	26.6	32	18
>121	6	3.4	8	4.5
Importance of calcium and Vit D	159	89.8	106	60
Yes	18	10.2	71	40
No				
Guidance				
Yes	153	86.4	105	59
No	24	13.6	72	41

Table 4: Consumption of dietary calcium in 24-hour diet recall

24-hour dietary intake	Diagnosis	No. of patients	Mean ± S. D	P Value
Calcium (mg/day)	Pre-menopausal	177	664.81 ± 216.76	0.222[×]
	Post-menopausal		632.39 ± 277.86	

[×]p>0.05, statistically not significant

Table 4 compares 24-hour dietary calcium intake (DCI) in the pre- and post-menopausal groups of the study. The average calcium intake was 664.81 ± 216.76 mg/day and 632.39 ± 277.86 mg/day (p = 0.222), ranging from 218.3 to 1429.90 mg/day.

Table 5: Comparison of calcium, vitamin, and phosphorous levels in pre- and post-menopausal women

Parameter (Sr.)	Diagnosis	No. of patients	Mean ± S. D	P Value
Calcium (mg/dl)	Pre-menopausal	177	9.18 ± 0.47	<0.001[*]
	Post-menopausal	177	8.91 ± 0.43	
Vitamin D(ng/ml)	Pre-menopausal	177	23.03 ± 6.01	0.043[*]
	Post-menopausal	177	21.75 ± 5.86	
Phosphorous(mg/dl)	Pre-menopausal	177	4.01 ± 0.54	0.004[*]
	Post-menopausal	177	4.19 ± 0.66	

p<0.05, statistically significant

Serum calcium level in the pre-menopausal (9.18 ± 0.47 mg/dl) women was significantly higher (p < 0.001) than the post-menopausal women (8.91 ± 0.43 mg/dl); similarly, vitamin D level in pre-menopausal was (23.03 ± 6.01ng/ml significantly higher compared to the post-menopausal women. Serum phosphorous level was significantly higher in the post-menopausal women (4.19 ± 0.66 mg/dl) compared to pre-menopausal women (4.01 ± 0.54 mg/dl), (Table 5).

Table 6: Correlation of serum calcium, phosphorous, sunlight exposure, dietary calcium and dietary calcium in post-menopausal women with vitamin D

Parameter	Correlation coefficient r value	p-value
Vitamin D v/s calcium	0.407	<0.001[*]
Vitamin D v/s phosphorous	-0.008	0.875[×]
Vitamin D v/s sunlight exposure(min)	0.028	0.605[×]
Vitamin D v/s dietary calcium	0.421	<0.001[*]
Vitamin D v/s dietary calcium in post- menopausal women	0.414	<0.001[*]

[×]p>0.05, statistically not significant, [*]p<0.05, statistically significant

Vitamin D showed a positive correlation with calcium, dietary calcium, dietary calcium in post- menopausal women and sunlight exposure(p<0.001), and a negative correlation with phosphorous. (p>0.05) (Table 6)

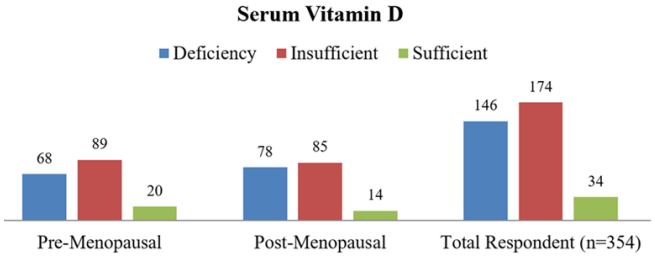

Figure 1: Bar diagram showing the serum vitamin D level in pre- and post-menopausal women

Figure 1 shows 68 pre-menopausal and 78 post-menopausal women had vitamin D deficiency, and 89 pre-menopausal and 85 post-menopausal women had insufficient vitamin D. In comparison, only 20 pre-menopausal and 14 post-menopausal women had sufficient vitamin D levels.

Discussion

Menopause is a state that is associated with numerous physiological and biochemical changes affecting bone metabolism [18]. The average age at which menopause occurs is influenced by genetic factors, lifestyle choices, socioeconomic conditions, educational attainment, and the nutritional status of the population studied [3, 19]. The average age of menopause found in the present study was 48.05 years (table 1). It was found to be 40.32 to 48.84 years for South Asian women, while in developed countries, it varies from 48.0 to 51 years [20]. A study conducted in Nepal reported the average age of menopause to be 48.7 [21].

In this study, 47 (26.5%) participants were overweight. In comparison, 2% were obese, with a higher BMI of 24.28 ± 0.49 kg/m^2 observed in post-menopausal women compared with pre-menopausal women ($p<0.001$) depicted in Table 2. Similarly, various other studies reported similar findings [22, 23]. The manifestation of obesity among the post-menopausal may be due to the deteriorated lipid metabolism resulting from the reduced effect of estrogen in post-menopausal women [24].

In this research, the 24-hour mean dietary recall of calcium was 664.81 ± 216.76 mg/day for pre-menopausal and 632.39 ± 277.86 mg/day for post-menopausal women. This could be due to individual variability in dietary habits and inaccuracies in self-reported dietary intake, as 24-hour dietary recalls rely on the memory of the study population, which can introduce errors. Consumption of milk, dairy products, and green leafy vegetables was 80.2% and 79%. Calcium absorption decreases as the oxalic acid content in food increases [25]. Although many edible plants are rich in total calcium, their bioavailability is reduced due to their complexation with oxalate, forming indigestible calcium-oxalate crystals [25, 26]. This interaction categorizes oxalate as an "antinutrient."

Furthermore, soluble oxalates can impair the absorption of minerals from other foods by binding to these minerals in the digestive tract, thereby decreasing their overall nutritional uptake [27]. Similarly, various other studies also reported low DCI in the study population [28, 29]. According to the Estimated Average Requirement (EAR) for calcium, which is 800 mg/day, participants in the present study did not meet the required intake. Likewise, a similar finding was obtained in a survey by Zareef *et al*. [30].

This research shows significantly higher serum calcium levels in pre-menopausal women, similar to other studies [10, 31, 32]. Calcium is the most essential mineral for maintaining the skeletal system in women throughout life. The menopausal phase is associated with increased bone resorption that lowers bone mass due to a decline in ovarian estrogen formation [2]. A decrease in intestinal absorption of calcium is also reported in menopause, and declining vitamin D levels are implicated [33, 34]. Estrogen may work by directly altering the intestinal responsiveness to calcitriol [35, 36]. This finding may be explained as an increased calcium requirement to maintain calcium homeostasis with advancing age, a continued decline in intestinal calcium absorption reported with ageing, and the apparent loss of intestinal adaptation to varying calcium intake in older women [37-39].

In this study, the mean vitamin D level in pre-menopausal women was higher than that of post-menopausal women. Various other studies have reported a drop in vitamin D in post-menopausal women compared to that in pre-menopausal women [10, 40, 41]. Vitamin D supports bone growth and its turnover. Its deficiency causes an increased risk for bone health in post-menopausal women [42]. Vitamin D is required to maintain a proper calcium level by promoting the intestinal absorption of calcium. A decline in levels of vitamin D in post-menopausal women [40, 43] are recognized to be induced by age-related decreases in the cutaneous synthesis of vitamin D, declines in renal production of the hormone calcitriol, poor intestinal sensitivity to vitamin D absorption, and a lack of exposure to the sun, as well as hyperparathyroidism, which increases the bone resorption and escalates the bone loss [33, 44, 45].

In this study, serum phosphorous levels were slightly higher in post-menopausal women than in pre-menopausal women. Serum levels of phosphorus and calcium are maintained mainly by two hormones, such as Parathyroid hormone (PTH) and calcitriol; therefore, any interference with the action of PTH can lead to lower serum calcium and an increase in serum phosphorus. Several studies also reported a rise in serum phosphorous in post-menopausal women compared to that in pre-menopausal women [23, 46, 47].

Vitamin D showed a positive correlation with serum calcium level (r value 0.407, $p<0.001$) in this research. Kiran B *et al*. reported similar findings [48]. It could be due to the involvement of vitamin D in the absorption of calcium from the gut [49, 50], while it showed a negative correlation with serum phosphorous values (r value -0.008, $p=0.875$). A similar finding was also reported by Kiran B *et al*. [48]. Vitamin D increases the efficiency of intestinal absorption of calcium by 30-40% and phosphorus absorption by approximately 80% [51]. Vitamin D deficiency leads to secondary hyperparathyroidism, resulting in phosphorus loss in the urine and decreasing intestinal absorption of phosphorus, which causes low or low normal phosphorus concentration, which is essential for bone mineralization [52, 53]. In this study, vitamin D with sunlight exposure in minutes shows a positive but insignificant correlation (r value 0.028, $p=0.605$). In contrast, some other studies showed a positive and significant correlation with sunlight exposure [15, 48]. A major source of Vitamin D is the sunlight [48]. However, participants of this study had limited exposure; 44 (12.4%) were not exposed to sunlight due to photosensitivity, heat sensitivity, work and lifestyle, and cultural norms, most of them use sunscreen and protective cloth.

The prevalence of hypovitaminosis D in this study population was 90.4%, with 146 (41.2%) as a deficiency and 174 (49.2%) as insufficiency. The prevalence of hypovitaminosis D in post-menopausal women in this study was 163 (92.1%), which included 44.1% as a deficiency and 48% as an insufficiency (figure 1). Beg *et al*. [54] reported that the overall prevalence of hypovitaminosis D in post-menopausal women was 88.5%. This state of hypovitaminosis D can be explained due to the complexion of the skin, inadequate exposure to the sun, dietary habits, decreased milk consumption, phytate-rich food, and the absence of a vitamin D fortification program [15]. This research found a positive correlation between serum vitamin D levels and DCI in the study population (r value 0.421, p <0.001). Similarly, post-menopausal women also demonstrated a positive correlation between serum levels of vitamin D and DCI (r value 0.414, p <0.001). A similar finding was also presented by Kamineni *et al*. [15].

Conclusion

Serum calcium and vitamin D levels were lower in post-menopausal women compared to pre-menopausal women, whereas serum phosphorous was relatively higher in post-menopausal women. As per EAR, the dietary calcium intake in both study populations was insufficient. Vitamin D positively correlated with serum calcium and dietary calcium in post-menopausal women. In contrast, it showed a positive correlation with sunlight exposure and a negative correlation with serum phosphorous. A significant association was observed between DCI and sunlight exposure with serum calcium and vitamin D. This study suggests that medical supervision of bone markers like serum calcium, vitamin D, and phosphorus is necessary. Therefore, periodic dosing of calcium and vitamin D, consuming foods rich in these nutrients and spending time in sunlight are essential to mitigate bone health problems.

Limitations and future scope of the study

The accuracy of self-reported dietary information may limit the study, as it may be subject to dietary recall bias. This could result in under- or over-reporting food consumption, leading to inaccurate results. This study could not cover many other bone markers like alkaline phosphatase, intact Parathyroid hormone (iPTH), total protein.

Relevance of the study

This cross-sectional study compared serum calcium, phosphorus, and vitamin D levels in pre- and postmenopausal women with nutritional correlation. The findings of this study strongly suggest that large-scale research is required to explore an association between vitamin and mineral status in pre- and post-menopausal women and to minimize its occurrence.

Abbreviations

Body Mass Index (BMI), cardiovascular diseases (CVD), dietary calcium intake (DCI), estimated average requirement (EAR), institutional review committee (IRC), Parathyroid hormone (PTH)

Acknowledgements

We acknowledge the participants and the nursing team for participating in the study. We thank Asst. Prof. Arun Pandeya (Biochemistry) and all the laboratory staff for their great help and support during the episode of the study.

Authors' contribution

a. Study planning: AD, JMT, NKC, KT
b. Data collection: AD, JMT
c. Data analysis/ interpretation: AD, KT
d. Manuscript writing: AD, JMT, NKC, KT
e. Manuscript revision: AD, JMT, NKC, KT
f. Final approval: AD, JMT, NKC, KT
g. Agreement to be accountable for all aspects of the work: AD, JMT, NKC, KT

Funding

No funding was received for this study.

Availability of data and materials

All data underlying the results are available as part of the article.

Competing interests

The authors declare that there are no conflicts of interest to disclose in relation to this manuscript.

Publisher's Note

NHRS remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

The publisher shall not be legally responsible for any types of loss, actions, claims, proceedings, demand or costs or damages whatsoever or howsoever caused arising directly or indirectly in connection with or arising out of the use of this material.

Author information

[1]Arun Dhungana, M.D. (Biochemistry), M.Sc. (Nutrition and Dietetics), Consultant Biochemist, Kathmandu Medical College Teaching Hospital, Kathmandu, Nepal. ORCID

[2]Jagat Man Tamang, M.Sc. (Running), Medical technologist, Golden Gate International College, Battisputali, Kathmandu, affiliated to Tribhuvan University, Nepal. ORCID

[3]Narendra Kumar Chaudhary, Researcher, M.Sc. (Nutrition and Dietetics), Nepal Orthopaedic Hospital, Jorpati, Kathmandu, Nepal. ORCID

[4]Dr. Kalpana Tiwari, PhD (Nutrition and Dietetics), Professor, CAFODAT College, Purbanchal University, Kumaripati, Lalitpur, Nepal

References

1. Jeffcoate's N. Clinical aspect of ovulation and menstrulation. In: Tindall VR, editor. Jeffcoate's N Principles of Gynaecology. 5th ed. London: Butterworth; 1987. p. 88.
2. Yadav KP, Batra J, Singh UN, Yadav R. Serum Vitamin D, Serum Calcium & Serum Phosphorus in Post-Menopausal Women in Farrukhabad District, Uttar Pradesh, India. Ann Int Med Den Res. 2020;6(1):BC01-BC4. http://www.aimdrjournal.com/wp-content/uploads/2021/06/BC1_OA_Yadav-edit.pdf
3. Shrestha NSS, Pandey A. A study of menopausal symptoms and its impact on lives of Nepalese perimenopausal and postmenopausal women. Journal of Kathmandu Medical College. 2017;6(1):4-8. https://doi.org/10.3126/jkmc.v6i1.18579
4. Afshari F, Bahri N, Sajjadi M, Mansoorian MR, Tohidinik HR. Menopause uncertainty: the impact of two educational interventions among women during menopausal transition and beyond. Prz Menopauzalny. 2020 Mar;19(1):18-24. https://doi.org/10.5114/pm.2020.95305
5. Sachdeva A, Seth S, Khosla AH, Sachdeva S. Study of some common biochemical bone turnover markers in postmenopausal women. Indian J Clin Biochem. 2005 Jan;20(1):131-4. https://doi.org/10.1007%2FBF02893058
6. Gupta N, Arora KS. The Status of Trace Elements after Menopause: A Comparative Study. Journal of Clinical and Diagnostic Research. 2011;5(4):795-7. https://www.jcdr.net/articles/pdf/1417/28-_2615.pdf
7. Dennehy C, Tsourounis C. A review of select vitamins and minerals used by postmenopausal women. Maturitas. 2010 Aug;66(4):370-80. https://doi.org/10.1016/j.maturitas.2010.06.003
8. Aggarwal S, Nityanand. Calcium and vitamin D in post menopausal women. Indian J Endocrinol Metab. 2013 Dec;17(Suppl 3):S618-20. https://doi.org/10.4103/2230-8210.123549
9. Fan T, Nocea G, Modi A, Stokes L, Sen SS. Calcium and vitamin D intake by postmenopausal women with osteoporosis in Spain: an observational calcium and vitamin D intake (CaVIT) study. Clin Interv Aging. 2013;8:689-96. https://doi.org/10.2147%2FCIA.S41335
10. Khadka B, Tiwari ML, Gautam R, Timalsina B, Pathak NP, Kharel K, *et al*. Correlates of Biochemical Markers of Bone turnover among Post-Menopausal Women. JNMA J Nepal Med Assoc. 2018 Jul-Aug;56(212):754-8. https://doi.org/10.31729/jnma.3604
11. Baidya S, Tuladhar ET, Sharma VK, Dubey RK, Raut M, Bhattarai A, *et al*. Association of Low Vitamin D and Intact Parathyroid Hormone (iPTH) in Nepalese Population: When Does iPTH Exactly Rise? J Endocr Soc. 2024 Feb 19;8(4):bvad143. https://doi.org/10.1210/jendso/bvad143
12. Cusano NE, Maalouf NM, Wang PY, Zhang C, Cremers SC, Haney EM, *et al*. Normocalcemic hyperparathyroidism and hypoparathyroidism in two community-based nonreferral populations. J Clin Endocrinol Metab. 2013 Jul;98(7):2734-41. https://doi.org/10.1210/jc.2013-1300
13. Qunibi WY, Nolan CR. Treatment of hyperphosphatemia in patients with chronic kidney disease on maintenance hemodialysis: results of the CARE study. Kidney Int Suppl. 2004 Sep(90):S33-8. https://doi.org/10.1111/j.1523-1755.2004.09006.x
14. Qunibi WY. Consequences of hyperphosphatemia in patients with end-stage renal disease (ESRD). Kidney Int Suppl. 2004 Sep(90):S8-S12. https://doi.org/10.1111/j.1523-1755.2004.09004.x
15. Kamineni V, Latha AP, Ramathulasi K. Association between serum 25-hydroxyvitamin D levels and bone mineral density in normal postmenopausal women. J Midlife Health. 2016 Oct-Dec;7(4):163-8. https://doi.org/10.4103%2F0976-7800.195694
16. Rangrez SS, Hadimani CP, Patil AS. Prevalence of osteoporosis, serum vitamin D and serum calcium deficiency cases among women: Ahospital based retrospective study. Int J Clin Biochem Res 2018;5(4):501-4. https://doi.org/10.18231/2394-6377.2018.0106
17. Sinha AK, Shah TN, Rai U. Status of vitamin D deficiency among the patients in a tertiary care hospital. Medical Journal of Eastern Nepal. 2022;1(1):7-12. https://doi.org/10.3126/mjen.v1i1.45854
18. Joshi K, Devi S, Lanjikar P. Evaluation of biochemical marker for bone turnover in post menopausal women. J Lumbini Med Coll. 2013;1(2):57-9. https://jlmc.edu.np/index.php/JLMC/article/view/20
19. Stanford JL, Hartge P, Brinton LA, Hoover RN, Brookmeyer R. Factors influencing the age at

natural menopause. J Chronic Dis. 1987;40(11):995-1002. https://doi.org/10.1016/0021-9681(87)90113-5
20. Sharma S, Tandon VR, Mahajan A. Menopausal symptoms in urban women. JK Science. 2007;9(1):13-7. http://jkscience.org/archive/volume91/menopausal.pdf
21. Rajbhandari S, Subedi RK, Dangal G, Phuyal A, Vaidya A, Karki A, *et al*. Menopausal Health Status of Nepalese Women. JNMA J Nepal Med Assoc. 2017 Jan-Mar;56(205):107-11. http://dx.doi.org/10.31729/jnma.2907
22. Ekhator CN, Ebomoyi MI. Comparative Study on the Effect of Parity on Serum Bone Mineralization Parameters (Calcium and Phosphate) in Pre- and Post-Menopausal Women. J Women's Health Reprod Med. 2018;2(1):1-5. https://www.imedpub.com/articles/comparative-study-on-the-effect-of-parity-on-serum-bone-mineralization-parameters-calcium-and-phosphate-in-pre-and-postmenopausal.pdf
23. Pardhe BD, Pathak S, Bhetwal A, Ghimire S, Shakya S, Khanal PR, *et al*. Effect of age and estrogen on biochemical markers of bone turnover in postmenopausal women: a population-based study from Nepal. Int J Womens Health. 2017;9:781-8. https://doi.org/10.2147/ijwh.s145191
24. Akahoshi M, Soda M, Nakashima E, Tominaga T, Ichimaru S, Seto S, *et al*. The effects of body mass index on age at menopause. Int J Obes Relat Metab Disord. 2002 Jul;26(7):961-8. https://doi.org/10.1038/sj.ijo.0802039
25. Weaver CM, Martin BR, Ebner JS, Krueger CA. Oxalic acid decreases calcium absorption in rats. J Nutr. 1987 Nov;117(11):1903-6. https://doi.org/10.1093/jn/117.11.1903
26. Heaney RP, Weaver CM. Oxalate: effect on calcium absorbability. Am J Clin Nutr. 1989 Oct;50(4):830-2. https://doi.org/10.1093/ajcn/50.4.830
27. Yang J, Punshon T, Guerinot ML, Hirschi KD. Plant calcium content: ready to remodel. Nutrients. 2012 Aug;4(8):1120-36. https://doi.org/10.3390/nu4081120
28. Kumari A, Kumari V, Kumar R, Rekha K. Study of Serum Calcium Level in Pre- and Post-menopausal Women of Jamshedpur, Jharkhand. Int J Sci Stud. 2018;6(6):18-20. https://doi.org/10.17354/ijss/2018/241
29. Fazlini MF, Suriah AR, Zaitun Y, Kandiah M, Chee WSS, Chan YM, *et al*. Calcium supplementation amongst postmenopausal women: Effect on serum calcium, phosphorus and magnesium level. International Food Research Journal. 2013;20(1):477-80. https://core.ac.uk/download/pdf/153811299.pdf
30. Zareef TA, Jackson RT, Alkahtani AA. Vitamin D Intake among Premenopausal Women Living in Jeddah: Food Sources and Relationship to Demographic Factors and Bone Health. J Nutr Metab. 2018;2018:8570986. https://doi.org/10.1155%2F2018%2F8570986
31. Achie LN, Mohammed A, Lawal YZ, Igashi J, Olorunshola KV. Serum calcium levels of premenopausal, perimenopausal and postmenopausal rural women of Zuturung District, Kaduna State, Nigeria. J Afr Ass Physiol Sci. 2020;8(2):133-9. https://www.ajol.info/index.php/jaaps/article/view/205714/193974
32. Patwa CK, Jindani NI, Afroz S. Study of serum calcium levels in premenopausal women and postmenopausal women. MedPulse International Journal of Physiology. 2017;4(2):14.6. https://doi.org/10.26611/103421
33. Veldurthy V, Wei R, Oz L, Dhawan P, Jeon YH, Christakos S. Vitamin D, calcium homeostasis and aging. Bone Res. 2016;4:16041. https://doi.org/10.1038/boneres.2016.41
34. Wishart JM, Scopacasa F, Horowitz M, Morris HA, Need AG, Clifton PM, *et al*. Effect of perimenopause on calcium absorption: a longitudinal study. Climacteric. 2000 Jun;3(2):102-8. https://doi.org/10.3109/13697130009167611
35. Fleet JC, Schoch RD. Molecular mechanisms for regulation of intestinal calcium absorption by vitamin D and other factors. Crit Rev Clin Lab Sci. 2010 Aug;47(4):181-95. https://doi.org/10.3109/10408363.2010.536429
36. Gennari C, Agnusdei D, Nardi P, Civitelli R. Estrogen preserves a normal intestinal responsiveness to 1,25-dihydroxyvitamin D3 in oophorectomized women. J Clin Endocrinol Metab. 1990 Nov;71(5):1288-93. https://doi.org/10.1210/jcem-71-5-1288
37. Heaney RP, Recker RR, Saville PD. Menopausal changes in calcium balance performance. J Lab Clin Med. 1978 Dec;92(6):953-63. http://dx.doi.org/10.1111/j.1753-4887.1983.tb07709.x
38. Ireland P, Fordtran JS. Effect of dietary calcium and age on jejunal calcium absorption in humans studied by intestinal perfusion. J Clin Invest. 1973 Nov;52(11):2672-81. https://doi.org/10.1172/jci107461

39. Gallagher JC, Riggs BL, Eisman J, Hamstra A, Arnaud SB, DeLuca HF. Intestinal calcium absorption and serum vitamin D metabolites in normal subjects and osteoporotic patients: effect of age and dietary calcium. J Clin Invest. 1979 Sep;64(3):729-36. https://doi.org/10.1172/jci109516
40. Pop LC, Shapses SA, Chang B, Sun W, Wang X. Vitamin D-Binding Protein in Healthy Pre- and Postmenopausal Women: Relationship with Estradiol Concentrations. Endocr Pract. 2015 Aug;21(8):936-42. https://doi.org/10.4158/ep15623.or
41. MacLaughlin J, Holick MF. Aging decreases the capacity of human skin to produce vitamin D3. J Clin Invest. 1985 Oct;76(4):1536-8. https://doi.org/10.1172/jci112134
42. Looker AC, Johnson CL, Lacher DA, Pfeiffer CM, Schleicher RL, Sempos CT. Vitamin D status: United States, 2001-2006. NCHS Data Brief. 2011 Mar(59):1-8. https://www.cdc.gov/nchs/data/databriefs/db59.pdf
43. Yasovanthi J, Venkata Karunakar K, Sri Manjari K, Pulla Reddy B, Ajeya Kumar P, Sesha Charyulu M, *et al*. Association of vitamin D receptor gene polymorphisms with BMD and their effect on 1, 25-dihydroxy vitamin D3 levels in pre- and postmenopausal South Indian women from Andhra Pradesh. Clin Chim Acta. 2011 Mar 18;412(7-8):541-4. https://doi.org/10.1016/j.cca.2010.11.035
44. Kinyamu HK, Gallagher JC, Prahl JM, DeLuca HF, Petranick KM, Lanspa SJ. Association between intestinal vitamin D receptor, calcium absorption, and serum 1,25 dihydroxyvitamin D in normal young and elderly women. J Bone Miner Res. 1997 Jun;12(6):922-8. https://doi.org/10.1359/jbmr.1997.12.6.922
45. Slovik DM, Adams JS, Neer RM, Holick MF, Potts JT, Jr. Deficient production of 1,25-dihydroxyvitamin D in elderly osteoporotic patients. N Engl J Med. 1981 Aug 13;305(7):372-4. https://doi.org/10.1056/nejm198108133050704
46. Ajay S, Gupta M, Sharma R. Level of biochemical bone markers in postmenopausal women in eastern u.p. (india): an indicator of osteoporosis. European journal of pharmaceutical and medical research. 2018;5(11):364-7. https://storage.googleapis.com/journal-uploads/ejpmr/article_issue/1540975797.pdf
47. Prabha YS, Ashalata K, VijyaBabu PVSS, Kumari PK, Nagamani M. A study of bone markers (serum calcium, serum phosphorus and serum Alkaline Phosphatase) in post menopausal women in east Godavari distirct, Andhra Pradesh, India. IOSR- JDMS. 2015;14(6):1-3. https://dx.doi.org/10.9790/0853-14640103
48. Kiran B, Prema A, Thilagavathi R, Jamuna Rani R. Serum 25-Hydroxy Vitamin D, Calcium,Phosphorus and Alkaline Phosphatase Levels In Healthy Adults Above the age of 20 Living in Potheri Village of Kancheepuram District, Tamilnadu. J App Pharm Sci. 2014;4(12):30-4. https://dx.doi.org/10.7324/JAPS.2014.41206
49. Heaney RP, Dowell MS, Hale CA, Bendich A. Calcium absorption varies within the reference range for serum 25-hydroxyvitamin D. J Am Coll Nutr. 2003 Apr;22(2):142-6. https://doi.org/10.1080/07315724.2003.10719287
50. Heaney RP. Vitamin D depletion and effective calcium absorption. J Bone Miner Res. 2003 Jul;18(7):1342; author reply 3. https://doi.org/10.1359/jbmr.2003.18.7.1342
51. Holick MF. Vitamin D deficiency. N Engl J Med. 2007 Jul 19;357(3):266-81. https://doi.org/10.1056/nejmra070553
52. Holick MF. Sunlight and vitamin D: both good for cardiovascular health. J Gen Intern Med. 2002 Sep;17(9):733-5. https://doi.org/10.1046/j.1525-1497.2002.20731.x
53. Holick MF. Vitamin D: importance in the prevention of cancers, type 1 diabetes, heart disease, and osteoporosis. Am J Clin Nutr. 2004 Mar;79(3):362-71. https://doi.org/10.1093/ajcn/79.3.362
54. Beg M, Akhtar N, Alam MF, Rizvi I, Ahmad J, Gupta A. Vitamin D status and serum osteocalcin levels in postmenopausal osteoporosis: Effect of bisphosphonate therapy. J Indian Acad Clin Med. 2014;15(3):172-6.