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Association of Vitamin D Status with Lifestyle and Metabolic Factors in Adult Females of Nepal: A Cross-Sectional Study

Brihaspati Rimal[1], Dr. Mohd Babu Khan[2]

[1]PhD Scholar, School of Life and Allied Health Sciences, Glocal University Mirzapur Pole, Saharanpur, Uttar Pradesh, India. (ORCID: 0009-0006-8700-8049)
[2]Assistant Professor, Glocal School of Life and Natural Sciences, Glocal University Mirzapur Pole, Saharanpur, Uttar Pradesh, India. (ORCID: https://orcid.org/0000-0001-8676-368X)

Corresponding Author: Dr. Mohd Babu Khan

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ABSTRACT

Background: Vitamin D plays a crucial role in several chronic illnesses beyond bone health. However, its status in developing countries including Nepal remains poorly documented. To guide public health initiatives, this study aims to investigate the association between vitamin D level and factors including lifestyle, and metabolic variables in adult Nepalese women.
Methods: This cross-sectional study was conducted between 1st March to 2nd April 2024, in Bharatpur in Bharatpur Metropolitan city, Nepal. A total of 103 adult participants aged between 18 to 70 years, who visited Chitwan Medical College, were included. Data were collected after obtaining informed consent through structured questionnaires regarding lifestyle, physical measurements and blood sample to measure serum 25-hydroxyvitamin D (25(OH) D. SPSS window version 23 was used for statistical analyses, employing chi-square tests and one way ANOVA to evaluate significant associations between vitamin D status and various variables.
Results: Many adult female participants had low levels of vitamin D, less than 20 ng/ml. This was linked to their age (p=0.003), the size of their waist compared to their hips (p=0.004), their body mass index (BMI) (p=0.022), and their blood pressure (p=0.030). Adult female, those with higher BMI, and those with more waist-to-hip ratio (WHR) had lower vitamin D levels. Low vitamin D was also connected to higher cholesterol (p=0.002) and higher blood pressure.
Conclusion: Vitamin D deficiency is prevalent among adult Nepalese women and is associated with age, obesity, hypertension and dyslipidemia. The present study also reflects the need for effective health strategies, including supplementation, lifestyle modifications, and public health education, to address vitamin D deficiency and its associated health risks.

Keywords: Vitamin D, Adult women, Metabolic Parameters, Lifestyle

1. INTRODUCTION

Vitamin D is a fat-soluble vitamin that is mostly produced in the skin through exposure to sunlight. It is important for maintaining healthy bones and metabolism of calcium and phosphorus.[1] Recent research has shown that's its importance extends beyond bone health, linking vitamin D to several chronic conditions, including diabetes, inflammatory diseases, and certain

types of cancer.[2] Despite of its importance for human health, vitamin D insufficiency and deficiency are very common, especially in women as reported in Middle East country.[3] It is important to look into variables affecting vitamin D levels in different groups of people as different factors including metabolic parameters, dietary habits, and lifestyle choices, resulted in differing levels of the vitamin D.[4]

In Nepal, there is a growing concern regarding vitamin D deficiency, especially in adult women, because of cultural practices that limit sun exposure, metabolic parameters, dietary restrictions, and financial issues.[5] Understanding how lifestyle and metabolic factors influence to vitamin D levels in this population can help shape public health interventions that lower the risk of health problems associated with vitamin D deficiency.[6]

The objective of this cross-sectional study is to investigate the relationship between various lifestyle and metabolic variables with vitamin D status in adult Nepalese women. Variables such as age, smoking habits, alcohol consumption, diet type, Waist-to-Hip Ratio (WHR), Body Mass Index (BMI), serum High Density Lipoprotein (HDL) levels were analyzed with other major clinical indexes including fasting blood glucose, blood pressure and serum triglycerides to detect independent predictors of Vitamin D deficiency and insufficiency in this population. The results of this study will therefore add to the knowledge about the factors influencing vitamin D status and guide focused interventions to raise vitamin D levels in at-risk populations.

2. METHODS AND MATERIALS

2.1. Study Design, Study Site, and Participants

This cross-sectional survey was conducted over one months from 1st March to 2nd April 2024, in Bharatpur Metropolitan City, a sub-urban area of Chitwan District, Nepal because urban and sub-urban have easy accessibility for the study and its diversified residence area. The sample size was calculated based on a previously reported 6.3 % prevalence rate of vitamin D deficiency among adult women in Kavre , Nepal, using a 95% confidence level and a 5% margin of error.[5]

$n= Z^2 P (1-P) / d^2$

n= Sample size, Z = 95% level of confidence, P= 6.3% previous prevalence, d = 5% margin error

As per calculation, a total of 103 women aged 18 to 70 age years, who have visited Chitwan Medical College for routine checkups were selected for the study. The primary aim was to assess the association between serum 25(OH)D levels, lifestyle factors, and various metabolic parameters. Participants were evaluated for serum 25(OH)D concentration along with relevant metabolic variables including body mass index (BMI), waist-to-hip ratio, and other health markers.

2.2. Recruitment of Study Subjects

Female participants were recruited on the basis of their routine visits to Chitwan Medical College and Teaching Hospital at medicine outpatient department. Written informed consent was obtained from the entire participant before to their inclusion in the study.

2.3. Data Collection

Data collection was carried out using structured questionnaires on lifestyle factors including age, smoking habits, alcohol consumption, diet, physical measurements including height, weight, BMI, waist circumference, blood pressure levels and blood samples collection to measure fasting blood glucose, serum 25-hydroxyvitamin D (25(OH)D) levels, triglycerides, cholesterol and high density lipoprotein (HDL). The equipment used for these assessments included a digital weighing scale, stadiometer, non-stretchable measuring tape, Omron-5 series digital blood pressure monitor, hexokinase assay for blood glucose [7], chemiluminescence immunoassay (CLIA) for vitamin D [8], glycerol phosphate

oxidase/phenol aminoantipyrine peroxidase (GPO/ PAP) for triglycerides [9], cholesterol oxidase/ phenol aminoantipyrine peroxidase (CHOD/PAP)[10] and direct method (dextran sulfate) for high density lipoprotein (HDL).[11] [12]

2.4. Blood Sample Collection and Analyses

Fasting blood samples were drawn from the cubital vein of the left hand. The blood was then collected in yellow stopped vacutainer tube followed by storage on ice box and transported within 20 min to the Chitwan Medical College Hospital, department of Biochemistry. The obtained blood samples were centrifuged at 3000 rpm for 10 minute to separate serum.[13] [14] The obtained serum samples were used for analyzing the concentration of glucose, 25-hydroxyvitamin D (25(OH)D), triglycerides, cholesterol, and high density lipoprotein (HDL) by hexokinase , chemiluminescence immunoassay (CLIA) , glycerol phosphate oxidase/phenol aminoantipyrine peroxidase (GPO/ PAP), cholesterol oxidase/ phenol aminoantipyrine peroxidase (CHOD/PAP) and direct method (dextran sulfate) respectively.

2.5. Outcome Variables and Criteria for Vitamin D Status

The primary outcome of the study was the assessment of vitamin D status, measured by serum 25-hydroxyvitamin D (25(OH) D) levels. Vitamin D levels were classified as deficiency (<20 ng/ml), insufficiency (between 20–30 ng/ml) and sufficiency (≥30 ng/ml).[15]

2.6. Statistical Methods

Statistical analyses on collected data were performed using the statistical package for the social sciences (SPSS) window version 23. This study analyzed vitamin D status across various range of lifestyle and metabolic variables where data were expressed as percentages of patients with different levels of vitamin D status. Prevalent of vitamin D deficiency, insufficiency, and sufficiency were tested across the variables using Chi-square test with a level of significance at $p < 0.05$. The means and standard deviations of the metabolic variables across vitamin D categories were compared statically using one-way ANOVA, following analyzing F value (variance between groups) and then level of significant p value at $p < 0.05$.

2.7. Ethical Considerations

Ethical clearance was obtained from the Institutional Review Board (IRB), Chitwan Medical College (reference code CMC-IRC/080/081/094. All participants provided written informed consent. Ethical guidelines were followed in accordance with the declaration of Helsinki, therefore all procedures performed in studies involving human participants took care of participant rights and protected their welfare.

2.8. Inclusion and exclusion criteria

Inclusion criteria include women aged above 18 years and older who visited Chitwan Medical College, internal medicine outpatient department for routine check-ups. Exclusion criteria include women with any known chronic diseases that could affect vitamin D metabolism, having vitamin D supplementation and pregnant women.

3. RESULTS

As shown in Table 1, significant results were observed in several variables. Age ($p = 0.003$) showed higher vitamin D deficiency in individuals ≥65 years (67.9%) compared to those <65 years (30.7%). Among vegetarians, 11.1% had vitamin D deficiency, while 43.6% of non-vegetarians were vitamin D deficient. Diet type ($p = 0.009$) revealed that vegetarians had a higher sufficiency (77.8%) than non-vegetarians (27.7%). Waist-to-hip ratio (WHR) ($p = 0.004$) indicated greater sufficiency in individuals with high WHR (58.3%). BMI ($p = 0.022$) showed higher deficiency in overweight and obese individuals, with 100% deficiency in 2nd grade obesity.

Table 1. Vitamin D status across various lifestyles and metabolic variables

Variables	**Vitamin D Deficiency < 20 ng/ml (%)**	**Vitamin D Insufficiency 20-30 ng/ml (%)**	**Vitamin D Sufficiency > 30 ng/ml (%)**	**P-value**
Age				0.003
< 65 (n=75)	23 (30.7%)	24 (32.0%)	28 (37.3%)	
≥ 65 (n=28)	19 (67.9%)	4 (14.3%)	5 (17.9%)	
Smoker or Non-Smoker				0.508
Smoker (n=18)	9 (50.0%)	3 (16.7%)	6 (33.3%)	
Non-Smoker (n=85)	33 (38.8%)	25 (29.4%)	27 (31.8%)	
Alcohol Consumption				0.245
Yes (n=7)	4 (57.1%)	0 (0%)	3 (42.9%)	
No (n=96)	38 (39.6%)	28 (29.2%)	30 (31.3%)	
Diet Type				0.009
Vegetarian (n=9)	1 (11.1%)	1 (11.1%)	7 (77.8%)	
Non-Vegetarian (n=94)	41 (43.6%)	27 (28.7%)	26 (27.7%)	
Waist-to-Hip Ratio (WHR)				0.004
High WHR (n=24)	4 (16.7%)	6 (25.0%)	14 (58.3%)	
Normal WHR (n=79)	38 (48.1%)	22 (27.8%)	19 (24.1%)	
Body Mass Index (BMI)				0.022
Underweight (<18.5 kg/m²) (n=6)	1 (16.7%)	3 (50.0%)	2 (33.3%)	
Normal weight (18.51-24.9 kg/m²) (n=52)	14 (26.9%)	15 (28.8%)	23 (44.2%)	
Overweight (25-29.9 kg/m²) (n=33)	18 (54.5%)	9 (27.3%)	6 (18.2%)	
1st Grade Obesity (30-34.9 kg/m²) (n=8)	5 (62.5%)	1 (12.5%)	2 (25.0%)	
2nd Grade Obesity (35-39.9 kg/m²) (n=4)	4 (100.0%)	0 (0%)	0 (0%)	
Serum HDL (mg/dL)				0.370
Normal (≥40 mg/dL, n=42)	14 (33.3%)	14 (33.3%)	14 (33.3%)	
Low HDL (<40 mg/dL, n=61)	28 (45.9%)	14 (23.0%)	19 (31.1%)	
Fasting Glucose (mg/dL)				0.633
Normal (<100 mg/dL, n=65)	25 (38.5%)	17 (26.2%)	23 (35.4%)	
High FBS (≥100 mg/dL, n=38)	17 (44.7%)	11 (28.9%)	10 (26.3%)	
Blood Pressure (BP) (mmHg)				0.304
Normal BP (<120/80 mmHg, n=56)	19 (33.9%)	17 (30.4%)	20 (35.7%)	
High BP (≥120/80 mmHg, n=47)	23 (48.9%)	11 (23.4%)	13 (27.7%)	
Serum Triglycerides (TG) (mg/dL)				0.068
Normal (<150 mg/dL, n=71)	24 (33.8%)	20 (28.2%)	27 (38.0%)	
High TG (≥150 mg/dL, n=32)	18 (56.3%)	8 (25.0%)	6 (18.8%)	

In this Table 2. Significant differences among the three groups categorized by vitamin D status. Age was significantly different across the groups ($F = 4.450$, $p = 0.014$), with older participants in the vitamin D deficiency group compared to those in the

insufficiency and sufficiency groups. Waist-to-hip ratio (WHR) showed a significant variation (F = 8.707, p < 0.001), with the highest WHR observed in the deficiency group, indicating a higher central obesity. Body mass index (BMI) also differed significantly among the groups (F = 7.739, p = 0.001), with the deficiency group exhibiting the highest BMI. Additionally, systolic blood pressure (SBP) was significantly different (F = 3.629, p = 0.030), with the highest values recorded in the vitamin D deficiency group. Cholesterol levels were significantly higher in the vitamin D deficiency group compared to the insufficiency and sufficiency groups (F = 6.665, p = 0.002).

Table 2. Metabolic variables across different Vitamin D status groups

Variable	Vitamin D Deficiency (<20 ng/ml)	Vitamin D Insufficiency (20-30 ng/ml)	Vitamin D Sufficiency (>30 ng/ml)	F	P
Age (years)	58.45 ± 15.08	49.43 ± 14.35	49.55 ± 15.36	4.450	0.014
WHR (Waist-to-Hip Ratio)	1.03 ± 0.12	0.95 ± 0.11	0.93 ± 0.13	8.707	0.000
BMI (Body Mass Index)	26.66 ± 4.38	23.94 ± 3.55	23.06 ± 4.28	7.739	0.001
SBP (Systolic Blood Pressure)	129.05 ± 16.54	123.04 ± 13.83	120.45 ± 10.92	3.629	0.030
DBP (Diastolic Blood Pressure)	83.52 ± 5.50	82.68 ± 6.30	81.36 ± 3.13	1.644	0.198
Cholesterol (mg/dL)	206.81 ± 102.71	156.00 ± 69.26	143.27 ± 49.03	6.665	0.002
Fasting Serum TG (mg/dL)	148.33 ± 67.49	142.14 ± 87.29	114.58 ± 42.21	2.513	0.086
Serum HDL (mg/dL)	44.95 ± 13.75	50.03 ± 13.28	48.00 ± 12.57	1.300	0.277
Fasting Blood Sugar (mg/dL)	119.74 ± 61.99	116.11 ± 38.55	101.21 ± 27.45	1.524	0.223

4. DISCUSSIONS

The current study presented the relationship between vitamin D levels with various metabolic parameters, revealing significant results. Here, the study identified significant differences between age, waist-to-hip ratio (WHR), body mass index (BMI), systolic blood pressure (SBP), and cholesterol levels with different vitamin D status among adult female.

The current data Table 1 showed a significant age-related difference in the status of vitamin D. In particular, 67.9% of females aged ≥65 years had vitamin D deficiency (<20 ng/ml) when compared to 30.7% of females aged less than 65 years (p = 0.003). This finding confirms the literature that states that there is an increasing prevalence of vitamin D deficiency in older adults. Reduced skin synthesis, lower dietary intake, and less efficient conversion of vitamin D to its active form all contribute to this higher prevalence with increasing age.[2] [16] The study also showed that the Waist to hip ratio (WHR) of adult females differed significantly by vitamin D status groups, with a p-value of 0.004. Individuals female with vitamin D deficiency had the highest WHR (1.03 ± 0.12), while those with sufficiency had the lowest Waist to hip ratio (WHR (0.93 ± 0.13). A higher WHR indicates more central obesity, and this agrees with previous studies that have implicated vitamin D deficiency in increased visceral fat accumulation and central obesity. It is reported that vitamin D has an effect on fat distribution and metabolic health; therefore, its deficiency may influence central obesity and further promote metabolic risks.[17] [18] Similarly, a significant difference was recorded in the

mean BMI among female subjects across the groups of vitamin D status (p = 0.022).The deficiency group had the highest BMI (26.66 ± 4.38), with the 2nd grade obesity group showing 100% deficiency rate. This finding is further supported by studies reporting an inverse relationship between the levels of vitamin D and higher BMI, since the fat-soluble vitamin is sequestered in adipose tissues. Thus, individuals with higher BMI may have reduced bioavailability of vitamin D, leading to deficiency.[19] [20]

As shown in Table 2, significant differences in the levels of SBP among female were noted (p = 0.030). Individuals with vitamin D deficiency had the highest SBP (129.05 ± 16.54), compared to those with insufficiency (123.04±13.83) and sufficiency (120.45 ± 10.92). This supports the association between vitamin D deficiency and increased risk of hypertension. In previous study, vitamin D is assumed to influence the regulation of blood pressure through its action on the renin-angiotensin-aldosterone system and endothelial function.[21] [22] [23] .Cholesterol levels were significantly higher in the vitamin D deficiency group female (206.81 ± 102.71) compared to those with insufficiency group female (156.00 ± 69.26) and sufficiency grouped female (143.27 ± 49.03) (p = 0.002). This finding concurs with other studies that found a link between vitamin D deficiency and dyslipidemia. Vitamin D might play a modulating role in cholesterol metabolism and synthesis, and deficiency may be associated with higher levels of total LDL cholesterol.[24] [25]

The current findings are in aligning with previous literature. Associations now identified between vitamin D deficiency, higher age, and greater central obesity, higher BMI, increased SBP, and increased cholesterol levels have similarly been noted in prior studies.[26] Indeed, prior studies have reported that the risk for vitamin D deficiency and its associated health problems increases with age.[27] Besides that, the connection of Vitamin D with obesity and even with hypertension has been widely reported, an optimum level of Vitamin D may prevent such risks.[28] Vitamin D is critically involved in many metabolic processes other than calcium homeostasis and skeletal health, including inflammation, insulin sensitivity, and endothelial function. [29]Vitamin D deficiency may further promote obesity, hypertension, and dyslipidemia through these pathways. Given the active role of vitamin D in the modulation of inflammatory processes and its influence on insulin sensitivity,[29] it is likely to affect fat distribution and further influence cardiovascular health.

CONCLUSIONS

Hence the present study explores the relationship between vitamin D status and various metabolic parameters, including age, waist-to-hip ratio (WHR), body mass index (BMI), and systolic blood pressure (SBP), and cholesterol levels in women. It observed that chances of vitamin D deficiency are higher in older women. The study also revealed the association between vitamin D deficiency and central obesity where higher WHR shows lower vitamin D levels and those with lower vitamin D levels had higher WHR. Higher BMI also pointed to vitamin D deficiency, this may be due to the reduced bioavailability of vitamin D in individuals having more fat tissue. Elevated systolic blood pressure was also noted in women with vitamin D deficiency, reinforcing the connection between deficiency and hypertension. Additionally, cholesterol levels were higher in those with deficient vitamin D status. Our present findings also justify that vitamin D might plays a role in inflammation, insulin sensitivity, and endothelial function and its deficiency may contribute to worsening obesity, hypertension, and dyslipidemia.

Declaration by Authors

Ethical Approval: Approved

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Conflict of Interest: All the authors declare no conflict of interest.

Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Review Board of Committee of Chitwan Medical (Reference code CMC-IRC/080/081/094).

Informed Consent Statement

Informed consent was obtained from all participants who were involved in the study.

Data availability statement

Raw data can be made available upon request from the corresponding author.

Author Contributions

Conceptualization: BR, MBK
Methodology: BR, SKC, SRY, SK, SKS, SS
Validation: BR, SKC, SRY, SK, SKS, SS, KM
Investigation: BR, SKC, SRY, SK, SKS, SS
Writing - Original Draft Preparation: BR, SKC, SS, SRY
Writing - Review and Editing: BR, SKC, SRY, SS
Supervision: MBK, SRY

REFERENCES

1. Holick, M. F. (2004). Sunlight and vitamin D for bone health and prevention of autoimmune diseases, cancers, and cardiovascular disease23. *The American Journal of Clinical Nutrition*, *80*(6), 1678S-1688S. https://doi.org/10.1093/ajcn/80.6.1678S
2. Rebelos, E., Tentolouris, N., & Jude, E. (2023). The Role of Vitamin D in Health and Disease: A Narrative Review on the Mechanisms Linking Vitamin D with Disease and the Effects of Supplementation. *Drugs*, *83*(8), 665–685. https://doi.org/10.1007/s40265-023-01875-8
3. AlFaris, N. A., AlKehayez, N. M., AlMushawah, F. I., AlNaeem, A. N., AlAmri, N. D., & AlMudawah, E. S. (2019). Vitamin D Deficiency and Associated Risk Factors in Women from Riyadh, Saudi Arabia. *Scientific Reports*, *9*, 20371. https://doi.org/10.1038/s41598-019-56830-z
4. Melguizo-Rodríguez, L., Costela-Ruiz, V. J., García-Recio, E., De Luna-Bertos, E., Ruiz, C., & Illescas-Montes, R. (2021). Role of Vitamin D in the Metabolic Syndrome. *Nutrients*, *13*(3), 830. https://doi.org/10.3390/nu13030830
5. Yogal, C., Borgen, M., Shakya, S., Karmarcharya, B., Koju, R., Mosti, M. P., Gustafsson, M. K., Åsvold, B. O., Schei, B., Stunes, A. K., & Syversen, U. (2022). Vitamin D Status among Women in a Rural District of Nepal: Determinants and Association with Metabolic Profile—A Population-Based Study. *Nutrients*, *14*(11), 2309. https://doi.org/10.3390/nu14112309
6. Sizar, O., Khare, S., Goyal, A., & Givler, A. (2024). Vitamin D Deficiency. In *StatPearls*. StatPearls Publishing. http://www.ncbi.nlm.nih.gov/books/NBK532266/
7. Sonagra, A. D., Zubair, M., & Motiani, A. (2024). Hexokinase Method. In *StatPearls*. StatPearls Publishing. http://www.ncbi.nlm.nih.gov/books/NBK587446/
8. Han, S., Qiu, W., Zhang, J., Bai, Z., & Tong, X. (2020). Development of a Chemiluminescence Immunoassay for Quantification of 25-Hydroxyvitamin D in Human Serum. *Journal of Analytical Methods in Chemistry*, *2020*(1), 9039270. https://doi.org/10.1155/2020/9039270
9. Penumarthy, S., Penmetsa, G. S., & Mannem, S. (2013). Assessment of serum levels of triglycerides, total cholesterol, high-density lipoprotein cholesterol, and low-density lipoprotein cholesterol in periodontitis patients. *Journal of Indian Society of Periodontology*, *17*(1), 30. https://doi.org/10.4103/0972-124X.107471
10. Lie, R. F., Schmitz, J. M., Pierre, K. J., & Gochman, N. (1976). Cholesterol oxidase-based determination, by continuous-flow analysis, of total and free cholesterol in serum. *Clinical Chemistry*, *22*(10), 1627–1630.

11. Nepal, G., Tuladhar, E. T., Dahal, S., Ahamad, S. T., Adhikari, S., & Kandel, A. (n.d.). Lifestyle Practices and Obesity in Nepalese Youth: A Cross-sectional Study. *Cureus*, *10*(2), e2209. https://doi.org/10.7759/cureus.2209
12. Talameh, Y., Wei, R., & Naito, H. (1986). Measurement of total HDL, HDL2 and HDL3 by dextran sulfate—MgCl2 precipitation technique in human serum. *Clinica Chimica Acta*, *158*(1), 33–41. https://doi.org/10.1016/0009-8981(86)90113-0
13. Mukai, K., Nakajima, Y., Nakano, T., Okuhira, M., Kasashima, A., Hayashi, R., Yamashita, M., Urai, T., & Nakatani, T. (2020). Safety of Venipuncture Sites at the Cubital Fossa as Assessed by Ultrasonography. *Journal of Patient Safety*, *16*(1), 98–105. https://doi.org/10.1097/PTS.0000000000000441
14. Turchiano, M., Nguyen, C., Fierman, A., Lifshitz, M., & Convit, A. (2013). Impact of Blood Sample Collection and Processing Methods on Glucose Levels in Community Outreach Studies. *Journal of Environmental and Public Health*, *2013*, 256151. https://doi.org/10.1155/2013/256151
15. Cheng, Q., Du, Y., Hong, W., Tang, W., Li, H., Chen, M., & Zheng, S. (2017). Factors associated to serum 25-hydroxyvitamin D levels among older adult populations in urban and suburban communities in Shanghai, China. *BMC Geriatrics*, *17*(1), 246. https://doi.org/10.1186/s12877-017-0632-z
16. Boucher, B. J. (2012). The Problems of Vitamin D Insufficiency in Older People. *Aging and Disease*, *3*(4), 313–329. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3501367/
17. Zhang, M., Li, P., Zhu, Y., Chang, H., Wang, X., Liu, W., Zhang, Y., & Huang, G. (2015). Higher visceral fat area increases the risk of vitamin D insufficiency and deficiency in Chinese adults. *Nutrition & Metabolism*, *12*(1), 50. https://doi.org/10.1186/s12986-015-0046-x
18. Cominacini, M., Fumaneri, A., Ballerini, L., Braggio, M., Valenti, M. T., & Dalle Carbonare, L. (2023). Unraveling the Connection: Visceral Adipose Tissue and Vitamin D Levels in Obesity. *Nutrients*, *15*(19), 4259. https://doi.org/10.3390/nu15194259
19. Cominacini, M., Fumaneri, A., Ballerini, L., Braggio, M., Valenti, M. T., & Dalle Carbonare, L. (2023). Unraveling the Connection: Visceral Adipose Tissue and Vitamin D Levels in Obesity. *Nutrients*, *15*(19), 4259. https://doi.org/10.3390/nu15194259
20. Lu, S., & Cao, Z.-B. (2023). Interplay between Vitamin D and Adipose Tissue: Implications for Adipogenesis and Adipose Tissue Function. *Nutrients*, *15*(22), Article 22. https://doi.org/10.3390/nu15224832
21. Jensen, N. S., Wehland, M., Wise, P. M., & Grimm, D. (2023). Latest Knowledge on the Role of Vitamin D in Hypertension. *International Journal of Molecular Sciences*, *24*(5), Article 5. https://doi.org/10.3390/ijms24054679
22. McMullan, C. J., Borgi, L., Curhan, G. C., Fisher, N., & Forman, J. P. (2017). The Effect of Vitamin D on Renin-Angiotensin-System Activation and Blood Pressure—A Randomized Control Trial. *Journal of Hypertension*, *35*(4), 822–829. https://doi.org/10.1097/HJH.0000000000001220
23. Santoro, D., Caccamo, D., Lucisano, S., Buemi, M., Sebekova, K., Teta, D., & De Nicola, L. (2015). Interplay of Vitamin D, Erythropoiesis, and the Renin-Angiotensin System. *BioMed Research International*, *2015*(1), 145828. https://doi.org/10.1155/2015/145828
24. Al Refaie, A., Baldassini, L., Mondillo, C., De Vita, M., Giglio, E., Tarquini, R., Gonnelli, S., & Caffarelli, C. (2024). Vitamin D and Dyslipidemia: Is There Really a Link? A Narrative Review. *Nutrients*, *16*(8), 1144. https://doi.org/10.3390/nu16081144
25. Huang, X., Yang, Y., Jiang, Y., Zhou, Z., & Zhang, J. (2023). Association between vitamin D deficiency and lipid profiles in overweight and obese adults: A systematic review and meta-analysis. *BMC Public Health*, *23*(1), 1653. https://doi.org/10.1186/s12889-023-16447-4
26. Kumaratne, M., Early, G., & Cisneros, J. (2017). Vitamin D Deficiency and Association With Body Mass Index and Lipid Levels in Hispanic American Adolescents. *Global Pediatric Health*, *4*,

2333794X17744141. https://doi.org/10.1177/2333794X17744141
27. Bruyère, O., Cavalier, E., Souberbielle, J.-C., Bischoff-Ferrari, H. A., Beaudart, C., Buckinx, F., Reginster, J.-Y., & Rizzoli, R. (2014). Effects of vitamin D in the elderly population: Current status and perspectives. *Archives of Public Health*, *72*(1), 32. https://doi.org/10.1186/2049-3258-72-32
28. Jensen, N. S., Wehland, M., Wise, P. M., & Grimm, D. (2023). Latest Knowledge on the Role of Vitamin D in Hypertension. *International Journal of Molecular Sciences*, *24*(5), 4679. https://doi.org/10.3390/ijms24054679
29. Argano, C., Mirarchi, L., Amodeo, S., Orlando, V., Torres, A., & Corrao, S. (2023). The Role of Vitamin D and Its Molecular Bases in Insulin Resistance, Diabetes, Metabolic Syndrome, and Cardiovascular Disease: State of the Art. *International Journal of Molecular Sciences*, *24*(20), 15485. https://doi.org/10.3390/ijms242015485

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