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The relationship between vitamin D levels and cardiovascular risk factors in offshore workers

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Abstract

Background: Numerous studies have linked vitamin D deficiency with cardiovascular diseases. Offshore workers have distinct characteristics of work such as irregular work-rest cycles and variable nutritional intake that may contribute to fluctuations in vitamin D status. Studying the connection between vitamin D levels and cardiovascular risk factors in offshore population is of significant relevance to occupational health management.

Objective: Using a cross-sectional design, this study aimed to determine the association between vitamin D levels and cardiovascular risk factors, namely age, systolic and diastolic blood pressure, fasting blood sugar, HbA1c, low density lipoprotein, high density lipoprotein, total cholesterol, triglycerides, and body mass index in an offshore worker population in the Middle East.

Methods: Data were collected over a six-month period from patient records at an occupational health clinic, encompassing socio-demographic variables, vitamin D measurements, and cardiovascular risk profiles. Pearson correlation was used to assess the strength of associations, while multiple linear regression was conducted to evaluate the combined influence of the cardiovascular risk factors on vitamin D levels.

Results: 249 patients were included in the analysis. The correlation between vitamin D levels and cardiovascular risk factors were as follows: age (weak, r = 0.12), HDL (negligible, r = 0.01), LDL (negligible, r = -0.05), HbA1c (negligible, r = -0.07), systolic blood pressure (negligible, r = -0.10), fasting blood sugar (weak, r = -0.11), triglycerides (weak, r = -0.12), total cholesterol (weak, r = -0.13), diastolic blood pressure (weak, r = -0.13), and BMI (weak, r = 0.14). Multivariate regression analysis revealed that cardiovascular risk factors exhibited a weak predictive capacity for vitamin D levels.

Conclusions: The associations between vitamin D levels and the evaluated cardiovascular risk factors are generally negligible to weak.

Keywords: Vitamin D; Cardiovascular Risk Factors; Offshore Workers

1. Introduction

Vitamin D plays a multifaceted role in human health. Its significance extends beyond bone metabolism, influencing various physiological processes, including cardiovascular system. Vitamin D deficiency has been associated with an increased risk of cardiovascular diseases (CVD), including heart failure, coronary artery disease and hypertension.[1,2,3] The mechanisms underlying this relationship are complex and involve several biological pathways. One of the primary

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mechanisms is through its anti-inflammatory properties. Vitamin D is known to modulate the immune response by reducing the expression of pro-inflammatory cytokines and enhancing the production of anti-inflammatory mediators.[4,5] This immunomodulatory effect is particularly relevant in the context of atherosclerosis, where chronic inflammation plays a pivotal role in disease progression. Studies have shown that vitamin D deficiency can lead to an increase in systemic inflammatory markers, which are implicated in the development of CVD.[6,7]

The association between vitamin D levels and cardiovascular risk factors has garnered significant attention in recent years, with numerous studies have explored the contribution of vitamin D deficiency to CVD. Several studies have reported an inverse relationship between vitamin D levels and traditional cardiovascular risk factors. A study found that lower levels of 25-hydroxyvitamin D (25(OH)D) were associated with worsened biomarkers of glycemic control and lipid metabolism, including insulin resistance, dyslipidemia and metabolic syndrome.[8]

Investigating the relationship between vitamin D levels and cardiovascular risk factors in offshore workers is of significant importance, as this population often faces limited sun exposure, irregular work hours, and high occupational stress all of which may contribute to health vulnerabilities. Understanding this connection can help in developing targeted health interventions, improving disease prevention strategies, and enhancing overall well-being in this unique working environment.

2. Methods

2.1. Study Design and Aim

Using a cross-sectional design, this study was intended to determine the association between vitamin D levels and some cardiovascular risk factors, namely age, gender, systolic blood pressure (SBP), diastolic blood pressure (DBP), fasting blood sugar (FBS), HbA1c, low density lipoprotein (LDL), high density lipoprotein (HDL), total cholesterol, triglycerides, and body mass index (BMI) in an offshore worker population in the Middle East.

2.2. Data Samples

The data was retrieved from electronic medical system. The study utilized patients data who visited an occupational health clinic in the Middle East during the period of six months and had laboratory tests conducted for health screening and follow-up purposes. The inclusion criteria were the data of patients aged over 40 years, which had cardiovascular risk factors profiles needed for this study, including FBS, HbA1c, SBP, DBP, total cholesterol, LDL, triglycerides, HDL, FBS, BMI, and vitamin D levels. Exclusion criteria encompassed patients with a previously diagnosed cardiovascular disease, those with autoimmune disorders and and those who took regular vitamin D supplements or hormone therapy that might influence the study's outcomes.

The available data was obtained during the patients' visits to the clinic. When the patients came to the clinic, the nurses recorded their identification information and measured their body weight, height, as well as SBP and DBP. A digital weighing scale with height meter was used for weight and height measurements. Using this data, the nurse calculated the patients' BMI using the standard formula: weight (in kilograms) divided by the square of height (in meters). Blood pressure was checked using a digital sphygmomanometer and based on the average of three measurements. All blood samples were collected by laboratory staff and tested in the clinic's laboratory, following standard protocols for biochemical data collection. Patients attended the laboratory were fasting for 8-12 hours before the blood draw. Blood was drawn from a vein using sterile needles and collection tubes. HbA1c levels were measured using high-performance liquid chromatography. LDL levels were calculated using the Friedewald equation, which incorporates measurements of total cholesterol, HDL, and triglycerides. HDL was measured using the direct enzymatic assay method, while total cholesterol was measured through the enzymatic colorimetric assay method. Triglyceride levels were also measured using enzymatic colorimetric methods. Vitamin D levels were determined using the enzyme-linked immunosorbent assay method, which provides measurements of 25-hydroxyvitamin D concentrations in the blood.

2.3. Statistical Analysis

The data were analyzed using some statistical methods. Pearson correlation analysis was used to determine the strength and direction of the relationship between vitamin D levels and each cardiovascular risk factor. The strength of association was categorized as : negligible correlation (0.00-0.10), weak correlation (0.10-0.39), moderate correlation (0.40-0.69), strong correlation (0.70-0.89) and very strong correlation (0.90-1.00).[9] Multiple linear regression was applied to evaluate the simultaneous impact of cardiovascular risk factors on vitamin D levels. Statistical analyses were performed using SPSS 20, with with results presented as regression coefficients, p-values, and 95% confidence intervals.

2.4. Ethical Approval

Ethical approval was not required for this study because the data used were secondary and provided to the team in an anonymized format.

3. Results

Over a six-month period, a total of 2,396 patients visited the clinic and underwent laboratory tests, with 326 patients data met the inclusion criteria. Of these, 73 records contained exclusion elements and were removed from the data. The remaining dataset consisted of 253 patient records, of which 4 were female patient records. To enhance the precision of the statistical analysis, these female patient records were excluded, resulting in a final dataset of 249 male patient records. The profiles of the data was presented in the Table 1.

Table 1 Profiles of Data Samples

Variable	Mean	Standard Deviation	95% CI
Age (years)	51.02	6.67	51.02 ± 0.83
Systolic BP (mmHg)	126.77	13.41	126.77 ± 1.68
Diastolic BP (mmHg)	79.94	8.63	79.94 ± 1.08
FBS (mmol/l)	5.84	1.38	5.84 ± 0.18
HbA1C (%)	6.05	1.31	6.05 ± 0.21
Total cholesterol (mmol/l)	4.99	1.15	4.99 ± 0.15
LDL (mmol/l)	3.21	1.07	3.21 ± 0.14
HDL (mmol/l)	1.26	0.36	1.26 ± 0.05
Triglyceride (mmol/l)	1.4	0.81	1.40 ± 0.10
BMI (kg/m2)	28.29	4.71	28.29 ± 0.60
Vit D (IU)	36.35	13.9	36.35 ± 1.94

The average age of the patients was 51.02 years (95% CI : 50.19 to 51.85). The means SBP and DBP were 126.77 mmHg (95% CI : 125.10-128.45) and 79.94 mmHg respectively (95% CI : 78.86-81.02). The means FBS and HbA1C were 5.84 mmol/L (95% CI : 5.66-6.02) and 6.05% (95% CI : 5.84-6.26) respectively. In terms of the cholesterol profile, the means of total cholesterol was 4.99 mmol/l (95% CI : 4.84-5.14), LDL 3.21 mmol/l (95% CI : 3.07-3.35), HDL was 1.26 mmol/l (1.21-1.31) and triglyceride was 1.40 mmol/l (95% CI : 1.30-1.50). The mean BMI was 28.29 kg/m2 (95% CI : 27.69-28.89) and mean vitamin D level was 36.35 IU (95% CI : 34.41-38.29).

The distribution of the data is illustrated through the histogram (Figure 1) and scatterplot (Figure 2) below.

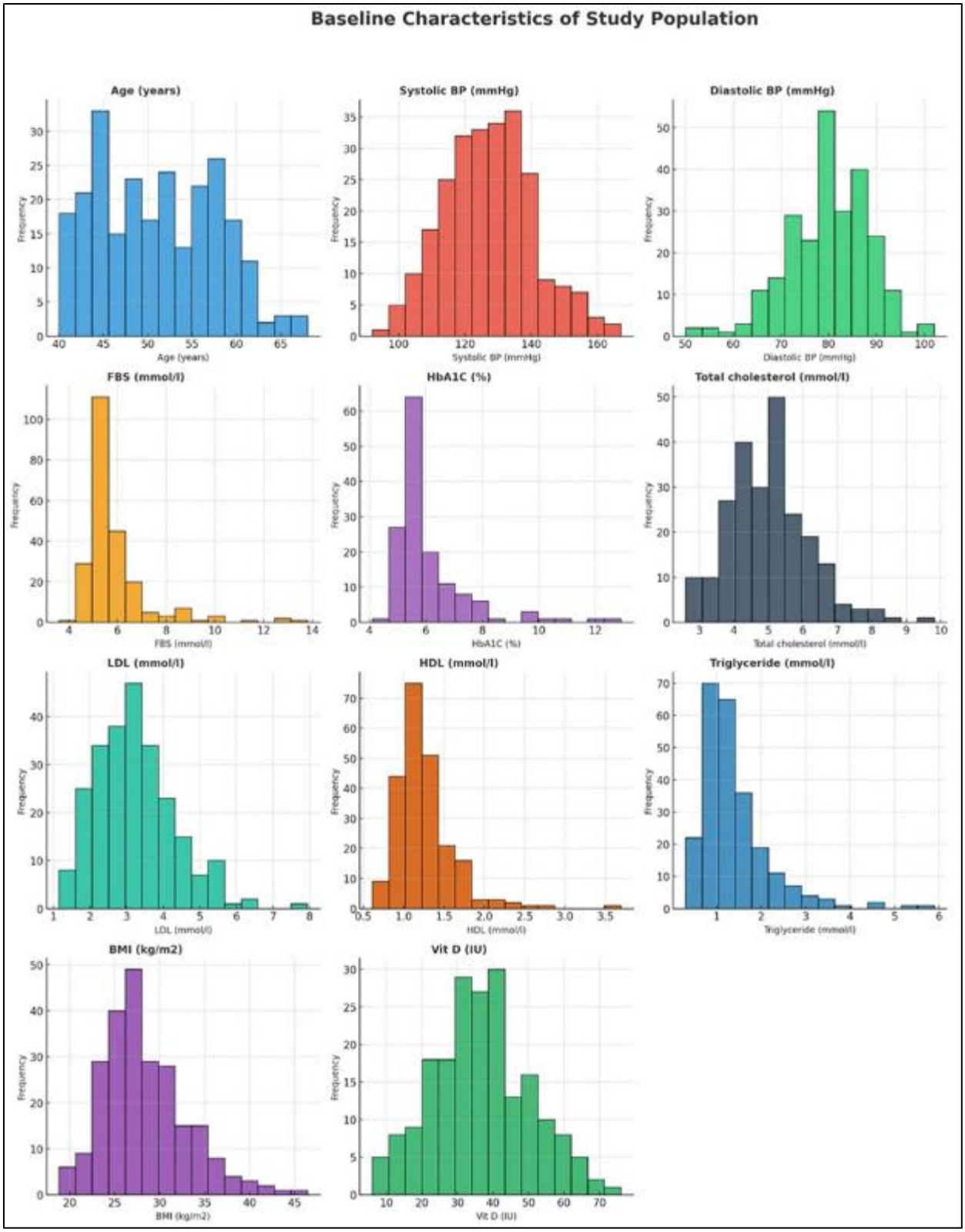


Figure 1 Histogram of Data Profiles

The histograms shows that the age of the subjects distributed around the middle age range, with most participants were between 45 and 60 years old. The blood pressure values exhibited a relatively normal distribution, with SBP centered around 120-130 mmHg and DBP around 75-85 mmHg. Both indicators of glucose levels (FBS and HbA1C) highlighted the presence of individuals with elevated levels, pointing to potential risks for diabetes. Cholesterol values (total cholesterol, HDL LDL and triglyceride) varied, with most participants maintained moderate levels, though there were

outliers with higher LDL and lower HDL, indicating cardiovascular risk. The BMI indicated a higher prevalence of overweight individuals. Vitamin D levels varied widely.

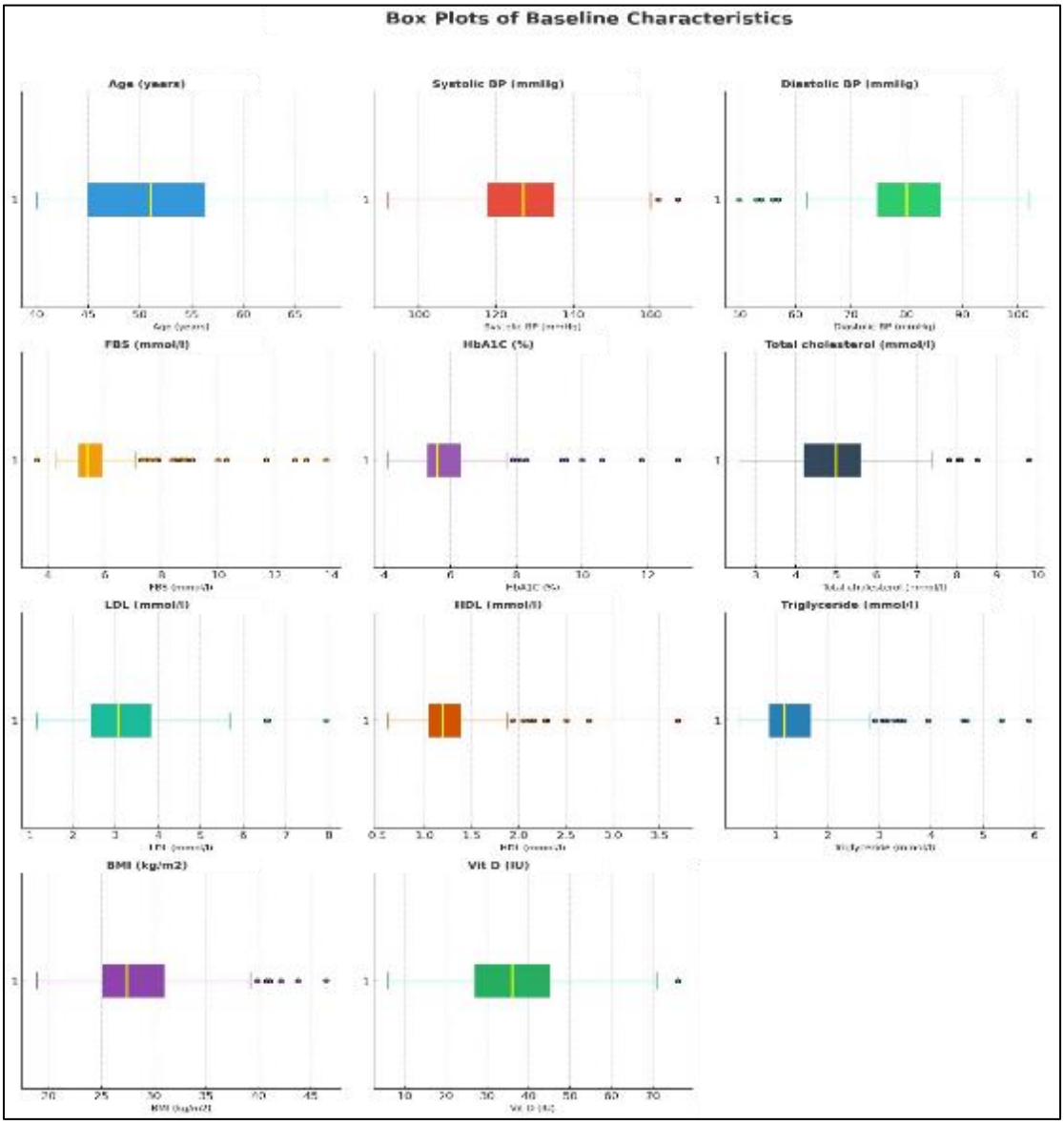
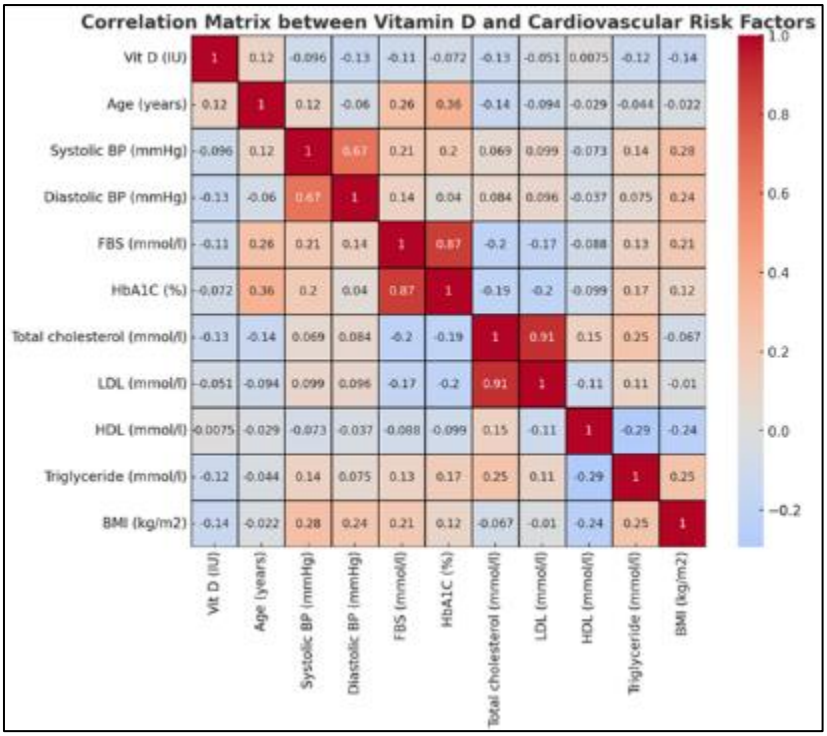


Figure 2 Box-Plot of Sample Characteristics

The box plots provide a visual summary of the spread and central tendency of the variables. The age distribution was fairly tight, with a median around 51 years, and few outliers. Both SBP and DBP showed consistent medians with some variation, particularly on the higher end of SBP. The presence of outliers in glucose metrics (FBS and HbA1C) might indicate individuals with poorly controlled diabetes. Cholesterol levels, particularly LDL, had a wider spread, with some participants displaying potentially extreme levels. The BMI box plot showed a skew toward higher values, with the median BMI indicating a trend toward overweight in the population. Vitamin D levels had a broad distribution, with the median suggesting that a significant portion of the population might have lower-than-recommended levels.

3.1. Correlation Analysis

Correlation analysis of the relationship between level of vitamin D with each cardiovascular risk factors was performed using Pearson method and presented in the Figure 3.



Notes: Positive correlations are shown in the shades of blue, while negative correlations are in the shades of red. The intensity of the color indicates the strength of the correlation, with deeper color representing stronger relationships.

Figure 3 Correlation Matrix between Vitamin D and Cardiovascular Risk Factors

Based on the matrix, the level of correlation between vitamin D levels with cardiovascular risk factors are as follow : age : weak (0.12), HDL : neglible (0.01), LDL : neglible (-0.05), HbA1c : neglible (-0.07), systolic BP : neglible (-0.10), FBS : weak (-0.11), triglyceride : weak (-0.12), total cholesterol : weak (-0.13), distolic BP : weak (-0.13) and BMI : weak (-0.14).

The analysis of correlations within different age subgroups revealed distinct patterns as shown in the Table 2.

Table 2 The Analysis Correlation with Different Age Subgroups

	Age Subgroup and Correlation		
Variables	**40-49**	**50-59**	**60+**
Vit D (IU)	1	1	1
Systolic BP (mmHg)	-0.266876519	0.048006626	-0.14772272
Diastolic BP (mmHg)	-0.184917107	-0.025144679	-0.326489824
FBS (mmol/l)	-0.04347366	-0.168480258	-0.039702084
HbA1C (%)	-0.073656871	-0.160105364	0.072494905
Total cholesterol (mmol/l)	-0.13818145	-0.096131059	-0.18246266
LDL (mmol/l)	-0.050859188	-0.017094646	-0.128120513
HDL (mmol/l)	-0.084058944	0.090820586	0.007671845
Triglyceride (mmol/l)	-0.062623294	-0.191602691	-0.101301318
BMI (kg/m^2)	-0.242984356	-0.042864803	-0.286747409

In the 40-49 age group, there were notable negative correlations between vitamin D levels and both SBP (-0.27) and BMI (-0.24), while other cardiovascular risk factors showed weaker negative correlations. In the 50-59 age group, correlations across most factors were generally weaker, with triglycerides (-0.19) and FBS (-0.17) displayed some negative correlations with vitamin D levels. Among individuals aged 60 and above, the strongest negative correlations were observed with DBP (-0.33) and BMI (-0.29), while other factors, including SBP (-0.15), exhibited relatively weak correlations.

A multivariate regression analysis was conducted using a multiple linear regression model to predict vitamin D levels. The model yielded an R-squared value of 0.063 and an F-statistic of 0.5507, suggesting that cardiovascular risk factors are weak predictors of vitamin D levels. The overall model was not statistically significant. The coefficients and significance levels of the individual predictors are as follows: age (coefficient = 0.20, p = 0.510), SBP (coefficient = 0.15, p = 0.474), DBP (coefficient = -0.15, p = 0.828), FBS (coefficient = -1.77, p = 0.429), HbA1c (coefficient = 0.22, p = 0.944), total cholesterol (coefficient = -8.56, p = 0.155), LDL (coefficient = 7.03, p = 0.229), HDL (coefficient = 4.13, p = 0.617), triglycerides (coefficient = 2.13, p = 0.568), and BMI (coefficient = -0.42, p = 0.295). None of these predictors were statistically significant at the 0.05 level. Consequently, the model did not provide a robust explanation for the variability in vitamin D levels observed in the sample.

4. Discussion

Most correlations between vitamin D level and cardiovascular risk factors were weak. HDL, LDL, HbA1c and SBP showed neglible correlations. Age has a weak positive correlation with vitamin D levels, while BMI has the strongest weak negative correlations. All the correlation coefficients were relatively close to zero. The negative coefficients suggested that there might be a slight inverse relationship between vitamin D levels and some of these risk factors, but the weak magnitude of these correlations implies that vitamin D levels did not strongly predict or correlate with these specific cardiovascular risk factors in the study population.

The results of this study need to be carefully examined based on several considerations. First, the confounding factors. Many unmeasured variables, such as physical activity of the offshore workers, dietary habits, or comorbid conditions, could be confounding factors and influence both vitamin D levels and cardiovascular risk factors. If these confounders are not accounted for in the analysis, they may obscure the true relationships between the variables. While a number of studies reported that there was a small but significant increase in cardiovascular risk associated with vitamin D deficiency, the causality remained unclear due to potential confounding factors and the limitations of observational study designs.[10] Another study reported the link between lower vitamin D levels with higher cholesterol level. The study, however, highlighted that the relationship was not straightforward, suggesting that other variables might influence these outcomes.[11] Furthermore, the heterogeneity in study designs, populations, and the specific cardiovascular outcomes assessed can lead to inconsistencies in findings.[12,13]

Second, an interplay of multiple factors. The relationships between vitamin D and cardiovascular risk factors are likely influenced by a complex interplay of multiple factors rather than a single factor. The weak correlations might reflect the difficulty in isolating the effect of vitamin D on cardiovascular risk in the presence of other contributing factors. Vitamin D's effects on cardiovascular health are mediated through various pathways, including its influence on inflammation and endothelial function.[14, 15, 16]. However, the complexity of these mechanisms means that vitamin D may not uniformly affect all individuals or all cardiovascular risk factors. For instance, a study found a significant correlation between low vitamin D levels and myocardial infarction risk, yet this relationship was not consistently replicated across other studies. This indicates that individual biological differences and the presence of other risk factors may modulate the effects of vitamin D.[17, 18] Furthermore, the presence of comorbidities such as diabetes and hypertension can mask the potential benefits of vitamin D, as these conditions themselves are significant risk factors for CVD.[17, 19, 20]

Third, timing of measurement. Vitamin D levels and cardiovascular risk factors can fluctuate over time due to seasonal changes, lifestyle modifications, or medical interventions. If the measurements were not taken simultaneously or did not reflect long-term averages, this could contribute to weaker correlations. The timing of vitamin D measurement can also affect observed correlations with cardiovascular risk factors. Vitamin D levels can vary significantly throughout the year due to seasonal changes in sunlight exposure, which is the primary source of vitamin D for most individuals.[14] Individuals may exhibit higher vitamin D levels during summer months and lower levels in winter, which may not accurately reflect their long-term status.[15] Studies that measure vitamin D levels at a single point in time may fail to capture these fluctuations, leading to an underestimation or overestimation of the relationship between vitamin D and cardiovascular risk factors.[16] Offshore workers typically follow irregular and rotating schedules, such as the 28/28 system, where they spend 28 days at the offshore site followed by 28 days off-duty at home. Variations in geographic

location, levels of sun exposure, and dietary intake between the offshore work period and the off-duty phase may lead to fluctuations in serum vitamin D concentrations over time.

Four, sample size and power. Although the study included 249 patients, this sample size might still be insufficient to detect significant correlations, especially if the true relationships between vitamin D levels and cardiovascular risk factors are subtle. Smaller sample sizes reduce the statistical power, making it harder to detect true associations even if they exist. The p-values indicate that there's insufficient evidence to reject the null hypothesis (that there is no effect). This could be due to the small sample size or weak underlying relationships. The linear model assumes a direct, proportional relationship between vitamin D levels and each predictor. If the true relationship is non-linear or more complex, a linear model might not capture it effectively, leading to weak correlations and non-significant results. Additionally, the model might suffer from omitted variable bias other important predictors that influence Vitamin D levels might be missing from the model. It is possible that vitamin D only influences cardiovascular risk factors above or below certain thresholds, which were not reached or adequately captured in the study population, leading to weak overall correlations. These potential reasons suggest that the relationship between vitamin D and cardiovascular risk is complex and may require more nuanced approaches, including stratified analyses, longitudinal studies, or larger sample sizes, to fully understand the connections. For stronger or more meaningful relationships, further analysis using different statistical methods or a larger sample size might be necessary.

5. Conclusion

This study reveals that the associations between vitamin D levels and the examined cardiovascular risk factors were predominantly negligible to weak. Specifically, age exhibited a weak positive correlation (0.12) with vitamin D levels, while other factors such as HDL, LDL, HbA1c, SBP, DBP, FBS, triglycerides, total cholesterol, and BMI showed negligible to weak correlations. When stratified by age groups, distinct patterns emerged. These variations across age groups highlight the complexity of interactions between vitamin D levels and cardiovascular risk factors and suggest that age may play a role in modulating these relationships. The multivariate regression analysis reinforced the notion of weak associations, revealing that the collective cardiovascular risk factors investigated were poor predictors of serum vitamin D levels.

These findings suggest that while there are some age-specific associations between vitamin D levels and certain cardiovascular risk factors, overall, vitamin D may not be a robust indicator of cardiovascular risk in the offshore workers populations. The predominantly weak and non-significant correlations imply that other factors, possibly including genetic predispositions, lifestyle choices, and environmental influences, as well as the nature of offshore works may have more substantial roles in determining vitamin D status and cardiovascular health. Future research with larger, more diverse populations and longitudinal designs is warranted to further elucidate these relationships and to explore additional variables that may impact both vitamin D levels and cardiovascular risk.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

References

[1] Mehta, A., Chokka, D., Shreesha, N., Seshu, A. et al. (2022). Correlation of vitamin d level and severity of coronary artery disease. Biomedicine, 42(5), 943-948. DOI:10.51248/.v42i5.1911

[2] Nawaz, N., Batool, T., Arif, S. et al. (2023). The relationship of serum 25-hydroxyvitamin d concentrations with mortality among the patients diagnosed with the cardiovascular diseases. PJMHS, 17(3), 275-277. https://doi.org/10.53350/pjmhs2023173275

[3] Gholamzad, A. (2023). Association between serum vitamin d levels and lipid profiles: a cross-sectional analysis. Scientific Reports, 13(21058). https://doi.org/10.1038/s41598-023-47872-5

[4] Khanolkar, S., Hirani, S., Mishra, A. et al. (2023). Exploring the role of vitamin d in atherosclerosis and its impact on cardiovascular events: a comprehensive review. Cureus. https://doi.org/10.7759/cureus.42470

[5] Ahuja, A., Agrawal, S., Acharya, S. et al. (2024). A comprehensive review of the immunomodulatory effects of vitamin d in sepsis. Cureus. https://doi.org/10.7759/cureus.53678

[6] Gachemba, Y. M., Khan, Z., Njau, E. et al. (2023). Vitamin d deficiency and its association with cardiovascular diseases among patients attending a private tertiary sector cardiovascular heart clinic in nairobi. Cureus. https://doi.org/10.7759/cureus.43012

[7] Santos, A. T. d., Zardo, A. d. L. G., Borato. et al (2022). Evaluation of vitamin d and inflammatory markers in elderly. Brazilian Journal of Pharmaceutical Sciences, 58. https://doi.org/10.1590/s2175-97902022e20248

[8] Farahmand, M.A., Daneshzad, E., Fung, T.T. et al. What is the impact of vitamin D supplementation on glycemic control in people with type-2 diabetes: a systematic review and meta-analysis of randomized controlled trails. BMC Endocr Disord 23, 15 (2023). https://doi.org/10.1186/s12902-022-01209-x

[9] Schober, P., Boer. C., Schwarte, LA. Correlation Coefficients: Appropriate Use and Interpretation. Anesth Analg. 2018 May;126(5):1763-1768. doi: 10.1213/ANE.0000000000002864. PMID: 29481436.

[10] Ruwanpathirana, T., Reid, C., Owen, A. et al. (2014). Assessment of vitamin d and its association with cardiovascular disease risk factors in an adult migrant population: an audit of patient records at a community health centre in kensington, melbourne, australia. BMC Cardiovascular Disorders, 14(157). https://doi.org/10.1186/1471-2261-14-157

[11] Gholamzad, A., Khakpour, N., Kabipour, T. et al. (2023). Association between serum vitamin D levels and lipid profiles: a cross-sectional analysis. Sci Rep 13, 21058. https://doi.org/10.1038/s41598-023-47872-5

[12] Nardin, M., Verdoia, M., Nardin, S. et al (2024). Vitamin D and Cardiovascular Diseases: From Physiology to Pathophysiology and Outcomes. Biomedicines. Mar 30;12(4):768. doi: 10.3390/biomedicines12040768. PMID: 38672124; PMCID: PMC11048686.

[13] Wang, L., Song, Y., Manson, J. et al. (2012). Circulating 25-hydroxy-vitamin d and risk of cardiovascular disease. Circulation Cardiovascular Quality and Outcomes, 5(6), 819-829. DOI: 10.1161/CIRCOUTCOMES.112.967604

[14] Kim, DH., Meza, C.A., Clarke, H. et al. (2020). Vitamin D and Endothelial Function. Nutrients. Feb 22;12(2):575. doi: 10.3390/nu12020575. PMID: 32098418; PMCID: PMC7071424.

[15] de la Guía-Galipienso, F., Martínez-Ferran, M., Vallecillo, N. et al. (2021). Vitamin D and cardiovascular health. Clin Nutr. May;40(5):2946-2957. doi: 10.1016/j.clnu.2020.12.025. Epub 2020 Dec 29. PMID: 33397599; PMCID: PMC7770490.

[16] Pál, É., Ungvári, Z., Benyó, Z., and Várbíró, S. (2023). Role of Vitamin D Deficiency in the Pathogenesis of Cardiovascular and Cerebrovascular Diseases. Nutrients, 15(2), 334. https://doi.org/10.3390/nu15020334

[17] Hallak, A., Malhis, M., and Abajy, M. (2018). Vitamin-d deficiency and risk of acute coronary syndrome. International Journal of Pharmacy and Pharmaceutical Sciences, 10(6), 171. https://doi.org/10.22159/ijpps.2018v10i6.26469

[18] Ann, Bugeja., Gregory, L Hundemer. (2024). Vitamin D and Hypertension: An Uncertain Relationship at Best. American Journal of Hypertension, Volume 37, Issue 12, December 2024, Pages 945–947, https://doi.org/10.1093/ajh/hpae114

[19] Mutlu, U., Ikram, M. A., Hofman A. et al. (2016) Vitamin D and retinal microvascular damage: The Rotterdam Study. Medicine (Baltimore): 95(49):e5477. doi: 10.1097/MD.0000000000005477. PMID: 27930528; PMCID: PMC5266000.

[20] Jensen, N.S., Wehland, M., Wise, P.M. et al. (2023). Latest Knowledge on the Role of Vitamin D in Hypertension. Int J Mol Sci. Feb 28;24(5):4679. doi: 10.3390/ijms24054679. PMID: 36902110; PMCID: PMC10003079.