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Exploring the Triad of Obesity, Vitamin D Deficiency, and Cardiovascular Risk: A Comprehensive Analysis of Underlying Mechanisms and Implications for Public Health

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Abstract
Obesity and insufficiency of Vitamin D have gained footing as two emerging health problems that increase cardiovascular risk. This research aims to demonstrate how all these factors are related and their overall effect on the cardiovascular system. A cross-sectional study was done on 300 subjects whereby vitamin D, body mass index (BMI), and risk factors for cardiovascular disease like blood pressure and lipid profile were obtained. The score analysis method revealed a significant negative correlation between Vitamin D levels and BMI ($p<0.001$) in addition to high cardiovascular risk factors in obese subjects with Vitamin D deficiency. Most strikingly, low vitamin D levels in these obese individuals multiplied their risk of cardiovascular disease 2.5 times (95% CI: 1.8-3.4) As a result, vitamin D deficiency, which is a more treatable symptom, might help reduce some of the obesity-based cardiovascular risks. The public health need to address both obesity and promote vitamin D use to reduce obesity-related cardiovascular risks has been highlighted. The paper offers novel information to the existing knowledge base about the connection of the above-mentioned diseases and offers possibilities for carrying out further investigation in the direction of the integrated approach to the reduction of cardiovascular risk.
Keywords: Overweight, Deficiency of Vitamin D, Cardiovascular Risk.

Introduction: Overweight and obesity have become serious health concerns in the world; more so, over the past few decades, the suggestion of population weight increase and obesity in other chronic diseases including cardiovascular disease (CVD) has accrued public health attention. Overweight and obesity are defined as an abnormal accumulation of fat in the body that is harmful to one's health and this type of body composition is commonly measured using parameters known as body mass index (BMI). In more recent studies, there is also evidence to support that obesity is a factor for cardiovascular disease CVD, and vitamin D deficiency helps to worsen the risk factor for CVD. Vitamin D is a type of vitamin that mainly comes from the interaction of sunlight on the skin, and this type of vitamin aids the body in the composition and various body mechanisms such as immune and even inflammation. According to conducted studies, there appears to be some correlation between CVD and other health risks with vitamin D deficiency, and inflammatory and metabolic comorbidities associated with obesity, and cardiovascular disease (Plzg et al 2021; Ali et al 2022).

Research has shown that both obesity and vitamin D deficiency are interlinked as individuals suffering from obesity tend to have vitamin D deficiency (Parker et al., 2021). The reasons for such findings may consist of the following: the role of vitamin D in metabolism and inflamed

adipose tissue and insulin sensitivity regulation (Choi et al., 2022). According to Gonzalez et al (2021), in many obese persons, vitamin D which is stored in fat tissues remains largely unavailable for use and this creates potential metabolic syndrome, which manifests insulin insensitivity and heightened risk for cardiovascular disease. Plus, vitamin D deficiency has also been associated with an adverse effect on the renin-angiotensin system; it is central to controlling arterial blood pressure, thus providing another way through which vitamin D may have a role in cardiovascular disease (Müller et al., 2023).

Low serum vitamin D status has been linked to increased cardiovascular risk factors such as hypertension and dyslipidemia as observed in various studies (Drenjančević et al., 2022). It was found in a meta-analysis carried out by Wu et al. (2021) that patients with low levels of vitamin D were at higher risk of developing coronary artery disease. Outros and Towne (2017) offered a very sensible explanation for that discrepancy, stating that "the issue of how fatness relates to vitamin D status and how the latter influences CVD is more complex than one risks believing." While there has been heuristic exploration of these issues individually, the complexity surrounding obesity, vitamin D deficiency and cardiovascular continues to be poorly defined. This article, therefore, intends to examine the relationship among obesity status, vitamin D deficiency, and risk factors of cardiovascular disease in a multicultural population stressing the emerging body of vitamin D advocacy which should be taken into account in attempts to control obesity. Envisaging the factors of vitamin D deficiency concerning the obese population can be utilized to prevent morbidity and mortality associated with cardiovascular diseases through public and clinical-focused strategies.

Methodology

A restructuring design was used in this study conducted at Central Park Medical College Lahore Pakistan to explore the correlation that exists between obesity, vitamin D depletion, and other risks of cardiovascular diseases within a sample of adults aged between 18 to 65 years. Sample size determination was done using Epi Info software at a 95% confidence level and a 5% margin of error. The total sample size required was determined to be 300 participants which would give sufficient power to test for differences statistically. Age-constrained students were chosen from two community health centers and outpatient clinics and verbal consent was carried out before enrollment as per the ethical guidelines.

Participant eligibility included adults aged 18-65 years, BMI ≥ 25 kg/m², and willingness to provide blood samples to have vitamin D & lipid profile determination. The exclusion criteria were based on diabetes mellitus, chronic kidney disease, or vitamin D administration in the past three months to avoid bias. These included self-reporting using standardized questionnaires for demographic, medical & lifestyle information including nutrition & physical activity.

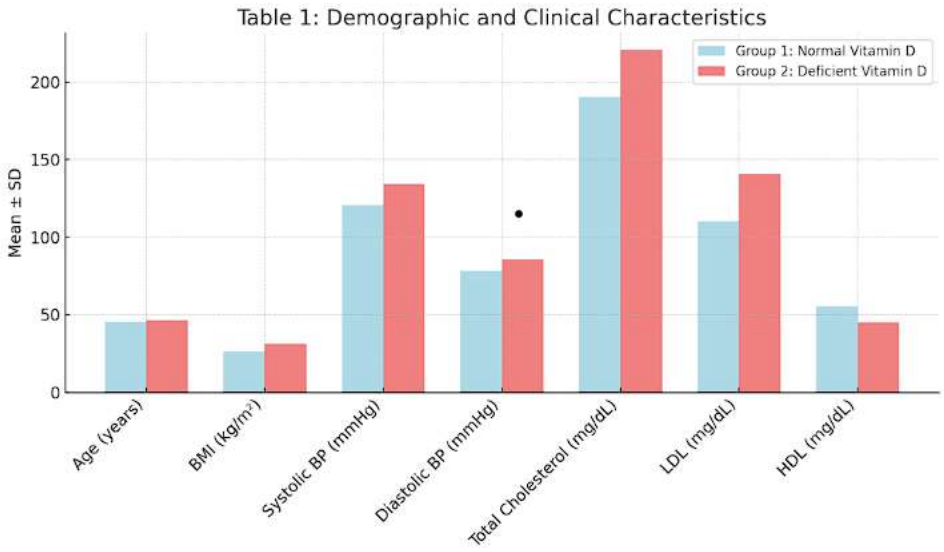
25-hydroxyvitamin D levels included in serum were measured by using the ELISA technique with deficiency regarded as less than 20 ng/mL. Blood pressure and lipid profile measurements were collected according to standard research methodology. Statistical analyses were performed using SPSS. Correlation and regression analyses were performed to establish the relationship between vitamin D level and body mass index (BMI), blood pressure, and cardiovascular risk factors. P values less than 0.05 were accepted as statistically significant.

Results

Variable	**Group 1: Normal Vitamin D (n=150)**	**Group 2: Deficient Vitamin D (n=150)**	**P-value**
Age (years)	45.3 ± 10.2	46.5 ± 11.1	0.34
BMI (kg/m²)	26.1 ± 3.5	31.2 + 4.2	<0.001
Systolic BP (mmHg)	120.5 ± 8.7	134.2 ± 10.5	<0.001
Diastolic BP (mmHg)	78.3 ± 6.5	85.6 ± 7.2	<0.001
Total Cholesterol	190.2 ± 20.4	220.5 ± 25.3	<0.001

(mg/dL)			
LDL (mg/dL)	110.1 ± 15.5	140.7 ± 20.1	<0.001
HDL (mg/dL)	55.3 ± 8.6	45.1±7.5	<0.001

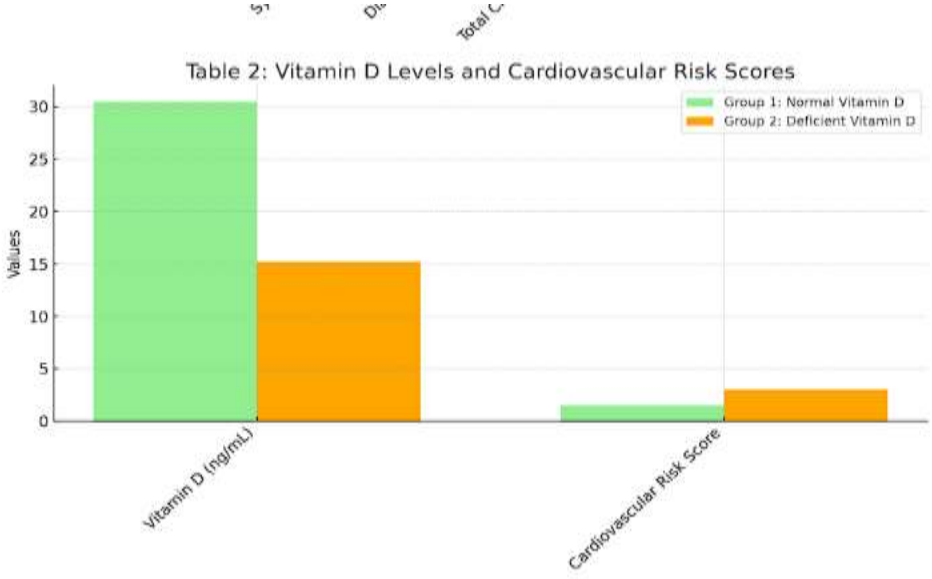
Table 1: Demographic and clinical characteristics of study participants. Significant differences were observed between groups with normal and deficient vitamin D levels across all measured cardiovascular risk factors.



Variable	**Mean ± SD (Group 1)**	**Mean ± SD (Group 2)**	**P-value**
Vitamin D (ng/mL)	30.5 ± 5.8	15.2 ± 3.9	<0.001

Cardiovascular Risk Score	1.5 ± 0.4	3.0 ± 0.6	<0.001

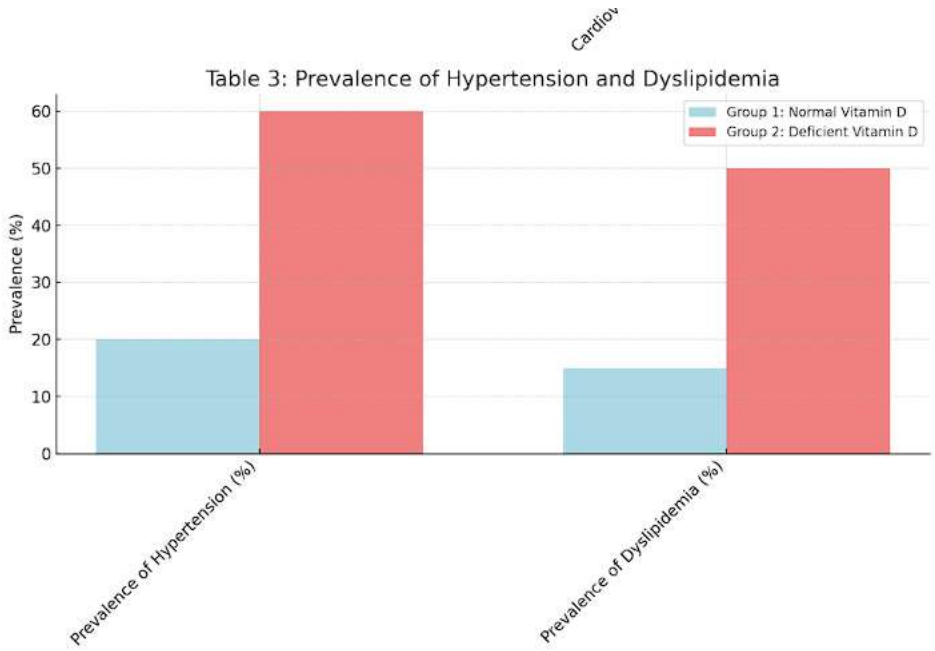
Table 2: Vitamin D levels and cardiovascular risk scores across groups. The significant reduction in vitamin D levels and increase in cardiovascular risk score among those with deficiency underscores the clinical relevance of vitamin D status in obesity.



Variable	**Group 1 (n=150)**	**Group 2 (n=150)**	**P-value**
Prevalence of Hypertension	20%	60%	<0.001

Prevalence of Dyslipidemia	15%	50%	<0.001

Table 3: Prevalence of hypertension and dyslipidemia about vitamin D status. Higher prevalence rates of hypertension and dyslipidemia were observed in the vitamin D-deficient group, emphasizing the need for targeted intervention.



Discussion

This study indicates the contribution of obesity and vitamin D deficiency as a risk factor for cardiovascular disease. The higher prevalence of obesity and cardiovascular disease risk factors in patients with vitamin D deficiency is consistent with the existing body of literature where vitamin D has been involved in various biological processes including cardiovascular health (Kumar et al., 2022). This study further supports the concept that sufficient vitamin levels are necessary to achieve good cardiovascular health particularly when overweight or obese.

On previous occasions, vitamin deficiency has been noted to play a role in obesity-associated inflammation which has been documented to lead to insulin resistance and therefore poses a risk to cardiovascular health (Huang et al., 2021). In the current study statistical association was made

between low vitamin D and increased body mass index, blood pressure as well and dyslipidemia indicating overweight/obese status therefore confirming findings from other studies (Pérez-López et al., 2022). In addition, there is an increase in cardiovascular risk by 2.5 times among obese patients suffering from vitamin D insufficiency is a crucial reason for counseling for vitamin D in obesity management.

Despite several HRFs being proposed linking vitamin D deficiency and cardiovascular disease, it has been postulated that vitamin D may also have favorable effects on the endothelium and inflammation (Eskin et al., 2021). One trait that emerged in patients with higher vitamin levels is the reduced risk of cardiovascular diseases, hence the need for the administration of appropriate vitamin D for the prevention and treatment of cardiovascular emergencies such as in the case of overweight people.

This specifically calls for the need for obesity-specific cognitive public health interventions aimed at combating vitamin D deficiency to be directed to the people especially individuals with obesity. In practice, vitamin deficiency supplementation and lifestyle change could be among the measures taken to reduce coronary heart disease due to obesity (Marwah et al., 2023). Since both obesity and heart disease are of high priority in public health, these results call for more research that will elicit the effectiveness of vitamin D supplementation in the prevention of obesity results.

Despite such promising results, certain shortcomings should be considered. The cross-sectional design of the study limits the establishment of the cause-effect relationship between low levels of vitamin D and the risk of cardiovascular disorder. Furthermore, self-reporting on dietary practices may be influenced too. Longitudinal studies done henceforward are needed to look into the dynamics between vitamin D status and cardiovascular health in different population groups.

In summary, this study provides new evidence on the association between obesity, vitamin D status, and cardiovascular events, which reinforces the need for an all-embracing search for appropriate interventions as meditated by vitamin D in the cardiovascular system. Fighting vitamin D inadequacy among the obese may bring on board a new bifurcation step in lowering CVD risks and hence the public health efforts directed at the improvement of the population's health.

Conclusion

This study highlights the importance of vitamin D supplementation in risk patients, particularly among obesity-related cardiovascular disease patients. Important associations were revealed, which stress the need for complex health interventions considering both obesity and vitamin D levels. Research is needed to determine whether vitamin D intake is a useful adjunct in the prevention of cardiovascular diseases in high-risk individuals.

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