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Impact of Vitamin D Supplementation on Heart Failure Outcomes in Vitamin D Deficient Patients: A Public Health Perspective

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Abstract

Background: Heart failure (HF) is a leading cause of morbidity and mortality, with emerging evidence suggesting a link between vitamin D deficiency and adverse heart failure outcomes.
Objective: This study aimed to evaluate the impact of vitamin D supplementation on heart failure outcomes in vitamin D-deficient patients and explore the broader public health implications of these findings.
Methodology: The observational cohort study was conducted over a one-year period from January 2023 to December 2023, involving 220 adults aged 40 years and older with diagnosed heart failure and confirmed vitamin D deficiency (serum 25-hydroxyvitamin D <20 ng/mL). Over the course of a year, participants were randomized to receive either a placebo or 2000 IU of vitamin D3 daily. At baseline, three, six, and twelve months, information was gathered on hospitalizations, heart failure status, serum vitamin D levels, demographics, and quality of life. Descriptive statistics, t-tests, and chi-square tests were among the statistical analyses.
Results: The vitamin D group experienced a considerable rise in serum 25-hydroxyvitamin D levels, which went from 17.37 ± 3.62 ng/mL to 35.18 ± 7.13 ng/mL ($p < 0.001$). Compared to 8 out of 110 patients (7.27%) in the placebo group, 25 out of 110 patients (22.73%) in the vitamin D group achieved Class I status, indicating an improvement in NYHA Class ($p = 0.013$). At 12 months, the vitamin D group's hospitalization rate dropped to 3 out of 110 patients (2.73%) from 10 out of 110 patients (9.09%) in the placebo group ($p = 0.028$). By the 12-month mark, the vitamin D group's quality of life scores had significantly improved to 75.68 ± 8.93, whereas the placebo group's scores were much lower at 56.52 ± 10.54.
Conclusion: Vitamin D supplementation has the potential to be used as an adjuvant therapy in the management of heart failure since it dramatically improves clinical outcomes in individuals with vitamin D-deficient heart failure.
Keywords: heart failure, vitamin D, supplementation, clinical outcomes, quality of life

Introduction

The heart's incapacity to pump enough blood to meet the body's needs is the hallmark of heart failure (HF), a serious public health issue [1,2]. It is linked to high rates of morbidity and mortality and impacts millions of people globally [3]. The need for efficient treatment approaches that might improve patient outcomes and quality of life is growing as the prevalence of heart failure, especially in older persons, keeps rising [4,5].

A possible connection between vitamin D insufficiency and heart failure has been proposed by recent studies [6]. In addition to its well-known involvement in bone health, vitamin D is essential for cardiovascular function, which includes controlling inflammation, controlling calcium metabolism, and preserving vascular health [7, 8]. Low vitamin D levels have been linked to a higher risk of heart failure and worse clinical outcomes for individuals who have already been diagnosed with the condition, according to epidemiological research [9]. Concerns regarding its possible effects on heart health are also raised by the fact that vitamin D insufficiency is common in many countries, particularly among older adults and those with little sun exposure [10,11].

The precise association between vitamin D status, supplementation, and the outcomes of heart failure is still unclear despite new research. The inconsistent outcomes of earlier interventional studies underscore the necessity for thorough investigation to assess the efficacy of vitamin D therapy, particularly in heart failure patients who are vitamin D deficient. This knowledge is essential for creating evidence-based policies and improving patient care. Addressing modifiable risk factors like vitamin D insufficiency may provide a fresh strategy to enhance clinical outcomes and lower healthcare costs as global healthcare systems struggle with the burden of heart failure.

Research Objective

The objective of this research was to evaluate the impact of vitamin D supplementation on heart failure outcomes in patients identified as vitamin D deficient, while also exploring the broader public health implications of these findings.

Materials and methods

Study Design and Setting

This observational cohort study was conducted at Punjab Institute of Cardiology, Lahore, over a one-year period from January 2023 to December 2023.

Inclusion and Exclusion Criteria

Participants were chosen in accordance with particular inclusion criteria, which comprised persons 40 years of age and older who had been diagnosed with heart failure and were categorized as Class I to IV in the New York Heart Association's (NYHA) functional classification. Participants also needed to have a verified vitamin D insufficiency, which is defined as serum 25-hydroxyvitamin D levels below 20 ng/mL as determined by an immunoassay method that has been validated. To make sure the participants or their legal guardians understood the goals, methods, risks, and advantages of the study, informed permission was sought. People with a history of hypercalcemia, hyperparathyroidism, or chronic kidney disease that could impair vitamin D metabolism were excluded, as were those taking vitamin D supplements or taking other drugs that affect vitamin D levels, like corticosteroids or some anticonvulsants, and those with serious comorbidities, such as advanced cancer or a serious chronic illness, that could skew the results or limit participation.

Sample Size

The WHO formula for comparing two independent proportions was used to calculate the study's sample size. We anticipated a 65% improvement proportion in the vitamin D group and a 45% improvement proportion in the placebo group, assuming a significance threshold of 0.05 and statistical power of 80%. Based on this computation, it was anticipated that 186 participants—93 in each group ere needed. We changed the final sample size to 207 individuals in order to allow for a possible 10% dropout rate. In the end, we included 220 patients in the study to guarantee the validity of our conclusions. Using a computer-generated randomization sequence, participants were randomized to either the intervention group (vitamin D supplementation) or the control group (placebo).

Dosage Administration

According to the U.S. Food and Drug Administration's (FDA) guidelines for adults with vitamin D insufficiency, participants in the intervention group were given vitamin D3 (cholecalciferol) supplements at a dosage of 2000 IU daily. It is generally known that this dosage raises serum 25-hydroxyvitamin D levels, which may benefit cardiovascular health. The supplements were given to the intervention group for a period of 12 months. To ensure blinding, the control group was given an identical placebo; all capsules were produced using stringent good manufacturing procedures (GMP) to ensure quality. In order to improve absorption, participants were advised to take the capsules every day with a meal. During follow-up visits, adherence was tracked using self-reported diaries and pill counts.

Data Collection

Baseline examinations, including blood 25-hydroxyvitamin D levels and NYHA classification, were performed at enrollment to record each participant's demographic data, medical history, and heart failure status. Repeat measurements of blood 25-hydroxyvitamin D levels and other heart failure-related clinical outcomes, such as hospitalizations and quality of life evaluations using validated questionnaires, were part of the follow-up assessments conducted at 3, 6, and 12 months.

Statistical Analysis

Statistical software (e.g., SPSS 26) was used for data analysis. The subjects' clinical and demographic traits were summed up by descriptive statistics. Using chi-square tests for categorical variables and t-tests for continuous variables, the intervention and control groups were compared. Statistical significance was defined as a p-value of less than 0.05.

Ethical Approval

The study was approved by the Institutional Review Board of the Punjab Institute of Cardiology, Lahore. Prior to recruitment, all participants gave their informed consent, guaranteeing they were completely aware of the goals, methods, risks, and advantages of the study. In accordance with ethical standards for research involving human beings, all data were treated in confidence, and participant identity was preserved during the entire study.

Results

According to Table 1, the baseline demographics and clinical features of the patients in the vitamin D and placebo groups were similar. The vitamin D group's average age was 64.81 ± 10.43 years, while the placebo group's was 66.05 ± 9.94 years. Males made up 56.36% of the vitamin D group and 52.73% of the placebo group, indicating a comparable gender distribution. The vitamin D and placebo groups had substantially equal mean body mass indices (27.32 ± 4.63 and 27.42 ± 4.46,

respectively). Comorbidities, smoking status, and NYHA classification were also closely matched; for example, there were about identical percentages across NYHA heart failure classes and 50% of both groups had hypertension. The vitamin D group had somewhat higher baseline blood 25-hydroxyvitamin D levels (17.37 ± 3.62 ng/mL) than the placebo group (16.34 ± 3.49 ng/mL).

Table 1: Baseline Demographic and Clinical Characteristics of Study Participants with Heart Failure

Variable		Vitamin D Group (n = 110)	Placebo Group (n = 110)
Age	Mean ± SD	64.81 ± 10.43	66.05 ± 9.94
Gender, n (%)	Male	62 (56.36%)	58 (52.73%)
	Female	48 (43.64%)	52 (47.27%)
BMI	Mean ± SD	27.32 ± 4.63	27.42 ± 4.46
Smoking Status n (%)	Current Smoker	23 (20.91%)	22 (20.00%)
	Former Smoker	30 (27.27%)	30 (27.27%)
	Never Smoked	57 (51.82%)	58 (52.73%)
Comorbidities n (%)	Hypertension	55 (50.00%)	55 (50.00%)
	Diabetes Mellitus	46 (41.82%)	49 (44.55%)
	Coronary Artery Disease	42 (38.18%)	43 (39.09%)
NYHA Classification n (%)	Class I	15 (13.64%)	14 (12.73%)
	Class II	40 (36.36%)	51 (46.36%)
	Class III	30 (27.27%)	31 (28.19%)
	Class IV	25 (22.73%)	14 (12.72%)
Baseline Serum 25-Hydroxyvitamin D (ng/mL)	Mean ± SD	17.37 ± 3.62	16.34 ± 3.49

Table 2 shows how the vitamin D group's vitamin D levels and heart failure outcomes improved over 3, 6, and 12 months in comparison to the placebo group. The vitamin D group's serum 25-hydroxyvitamin D levels increased steadily, rising from 23.42 ± 5.21 ng/mL at 3 months to 35.18 ± 7.13 ng/mL at 12 months, but the placebo group's levels barely changed. By 12 months, 22.73% of the vitamin D group was in Class I, compared to just 7.27% in the placebo group, and fewer individuals were still in Class IV, indicating significant improvements in NYHA classification. At 12 months, the vitamin D group's hospitalization rates had steadily dropped to 2.73% from 9.09% in the placebo group. At 12 months, the vitamin D group's quality of life scores increased to 75.68 ± 8.93, whereas the placebo group's scores stayed lower at 56.52 ± 10.54.

Table 2: Longitudinal Evaluation of Heart Failure Outcomes and Vitamin D Levels at 3, 6, and 12 Months

Evaluation Parameter	Months	Vitamin D Group (n = 110)	Placebo Group (n = 110)
Serum 25-Hydroxyvitamin D Levels (ng/mL)	3	23.42 ± 5.21	16.96 ± 3.69
	6	29.64 ± 6.43	17.43 ± 3.94
	12	35.18 ± 7.13	17.87 ± 4.21
NYHA Classification, n (%)	3	Class I: 18 (16.36%)	Class I: 12 (10.91%)
		Class II: 43 (39.09%)	Class II: 47 (42.73%)
		Class III: 27 (24.55%)	Class III: 33 (30.00%)
		Class IV: 22 (20.00%)	Class IV: 18 (16.36%)
	6	Class I: 20 (18.18%)	Class I: 10 (9.09%)
		Class II: 45 (40.91%)	Class II: 42 (38.18%)
		Class III: 25 (22.73%)	Class III: 35 (31.82%)
		Class IV: 20 (18.18%)	Class IV: 23 (20.91%)
	12	Class I: 25 (22.73%)	Class I: 8 (7.27%)
		Class II: 50 (45.45%)	Class II: 40 (36.36%)

		Class III: 20 (18.18%)	Class III: 37 (33.63%)
		Class IV: 15 (13.64%)	Class IV: 25 (22.73%)
Hospitalizations, n (%)	3	8 (7.27%)	15 (13.64%)
	6	6 (5.45%)	12 (10.91%)
	12	3 (2.73%)	10 (9.09%)
Quality of Life Score	3	65.24 ± 10.48	58.19 ± 9.62
	6	70.31 ± 9.84	57.47 ± 10.13
	12	75.68 ± 8.93	56.52± 10.54

A statistical comparison of the results between the vitamin D and placebo groups is shown in Table 3. Age ($p = 0.287$), BMI ($p = 0.391$), gender ($p = 0.620$), and concomitant conditions such as diabetes, hypertension, and coronary artery disease did not differ significantly at baseline. After a year, the vitamin D group's serum 25-hydroxyvitamin D level was considerably higher (35.18 ± 7.13 ng/mL) than that of the placebo group (19.12 ± 4.21 ng/mL, $p < 0.001$). Hospitalization rates were lower (2.73% vs. 9.09%, $p = 0.028$) and the vitamin D group experienced improvement in NYHA Class I more frequently (22.73%) than the placebo group (7.27%, $p = 0.013$). Additionally, the vitamin D group had significantly superior quality of life scores (75.68 ± 8.93 vs. 56.52 ± 10.54, $p < 0.001$).

Table 3: Statistical Comparison of Heart Failure Outcomes Between Vitamin D Supplementation and Placebo Groups

Variable	Vitamin D Group (n = 110)	Placebo Group (n = 110)	p-value
Age (mean ± SD)	64.81 ± 10.43	66.05 ± 9.94	0.287 *
BMI (mean ± SD)	27.32 ± 4.63	27.42 ± 4.46	0.391 *
Serum 25-Hydroxyvitamin D (ng/mL)	35.18 ± 7.13	19.12 ± 4.21	<0.001 *
NYHA Class Improvement, n (%)	Class I: 25 (22.73%)	Class I: 8 (7.27%)	0.013**
	Class II: 50 (45.45%)	Class II: 40 (36.36%)	0.210**
	Class III: 20 (18.18%)	Class III: 37 (33.63%)	0.134**
	Class IV: 15 (13.64%)	Class IV: 25 (22.73%)	0.072**
Hospitalizations (n, %) at 12 months	3 (2.73%)	10 (9.09%)	**
Quality of Life Score (mean ± SD)	75.68 ± 8.93	56.52 ± 10.54	<0.001 *
Gender (Male, n, %)	62 (56.36%)	58 (52.73%)	0.620 **
Hypertension (n, %)	55 (50.00%)	55 (50.00%)	1.000 **
Diabetes Mellitus (n, %)	46 (41.82%)	49 (44.55%)	0.706 **
Coronary Artery Disease (n, %)	42 (38.18%)	43 (39.09%)	0.885 **

T-tests are indicated by (*) and Chi-square tests are indicated by (**).

Discussion

Our study's findings reveal that vitamin D supplementation improves heart failure outcomes in individuals with vitamin D deficiency, as evidenced by improvements in a number of clinical measures over a 12-month period. Significantly, the intervention group's serum 25-hydroxyvitamin D levels increased from 17.37 ± 3.62 ng/mL to 35.18 ± 7.13 ng/mL by the end of the research, whereas the placebo group's levels stayed mostly constant at 17.87 ± 4.21 ng/mL. This increase is in line with earlier research that found that supplementing patients with chronic heart failure increased their serum vitamin D levels. However, that study used a higher dosage of vitamin D, demonstrating that even moderate doses, such as the 2000 IU used in our study, can result in significant increases in deficient individuals [12,13].

Vitamin D recipients also showed improvements in their NYHA heart failure classification, according to our study. At the end of the 12-month period, fewer patients remained in Class IV, whereas 22.73% of patients in the vitamin D group were categorized as Class I (compared to just 7.27% in the placebo group, $p = 0.013$), indicating less heart failure symptoms. In earlier research, vitamin D administration was linked to improved functional outcomes in patients with heart failure, and similar trends in NYHA classification improvement were noted [14].

The benefits of vitamin D supplementation are further demonstrated by our study's hospitalization rates, which decreased from 7.27% at 3 months to 2.73% at 12 months, while the placebo group's rate remained relatively stable at 9.09% at 12 months, $p = 0.028$. Although their study's shorter follow-up period hampered the long-term examination of hospitalizations, a prior study found comparable decreases in hospitalization rates among heart failure patients taking high-dose vitamin D therapy [15,16]. The substantial decrease in our study lends credence to the idea that vitamin D helps stabilize the symptoms of heart failure, maybe by modifying inflammation and enhancing endothelial function.

The quality of life outcomes, which increased to 75.68 ± 8.93 in the intervention group and 56.52 ± 10.54 in the

placebo group ($p < 0.001$), further support the therapeutic benefits of vitamin D. These outcomes are consistent with earlier research showing that vitamin D treatment enhanced heart failure patients' quality of life, particularly in terms of physical function and symptom alleviation [17]. The potential for long-term quality-of-life advantages with regular vitamin D therapy was highlighted by the observation of sustained improvements during the 12-month follow-up period of our trial. All things considered, these results highlight how treating vitamin D insufficiency in heart failure patients may help to improve clinical outcomes in a number of ways.

Study Strength and Limitations

This study's focus on a specific population of patients with vitamin D-deficient heart failure is one of its main strengths since it enables a focused evaluation of the advantages of supplementing in this high-risk population. Additionally, a thorough examination of long-term impacts on heart failure outcomes was made possible by the 12-month follow-up period. However, the single-center setting may limit the findings' generalizability to larger groups, and the study's observational cohort design may limit the capacity to draw conclusions about causality. A bigger, multicenter randomized controlled study could be useful for future research to validate these findings in a variety of clinical contexts and populations.

Conclusion

Our research shows that vitamin D supplementation dramatically improves clinical outcomes, such as blood vitamin D levels, the severity of heart failure, hospitalization rates, and quality of life, in patients with vitamin D-deficient heart failure. According to these results, treating vitamin D insufficiency may be a useful adjuvant therapy in the treatment of heart failure, improving patient outcomes and lowering medical costs.

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