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Association between 25-hydroxy vitamin D insufficiency and serum uric acid levels compared to the gender and age categories

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Abstract
Vitamin D and uric acid play important roles in human physiology, with their levels influenced by various factors, including age, gender, diet, and metabolic health. This cross-sectional and case-control study aims to conduct a comparative analysis of 25-hydroxy vitamin D deficiency and serum uric acid levels among genders and different age groups, including 191 males and females with insufficient vitamin D3. The participants' ages range from 21 to 73 years, and they are classified according to World Health Organization age group classification into three age categories: young adults (21-30), middle-aged adults (31-45), and old-aged adults (>45). Blood samples were collected from the participants to measure 25-hydroxy vitamin D and uric acid levels, and the assays were performed using Roche COBAS C311, COBAS e 411/601, and Beckman Coulter (DXC 700 AU) analyzers. The validation procedure is done according to the College of American Pathologists, and electrochemiluminescence immunoassay was used for precision, accuracy, and linearity. The results revealed a significant difference in the mean of vitamin D levels between males and females ($p=0.031$) and an insignificant difference in the mean of uric acid levels compared to the gender groups ($p=0.289$). Also, these results demonstrated a significant difference in the mean of vitamin D3 among different age groups ($p=0.006$) associated with decreased mean levels of vitamin D3 in older adults (15.5 ± 5.8) compared with young adults (19.5 ± 6.6); conversely, insignificant differences were observed in the mean of uric acid among the age categories ($p=0.057$). From these results, we observed a strong and significant correlation between the age groups, severity of vitamin D deficiency, and serum uric acid levels. This significant relationship was observed between the age groups and the severity of vitamin D deficiency among individuals with hypouricemia ($p=0.048$). This study concludes that gender significantly correlates with vitamin D3 deficiency. Additionally, a stronger significant association was found between the severity of vitamin D3 deficiency and different age groups among individuals with hypouricemia.

Introduction

Vitamin D and uric acid play important roles in human physiology, with their levels influenced by various factors, including age, gender, diet, and metabolic health. Vitamin D, primarily measured in the form 25-hydroxy vitamin D [25(OH)D], is an essential fat-soluble vitamin responsible for calcium homeostasis, bone metabolism, and immune function.[1-3] However, vitamin D insufficiency has become a prevalent global health issue, affecting various age groups due to limited sun exposure, dietary deficiencies, and lifestyle factors.[4,5] The uric acid, a metabolic product due to purine, has been widely studied for its due to play essential role as an antioxidant and a pro-oxidant.[6] Uric acid served as a protective agent against oxidative stress; elevated serum uric acid level was associated with gout conditions, hypertension, and cardiovascular diseases.[7,8] Several studies reported an inverse association between 25(OH)D levels and serum uric acid concentrations,[9,10] suggesting that vitamin D insufficiency contributed to hypouricemia and associated metabolic disorders. Furthermore, age and gender are critical factors influencing both vitamin D status and uric acid metabolism.[11,12] Aging is often accompanied by a decrease in vitamin D synthesis due to reduced skin conversion efficiency and dietary intake, while serum uric acid levels tend to fluctuate based on renal function and lifestyle changes across different age groups.[13,14] The association between inadequate 25(OH)D levels and increased serum uric acid remains insufficiently characterized, especially across different age demographics. Considering that vitamin D metabolism and uric acid homeostasis may vary with age and gender, it is essential to assess these relationships in a stratified manner to elucidate potential age and gender-dependent variations.[15-17] This study aims to assess the correlation between 25(OH)D insufficiency and serum uric acid levels in relation to gender and age categories.

Materials and Methods

A cross-sectional and case-control study was conducted in Thumbay Hospital, Ajman, on 191 male and female patients with insufficiency of 25(OH)D3. The Institutional Review Board of Gulf Medical University approved the study (Ref. no. IRB-COHS-STD-17-JAN-2024). A signed informed consent was obtained from all participants after explaining the details of the study objectives and the risks and benefits of participating in the study. The age of participants ranged between 21 to 73 years, and participants were classified according to the World Health Organization (WHO) age group classification into three age categories: young adults (21-30), middle-aged adults (31-45), and old-aged adults (>45). 5 mL of the blood was collected in a plain container to obtain serum used to measure vitamin D3 and uric acid levels. Serum 25-hydroxyvitamin D_3 levels were measured using the Roche Cobas e 411/601 analyzer (F. Hoffmann-La Roche Ltd, Basel, Switzerland) and quantified using a spectrophotometer. Serum uric acid levels were determined using the Cobas C311 analyzer (F. Hoffmann-La Roche Ltd, Basel, Switzerland), an automated immunoassay system, with results quantified using electrochemiluminescence. The results were analyzed by SPSS version 26 (IBM, Armonk, NY, USA), mean and standard deviation were calculated, and "t" independent test, Chi square, one-way analysis of variance statistical tests were used for comparison, and linear regression were used for comparison and correlation analysis. The p-value was obtained to assess the significance of the results, and a p-value of <0.05 was considered significant.

Results

This study included 191 male and female participants with vitamin D3 deficiency who were recruited from Thumbay Hospital, Ajman. Participants ranged in age from 21 to 73 years and were categorized according to the WHO age classification into three groups: young adults (21-30 years), middle-aged adults (31-45 years), and older adults (>45 years). The largest group was middle-aged adults, comprising 40% of the total participants, followed by older adults 39%, and young adults at 21%. The gender distribution among the participants showed a slight majority of males, constituting 53% of the total participants, with females accounting for 47% (Tables 1 and 2).

The results revealed significant differences in the mean of vitamin D3 between males (18.5±6.16) and females (17.9±7.1) with a significant p-value of 0.031. An insignificant difference in the mean was

observed in the uric acid level between males (5.7±1.3) and females (4.5±1.1), with a p-value of 0.289 (Table 3). The mean of vitamin D3 in young adults was 19.5±6.6, in middle-aged adults, it was 18.4±6.5, and in old-aged adults, it was 15.5±5.8. These results revealed a significant difference in the mean of the vitamin D3 among the age groups (p=0.006). While the mean of the uric acid in young adults was 5.0±1.2, in middle-aged adults, it was 5.3±1.4, and in old-aged adults, it was 5.2±1.3. This showed an insignificant difference between the age groups, with a p-value of 0.057 (Table 4). The results demonstrated a significant association between the age groups and the severity of Vitamin D3 deficiency among individuals with hypouricemia (p=0.048), also the results revealed an insignificant association between the age groups and the severity of vitamin D deficiency among individuals with hyperuricemia (p=0.069) and normal uric acid levels (p=0.057). From these results, a significant relationship was observed between uric acid levels and the severity of vitamin D3 deficiency, compared with the different age categories (Table 5 and Figures 1 and 2).

Discussion

This study aimed to assess the relationship between vitamin D3 deficiency and serum uric acid levels compared with different age groups and gender in 191 participants at Thumbay Hospital, Ajman. The study demonstrated significant differences in the mean of vitamin D3 levels between males and females among different age groups. In contrast, there was an insignificant correlation between age or gender and uric acid levels. Also, from this study, it was observed that males had significantly higher mean vitamin D3 levels (18.5±6.16 ng/mL) compared to females (17.9±7.1 ng/mL), with a significant p-value of 0.031. This finding aligns with previous studies reporting gender-related differences in vitamin D levels, with males presenting higher circulating vitamin D levels than females.[18,19] However, insignificant differences were observed in uric acid levels between males (5.7±1.3 mg/dL) and females (4.5±1.1 mg/dL), consistent with a previous study that found that gender had insignificant effect on uric acid levels.[20] The mean of vitamin D3 level in the young adults (19.5±6.6 ng/mL) showed significantly higher levels than old-aged adults (15.5±5.8 ng/mL). This is consistent with another study that suggested that vitamin D deficiency is highly prevalent in younger populations.[21] Furthermore, a significant association was observed between age and the severity of vitamin D deficiency among individuals with hypouricemia, indicating that age plays an essential role in the relationship between vitamin D and uric acid levels. This association confirmed that the potential interplay between these two biomarkers, particularly in older adults, was a higher risk of both deficiencies due to factors such as impaired renal function and reduced dietary intake.[2,22] The study revealed a strong association between the severity of vitamin D deficiency, age groups, gender, and serum uric acid levels. This relationship was significant among individuals with hypouricemia. The low uric acid levels were associated with severe vitamin D deficiency in certain age groups.

Conclusions

The study revealed a strong, significant association between the severity of vitamin D3 deficiency and age categories among individuals with hypouricemia.

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Table 1. Overall characteristics of the patients.

Demographic	Variable	Age range (years)	Patients (n=191)	
			Number	%
Age groups	Young Adults	(21-30)	40	21
	Middle-aged adults	(31-45)	77	40
	Old-aged adults	(>45)	74	39
Gender	Male	(21-71)	102	53
	Female	(23-73)	89	47

Table 2. Demographic distribution of age groups by gender

Demographic	Variable	Gender			
		Male (n=102)		Female (n=89)	
		Number	%	Number	%
Age groups	Young Adults	17	9	21	11
	Middle-aged adults	43	22	35	18
	Old-aged adults	42	21	33	19

Table 3. Differences in vitamin D and uric acid levels between male and female

Biomarkers	Male		Female		p
	Range	Mean ± SD	Range	Mean ± SD	
Vitamin D ng/mL	(4.2-29.7)	(18.5±6.16)	(5.3-29.9)	(17.9±7.1)	**0.031**
Uric acid mg/dL	(1.5-8.5)	(5.7±1.3)	(1.8-7.0)	(4.5±1.1)	**0.289**

Independent *t*-test was used to obtain p-values; $p<0.05$ was considered significant. SD, standard deviation.

Table 4. Comparison of mean vitamin D and uric acid levels across age groups.

Age group	Vitamin D3 conc ng/mL		Uric acid conc mg/dL	
	Range	(mean ± SD)	Range	(mean ± SD)
Young adults	5.1-29.7	19.5±6.6	2.6-7.9	5.0±1.2
Middle-aged adults	5.3-29.6	18.4±6.5	1.8-8.5	5.3±1.4
Old-aged adults	4.2-29.9	15.5±5.8	1.5-8.5	5.2±1.3
p	0.006		0.057	

One-way analysis of variance was used to obtain p-values; $p<0.05$ was considered significant. SD, standard deviation.

Table 5. Correlation of uric acid and vitamin D deficiency by age categories.

Variables		Severity of vitamin D deficiency Count			Total	p
		Mild	Moderate	Sever		
Hypouricemia	Young adults	2	1	6	9	0.048
	Middle-aged adults	5	2	6	13	
	Old-aged adults	10	2	5	17	
	Total	17	5	17	39	
Hyperuricemia	Young adults	2	3	4	9	0.069
	Middle-aged adults	3	5	1	9	
	Old-aged adults	3	2	1	6	
	Total	8	10	6	24	
Norm uricemia	Young adults	6	4	12	22	0.057
	Middle-aged adults	21	17	17	55	
	Old-aged adults	27	7	17	51	
	Total	54	28	46	128	

Chi square test was used to obtain p-values; $p<0.05$ was considered significant.

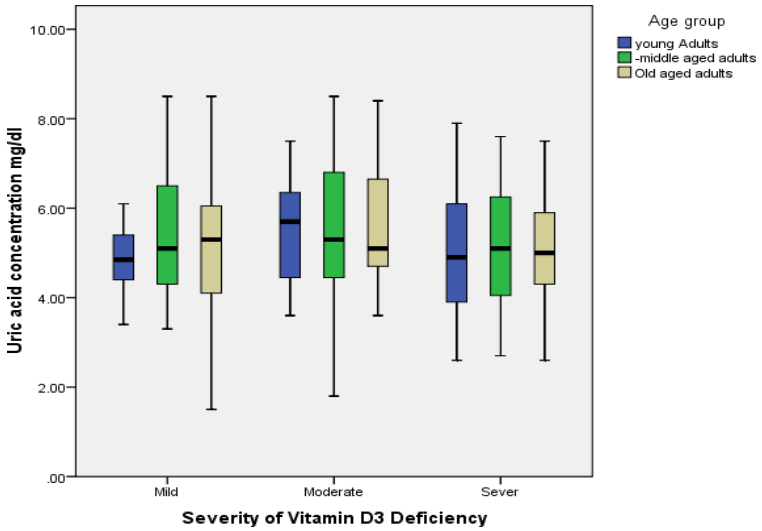

Figure 1. Mean correlation between vitamin D deficiency severity and uric acid across age groups.

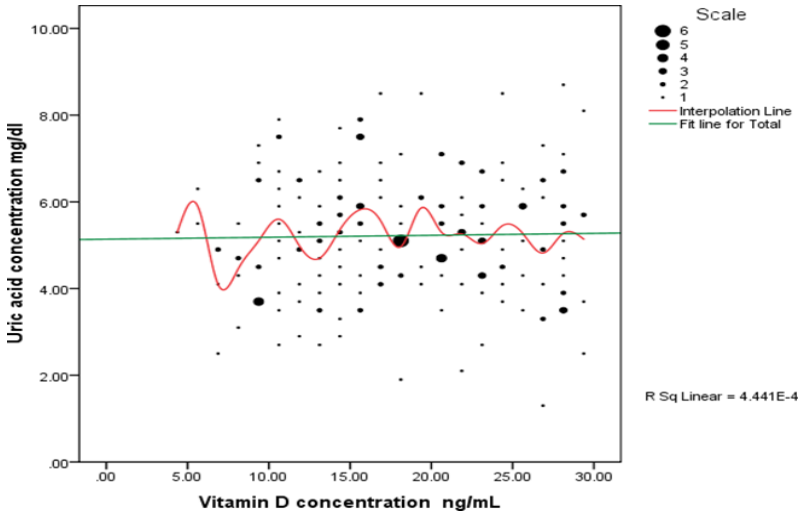

Figure 2. Correlation of vitamin D3 (ng/mL) and uric acid (mg/dL) – scatter dot plot.