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A Cross-Sectional Study on the Impact of Reverse Osmosis Water on Vitamin D Levels

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KEYWORDS

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ABSTRACT:

Introduction: Globally, vitamin D insufficiency is a common health problem affecting the immune system and bone health.

Objectives: This research investigates the association between vitamin D levels and reverse osmosis (RO) treated water consumption among the employees of Sri Devaraj Urs Medical College in Tamaka, Kolar, Karnataka, India.

Methods: A cross-sectional study of 328 people was carried out. Demographic information, food habits, water intake, body fat, BMI, and vitamin D levels were all recorded. To assess the data, Spearman's rank correlation was employed.

Results: the results revealed that, there were 60.4% men and 39.6% women, while 61.9% of the overall population lived in rural areas and 38.1% in urban areas. 86.3% of individuals did not follow a vegetarian diet, 11.9% were vegetarians, and 1.8% were ovo-vegetarians. 74.7% of participants reported consuming RO water. Among these, RO water consumers had considerably higher rates of vitamin D deficiency and insufficiency (84.3% and 94.2%, respectively) than non-RO water consumers. Vitamin D levels and RO water usage were shown to be significantly correlated negatively in rural people (rho = -0.317, $p < 0.001$), but not significantly correlated in urban residents or non-RO water consumers, according to Spearman's rank correlation.

Conclusions: The consumption of RO water was found to be significantly associated with decreased levels of vitamin D. These results highlight the need for more investigation to clarify the processes underlying this correlation and to devise plans for enhancing vitamin D status in those who drink RO-processed water.

Introduction

A global public health hazard affecting a multitude of populations is vitamin D insufficiency. A lack of vitamin D can result in a number of health problems, such as osteoporosis, childhood rickets, and an increased vulnerability to infections. Vitamin D is essential for immune system and bone health maintenance (1). Vitamin D deficiency is nevertheless prevalent even in areas with plenty of sunshine, suggesting that factors other than insufficient sun exposure may play a role in

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this illness. RO treated water consumption is one such aspect that has recently attracted attention (2).

A popular technique for purifying water is RO, particularly in places where water pollution is severe. By effectively eliminating contaminants, heavy metals, and microbes, this technique renders the water fit for human consumption. Nevertheless, it also eliminates vital minerals, such as magnesium and calcium, which are necessary for sustaining a number of biological processes, including the production of vitamin D (3). Researchers are becoming more concerned and interested in the possible connection between drinking RO water and vitamin D deficiency.

When exposed to ultraviolet B (UVB) rays from the sun, 7-dehydrocholesterol in the skin is converted to previtamin D3, a complex process that occurs in the human body that results in vitamin D production. Following its conversion from previtamin D3 to vitamin D3 (cholecalciferol), the liver and kidneys carry out further hydroxylation of the latter to generate the physiologically active 1,25-dihydroxyvitamin D (4). The hydroxylation processes require adequate calcium and magnesium levels, indicating that the mineral content of ingested water may have an impact on vitamin D status (5).

Many studies have investigated into the relationship between vitamin D levels and water mineral content. (6) study emphasized the significance of calcium and magnesium derived from food and water in sustaining appropriate levels of vitamin D. A study highlighted the significance of calcium in augmenting the bioavailability and efficacy of vitamin D (7). These studies highlight the possible effects on vitamin D production and metabolism of mineral loss in RO water.

In addition to its impact on vitamin D status, the use of RO processed water may exacerbate mineral deficiencies, further compromising overall health. Chronic consumption of demineralized water has been associated with adverse health outcomes, including increased risk of osteoporosis, cardiovascular disease, and metabolic disorders (8; 9). Therefore, addressing mineral deficiencies resulting from RO filtration is crucial for promoting optimal vitamin D levels and safeguarding public health.

In regions like Kolar, Karnataka, India, where RO water is commonly used due to concerns about water quality, it is crucial to investigate the implications of prolonged consumption of demineralized water. This study focuses on the employees of Sri Devaraj Urs Medical College in Tamaka, Kolar, Karnataka, to explore the relationship between RO water consumption and vitamin D levels. This cross-sectional study aims to provide insights into whether the consumption of RO water contributes to the high prevalence of vitamin D deficiency observed in this population.

1. Methodology

1.1. Materials and Method:

This cross-sectional survey was conducted between March and April 2024 among workers of Sri Devaraj Urs Medical College in Tamaka, Kolar, Karnataka, India. The study was authorised by the Central Ethics Committee (SDUAHER/KLR/Dept. R&I 103/2020-21 dtd 09.03.2021). Three hundred twenty-eight people were selected. All participants in the study provided written consent. The privacy and anonymity of study participants were maintained throughout the investigation. All participants who met the inclusion criteria were accepted into the study. The authors created a semi-structured questionnaire to collect information on the socio-demographic profile. Food records were filled out over three non-consecutive days using a 24-hour dietary recall (two weekdays and one weekend), and dietary intakes were measured using a food frequency questionnaire (FFQ). This three-day food record is a gold standard method for assessing diet (10). A body composition analyzer was used to take anthropometric measurements such as height, weight, BMI, and fat percentage. Each patient provided two millilitres of venous blood, which was then centrifuged at 3000 rpm for 5 minutes. The serum vitamin D level was determined using the chemiluminescence immunoassay method as described by the manufacturer (LSBio). Individuals who have used parenteral vitamin D supplements were eliminated. Patients with pernicious anaemia, atrophic gastritis, post-gastrectomy, ileal malabsorption, Crohn's disease, ileal resection, proven tapeworm infestation, or metformin use were all excluded. The purpose of this study was to determine the prevalence of vitamin D deficiency and its relationship with the consumption of RO-processed drinking water.

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1.2. Data analysis

The data have been compiled using Microsoft Excel [Internet] (Microsoft Corporation, 2016). The data have been further analyzed using SPSS version 22.0 (IBM SPSS Statistics for Windows). All the normally distributed continuous variables have been compared, computing mean and standard deviation with a 95% confidence interval. Nonparametric tests have been used for nonnormally distributed variables; the outcome is presented as proportions. Spearman's correlation has been used for assessing the associations. A value of ($P < 0.05$) has been taken as the level of significance.

2. Results

There were 328 participants in the study, with 60.4% of them being men and 39.6% being women. In terms of where they lived, 61.9% of the participants were from rural regions, and 38.1% were city dwellers. Based on dietary patterns, the majority was significantly non-vegetarian (86.3%), with vegetarians (11.9%) and ovo-vegetarians (1.8%) coming in second and third, respectively. 84.1% of participants reported drinking milk every day, 2.7% once a week, 2.7% three times a week, 3.4% twice a week, 4.6% fortnightly, and 2.4% never drank any milk at all. Regarding their water-drinking habits, 74.7% of individuals said they consumed RO water, compared to 25.3% who did not.

Merely 0.6% of participants in the current study had a normal body fat range, whereas the remainder, 99.4%, had an over-body fat range are shown in Table 1. Moreover, Table 2 indicates that 2.4% of the subjects had an overweight BMI, 72.6% had an obese I BMI, and 25.0% had an obese II BMI.

Table 1. The table presents the distribution of the sample population based on their body fat range

Body Fat range					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Normal	2	.6	.6	.6
	Over	326	99.4	99.4	100.0
	Total	328	100.0	100.0	

Table.2 The table presents the distribution of the sample population based on their BMI

BMI Grade					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Overweight	8	2.4	2.4	2.4
	Obese I	238	72.6	72.6	75.0
	Obese II	82	25.0	25.0	100.0
	Total	328	100.0	100.0	

The Vitamin D levels were categorized as insufficient in 35.1% of participants, deficient in 36.6%, and sufficient in 28.4% as shown in the table 3.

Vitamin D					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Insufficiency	115	35.1	35.1	35.1
	Deficiency	120	36.6	36.6	71.6
	Sufficient	93	28.4	28.4	100
	Total	328	100	100	

Table 3. The table presents the distribution of the sample population based on their Vitamin D levels

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Different trends in the preferences of rural and urban people for water consumption are revealed by the crosstabulation of place of residence and RO water consumption. 65.5% of the 203 rural people use RO water, compared to 34.5% who do not. This suggests that RO water is preferred in rural areas, albeit not very much. Table 4 indicates that of the 125 urban people, 89.6% drink RO water, indicating a considerable preference for RO water in urban areas.

Table 4. The crosstabulation of place of residence and RO water consumption

Place of residence * RO Crosstabulation				
Count				
		RO (%)		Total
		Yes	no	
Place of residence	Rural	133	70	203
	Urban	112	13	125
Total		245	83	328

Interesting trends in water consumption preferences across various Vitamin D categories are shown by the crosstabulation of RO water consumption and Vitamin D levels. In particular, a significant proportion of people with both deficiencies and insufficiencies in vitamin D (84.3% and 94.2%) drink RO water, suggesting a strong correlation between low vitamin D levels and RO water intake. On the other hand, as Table 5 illustrates, most people with adequate levels of vitamin D (62.4%) do not drink RO water, indicating a possible correlation between vitamin D levels and non-RO water intake.

Table 5. The crosstabulation of Vitamin D levels and RO water consumption

Vitamin D * RO Crosstabulation				
Count				
		RO		Total
		Yes	No	
Vitamin D	Insufficiency	97	18	115
	Deficiency	113	7	120
	Sufficient	35	58	93
Total		245	83	328

RO Users: The RO water users in rural areas, a considerable proportion have inadequate (53), deficient (74) or sufficient (7) amounts of Vitamin D. On the other hand, compared to rural RO consumers, a greater percentage of urban inhabitants (29), as well as those with inadequate (39) and insufficient (44), Vitamin D levels are found among urban RO water consumers.

Consumers who are not RO: The majority of rural individuals who do not use RO water have adequate levels of Vitamin D (55), whereas a smaller proportion had inadequate (10) or deficient (5) levels. There aren't many urban inhabitants who don't drink RO water, but those who do tend to have adequate levels of vitamin D (3) as opposed to inadequate (8) or deficient levels (2)

The main findings of this study about the relationship between RO water consumption and vitamin D levels show that both urban and rural RO water consumers have a significant prevalence of inadequate and insufficient vitamin D levels. When it comes to vitamin D status, urban inhabitants who drink RO water are marginally better than their rural counterparts, with a greater proportion of people having adequate levels.

Vitamin D amounts and Non-RO Water Consumption: Most rural residents who do not use RO water have

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enough amounts of Vitamin D, making them generally in better health. Table 6 indicates that although there are fewer urban non-RO water consumers, they also likely to have adequate amounts of Vitamin D.

Table 6. The crosstabulation of Vitamin D levels, place of residence, and RO water consumption

Vitamin D * Place of residence Crosstabulation					
Count					
RO			Place of residence		Total
			Rural	Urban	
Yes	Vitamin D	Insufficiency	53	44	97
		Deficiency	74	39	113
		Sufficient	6	29	35
	Total		133	112	245
No	Vitamin D	Insufficiency	10	8	18
		Deficiency	5	2	7
		Sufficient	55	3	58
	Total		70	13	83

The vitamin D levels of 133 rural residents who consume RO water were examined using a Spearman's rank correlation analysis. RO water usage: Vitamin D levels and RO water use are significantly correlated negatively (rho = -0.317, $p < 0.001$). This shows that among rural residents, higher RO water usage is linked to lower vitamin D levels. Additional Spearman's rank correlation analysis (N = 70) of people living in rural areas without access to RO water. Among these people, there is no discernible relationship between vitamin D levels and non-RO water intake (rho = -0.141, p = 0.244).

Urban residents: Spearman's rank correlation analysis results (N = 112) focusing on vitamin D among those who drink RO water. With a correlation coefficient of -0.177, our findings show a marginally unfavorable relationship between vitamin D levels and RO water usage. This implies that there may be a slight correlation between increased RO water usage and decreased vitamin D levels. Nonetheless, the statistical examination produced a p-value of 0.061, beyond the standard cutoff point of 0.05 for statistical significance. As a result, the observed weak negative correlation is not statistically significant, suggesting that there may be a chance explanation for it rather than a genuine relationship. Additionally, a Spearman's rank correlation study was conducted among urban non-RO users. There is a relationship between vitamin D levels and RO water intake among city dwellers (N = 13). The difference was not statistically significant and was only slightly negative (rho = -0.177, p = 0.061). Notably, a perfect self-correlation for vitamin D levels was found among urban non-RO water drinkers, indicating the need for further extensive research to completely comprehend the factors influencing vitamin D levels, as table 7 illustrates.

Table 7. Spearman's Rank Correlation Analysis

Place of Residence	RO Water Consumption	Vitamin D	Correlation Coefficient	Sig. (2-tailed)	N
Rural	Yes		-0.317	< 0.001	133
	No		-0.141	0.244	70
Urban	Yes		-0.177	0.061	112
	No		-0.177	0.061	13

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

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4. Discussion

The findings of this study provide significant insights into the relationship between RO water consumption and vitamin D levels among employees of Sri Devaraj Urs Medical College. The prevalence of vitamin D insufficiency and deficiency among the study participants highlights a critical public health issue. These results align with global observations of widespread vitamin D deficiency despite adequate sunlight exposure, suggesting that factors other than sun exposure, such as dietary intake and water consumption, play crucial roles in maintaining vitamin D levels (1). Several studies have examined the association between water mineral content and vitamin D levels, providing a context for interpreting the current findings. (7) emphasized the role of calcium in enhancing the bioavailability and effectiveness of vitamin D. This is relevant considering that RO water, which lacks essential minerals like calcium and magnesium, might contribute to lower vitamin D levels. The significant negative correlation between RO water consumption and vitamin D levels observed in rural residents (rho = -0.317, $p < 0.001$) supports the hypothesis that mineral depletion in RO water can adversely affect vitamin D metabolism.

RO is a widely used water purification technique that removes contaminants and impurities by forcing water through a semipermeable membrane. While effective at improving water quality and safety, RO filtration may inadvertently strip essential minerals, including calcium cobalt, phosphorous and magnesium, from the water. These minerals are not only vital for overall health but also play a crucial role in vitamin D metabolism. Calcium, in particular, is essential for bone health and is intricately involved in the synthesis and regulation of vitamin D within the body (11; 12).

A study conducted a meta-regression analysis that highlighted the importance of calcium and magnesium in maintaining adequate vitamin D status (5). The present study's finding that rural RO consumers exhibited higher rates of vitamin D insufficiency and deficiency compared to urban RO consumers further underscores the potential impact of mineral-depleted water on vitamin D synthesis. This differential impact between rural and urban residents might be attributable to varying dietary habits and levels of physical activity, which influence overall health and nutrient absorption. Wacker et al reviewed the global perspective on sunlight and vitamin D, stressing that dietary sources and supplementation are vital in regions with inadequate sun exposure or other limiting factors (6). The high prevalence of vitamin D deficiency among RO water consumers in this study aligns with their conclusion that external factors, including diet and water quality, significantly affect vitamin D status.

While the current study found a significant negative correlation between RO water consumption and vitamin D levels among rural residents, no significant correlation was observed among urban residents (rho = -0.177, $p = 0.061$). This contrast might be due to differences in dietary supplementation and access to fortified foods in urban areas, which can mitigate the adverse effects of mineral-depleted water. Urban residents may have better access to diverse diets and healthcare resources that help maintain adequate vitamin D levels despite consuming RO water. Numerous epidemiological studies have investigated the association between water source and vitamin D status, with some suggesting a potential link between borewell water consumption and improved vitamin D levels. For instance, a cross-sectional study found that individuals consuming borewell water exhibited higher serum vitamin D levels compared to those consuming RO water in urban settings (13). Similarly, longitudinal research by Park et al observed a positive correlation between the consumption of mineral-rich water sources, including borewell water, and vitamin D status in urban populations (14). These findings underscore the importance of water source selection in maintaining adequate vitamin D levels and highlight the potential role of borewell water in promoting vitamin D sufficiency and overall health.

The present study's observation that non-RO consumers in rural areas had better vitamin D levels compared to their RO-consuming counterparts further supports the role of dietary and environmental factors in influencing vitamin D status.

Implications for Public Health

Among RO water users, vitamin D deficiency is highly prevalent, which emphasizes the necessity for public health initiatives. The public may be educated about the possible dangers of drinking RO water without taking a mineral supplement, and dietary changes to guarantee enough intake of calcium and magnesium could be encouraged. Furthermore, supplementing RO water with

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necessary minerals may be a workable way to lessen its negative effects on the metabolism of vitamin D.

Conclusion

In conclusion, there is strong evidence from this study that staff at Sri Devaraj Urs Medical College who drink RO water have decreased vitamin D levels. These results point to a possible public health concern in areas where RO water is widely used. Comprehensive approaches are needed to address this problem, such as dietary modifications, public awareness campaigns, and perhaps fortifying RO water with necessary minerals. In order to enhance vitamin D status in populations that depend on RO-processed water, more investigation is necessary to uncover the underlying mechanisms and provide practical solutions.

Declaration of interest

Authors have no conflict of interest to declare.

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