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ORIGINAL ARTICLE

Questionnaire-based assessment of Vitamin D levels in the body: An Indian pilot study

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Abstract

Aim: The study was conducted to validate a questionnaire-based assessment of Vitamin D status using the Food Frequency and Lifestyle Questionnaire (FFLQ) by comparing it against its biochemical parameter, namely serum level of 25-hydroxyvitamin D (25(OH)D). **Methods:** A questionnaire-based study was conducted with 21 subjects (seven males and 14 females) aged 18 years and above, who had undergone a master health checkup inclusive of Vitamin D testing. Inclusion criteria stipulated that the serum 25(OH)D test had to be conducted within 1 month of enrolment of the subject. Participants were administered the validated FFLQ to evaluate their Vitamin D status and its association with certain lifestyle parameters. Scores obtained from the FFLQ were then compared with serological levels of 25(OH)D. **Results:** The age of the subjects in the study ranged from 26 to 77 years, with 42% of male subjects (3 out of 7) and 64% of female subjects (9 out of 14) exhibiting Vitamin D deficiency. Among the 12 participants below 40 years old, 58% (7 out of 12) were identified with Vitamin D deficiency. Among the nine participants above 40 years old, 55% (5 out of 9) had Vitamin D deficiency. Spearman's rank correlation coefficient testing was applied in view of the non-normally distributed data. The analysis revealed a statistically significant positive correlation ($r = 0.563$, $P = 0.008$) between the overall FFLQ scores and the serum 25(OH)D levels. **Conclusion:** This study observed that low FFLQ scores correlated with Vitamin D deficiency, whereas high scores indicated optimal Vitamin D levels. The FFLQ thus established itself as a potentially valuable screening tool for identifying Vitamin D deficiency in the general population, offering a cost-effective and non-invasive alternative to laboratory assessments.

Introduction

Vitamin D plays a vital role in promoting bone strength and the maintenance of a robust immune system.[1] The primary forms of Vitamin D are Vitamin D2, also known as ergocalciferol and Vitamin D3, or cholecalciferol. While Vitamin D3 is endogenously synthesized in the skin upon exposure to sunlight, and Vitamin D2 is derived from dietary sources. Vitamin D deficiency is known to be associated with an elevated risk of certain diseases.[2]

Mostly young adults are at a higher risk for Vitamin D deficiency.[3] It can be attributed to a suboptimal dietary intake of Vitamin D, reduced outdoor exposure, and an increasing trend in the usage of sunscreens. The shift in the preferred consumption of carbonated drinks over milk, especially in the younger population, further contributes to the reduced levels of calcium and Vitamin D.[4]

Serum concentration of 25-hydroxyvitamin D (25[OH]D) is considered to be the best tool to assess Vitamin D status. A concentration of < 20 ng/mL indicates a deficiency of Vitamin D.[5]

The primary etiopathogenesis behind Vitamin D deficiency stems from inadequate exposure to sunlight, which is the leading source of this essential vitamin. The other causes include acute and chronic illnesses such as type 2 diabetes, certain cancers, pre-eclampsia, autoimmune disorders, cardiovascular diseases, and rarely, neurological disorders.[6,7]

Limited natural sources of Vitamin D and its inadequacy in fortified foods make it challenging to meet the daily requirement levels in both children and adults. Assessing Vitamin D levels in the general population gains prime importance in this venture to detect deficiency but suffers primarily due to cost considerations. Therefore, it is imperative to identify a cost-effective, rapid, non-invasive, and user-friendly tool for screening for potential Vitamin D deficiency. The implied tool should enable timely diagnosis and early therapeutic interventions to address the deficiency promptly.

This study seeks to assess the efficacy of a questionnaire tailored to evaluate an individual's Vitamin D status, by investigating the correlation between the questionnaire scores and the actual Vitamin D levels in the body. To achieve this objective, we have adapted a revised version of the validated questionnaire originally developed by Larson-Meyer *et al.* to suit the Indian diet.[8] Notably, there is a dearth of Indian studies in the existing literature that have examined the relationship between biochemical levels of Vitamin D and the questionnaire scores.

Methods

This questionnaire-based research was conducted at a tertiary eye hospital, following ethical clearance, over a period of 6 months. The validated questionnaire was originally developed by Larson-Meyer *et al.* who validated the Food Frequency and Lifestyle Questionnaire (FFLQ) for assessing Vitamin D status and its correlation with lifestyle parameters.[8,9] For the purpose of this study, the FFLQ was revised and adapted for the Indian diet and lifestyle. The questionnaire comprises sections measuring Vitamin D intake from diet, sunlight (UVB exposure), and supplements [Table 1].

The study involved participants aged 18 and above who had undergone a master health checkup, including Vitamin D testing. Laboratory testing of 25(OH)D was considered only if the blood sample was obtained within a month from the date of testing. Only subjects who expressed willingness to undergo Vitamin D testing were included in the study. Individuals with renal failure, cardiovascular diseases, diabetes, and those currently on Vitamin D supplementation were excluded from the study.

Informed consent was secured from all participants who willingly agreed to take part in the study. A detailed explanation of the research was provided to each participant at their convenience. The scores obtained from the questionnaire were then compared with the laboratory results of Vitamin D levels. The associations between lifestyle parameters and Vitamin D levels were analyzed in detail.

Statistical analysis

The data were entered and coded in MS Excel, and statistical analyses were performed using SPSS (the Statistical Package for the Social Sciences, version 23, IBM USA). Upon conducting the Shapiro–Wilk test to assess the normality of distribution, the results indicated a non-normal distribution of the data ($P < 0.001$). Subsequently, given the non-normal distribution, the analysis transitioned to Spearman's rank correlation coefficient test.

Results

This questionnaire-based study, encompassing 25 modified inquiries pertaining to dietary and lifestyle parameters, scrutinized a cohort of 21 participants (seven males and 14 females). The primary objective was to elucidate the correlation between the responses to Vitamin D questionnaires and corresponding laboratory results.

Participants, ranging in age from 26 to 77 years, underwent the assessment. Vitamin D deficiency was identified in 42% of male subjects (3 out of 7) and 64% of female subjects (9 out of 14). Specifically, within the subset of participants below 40 years old, 58% (7 individuals) were Vitamin D deficient, whereas 55% (5 individuals) above 40 years old exhibited deficiency.

Spearman's rank correlation was employed to evaluate the association between dietary factors and Vitamin D levels in the laboratory report. Among vegetarian dietary factors, milk intake showed a weak positive correlation with Vitamin D levels ($r = 0.12$, $P = 0.61$). The correlation between cereal intake and Vitamin D levels exhibited stronger statistical significance ($r = 0.44$, $P = 0.04$). However, the correlation between fruit intake and Vitamin D levels showed non-statistical significance and a negative correlation ($r = -0.102$, $P = 0.661$).

Among non-vegetarian dietary factors, the relationship between liver intake and Vitamin D levels showed a statistically significant and positive correlation ($r = 0.515$ $P = 0.017$). Conversely, fatty fish intake showed a weak positive correlation without statistical significance ($r = 0.12$, $P = 0.58$). Weak positive correlations were noted between egg intake, meat intake, and Vitamin D levels, none of which achieved statistical significance ($r = 0.235$, $P = 0.306$; $r = 0.26$, $P = 0.26$, respectively).

In terms of supplement intake, the report indicated a negative correlation between multivitamin tablet intake and Vitamin D levels in the blood, which was not statistically significant ($r = -0.26$, $P = 0.25$). Similarly, the relationship between consumption of calcium tablets and Vitamin D levels showed a negative correlation that was not statistically significant ($r = -0.27$, $P = 0.23$). In addition, the relationship between vitamin and calcium tablet intake and Vitamin D levels reveals a poor positive correlation, which is also not statistically significant ($r = 0.022$, $P = 0.92$).

In the investigation of the health status of individuals, a positive correlation was observed between gait disorders and Vitamin D levels, although without statistical significance ($r = 0.42$, $P = 0.054$). On the contrary, relationships between gait and ulcerative colitis exhibited statistical significance, manifesting a positive correlation ($r = 0.509$, $P = 0.018$).

On evaluating lifestyle factors, the correlation between living status (rural or urban) and Vitamin D levels showed a

Table 1: Table showing the questionnaire responses comprising Indian diets and lifestyle

Diet and lifestyle questionnaire	never 0	1-3/m-1	1/wk 2	2-4/wk-3	5-6/wk-4	1/d-5	2-3/day-6	4-5/d-7	>6/day-8
Milk									
Soy milk/rice milk 1 cup									
Cereal (Vitamin D fortified), raisin, and oat.3/4 cup									
Fruits intake									
Liver cooked 3 1/2 oz									
Other fatty fish 3 1/2 oz									
Egg									
Meat									
Pure vegetarian									
Supplement section (yes=1/no=0)									
Multivitamin tablet									
Calcium tablet									
Vitamin D tablet									
Vitamin D + Calcium									
Sunlight section									
	never-0	1–3 h/m-1	1 h/wk-2	2–4 h/wk-3	5–6 h/wk-4	1/2–1 h/day-5	>2 h/d-6		
How much sunlight exposure 10 am–3 pm									
How often do you use sunscreen	never 2		sometimes1		always-0				
What SPF do you use?									
Where were you living in the past 3 months	city-0				village-1				
What do you wear outdoors	long sleeves 0		short sleeves-1		shorts-1		work in sun-1		
	hat 0				pants-0		gloves		
History of gait disorders and falls	yes 0	no 1							
History of gastrointestinal diseases such as Crohn's disease, ulcerative colitis	yes 0	no 1							
History of gait disorders and falls and osteoporosis	yes 0	no 1							
History of bone pain and fatigue	yes 0	no 1							

m: Month, wk: Week, SPF: Sun protection factor

non-statistically significant negative correlation (r = −0.027, P = 0.908). The use of sunscreen exhibited a statistically significant positive correlation (r = 0.447, P = 0.042), whereas the use of sun protection factor (SPF) demonstrated a statistically significant negative correlation (r = −0.551, P = 0.010). The relationship between the type of outdoor wear (closed or short sleeves) and Vitamin D levels showed a negative correlation which was statistically significant with r = −0.295 P = 0.194, whereas sunlight exposure showed a non-statistically significant positive correlation (r = 0.310, P = 0.171).

The relationship between the overall questionnaire score and Vitamin D levels in the laboratory report showed a positive correlation which was statistically significant (r = 0.563, $P = 0.008$) [Figure 1].

Discussion

This study revolved around a hypothesis, which posits the utility of a questionnaire centered on dietary and lifestyle habits to discern individuals at varying risk levels for Vitamin D deficiency. In our investigation, a heightened prevalence of Vitamin D deficiency was noticed among females, aligning with findings from a study in Libya.[10] However, contrary to the Libyan study, our research unveiled that fish intake did not exert a significant influence on Vitamin D status within our population.

During our pilot study, a noteworthy observation surfaced: individuals employing sunscreens exhibited a propensity for Vitamin D deficiency. A meta-analysis corroborated the theoretical risk associated with Vitamin D deficiency due to sunscreen use, although evidence from field trials and observational studies suggests that this risk is generally low. Nonetheless, the meta-analysis emphasized the scarcity of data regarding the relevance of very high SPF-containing sunscreens.[11]

We investigated the habitual use of sunscreen/cosmetics with SPF, with a particular focus on SPF ≥15. However, it is essential to acknowledge a potential source of bias in our study as we did not include a specific inquiry regarding which of the participants' unprotected skin surfaces or specific body parts were exposed to sunlight or UV lamps.

The revised version of our questionnaire consisted of only 25 questions, ensuring a quick and easy response process. It should be noted that the questionnaire, although self-administered, serves as a tool for health-care professionals. It is worth noting that various studies on Vitamin D assessment questionnaires have been previously published. Each of these studies had adapted their questions based on local food intake and cultural nuances.[12,13]

Our questionnaire was based on the common factors affecting Vitamin D levels production/intake, absorption, and metabolism such as

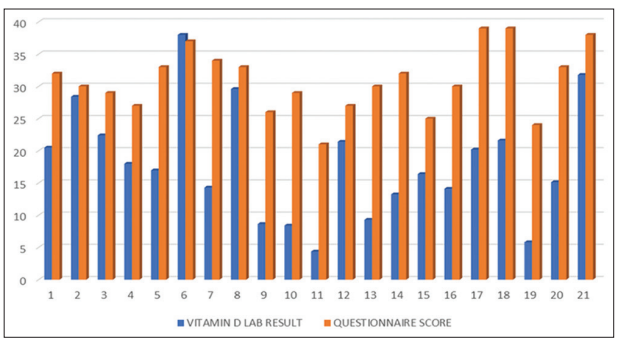

Figure 1: Graph depicting the relationship between participants' overall questionnaire scores and their corresponding Vitamin D levels as assessed through laboratory results

- Geographical information on the place of residence
- Regular outdoor physical activity
- Exposure to sunlight
- Habitual use of sunscreen/cosmetics with SPF
- Consumption of foods containing Vitamin D
- Presence of certain pathologies interfering with the production and absorption of Vitamin D
- Drug therapies
- Use of multivitamin supplements or Vitamin D supplements.

In Georgia, such type of questionnaire was used to assess the knowledge level about Vitamin D and its influence on their child's health. Their results report that parental knowledge about the Vitamin D and its importance is low.[14] In developing nations, the implementation of such awareness questionnaires can prove to be a valuable tool for education, aiding individuals in comprehending the significance of scientific facts and fostering a better understanding of their importance.

Similar awareness studies were done in the United Kingdom as well.[15] A study conducted in Pakistan examined the knowledge, attitudes, and practices related to Vitamin D among university students. Their findings revealed that despite being at a higher risk for Vitamin D deficiency, awareness was found to be relatively low among these university students.[16]

One notable strength of employing such questionnaires is their utility in assessing Vitamin D status as a non-invasive screening tool. Whether self-administered or conducted through telephone interviews, these questionnaires offer a cost-effective alternative to serum 25(OH) D testing. However, limitations include the use of a very small sample size, a focus on a limited set of dietary questions, and a lack of consideration for age and gender differences.

This study is in its preliminary stages, relying on a relatively modest sample size. Consequently, there is potential for refining the questionnaire, and we intend to broaden our data collection efforts to enhance its structure. Given the existing lack of awareness, not only in developed nations but also in developing countries, it is recommended for the latter to undertake multicenter awareness studies, to bolster knowledge dissemination among their population.

Conclusion

The significance of Vitamin D deficiency in the escalating non-communicable disease burden underscores the potential value of a screening tool, such as the validated questionnaire by Larson-Meyer *et al*. Further research is essential to optimize the existing questionnaire and formulate cost-effective algorithms for identifying individuals who might require further investigation using serum 25(OH)D measurement. While the questionnaire demonstrates a moderate level of utility in the identification of Vitamin D deficiency, ongoing trials hold promise for enhancing its predictive capacity in detecting this nutritional insufficiency.

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Nil.

Conflicts of Interest

There are no conflicts of interest.

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