

SUNLIGHT EXPOSURE AND SERUM VITAMIN D STATUS AMONG COMMUNITY DWELLING HEALTHY WOMEN IN SRI LANKASubasinghe HWAS^{1,3*}, Lekamwasam S.², Ball P.³, Morrissey H.³ and Waidyaratne EI.²¹Faculty of Allied Health Sciences, University of Ruhuna, Sri Lanka.²Faculty of Medicine, University of Ruhuna, Sri Lanka.³School of Pharmacy, University of Wolverhampton, United Kingdom.***Corresponding Author: Ms. Subasinghe HWAS**

Faculty of Allied Health Sciences, University of Ruhuna, Sri Lanka.

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ABSTRACT

Introduction: Hypovitaminosis D is prevalent and linked with a multitude of co-morbidities. The high prevalence of hypovitaminosis D, despite the availability of sunlight throughout the year has raised many questions. **Objective:** This study aimed to assess the prevalence of vitamin D deficiency and its associations with diet and sunlight in premenopausal women in Sri Lanka. **Methods:** Community dwelling healthy women between 20-40 years (n = 132) were selected. Consumption of vitamin D (vit-D) rich dairy and non-dairy foods were estimated. Serum vit-D and calcium were measured. Vit-D reference values introduced by Lips *et al* were used to categorize subjects. **Results and conclusion:** Eight subjects (6.1%) were Vit-D deficient while 68 (51.5%) had Vit-D insufficiency. No difference in vit-D status according to age (20-30 vs 31-40 years). Vit-D was higher in women who had sun exposure >2 hours/day compared to women with <2 hours sunlight. Vit-D positively associated with dairy (Pearson r = 0.20, p = 0.023) and non-dairy vit-D rich food intake (Pearson r = 0.21, p = 0.014). Hypovitaminosis D is prevalent among community dwelling healthy middle-aged women in Sri Lanka. Higher vit-D level is associated with sufficient duration of sun exposure and dairy, non-dairy food intake.

KEYWORDS: Vitamin D, Women, Sri Lanka, Sun light, Dairy, Deficiency.**INTRODUCTION**

Vitamin D is essential for the maintenance of calcium homeostasis and optimum skeletal health. In the body, vitamin D is available in two bioequivalent forms: D₂ (ergocalciferol) and D₃ (cholecalciferol). Vitamin D₂ is obtained from vegetables, mushrooms and oral supplements while vitamin D₃ is obtained mainly from skin exposure to ultraviolet B (UVB) radiation in sunlight and from oily fish, fortified foods and oral supplements in limited amounts. D₃ is the circulating mode while D₂ is the active metabolite responsible for major biological actions. Recent studies have discovered the pleiotropic effects of vitamin D therapy especially on renal, cardiovascular, reproductive and immune systems in the body.^[1-3]

Vitamin D deficiency (VDD) has become a major public health problem as it is prevalent in all age groups and ethnicities.^[4] Further, VDD is not uncommon in countries with sufficient UV-B light and among populations who consume vitamin D fortified food.^[5] According to Forrest (2011), VDD is found in 41.6% Americans and among them the highest rate is noted in blacks (82.1%), followed by Hispanics (69.2%).^[6]

Higher prevalence of VDD is found among both South and Southeast Asian populations despite sunlight throughout the year in some regions.^[7-9] Nearly 70% of Indian population are VDD or insufficient (VDI) despite high consumption of dairy products.^[10] Certain religious beliefs and cultural practices, wearing fully covered cloths, vegetarian food pattern and dwelling in multi-storied apartments are associated with low vitamin D levels in India.^[11,12] Recent studies show that a significant portion of Indian females living in North as well as South including Muslims have hypovitaminosis D. Nearly 76% of South Indian females inclusive-of pregnant women, child bearing mothers and postmenopausal women have VDD.^[7,11] Furthermore, 96% of neonates, 91% of healthy school girls and 84% of pregnant women in North India suffer from VDD.^[7,12,13] Prevalence of VDD is above 70% among healthy adult Pakistani population and another 21% has insufficient vitamin D levels.^[7] More importantly 55% of infants and 45% of nursing mothers in Pakistan have serum vitamin D below 10 ng/ml.^[14,15] Similar situation is observed in Bangladesh where many women wear veil that restricts exposure to sun.^[7,16] Many studies, especially from South Asia support the link between limited sun exposure and low vitamin D level.^[14,15] According to the Thai 4th

National Health Examination Survey, 57% of females and 33% males have vitamin D <30 ng/ml.^[8]

Vitamin D is mainly synthesized in the skin^[17,18] but the process is influenced by environmental and lifestyle factors. People with dark skin are more susceptible to VDD probably because melanin pigment absorbs Ultra-Violet B^[18]. Sun screen applications and minimum outdoor activities are human behaviours that, reduce vitamin D production endogenously. Further, skin vitamin D production varies according to the time of the day, season of the year and zenith angle of the sun.^[17]

Studies on vitamin D in Sri Lankan population are scarce. Limited data, however, show a high prevalence of VDD among community-dwelling women. Rodrigo et al (2013) showed that 56.2% women aged 20-40 years have either VDD or VDI (<35 nmol/l).^[19] A study conducted in the central part of Sri Lanka showed that, 58.6% of women aged 30-60 years have vitamin D <50 nmol/l.^[20]

The high prevalence of hypovitaminosis D in some Asian countries despite the abundance of sunlight throughout the year has raised many questions. Whether this is related to the restricted exposure to sunlight or the inability of the pigmented skin to produce sufficient vitamin D is unknown. Further, the high prevalence observed is a result of the inappropriate cut-off values used to define VDD and VDI is also being raised.

It is important for a country to know the determinants of vitamin D level of the population. The information can be used in designing health promotion programs to optimize vitamin D level at population level. This will prevent indiscriminate use of vitamin D supplementation and thereby reduce the additional cost that patients have to bear.

The objective of this study was to assess the prevalence of hypovitaminosis D and its associations with the anthropometry, diet and sunlight exposure among young women in two selected areas in Sri Lanka.

MATERIALS AND METHODS

This cross-sectional study was conducted in Matara (Southern province) and Kandy (Central province) districts in Sri Lanka. Ethical approval was obtained from the Ethics Review committee of Faculty of Medicine, University of Ruhuna prior to data collection (Ref No. 09.03.2016:3.3).

Two Pradeshiya Sabha Divisions (intermediate administrative unit) were selected from each district and two Grama sewa divisions (the smallest administrative unit) of each Pradeshiya sabha divisions were selected, randomly, for data collection. Community-dwelling women between 20-40 years of age were invited to participate in the study by posters displayed in public places. Women who filled the 'expression of interest form' were invited to take part in the study.

Postmenopausal women, pregnant or breast-feeding mothers, women who had diseases (chronic diseases of liver, kidney, heart or lungs and endocrine diseases) or were on medications that can affect vitamin D metabolism (corticosteroids, hormonal contraceptives, diuretics, vitamin D supplementations) were excluded from the study sample.

All the participants (n = 132) were educated about the research and their written consent was obtained before enrolling into the study. Data were collected by interviewing them individually using a content validated data sheet. Their weight and height were measured adhering to the standard protocols. Five millilitres of venous blood were drawn for biochemical analyses. Vitamin D analysis was performed by Chemiluminescence Binding Assay method using CobasElecysys 411 analyser (Roche Diagnostics International Ltd, Switzerland). Exposure to sunlight was measured as the number of hours stayed outdoor between 6.30am-6.30pm while not taking measures to avoid sun exposure (use of an umbrella or sun cream). The times of sunrise and sunset were monitored with the meteorological department website during the study period. Participants were divided into two categories as; sun exposure time <2 hours/ day and 2-6 hours/ day.

Amount of dairy and non-dairy vitamin D rich food intake was estimated by a food frequency questionnaire. Dairy food consumption was measured as the number of glasses of milk (either fresh milk or milk powder), wedges of cheese, tea spoons of butter and cups of yogurt and curd. These numbers were added and total dairy intake was calculated in units per week. The weekly intake of non-dairy vitamin D rich food was calculated in the same manner considering weekly consumption of fish and meat products (pieces).

Based on the consumption, subjects were categorized as 'low', 'medium' and 'high' consumption considering 33rd and 66th percentiles to decide the cut-off level of those categories. (The cut-off values of dairy food consumption; 0 - 9 'low', 10 - 15 'medium' and 16 ≤ 'high'. In non-dairy vitamin D rich food consumption; 18 - 51 'low', 52 - 70 'medium' and 71 ≤ 'high'.)

Statistical Analysis

All the measurements including serum vitamin D level are presented as mean ± SD. Pearson correlations were calculated to assess the associations between continuous variables. Independent t-test and ANOVA with post-hoc test were used to detect significant differences between groups. P<0.05 was considered as statistically significant.

RESULTS

Vitamin D and serum calcium were measured in 132 females between 20 - 40 years. Mean (SD) body weight, height, BMI and age of the study sample were 55.2 (11.0) kg, 155 (5.9) cm, 23 (4.5) kg/m² and 31.3 (5.9)

years, respectively. Average serum vitamin D was 20.58 (8.21) ng/mL and calcium was 9.28 (0.64) mg/dL. Mean serum vitamin D level was not different in the two

districts or in two age groups; 20 - 30 and 31 - 40 (Table 1).

Table 1: Serum vitamin D levels and calcium at different age categories and two districts.

Variable		N	Vitamin D (ng/ml) Mean (SD)	Calcium (mg/dl) Mean (SD)
District	Matara	71	20.26 (9.18)	9.39 (0.36)
	Kandy	61	20.96 (6.96)	9.16 (0.85)
Age (years)	20-30	60	20.33 (8.91)	9.42 (0.67)
	31-40	72	20.79 (7.63)	9.17 (0.60)

This table shows mean (SD) serum vitamin D (ng/ml) and calcium (mg/dl) levels of women in two districts and two age categories.

Vitamin D cut-off values published by Lips *et al.*^[21,22] were used to assess vitamin D status in this study group. According to that, vitamin D <10 ng/ml- "deficient" (VDD), 10 - 20 ng/ml "insufficient" (VDI), vitamin D >20 ng/ml- "adequate". VDD was observed in 6.1% (n = 8) subjects while 51.5% (n = 68) were VDI (10 - 20 ng/ml). Only 42.4% women in the study sample (n = 56) had normal (>20 ng/ml) vitamin D levels.

No significant correlations were observed between serum vitamin D and age (r = -0.01, p = 0.90) body weight (r = -0.11, p = 0.21) or BMI (r = -0.11, p = 0.21).

Among the 132 females who had vitamin D analysis, 81 people reported sun exposure <2 hours while 51 reported sun exposure 2 - 6 hours per day during their routine

work. Majority of women with VDD (75%) and VDI (69%) had exposed to sun light less than two hours per day.

Vitamin D level of women who had exposed to sun light <2 hours per day (19.11 ng/ml) was significantly lower (p = 0.009) compared to women who had 2 - 6 hours of sun exposure (22.93 ng/ml). Among women who had <2 hours sun exposure, 60.5% were vitamin D deficient. In contrast, only 43.1% of women with 2 - 6 hours of sun exposure were vitamin D deficient.

Table 2 shows the mean vitamin D and calcium levels in different categories based on dairy or non-dairy food intake.

Table 2: Vitamin D status of dairy and non-dairy food categories of premenopausal women.

Food type	Variable	Food quantity		
		Low	Medium	High
Non-Dairy vitamin D rich foods	Number (n)	46	42	44
	Vitamin D mean (SD) ng/ml	18.08 (7.04)	20.43 (8.22)	23.34 (8.63)
	Calcium mean (SD) mg/dl	9.27 (0.69)	9.18 (0.55)	9.40 (0.66)
Dairy food	Number (n)	48	42	42
	Vitamin D mean (SD) ng/ml	19.76 (7.18)	18.89(7.87)	23.22 (9.13)
	Calcium mean (SD) mg/dl	9.25 (0.64)	9.26 (0.53)	9.34 (0.75)

Note: SD = standard deviation

Vitamin D showed a positive association with the amount of dairy food intake per week (Pearson r = 0.20, p = 0.023) and adjusting this for the non-dairy vitamin D rich food consumption did not change the results materially. ANOVA with Bonferroni post-hoc analysis showed that vitamin D levels of 'medium' and 'low' dairy groups were significantly lower compared to 'high' dairy group (table 2, p = 0.045). However, vitamin D level between 'low' and 'medium' dairy groups was not significantly different (p > 0.05).

Further, serum vitamin D showed a positive correlation, independent of dairy food consumption, with the intake of non-dairy vitamin D rich food (Pearson r = 0.21, p = 0.014). The mean serum vitamin D level of 'high' non-dairy group was significantly higher compared to 'low' and 'medium' groups (p = 0.006). However, there was

no significant difference of vitamin D level between the 'low' and 'medium' non-dairy groups.

DISCUSSION

This study shows a high prevalence of VDD/VDI among community dwelling healthy females of 20 - 40 years in two selected districts in Sri Lanka. Further, the study demonstrates a positive association between vitamin D and exposure to sunlight. In addition, high dietary intake of vitamin D, both dairy or non-dairy, is associated with higher serum vitamin D level.

The high prevalence of VDD/VDI seen among study subjects is concordant with previous studies done in Sri Lanka.^[19,20] Unlike previous studies which included one area^[19,20] we recruited subjects from two geographically distinct regions in the country. While Matara is in the southern coastal area, Kandy is in the mid country and

has a mountainous geography. We found no regional difference in vitamin D level in this study.

Previous studies have shown a high prevalence of hypovitaminosis D among females despite abundance of sunlight throughout the year.^[8,10,12,13] There are uncertainties regarding the adequate duration and the ideal time of the day for sun exposure required for adequate vitamin D synthesis.^[17,23] According to Nimitphong and Holick, exposing face and arms to sunlight for 25 minutes, 3 times a week at 9 a.m. helps maintaining adequate vitamin D level.^[8] We too observed a significant association between the duration of sun exposure and vitamin D level. Majority of women (61%) in our study were office workers with very limited sun exposure. Most of them reported only 5 - 10 minutes sun exposure, mostly in early morning or late evening where UV-B exposure is minimum. A study conducted in India shows that, the maximum endogenous vitamin D production is between 11.00 am and 2.00 pm when the zenith angle is narrow.^[10]

Apart from restricted sun exposure, dark skin and clothing pattern may have contributed to hypovitaminosis D seen among our subjects. Melanin pigment absorbs UV-B light making skin vitamin D production ineffective. Hence, people with dark skin need more sun exposure to achieve optimum vitamin D level.^[17,18] Sri Lankans usually possess a dark skin colour and thus need to stay longer under the direct sunlight. Majority of our subjects wore "Saree" for work which covered the entire body except the face and part of upper arms.

Fatty fish is the richest natural food source of vitamin D while egg yolk and cod liver oil are also rich in vitamin D.^[24] Vitamin D content in other dietary sources is minimal unless they are fortified. Strict vegetarians are at high risk of hypovitaminosis D. Fortified food items are expensive and they are not very popular in Sri Lanka and other developing South-Asian countries.^[25]

We presume that our findings could be of interest to many sections related to community health in Sri Lanka. This study will add to the emerging body of evidence that VDD and VDI are prevalent in Sri Lanka. The positive association of vitamin D with sun exposure and some food products can be used in health promotion campaigns. Life style modifications would be the best option to address hypovitaminosis D which has a high prevalence. Fortification of commonly used food items with vitamin D can also be considered. Many countries have adopted the policy of fortifying commonly consumed food items to combat hypovitaminosis D.^[26,27]

As a health promotion behaviour, people can be encouraged to have more sun exposure. In Sri Lanka, day time temperature varies from 26°C to 32°C, except in hill country.^[28] People avoid sun exposure due to high

temperature and high humidity especially in hours where vitamin D production is maximum.^[10]

Future research are needed to investigate the best time and the optimum period of sun exposure that enhance vitamin D production in the local setting. Attention should be paid to the detrimental effects of sun exposure particularly the possibility of skin malignancies. Further, it is essential to identify food items that can be fortified with vitamin D in Sri Lankan context. These food items should be freely available, affordable and acceptable to all communities.

Indiscriminate vitamin D supplementation should not be considered until inexpensive life-style modifications are implemented and cost effectiveness of such supplementation is proven. Recent reports highlight the emergence of hypercalcaemia due to indiscriminate use of vitamin D by clinicians in some countries.^[29,30]

This study has few limitations. Subjects were selected by open invitations and those who responded could be health conscious people. This may make the sample not representative of the population. Also, we have studied only middle-aged women and this data cannot be applied to men and women outside this age range. Measurement of sun exposure was crude and we suggest prospective studies where subjects maintain a record of daily sun exposure and food intake as well.

CONCLUSION

In conclusion, our results show a high prevalence of vitamin D deficiency/insufficiency among community dwelling healthy middle-aged women in Sri Lanka. Data also indicate a positive association of vitamin D with the duration of sun exposure and daily consumption of food rich in vitamin D.

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CONFLICT OF INTEREST

The Authors declare that there is no conflict of interest.

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