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Vitamin D deficiency, associated factors & possible adverse outcomes in a tertiary care institute in Sri Lanka

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Abstract

Background & objective:

Around 50 % of the population is affected with vitamin D insufficiency worldwide. Vitamin D has multiple actions in the body and out of that calcium homeostasis is one of its many roles. It is also needed for bone growth and bone remodeling by osteoblasts and osteoclasts. Furthermore, recent research has demonstrated that vitamin D has impact on several biologic processes with several clinical implications including obesity, diabetes mellitus, and metabolic syndrome, cancer, cardiovascular disease and immune function. Studies on factors associated with vitamin D deficiency and its complications in local setting are lacking. We studied the vitamin D status, associated factors and outcome of patients attending the NHSL.

Methods:

A descriptive cross sectional study was conducted from March/ 2019 to March/ 2020 at the Endocrinology Unit of the National Hospital of Sri Lanka. Consecutive sampling was done recruiting all patients who have had vitamin D assessment as part of the routine medical care. Interviewer administered questionnaire was used collect data. Vitamin D sufficiency, insufficiency and deficiency was defined on levels of >50ng/ml, 20-50ng/ml, <20ng/ml respectively. Categorical and numerical variables were analyzed using Chi-square and independent sample t-tests respectively.

Results:

153 subjects who meets the inclusion and exclusion criteria were recruited in to the study over a period of one year. Out of the study population, majority were females (85.6%). The population mean age was 52.1 (SD ± 14.38) years and ranged from 18-89 years. The mean weight was 59.4 (SD ± 15.70) kg and BMI was 31.3 (SD ± 7.54) kg/m^{-2}. Out of the whole population 58.8% had vitamin D deficiency while 31.4 % suffered from vitamin D insufficiency. Only 9.8% the values within the normal range. The mean vitamin D status of the population is 20.9 ng/ml. Out of the possible factors causing a lower vitamin D level being included in the Muslim ethnicity, lack of education, lower income, lack of milk in the diet, the more time spent watching television, and use of clothes covering more than 90% a body surface area and having a darker skin had lower vitamin D level when compared to the other categories. The more falls (3-4 falls during the last year), the presence of cardiovascular disease, recent upper respiratory infection, chronic pain, chronic fatigue syndrome, hypertension, depression and periodontal disease had a tendency towards to association with low/insufficient vitamin D level though the value is not statistically significant. Multiple Linear Regression Analysis was carried out to determine the predictors of vitamin D status. Out of the possible factors skin colour had a significant association with vitamin D insufficiency and deficiency ($F=4.355$, $p<0.05$). Other factors such as ethnicity, education level, employment status, monthly income, marital status, no of family members, no of dependents, food preference, frequency of fish/meat intake out of non-vegetarians, frequency of milk intake, screen time per day, outdoor hours per day, sunscreen use and use of clothes which cover >90% body service area (BSA) did not exhibit a significant association the vitamin D status of the population.

Conclusions:

Majority of the patients who has undergone vitamin D level assessment in the study setting had Vitamin D levels in the deficient or insufficient range. Being included in the Muslim ethnicity, lack of education, lower income, lack of milk in the diet, the more time spent watching television, and use of clothes covering more than 90% a BSA and having a darker skin is likely to predispose lower vitamin D status. Vitamin D insufficiency and deficiency is possibly associated with more falls, the presence of cardiovascular disease, recent upper respiratory infection, chronic pain, chronic fatigue syndrome, hypertension, depression and periodontal disease cardiovascular disease, recent upper respiratory tract infection, chronic pain and chronic fatigue syndrome. Further large-scale studies to recognize potential causes and outcomes are needed in the future.

Keywords: Vitamin D, Insufficiency, Deficiency, Causes, Outcomes, Tertiary care institute

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Background

Vitamin D is a secosteroid fat-soluble vitamin that is naturally present in food and available as a dietary supplement. In addition to the external supply the endogenous production also contribute to the serum vitamin D levels by the action of external ultraviolet rays in the sunlight reaching the skin and triggering vitamin D synthesis. The exogenous and endogenous vitamin D obtained from food/ supplement and sun exposure respectively, is biologically inactive and should undergo activation in the body which includes two steps of hydroxylation. The first steps involves the 25-hydroxylase enzyme and occurs in the liver and thus converts inactive vitamin D to 25-hydroxyvitamin D [25(OH)D], also known as calcidiol. The second hydroxylation occurs primarily in the kidney and leads to formation of calcitriol which is the physiologically active vitamin D also known as 1,25-dihydroxyvitamin D [1,25(OH)2D]. Vitamin D has multiple actions in the body and out of that calcium homeostasis is one of its many roles. Vitamin D promotes calcium absorption in the gut and maintains an adequate serum calcium concentration to allow normal bone mineralization and to prevent hypocalcemic effects on the body. Furthermore, the action of vitamin D helps to maintain bone growth and bone remodeling [1]. Adequate vitamin D levels prevents osteomalacia in adults and vitamin D dependent rickets in children [1]. Vitamin D plays an important role in preventing osteoporosis in elderly by working together with body calcium. In one study, serum levels of 25-hydroxyvitamin D were directly related to bone mineral density in multiple ethnic groups with a maximum bone mineral density achieved when the 25-hydroxyvitamin D level reached 40 ng per milliliter or more [2]. Vitamin D plays a pivotal role in the regulation of encoding of proteins by specific genes that are involved in multiple cellular actions including cell proliferation, differentiation, and cell death [1]. Furthermore, recent research has demonstrated that vitamin D has an impact on several biologic processes with several clinical implications including obesity, diabetes mellitus, and metabolic syndrome, cancer, cardiovascular disease and immune function [3].

Upcoming evidence indicates that vitamin D is protective against cancer. Numerous scientific publications support the role of vitamin D in reducing colorectal cancer incidence [4]. In a recent meta-analysis of studies that examined serum 25(OH)D concentrations prospectively in relation to colorectal cancer, individuals with 25(OH)D concentrations ≥82 nmol/L had a 50% lower incidence of colorectal cancer than did those with 25(OH)D ≤30 nmol/L [4]. Though a possible association between low vitamin D status and increased breast cancer risk was detected in the experimental studies the current data has failed to prove a similar association [5]. Similarly, a proper association between prostate cancer risk and vitamin D status is not scientifically determined [6].

In a study done by Smolders et al., on patients with multiple sclerosis, a higher exacerbation risk and increased disease activity on MRI is Predicted by low

vitamin D levels in individuals with early remitting-relapsing multiple sclerosis [7]. Similar observations have been made for rheumatoid arthritis & osteoarthritis[8][9]. A recent meta-analysis has demonstrated that vitamin D supplementation in children reduces the risk of type 1 diabetes [10]. Furthermore, vitamin D deficiency has been shown to increase insulin resistance, decrease insulin production, ultimately leading to metabolic syndrome[11]. Another study showed that a combined daily intake of 1200 mg of calcium and 800 IU of vitamin D lowered the risk of type 2 diabetes by 33% (relative risk, 0.67; 95% CI, 0.49 to 0.90) as compared with a daily intake of less than 600 mg of calcium and less than 400 IU of vitamin D[12].

In a study of patients who had a diagnosis of hypertension were exposed to ultraviolet B radiation three times a week for 3 months with an increment of 25-hydroxyvitamin D levels by approximately 180%, detected to have a normal blood pressure at the end of the study [13]. Vitamin D deficiency is associated with congestive heart failure and blood levels of inflammatory factors, including C-reactive protein and interleukin-10 [14][15].

Vitamin D deficiency has been linked to an increased incidence of schizophrenia and depression [16][17]. Maintaining a satisfactory vitamin D level in utero and early years of life after birth may help to maintain an optimal vitamin D receptor dependent transcriptional activity in the brain which in turn will determine brain development as well as for maintenance of mental function later in life [18].

Measurement of the serum concentration of 25(OH) vitamin D is the best indicator of vitamin D status. It reflects the vitamin D produced on the dermis and that obtained from food & supplements and has a fairly long circulating half-life of 15 days (1)(19) . 25(OH) vitamin D levels correlate with the endogenous and exogenous production, but it is not evident how much the levels correlate with the possible health outcomes [1]. In contrast, circulating 1,25(OH)2 vitamin D measurement is not considered as an effective indicator of circulating vitamin D status as it has a short half-life (15 hours) and the serum levels are closely regulated by factors including parathyroid hormone, serum calcium, and serum phosphate [20]. Levels of 1,25(OH)2D do not typically decrease until vitamin D deficiency is severe [20]. Nevertheless, serum 25(OH) vitamin D level is not a marker of body vitamin D storage.

Multiple controversies exist on the optimal concentration of serum 25-hydroxyvitamin D levels to achieve optimal health benefits. Nevertheless, the majority of experts define vitamin D deficiency as 25-hydroxyvitamin D levels lower than 20 ng /ml (50 nmol/L) [2]. Several studies have looked at the vitamin D level in relation to the serum PTH level on the basis that the rise in PTH define the inadequate vitamin D levels in the body. The literature suggests that 25-Hydroxyvitamin D levels are inversely associated with PTH levels until the 25-hydroxy vitamin D levels former reach 30 to 40 ng /ml (75 to 100 nmol/L), beyond that the PTH levels start to plateau[21].Considering the above,a 25-hydroxyvitamin D of 21 to 29 ng /ml (52 to 72 nmol/L) is considered as vitamin D insufficiency, and a level above 30 ng/ml is considered to indicate vitamin D sufficiency in the literature [22].

Around 50 % of the population are affected with vitamin D insufficiency worldwide [20]. The increasing prevalence is attributed to many factors including lifestyle changes, reduced sunlight exposure and other personal, social environment factors. Exposure to sunlight is important for ultraviolet – B induced vitamin D production in the skin. Asians and dark pigmented people require more exposure to ultraviolet –B compared to white people due to increased absorption of ultraviolet – B to the melanin in the skin [23]. The prevalence of vitamin D deficiency (<20ng/ml) & insufficiency (20-30ng/ml) was found to be 57.2% and 31% respectively, in an urban population in Sri Lanka [24].

Although there are had been several large-scale studies done globally as well as in Asia to assess the prevalence of vitamin D deficiency, the studies done to assess it's possible causation and associated adverse health outcomes, in Sri Lanka are sparse. The above information would be valuable in preventing, treating, and avoiding adverse health effects in the community.

Methods

Adult males & females aged >18 years who are attending the Diabetes and Endocrinology clinic at the National Hospital of Sri Lanka who were requested to undergo vitamin D assessment and guided by clinical requirements was recruited to the study. The urban and suburban residents living in Colombo attend the clinic and the current study sample represent the above population.

Sample size

Sample size of 160 was calculated using the Lwanga and Lameshow 1991 formula of $n = z^2 p (100-p)D/d^2$. Studies done in the past to determine the prevalence of vitamin D insufficiency and deficiency have detected varying prevalence among different groups of populations. As patients only with clinical indications underwent vitamin D assessment, a prevalence of 85% was considered when calculating the sample size. The desired level of precision was taken as 5% (0.05) with a 95% confidence interval. The sample size calculation was done using the EPI 6 sample calculation software. Hundred and fifty three patients were recruited to the study over a period of one year from March/ 2019 to March/ 2020.

Sampling technique

Males and females aged > 18 years attending the diabetes and Endocrinology clinic who underwent vitamin D assessment were considered to be enrolled to the study. Patients who are unable to give consent or not giving consent, not meeting the inclusion criteria and or pregnant females were excluded. The participants were selected using sequential sampling method with recruitment of all the patients who come with a vitamin D assessment reports.

Data collection

The selected participants who are attending the diabetes and endocrine clinic at the National Hospital of Sri Lanka was informed regarding the study by a team of investigators. The suitable candidates were educated about the research and were invited to the study. Informed written consent was obtained by the questionnaire administrators prior to recruitment. The required data was collected with the help of an interviewer administered questionnaire. Measurements were taken on height, weight, waist circumference and muscle power according to the Medical Research Council (MRC) scale [25]. The Body Mass Index (BMI) was calculated by dividing weight (kilograms) by height (meters) squared (kg/m^2). Power was graded from 0-5 according to the MRC scale [25]. The skin color of the women was assessed according to the classification by Fitzpatrick and only category IV, V to VI were seen in the study population which were renamed as fair, intermediate and dark respectively [26]. Blood samples were evaluated for the vitamin D status (Direct Chemiluminescence method, Advia centaur analyser). The Endocrine Society Clinical Practice Guidelines were used to classify vitamin D status [27]. The values of 25(OH)D (25 hydroxy vitamin D) levels <20 ng/ml were diagnosed as deficient, the values between 20 and 30 ng/ml as insufficient and values >30 ng/ml as sufficient.

Statistical analysis

Data analysis was done using Statistical Package for Social Sciences 18 (SPSS 18). The prevalence is given in percentages with 95% confidence interval. Population characteristics were described according to descriptive data. Two sample t-test was used to compare continuous variables, while a chi-square test was used for categorical variables. Multiple linear regression analysis was used to investigate the factors associated with vitamin D status and a stepwise selection method was adopted to select significant variables. P value of 0.05 was considered as significant.

Ethical Issues

Ethical approval was acquired from the Ethical Review committee of the National Hospital of Sri Lanka. All the steps were taken to secure the confidentiality of participants. The data were encoded with numbers to avoid personal identification of the subjects.

Results

153 subjects who met the inclusion and exclusion criteria were recruited in to the study over a period of one year. Out of the study population, the majority were females (85.6%). The population mean age was 52.1 (SD ± 14.38) years and ranged from 18-89 years. Majority were Sinhalese (87.6%) followed my Muslim and Sri Lankan Tamils. Forty nine percent had been educated up to ordinary level while 7.8 % had obtained tertiary education. Sixty three percent (62.7 %) had a monthly income of less than Rs. 30,000.00 per month. Most study participants were married (79.1 %). Thirty two percent had five or more family members in the family whereas 58.8 % had two or more dependents in the family. Table 1 summarizes the study group socio-demographic characteristics.

The mean weight was 59.4 (SD ± 15.70) kg and BMI was 31.3 (SD ± 7.54) kg/m^{-2}. Males had a mean waist circumference (WC) of 91.1 (SD ± 11.36) cm while females had a value of 84.8 (SD ± 11.43) cm. Table 2 summarizes the study group anthropometric measurements.

Patients were categorized in to underweight, normal, overweight and obesity according to the Asian and WHO global and cutoffs [28].

Table 1 : Study group Socio-demographic characteristics

		Both sexes (N=153)	Males (N=22)	Females (N=131)
Mean age (SD) years		52.1 (14.38)		
Ethnicity % (N)	Sinhalese	87.6 (134)	95.5 (21)	86.3 (113)
	Muslim	5.9 (9)	4.5 (1)	6.1 (8)
	Sri Lankan Tamil	5.2 (8)	0.0 (0)	6.1 (8)
	Others	1.3 (2)	0.0 (0)	1.5 (2)
Education level % (N)	No education	5.9 (9)	4.5 (1)	6.1 (8)
	Grade 5	13.7 (21)	27.3 (6)	11.5 (15)
	Ordinary Level	49.0 (75)	45.5 (10)	49.6 (65)
	Advanced Level	23.5 (36)	13.6 (3)	25.2 (35)
	Tertiary	7.8 (12)	9.1 (2)	7.6 (10)
Employment status % (N)	Employed	41.3 (63)	59.1 (13)	38.2 (50)
	Unemployed	58.8 (90)	40.9 (9)	61.8 (81)
Monthly income (Rs.) % (N)	< 10000	11.1 (17)	9.1 (2)	11.5 (15)
	10001-20000	26.1 (40)	31.8 (7)	25.2 (33)
	20001-30000	25.5 (39)	31.8 (7)	24.4 (32)
	30001-40000	17.6 (27)	13.6 (3)	18.3 (24)
	40001-50000	11.1 (17)	0.0 (0)	13.0 (17)
	>50000	8.5 (13)	13.6 (3)	7.6 (10)
Marital Status % (N)	Married	79.1 (121)	63.6 (14)	81.7 (107)
	Unmarried	16.3 (25)	31.8 (7)	13.7 (18)
	Widowed	2.6 (4)	4.5 (1)	2.3 (3)
	Divorced	2.0 (3)	0.0 (0)	2.3 (3)
No of family members % (N)	1	11.8 (18)	4.5 (1)	13.0 (17)
	2	12.4 (19)	31.8 (7)	9.2 (12)
	3	21.6 (33)	4.5 (1)	24.4 (32)
	4	22.2 (34)	22.7 (5)	22.1 (29)
	≥ 5	32.0 (49)	36.4 (8)	31.3 (41)
No of dependents % (N)	0	24.2 (37)	13.6 (3)	26.0 (34)
	1	17.0 (26)	22.7 (5)	16.0 (21)
	2	27.5 (42)	18.2 (4)	29.0 (38)
	3	20.9 (32)	36.4 (8)	18.3 (24)
	4	7.2 (11)	9.1 (2)	6.9 (9)
	≥ 5	3.3 (5)	0.0 (0)	3.9 (5)

Table 2 : Study group Anthropometric measurements

	Both sexes (N=153)	Males (N=22)	Females (N=131)
Mean Height (SD) cm	151.5 (10.36)	158.2 (10.53)	150.4 (9.96)
Mean Weight (SD) kg	59.4 (15.70)	60.4 (17.30)	59.24 (15.49)
Mean BMI (SD) kg/m2	31.3 (7.54)	28.9 (7.60)	31.7 (11.44)
Mean WC (SD) cm	85.5 (11.5)	91.1 (11.36)	84.8 (11.43)

According to the Asian cutoffs most were obese (71.3 %) while 17.4 % were in the overweight range. Global cutoffs diagnosed 52.7%, which is the majority, as obese (Figure 1).

Out of the whole population 58.8% had vitamin D deficiency while 31.4 % suffered from vitamin D insufficiency (Figure 2). Only 9.8% had the values within the normal range. The mean vitamin D status of the population were 20.9 ng/ml. The males had a lower mean vitamin D level of 19.8 ng/ml when compared to females (21.1 ng/ml) There was no significant difference in between the two groups (p=0.573). When compared to younger and older age categories the middle aged people (age 30-59 years) had the lowest mean vitamin D level of 20.7 ng/ml though the difference is not statistically significant (Table 3).

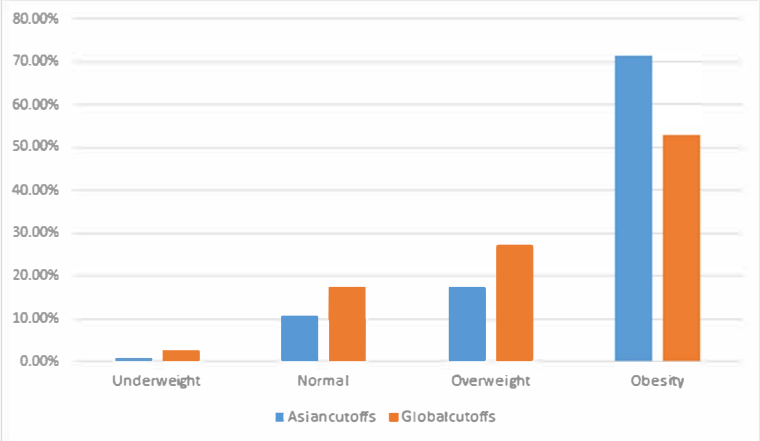

Figure 1: Prevalence (%) of underweight, normal weight, overweight and obesity according to Asian and Global cutoffs

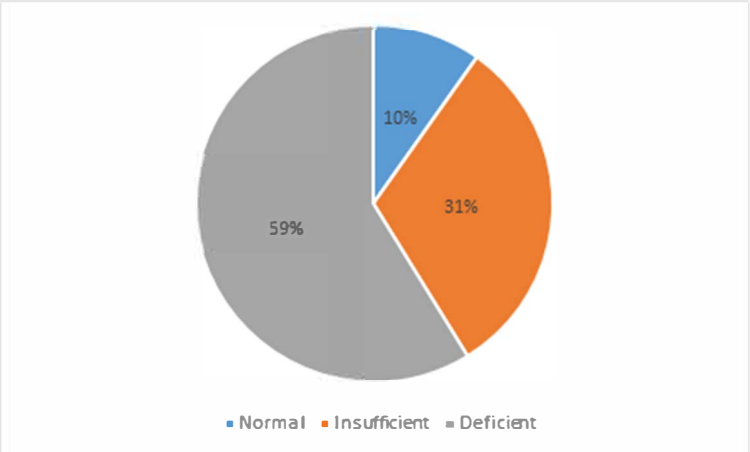

Figure 2: Vitamin D status of the study population

Table 3 : Vitamin D status of the study population according to Gender and Age categories

	Mean (ng/mL) (SD)	Normal % (N)	Insufficiency % (N)	Deficiency % (N)	P value
Whole population (N=153)	20.9 (9.89)	9.8 (15)	31.4 (48)	58.8 (90)	
According to gender					
Males (N=22)	19.8 (6.94)	4.5 (1)	31.8 (7)	63.6 (14)	0.573 (Anova)
Females (N=131)	21.1 (10.30)	10.7 (14)	31.3 (41)	58.0 (76)	
According to age category					
18 – 29 years (N=12)	21.4 (13.39)	16.7 (2)	8.3 (1)	75.0 (9)	0.420 (Chi-square)
30 – 59 years (N=84)	20.7 (10.13)	10.7 (9)	28.6 (24)	60.7 (51)	
≥ 60 years (N=57)	21.2 (8.79)	7.0 (4)	40.4 (23)	52.6 (30)	

We have studied the association between numerous factors affecting vitamin D level including ethnicity, education level, employment status, monthly income, marital status, number of family members, number of dependents, food preference, frequency of fish/meat intake out of non-vegetarians, frequency of milk intake, screen time per day, outdoor hours per day, sunscreen use, clothes which cover >90% BSA, skin colour. Even though the factors including exclusive breast feeding, mal-absorption, burns, the presence of chronic kidney disease, chronic liver cell disease, systemic lupus erythematosis (SLE), multi nodular goiter (MNG), pancreatic disease, hyperparathyroidism, bariatric surgery, recent prolonged hospitalization, chronic granulomatous conditions, lymphoma, primary hyperparathyroidism, antiepileptic use, use of antitubercular drugs, use of antiretroviral drugs, theophyllin use were inquired during the study the data were not further analyzed as the numbers were less than five. The Muslim ethnicity had the lowest mean vitamin D level (14.8 ng/ml). Uneducated population had lower vitamin D level when compared to the other groups (15.9 n/ml). People who had an income < Rs. 10,000.00 had a lower mean vitamin D level (17.4 ng/ml) when compared to the better earned groups. The lowest vitamin D level was seen in the group who did not include milk in their diet (18.6 ng/ml). People who were spending more than four hours per a day on watching television had a vitamin D level of 19.1 ng/ml which is lower when compared to the people who spent less time watching television. Individuals who used clothes which covered body surface area for more than 90% (13.2 ng/ml) had darker skin colour (18.7 ng/ml) had lower vitamin D level when compared to the other categories. The possible factors affecting vitamin D levels in the population and the mean vitamin D level in the each category as well as the percentages in the vitamin D categories are summarized in the Table 4.

The study was extended to look at possible outcome measures dependent on the vitamin D level including muscle power, falls during the last year, history of fractures, a diagnosis of cancer, cardiovascular disease, cerebrovascular disease, osteoporosis, osteopenia, rheumatoid arthritis, autoimmune thyroid disease, type 2 Diabetes Mellitus, recent upper respiratory tract infection, chronic pain, chronic fatigue syndrome, hypertension, depression and

periodontal disease. The more falls (3-4 falls during the last year) was associated with lower vitamin D level (13.1 ng/ml). The presence of cardiovascular disease and recent upper respiratory infection had a tendency towards to association with vitamin D level though the value is not statistically significant. Patients who complained of chronic pain and chronic fatigue syndrome had lower vitamin D levels at levels of 19.7ng/ml, 19.2 ng/ml respectively. Patients who were diagnosed with hypertension, depression and periodontal disease had a lower vitamin D level when compared to the individual without them. Though the study also explored the outcome factors such as the presence of multiple sclerosis, type 1 Diabetes Mellitus, Tuberculosis, Parkinson's disease, Alzheimer's disease, pelvic floor disorders and age related macular degeneration they were not analyzed as the patient number was less than five. The possible outcome factors and mean vitamin D level and the percentages in the vitamin D categories are summarized in the Table 5.

Multiple Linear Regression Analysis was carried out to determine the predictors of vitamin D status. Out of the possible factors skin colour had a significant association with vitamin D status ($F=4.355$, $p<0.05$). Other factors such as ethnicity, education level, employment status, monthly income, marital status, no of family members, no of dependents, food preference, frequency of fish/meat intake out of non-vegetarians, frequency of milk intake, screen time per day, outdoor hours per day, sunscreen use and clothes which cover >90% BSA did not exhibit a significant association with the vitamin D status of the population.

Discussion

Measurement of vitamin D level has become a common phenomenon in everyday practice [29]. With the increased tendency to measure the vitamin D levels, the insufficiency or deficiency of vitamin D levels has become a global as well as a frequently encountered problem locally. The available data suggest that vitamin D status seems to be an overlooked problem in temperate countries like Asia as it is expected to have adequate vitamin D levels in the presence of sufficient sunshine. In the current study, the majority of the study population were found to have Vitamin D deficiency (58.8%) or insufficiency (31.4 %) which is consistent with the available global data. The study in the discussion has detected more or less similar vitamin levels in both males and females (males=19.8 nmol/L, females= 21.1 nmol/L). Overall, the common determinants of lesser vitamin D status in Southeast Asia populations are younger age, female gender, urban living, exposure to sunlight, and dietary intake of sufficient vitamin D intake and physical inactivity [30][31][32][33] [34]. The current study has looked at multiple factors predicting the vitamin D status. Out of the factors studies, a positive association is seen with low vitamin D level and Muslim ethnicity, lack of education, lower income, lack of milk in the diet, the more time spent watching television, and use of clothes covering more than 90% body surface area and having a darker skin though the difference is not statistically significant. Though it is commonly thought that lower socioeconomic status is associated with lower vitamin D levels it is not the case in a study done in India as well as in the current study [35].

As commonly known vitamin D plays a key role in bone metabolism and its deficiency leads to rickets in children and osteomalacia, secondary hyperparathyroidism, osteoporosis, higher fracture risk and falls in adults [36][37]. Vitamin D deficiency is long been recognized to be associated with respiratory infections [38]. More recent studies have shown that calcitriol facilitates the production of cathelicidin which is an antimicrobial protein and enhances mycobacterial killing [39]. Furthermore, vitamin D activates T helper cells and contributes to anti-inflammatory properties of an individual [40]. Thus, low vitamin D status is found to be associated with an increased risk of autoimmune diseases and infections [14][41]. Furthermore, vitamin D is found to be associated with insulin production and secretion [42]. Thus, as expected low vitamin D status is found to be associated with the development of both type 1 and 2 diabetes [43]. An association between vitamin D deficiency and cardiovascular disease is detected in observational studies [44][45]. The current study has looked at numerous possible outcomes of vitamin D deficiency and insufficiency, and a positive association is seen in patients with more falls, the presence of cardiovascular disease, recent upper respiratory infection, chronic pain, chronic fatigue syndrome, hypertension, depression and periodontal disease cardiovascular disease, recent upper respiratory tract infection, chronic pain and chronic fatigue syndrome though the association is not statistically significant.

This study has several limitations. The study population was selected according to the availability of the vitamin D levels which were requested as a part of the routine management of the patient which might have led to inclusion of only a specified group of patients. The study has failed to demonstrate a significant association between many studied determinants and possible outcomes. The main factor contributing to the above is thought to be the lower

number of study population studied. Further studies with a larger population size and follow-up studies that span over a longer period of time may help to overcome the above problem.

Conclusions

Majority of the patients who had undergone vitamin D level assessment in the study setting had Vitamin D levels in the deficient or insufficient range. Being included in the Muslim ethnicity, lack of education, lower income, lack of milk in the diet, the more time spent watching television, and use of clothes covering more than 90% a BSA and having a darker skin is likely to predispose lower vitamin D status though a statistical significance was not demonstrated in the current study. Vitamin D insufficiency and deficiency is has a trend towards leading to more falls, the presence of cardiovascular disease, recent upper respiratory infection, chronic pain, chronic fatigue syndrome, hypertension, depression and periodontal disease cardiovascular disease, recent upper respiratory tract infection, chronic pain and chronic fatigue syndrome. Thus, vitamin D replenishment can lead to good clinical outcome in the above groups. Further large scale studies to recognize potential causes and outcomes are needed in the future.

Abbreviations

BMI - Body mass index
BSA - Body surface area
PTH- Parathyroid hormone
OH - Hydroxy
SLE - Systemic lupus erythematosis
MNG - Multi nodular goiter
MRC - Medical research council

Declarations

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An abstract has been published before on Endocrine abstracts.

Ethics approval and consent to participate

Ethical approval was obtained from the Ethical Review committee of the National Hospital of Sri Lanka. All participants who enrolled in the study signed an informed consent form.

Competing interests

None of the authors have any financial or non-financial competing interests to disclose.

Authors' information

IR is a specialist registrar at National Hospital of Sri Lanka. JPN is a research assistant attached to Diabetes and Endocrinology unit at National Hospital of Sri Lanka. NPS and MS are Senior Consultant Endocrinologists at National Hospital of Sri Lanka.

Authors' contributions

IR, MS and NPS designed the study and were involved in data collection, statistical analysis, interpretation of data and drafting the manuscript. JPN and IR were involved in data collection, data entry and data analysis. All authors read and approved the final manuscript.

Availability of data and materials

The data analyzed in this paper can be made available to researchers. Requests for access to the dataset used in this paper should be directed to the corresponding author.

Table 4 : Possible factors affecting vitamin D status

Factor	Category	Mean Vitamin D Level (SD)	Anova F	Anova Sig.	Normal & Insufficiency %	Deficiency % (N=90)	Deficiency % (N=90)
Gender	Males (N=22)	19.8 (6.94)	0.32	0.573			0.602
	Females (N=131)	21.1 (10.30)					
Ethnicity	Sinhala (134)	21.6 (10.13)	1.747	0.16	93.7 (59)	83.3 (75)	0.154
	Muslim (9)	14.8 (6.27)			1.6 (1)	8.9 (8)	
	Sri Lankan Tamil (8)	18.3 (7.04)			4.8 (3)	5.6 (5)	
	Others (2)	15.6 (6.01)			0.0 (0)	2.2. (2)	

Education level	No education (9)	15.9 (6.01)	1.147	0.33	1.6 (1)	8.9 (8)	0.213
	Grade 5 (21)	20.8 (10.24)			12.7 (8)	14.4 (13)	
	Ordinary Level (75)	20.9 (9.20)			54.0 (34)	45.6 (41)	
	Advanced Level (36)	20.7 (10.30)			20.6 (13)	25.6 (23)	
	Tertiary (12)	25.2 (13.55)			11.1 (7)	5.6 (5)	
Employment status	Employed (63)	20.6 (10.28)	0.077	0.78	38.1 (24)	43.3 (39)	0.517
	Unemployed (90)	21.1 (9.64)			61.9 (39)	56.7 (51)	
Monthly Income	< 10000 (17)	17.4 (5.15)	2.234	0.05	4.8 (3)	15.6 (14)	0.066
	10001-20000 (40)	19.7 (8.84)			23.8 (15)	27.8 (25)	
	20001-30000 (39)	24.4 (11.07)			36.5 (23)	17.8 (16)	
	30001-40000 (27)	22.6 (10.59)			19.0 (12)	16.7 (15)	
	40001-50000 (17)	17.2 (7.29)			7.9 (5)	13.3 (12)	
	>50000 (13)	19.9 (12.57)			7.9 (5)	8.9 (8)	
Marital status	Married (121)	21.4 (10.43)	0.906	0.44	81.0 (51)	77.8 (70)	0.209
	Unmarried (25)	18.2 (6.37)			11.1 (7)	20.0 (18)	
	Widowed (4)	24.5 (11.81)			4.8 (3)	1.1 (1)	
	Divorced (3)	20.1 (8.05)			3.2 (2)	1.1 (1)	
No of family members	1 (18)	20.5 (6.95)	1.123	0.25	15.9 (10)	8.9 (8)	0.484
	2 (19)	18.1 (5.75)			7.9 (5)	15.6 (14)	
	3 (33)	20.1 (9.57)			20.6 (13)	22.2 (20)	
	4 (34)	21.8 (8.99)			23.8 (15)	21.1 (19)	
	≥ 5 (49)	22.1 (12.55)			31.7 (20)	32.2 (29)	
No of dependents	0 (37)	19.5 (6.52)	1.905	0.08	25.4 (16)	23.3 (21)	0.213
	1 (26)	17.8 (9.12)			11.1 (7)	21.2 (19)	
	2 (42)	24.5 (10.67)			36.5 (23)	21.2 (19)	
	3 (32)	20.1 (10.30)			19.0 (12)	22.2 (20)	
	4 (11)	19.1 (6.60)			4.8 (3)	8.9 (8)	
	≥ 5 (5)	26.3 (20.8)			3.2 (2)	3.3 (3)	

Food preference	Non-vegetarian (137)	21.1 (9.93)	0.269	0.76	90.5 (57)	88.9 (80)	0.698
	Lacto-ovo (1)	16.18 (0)			0.0 (0)	1.1 (1)	
	Vegetarian (15)	19.6 (9.86)			9.5 (6)	10.0 (9)	
Frequency of fish/meat intake out of non-vegetarians	Daily (35)	20.5 (9.68)	2.603	0.78	26.8 (15)	26.3 (20)	0.383
	3-7/week (56)	23.4 (12.29)			48.2 (27)	38.2 (29)	
	<3 /week (41)	18.9 (5.58)			25.0 (14)	35.5 (27)	
Frequency of milk intake	> 2 glasses (5)	22.7 (10.54)	0.765	0.51	6.5 (4)	1.1 (1)	0.116
	1-2 glasses (29)	21.9 (10.05)			21.0 (13)	17.8 (16)	
	< 1 glass (88)	21.3 (10.36)			59.7 (37)	56.7 (51)	
	None (30)	18.6 (8.31)			12.9 (8)	24.4 (22)	
Screen time per day	< 1 hour (24)	18.93 (6.19)	4.111	0.008	17.5 (11)	14.4 (13)	0.485
	1-2 hours (38)	25.5 (12.69)			30.2 (19)	21.1 (19)	
	2-4 hours (15)	21.5 (12.75)			9.5 (6)	10.0 (9)	
	>4 hours (76)	19.1 (7.82)			42.9 (27)	54.4 (49)	
Outdoor hours per day	< 1 hour (123)	20.6 (9.51)	0.948	0.41	82.5 (52)	78.9 (71)	0.268
	1-2 hours (16)	24.7 (13.87)			12.7 (8)	8.9 (8)	
	2-4 hours (5)	20.9 (5.17)			3.2 (2)	3.3 (3)	
	>4 hours (9)	19.1 (8.20)			1.6 (1)	8.9 (8)	
Sunscreen use	Yes (6)	21.2 (6.85)	0.007	0.93	4.8 (3)	3.3 (3)	0.654
	No (147)	20.9 (10.00)			95.2 (60)	96.7 (87)	
Clothes which cover >90% BSA	Yes (6)	13.2 (3.17)	3.184	0.07	4.8 (3)	3.3 (3)	0.057
	No (147)	21.2 (9.93)			95.2 (60)	96.7 (87)	
Skin colour	Fair (26)	21.5 (12.23)	1.401	0.25	8	18	0.073
	Intermediate (82)	21.7 (9.59)			40	42	
	Dark (43)	18.7 (8.51)			13	30	

Table 5 : Possible outcomes associated with vitamin D status

Outcome	Category (N)	Mean Vitamin D Level (SD)	Anova F	Anova Sig.	Normal & Insufficiency % (N=63)	Deficiency % (N=90)	Chi square
Muscle power	4 (2)	27.69 (10.12)	1.217	0.299	1.6 (1)	1.1 (1)	0.345
	5 (151)	20.8 (9.86)			98.4 (62)	98.9 (89)	
Falls during last year	None (147)	20.9 (9.47)	1.771	0.174	98.4 (62)	94.4 (85)	0.327
	1-2 (3)	28.2 (25.79)			1.6 (1)	2.2 (2)	
	3-4 (3)	13.1 (5.4)			0 (0)	3.3 (3)	
History of fractures	Yes (12)	22.3 (12.56)	0.239	0.626	9.5 (6)	6.7 (6)	
	No (141)	20.8 (9.66)			90.5 (57)	93.3 (84)	
Cancers	Yes (3)	23.3 (8.82)	0.170	0.681	3.2 (2)	1.1 (1)	0.365
	No (150)	20.8 (9.92)			96.8 (61)	98.9 (89)	
Cardio-vascular disease	Yes (4)	15.6 (2.47)	1.203	0.275	0 (0)	4.4 (4)	0.09
	No (149)	21.1 (9.96)			100.0 (63)	95.6 (86)	
Cerebro-vascular disease	Yes (1)	23.9 (0)	0.095	0.759	1.6 (1)	0 (0)	0.23
	No (152)	20.9 (9.91)			98.4 (62)	100.0 (90)	
Osteopo-rosis	Yes (33)	23.4 (13.30)	2.711	0.102	27.0 (17)	17.8 (16)	0.173
	No (120)	20.2 (8.65)			73.0 (46)	82.2 (74)	
Osteope-nia	Yes (11)	21.6 (12.93)	0.062	0.803	11.1 (7)	4.4 (4)	0.116
	No (142)	20.9 (9.66)			88.9 (56)	95.6 (86)	
Rheuma-toid ar-thritis	Yes (10)	21.3 (13.39)	0.020	0.887	3.2 (2)	8.9 (8)	0.159
	No (143)	20.9 (9.65)			96.8 (61)	91.1 (82)	
Autoim-mune thy-roid dis-ease	Yes (4)	29.6 (18.89)	3.181	0.076	3.2 (2)	2.2 (2)	0.716
	No (149)	20.6 (9.53)			96.8 (61)	97.8 (88)	
Type 2 Diabetes Mellitus	Yes (21)	21.5 (10.59)	0.088	0.767	14.3 (9)	13.3 (12)	0.866
	No (132)	20.8 (9.80)			85.7 (54)	86.7 (78)	
Recent upper re-spiratory tract in-fection	Yes (4)	16.9 (1.49)	0.653	0.420	0 (0)	4.4 (4)	0.09
	No (149)	21.0 (9.99)			100.0 (63)	95.6 (86)	

Chronic pain	Yes (35)	19.7 (9.46)	0.730	0.394	20.6 (13)	24.4 (22)	0.581
	No (118)	21.3 (10.01)			79.4 (50)	75.6 (68)	
Chronic fatigue syndrome	Yes (19)	19.2 (7.74)	0.683	0.410	9.5 (6)	14.4 (13)	0.364
	No (134)	21.2 (10.14)			90.5 (57)	85.6 (77)	
Hyper-tension	Yes (131)	19.5 (6.04)	0.797	0.373	19.0 (12)	21.1 (19)	0.755
	No (122)	21.3 (10.63)			81.0 (51)	78.9 (71)	
Depres-sion	Yes (3)	20.4 (7.10)	0.009	0.924	1.6 (1)	2.2 (2)	0.78
	No (150)	20.9 (9.94)			98.4 (62)	97.8 (88)	
Periodon-tal disease	Yes (3)	19.8 (4.47)	0.039	0.844	1.6 (1)	2.2 (2)	0.78
	No (150)	20.9 (9.96)			98.4 (62)	97.8 (88)	

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