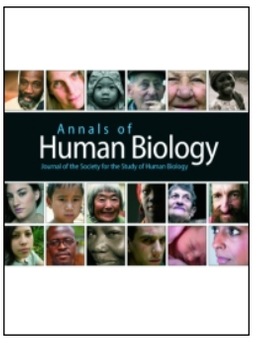

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Prevalence of vitamin D deficiency and its associated factors among urban elderly population in Hyderabad metropolitan city, South India

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Abstract

Background Deficiency of vitamin D has been associated with various health conditions. However, vitamin D deficiency (VDD) and factors associated with VDD are not well studied, especially in Indian urban elderly.

Aim To assess the prevalence of VDD and its associated factors among the urban free-living elderly population in Hyderabad.

Subjects and methods A community-based cross-sectional study was conducted among 298 urban elderly (≥60 years) by adapting a random sampling procedure. Demographic particulars were collected. Blood pressure and anthropometric measurements were recorded using standard equipment. Fasting glucose, lipid profile and 25-hydroxy vitamin D [25(OH) D] were estimated in plasma samples.

Results The mean ± SE plasma vitamin D and the prevalence of VDD among the urban elderly population were 19.3±0.54 (ng/ml) and 56.3%, respectively. The prevalence of VDD was significantly associated with education, high body mass index (BMI), hypertension (HT) and metabolic syndrome (MS). Multiple logistic regression analysis revealed HT as a significant predictor of vitamin D deficiency and the risk of VDD was double among elderly with hypertension.

Conclusion The prevalence of VDD was high among the urban elderly population in the south Indian city of Hyderabad. High BMI, MS, HT and education are significant associated factors of VDD.

Key words: Vitamin D Deficiency, Urban Elderly, Hypertension, Metabolic Syndrome.

Introduction

Vitamin D is one of the important fat-soluble vitamins and plays an important role in human health (Holick, 2010). The two major sources of vitamin D for humans are sunlight and diet. In general, the human skin synthesizes vitamin D3 (cholecalciferol) from 7-dehydrocholesterol during its exposure to solar ultraviolet B (UVB) radiation. Vitamin D plays a primary role in calcium and phosphorus homeostasis and bone metabolism. Deficiency of this vitamin is associated with rickets in children and osteoporosis in adults (Holick, 1996). Vitamin D is also utilised by the other non-skeletal tissues through vitamin D receptors (VDRs) in the body (Bikle D, 2009). Deficiency of vitamin D has been associated with various health conditions. To substantiate it, several studies have reported the relationship between low vitamin D levels and multiple diseases like cardiovascular diseases (Wang et al., 2008), hypertension (Holick, 2007), dyslipidemia (Chaudhuri et al., 2013), insulin resistance (Chiu et al., 2004), obesity (Pereira-Santos et al., 2015), diabetes (Mathieu et al., 2005), metabolic syndrome (Prasad & Kochhar, 2015), Alzheimer's disease (Evatt et al., 2008) and certain cancers (Holick, 2007). VDD also leads to secondary hyperparathyroidism, insufficient bone calcification and most likely osteomalacia with an increased risk of osteoporosis, falls and fractures (Wren et al., 2014; Bischoff-Ferrari et al., 2009). However, studies on VDD and its association with the above conditions are not well studied, especially among Indian elderly populations.

Individual vitamin D status is usually estimated by measuring plasma/serum levels of 25-hydroxyvitamin D (25[OH] D) which is the major circulating form of vitamin D (DeLuca, 2004; Calvo et al., 2005) and circulating vitamin D levels of less than 20ng/ml indicates vitamin D deficiency in general populations (Bischoff-Ferrari et al., 2006).

VDD is now recognised as a global health problem (Mithal et al, 2009) and it has been reported in all age groups all over the world (Palacios & Gonzalez, 2014). The prevalence world wide of vitamin D deficiency in elderly ranges from 3% to 100% (Holick, 2007; Palacios & Gonzalez, 2014). In comparison to other regions of the world, India is a tropical country with abundant sunlight throughout the year, but the prevalence of VDD is very common in all age groups and in both genders ranging from 10.4% to 100% (Marwaha et al., 2005; G R & Gupta, 2014; Harinarayan & Joshi, 2009; Marwaha & Sripathy, 2008). Although several studies have reported the vitamin D status of all age groups in India, very few studies have covered the elderly (≥60 years) population (Marwaha et al., 2011; Bachhel

et al., 2015) and most of these are hospital-based studies (Baidya et al., 2012; Chaudhuri et al., 2013; Mattam & Sunny, 2016).

Though sunlight is the major source for skin to synthesise vitamin D, increasing age (Hagenau et al., 2009), lack of exposure to sunlight, low dietary intake (Omdahl et al., 1982), an association of chronic diseases and other factors may contribute to VDD among elderly people (Tsiaras & Weinstock, 2011). TAlthough several western studies have reported the association of VDD with age, gender, (Daly et al., 2012; Song et al., 2014) personal habits, education (Daly et al., 2012; Lee, 2012; Brot et al.,1999), type of diet (Crowe et al., 2011; Baig, et al., 2013) , overweight & obesity (Daly et al., 2012) and high BMI (Konradsen et al., 2008; Lagunova et al., 2009), such data is not readily available in tropical countries like India especially in the urban elderly population. Thus, understanding the factors that are associated with VDD in the elderly population is very important, and will facilitate initiation of intervention measures for prevention and control of VDD and its risk factors among the elderly population. Therefore, a community-based study was undertaken with the objectives to assess the prevalence of VDD and its associated factors among the free-living urban elderly population.

Subject and methods

Study design and participants

A community-based cross-sectional study adopting random sampling procedure was carried out among urban elderly in Hyderabad metropolitan city in south India during the year 2014-15. The latitude of the city is "17.3850° N, 78.4867° E". This study was approved by the Institutional Human Ethics Committee (IHEC) of National Institute of Nutrition, Hyderabad. Subjects of ≥ 60 years were included and those who were bedridden were excluded from the study. Subjects who were currently taking vitamin D supplements or statins were excluded from the study. Assuming the prevalence of VDD as 65% among urban elderly with 95% confidence interval (CI), the relative precision of 10% and non-response of 20%, a sample size of 247 was calculated. However, we recruited 298 subjects for the present study. The Hyderabad city was divided into six zones and one municipal ward was randomly selected from each zone. The proportion of these municipal wards was around 5%. Each ward was divided into Census Enumeration Blocks (CEBs) and one CEB was selected randomly. Subjects were recruited from the households with elderly individuals starting from the

northeast corner of the CEB and the survey continued until we achieved the required sample size for each ward. In the event that the required number of subjects was not covered within the selected CEB, the adjacent CEB was surveyed to get the required number of elderly subjects. The non-response rate in this present study was 11%.

A pre-tested questionnaire was administered to all the subjects to collect the information on socio-demographic particulars, lifestyles, physical activity, type of diet and history of non-communicable diseases (NCDs). Height was measured using the anthropometric rod, weight was measured with minimum clothing using SECA digital weighing scale and body mass index (BMI) was calculated (James et al., 1988). Hip circumference (HC) and waist circumference (WC) were measured using SECA (201) measuring tape. The WHO recommended BMI cut-off values for Asian adults were used to calculate overweight and obesity (Weisell, 2002), while the WC cut-off values of ≥ 90 cm and ≥ 80 cm were considered for men and women respectively, to calculate central obesity (Alberti et al., 2005).

Blood pressure was measured thrice at a five-minute interval on the left arm of the subject using OMORAN BP apparatus (7130). The mean of the three measurements was taken to calculate systolic and diastolic blood pressures. Elderly with systolic BP of ≥140 mmHg and/or diastolic BP of ≥90 mmHg and/or those on medication for high BP were considered as hypertensive (Chobanian et al., 2003). History of diabetes was defined as having physician-diagnosed diabetes and/or using anti-diabetic medication based on self-reported information or fasting blood glucose ≥126mg/dl (World Health Organization, 2006).

History of dyslipidemia was defined as having physician-diagnosed dyslipidemia and/or using lipid lowering medication based on self-reported information or high triglyceride (TG≥150mg/dl)/ Total cholesterol (TC ≥200mg/dl)/ low levels of high-density lipoprotein (HDL) cholesterol (<40 mg/dL in men and <50 mg/dL in women) in according to the guidelines of National Cholesterol Education Programme (NCEP) guidelines (NECP, 2001). For the current study, the International Diabetes Federation (IDF) criteria were used for calculating metabolic syndrome (MS), (IDF, 2006).

Fasting intravenous blood samples (6.0 ml) were drawn into heparinized tubes, centrifuged and plasma samples were stored at -80°C until further analysis. Lipid profile (Triglycerides, Cholesterol and HDL) was estimated by kit methods (Biosystems). LDL was calculated using the Friedewald formula. Plasma 25(OH) D concentrations were estimated

using Radioimmunoassay (RIA) assay kit (DiaSorin, Italy) according to the manufacturer's instructions. Elderly subjects with vitamin D values <20ng/ml were considered as vitamin D deficient (Bischoff-Ferrari et al., 2006).

Statistical analysis

Statistical analysis was performed using the Statistical Package for Social Science (SPSS, 2005, version 19.0, Chicago). Data are presented as mean ± SE or number (%). Mean values of anthropometric measurements, blood pressure and vitamin D were compared across the gender by t-test/Mann Whitney U test. Chi-square test was performed to study the association between the prevalence of VDD and different variables. Risk estimates of vitamin D with age, education, BMI, diabetes and HT were assessed by univariate and multivariate logistic regression analysis and p <0.05 was considered as statistically significant.

Results

Demographics of the study participants are presented in Table 1. A total of 298 [194 male (65.1%) and 104 female (34.9%)] elderly subjects were recruited for the present study. The mean age of the study population was 66.68±0.34 years. The mean (±SE) anthropometric measurements of the study participants are presented in Table 2. The mean height, weight and WC of elderly men were higher compared to their female counterparts, whereas the mean BMI of women was relatively higher compared to the men. There were significant (p<0.05) gender differences in height, weight, BMI and DBP but not for the WC, SBP and vitamin D.

The prevalence of VDD and its association with various socio-demographic variables is presented in Table 3. The prevalence of VDD (<20ng/ml) among the urban elderly population was 56.3% and was relatively higher (57.2%) among men compared to women (54.5%). The prevalence of VDD increased with age and there was no significant difference between the age groups. There was a significant (p<0.05) association between the prevalence of VDD and higher level educational status of the elderly (Table 3).

The association between the prevalence of VDD and lifestyle habits is provided in Table 4. There was no significant association between the prevalence of VDD and lifestyle habits among study subjects. Nevertheless, the prevalence of VDD was relatively higher among the current smokers and vegetarians.

The association between the prevalence of VDD and NCDs amongst the urban elderly population is presented in Table 5. The prevalence of VDD was significantly (p<0.05) higher

among the elderly with metabolic syndrome (MS), overweight/obesity (BMI ≥25 kg/m^2) and hypertension. Similarly, though not statistically significant, the prevalence of VDD was higher among elderly with diabetes mellitus, abdominal obesity and dyslipidemia (p>0.05). Likewise, stepwise logistic regression analysis revealed that the risk of VDD was double among the elderly with hypertension (OR: 1.9; CI of 1.1-3.2; p<0.023).

Discussion

Our community-based study on the prevalence of VDD, is perhaps for the first of its kind exclusively carried out among free-living urban elderly of Hyderabad metropolitan city in south India. The results revealed that the prevalence of VDD among the urban elderly population was 56.3% which is comparable to the corresponding figures (58%) reported for urban male adults of 50 years and over in Varanasi (Agrawal NK & Sharma B, 2013). However, Marwaha et al. reported a very high prevalence of VDD (91.2%) among urban older adults (65 years and over) of Delhi (Marwaha et al., 2011). Similarly, another study carried out by Garg et al. also reported a high prevalence of VDD (91.3%) among urban adults (50 years and over) of Delhi (Garg et al., 2013). The high prevalence of VDD in different regions of India could be attributed to socio-religious and cultural practices which do not facilitate sufficient sun exposure (Ritu, 2014).

The factors/variables (modifiable and non-modifiable) which are associated with the prevalence of VDD were also studied. Several western studies have documented the increasing prevalence of VDD with advancement of age (Hagenau et al., 2009; MacLaughlin & Holick, 1985). Similar observations were reported by Daly et al and Song et al in their studies carried out in Australia and Korea, respectively (Daly et al., 2012; Song et al., 2014). In the present study, the prevalence of VDD increased with increasing age. The possible reasons for this scenario could be due to decrease in synthesis of vitamin D by the skin, malabsorption, decrease in conversion of the active form of vitamin D by the kidney and also reduction in the vitamin D receptors. (Christopher Gallagher, 2013).

Although the reason behind the association of VDD with level of education is unknown, a study carried out among adults including the elderly in Australia reported higher prevalence of VDD with higher level of education when compared to people who completed high/primary school or never attended school (Daly, 2012). Similar findings are reported in the present study, where the prevalence of VDD was significantly (p<0.017) higher among the elderly with a higher level of education. In contrast to these observations, a high

prevalence of VDD was reported among the US adult population for those who had no college education (Forrest and Stuhldreher, 2011).

Likewise, personal habits such as smoking (Daly et al., 2012; Jiang et al., 2016), alcohol consumption (Lee et al., 2015) and physical activity (Scragg & Camargo, 2008; Daly et al, 2012) may also have an influence on vitamin D status. In the present study, no association was found between the prevalence of VDD and current smoking or alcohol consumption. Some studies reported a positive association between physical activity and vitamin D status (Wanner et al., 2015; Marina De Rui et al., 2014). However, in our study, physical activity was not significantly associated with VDD and this could be due to various reasons such as insufficient physical activity or initiation of physical activity after they became aware of age - related health disorders.

Apart from personal habits, diet also has a prominent role in maintaining levels of plasma vitamin D in humans. In our study, the prevalence of VDD was relatively higher (58%) among vegetarians as compared to their non-vegetarian counterparts (50.9%). This high prevalence of VDD among vegetarians may be due to the availability of vitamin D2 in high concentrations in vegetarian diet sources which is a biologically less active form compared to vitamin D3 which is mainly available in animal sources, primarily in fish oil (Heaney et al., 2011). In addition, the fibre and phytates present in the vegetarian diet may deplete the storage of vitamin D (Khadilkar, 2010). Our study results were consistent with the recent study conducted in urban India (Harsh et al., 2016).

Obesity, one of the lifestyle disorders, was significantly associated with the prevalence of vitamin D deficiency (Lagunova et al., 2009; Konradsen et al., 2008). Oliai et al reported from their cross-sectional study that the elderly with high BMI and body fat had significantly lower levels of serum 25(OH) D (Oliai Araghi et al., 2015). These findings were in agreement with the findings of our study. This could be attributed to low circulating and low bioavailability of vitamin D among obese subjects (Earthman et al., 2012; Wortsman et al., 2000).

Similarly, there was an association between vitamin D deficiency and insulin resistance (Bachali et al., 2013; Wright et al., 2015), as well as risk for development of type-2 diabetes (Husemoen et al., 2012; Afzal et al., 2013). A cross-sectional study also reported an association between 25(OH)D levels and laboratory indicators of type 2 diabetes in healthy older adults of ≥45 years and above (Mauss et al., 2015). Though the association was

not significant, the prevalence of VDD in the present study was higher among elderly diabetics as compared to non-diabetics (p>0.05).

Earlier studies carried out in India and Eastern Finland have demonstrated the association between the prevalence of VDD and dyslipidemia (Chaudhuri et al., 2013; Karhapää et al., 2010). Though not statistically significant (p>0.05), the results of the present study revealed that the prevalence of VDD was relatively higher among elderly with dyslipidemia. Similarly, there is increasing evidence to suggest that VDD is significantly associated with Metabolic Syndrome (MS) in different age groups (Moy FM & Bulgiba A, 2011; Lee et al., 2013; Vitezova et al., 2015). The present study also revealed that VDD was significantly (p<0.05) associated with the prevalence of MS among the elderly. Likewise, the prevalence of VDD was significantly (p<0.01) higher among elderly with hypertension (HT) as compared to the normotensives and our observations are in agreement with earlier studies (Vaidya & Forman, 2010; Tamez H & Thadhani, 2012; Pilz et al., 2009). Multiple logistic regression analysis revealed HT as a significant (p<0.023) predictor of vitamin D deficiency and the risk of VDD was double among elderly with hypertension.

Limitations of the study

Though sunlight exposure is an important determinant of vitamin D status, information on sunlight exposure was not collected. Calcium and PTH were not estimated in the present study. Though we collected some information on lifestyle variables like current or past history of smoking and alcohol consumption including duration, we did not collect information on the frequency of smoking or thte frequency and volume of alcohol consumption which may have underestimated the association of VDD with personal habits. The data presented in the study is from a sample of healthy, urban elderly population living in Hyderabad metropolitan city. Therefore, findings from the current study may not be generalisable to other populations.

Conclusions

In general, the prevalence of VDD was high among the urban elderly population of the south Indian city of Hyderabad. High BMI, MS, HT and higher educational status are factors significantly associated with VDD among the elderly. Therefore, it is essential to take appropriate intervention measures such as primordial prevention i.e. prevention of the

development of risk factors for lifestyle diseases through health and nutrition education (HNE) and behavioural change communication (BCC).

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Conflicts of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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Table 1. Coverage particulars of elderly population (n=298)

Characteristics	n	Percent
Gender		
Male	194	65.1
Female	104	34.9
Age (years)		
60-64 Years	120	40.3
65-69 Years	92	30.9
≥70 Years	86	28.9
Type of family		
Nuclear	163	62.2
Extended nuclear	38	14.5
Joint family	61	23.3
Literacy status		
Illiterate	29	11.1
Read & write	7	2.7
Primary	18	6.9
Secondary	45	17.2
Inter (10+12)	52	19.9
Graduate	81	31.0
Post graduate	29	11.1
Marital status		
Married	260	99.2
Single	2	0.8
Living with spouse	217	82.8
Living alone	45	17.2
Currently working		
Yes	39	14.9
No	223	85.1
Past occupation		
Labour	10	3.8
Artist	2	0.8
Service	124	47.5
Business	13	5.0
Others	112	42.9
Main source of livelihood		
Own income	107	41.0
Support from family	83	31.8
Support from govt./NGO	60	23.0
Others	11	4.2
Personal habits		
Current smokers		
Yes	23	8.8
No	238	91.2
Alcohol consumption		
Yes	62	23.8
No	199	76.2
Physical activity	162	62.1
No physical activity	99	37.9
Type of diet		

Vegetarian	101	38.7
Non-vegetarian	160	61.3

n: number.

Table 2. Mean (SE) anthropometric measurements, blood pressure and vitamin-D levels among urban elderly population

Variables	Men			Women			Total		
	Anthropometric measurements								
	Mean	SE	n	Mean	SE	n	Mean	SE	n
Height (Cm)*	164.9	0.46	194	152.0	0.65	104	160.0	0.51	298
Weight (Kg)*	68.9	0.75	194	62.4	1.03	104	66.6	0.63	298
BMI (Kg/m^2)*	25.3	0.23	194	26.9	0.40	104	25.9	0.21	298
WC (Cm)	93.2	0.72	193	89.4	0.93	102	91.9	0.58	295
	Blood Pressure								
SBP (mmHg)	133.8	1.13	194	135.8	2.13	104	134.5	1.13	298
DBP (mmHg)*	80.3	0.79	194	83.5	1.03	104	81.4	0.63	298
	Vitamin-D (ng/ml)								
Vitamin D (ng/ml)	18.8	0.58	187	20.2	1.10	99	19.3	0.54	286

Values are Mean ± SE; * statistically significant ($p<0.05$) between genders, n: number.
BMI: Body mass index; WC: Waist circumference; SBP: Systolic blood pressure; DBP: Diastolic blood pressure.

Table 3. Association between the prevalence (%) of vitamin D deficiency and various demographic variables among urban elderly population

Variables	Categories	n	VDD (%)	Chi-Square	p-Value
Gender	Men	187	57.2	0.188	0.665
	Women	99	54.5		
Age	60-64	112	52.7	1.493	0.474
	65-69	91	56.0		
	≥70	83	61.4		
Type of House†	*Pucca*	256	54.3	1.696	0.428
	Semi Pucca	3	33.3		
	Kutcha	1	0.0		
Type of Family	Nuclear	161	53.4	0.919	0.632
	Ext. Nuclear	38	60.5		
	Joint	61	50.8		
Education	Illiterate	35	42.9	8.113	0.017
	1-10	62	41.9		
	College	162	60.5		
Marital Status	Yes	258	54.3	2.351	0.125
	No	2	0.0		
Working Currently	Yes	39	61.5	1.092	0.296
	No	221	52.5		
Main Source of Livelihood	Own	107	56.1	5.579	0.134
	Family	81	53.1		
	Govt/NGO	60	45.0		
	Others	11	81.8		
Past Occupation	Service	124	57.3	0.083	0.774
	Others	162	55.6		

† Type of house

***Kutcha* house:** It comprises of mud wall and thatched roof.

***Semi-Pucca* house**: Brick/stone wall with asbestos or tin roof.

***Pucca* house:** Brick wall with reinforced concrete cement (RCC)

Table 4. Association between the prevalence (%) of vitamin D deficiency and lifestyles among urban elderly population

Variables	Categories	n	VDD (%)	Chi-Square	p-Value
Tobacco	Yes	22	63.6	0.961	0.327
	No	237	52.7		
Alcohol	Yes	61	49.2	0.421	0.464
	No	198	55.2		
Physical Activity	Yes	162	54.9	0.281	0.596
	No	97	51.5		
Fruits Consumption	Yes	243	53.9	0.092	0.761
	No	16	50.0		
Type of diet	Veg	100	58.0	1.229	0.268
	Non-Veg	159	50.9		

n:number.

Table-5. Association between the prevalence (%) of vitamin D deficiency and non-communicable diseases (NCDs) amongst urban elderly population

Variables	Categories	n	VDD (%)	Chi-Square	p-Value
WC^{β} (cms)	Normal	107	49.5	2.207	0.137
	Abdominal obesity	167	58.7		
$WHR^{\ddagger}$	Normal	37	43.2	1.835	0.176
	Obese	219	55.3		
Triglycerides (mg/dL)	<150	215	53.5	1.860	0.173
	≥150	65	63.1		
Total Cholesterol (mg/dL)	<200	243	56	0.148	0.700
	≥200	38	52.6		
HDL (mg/dL)	Low	197	56.9	0.477	0.490
	Normal	84	52.4		
LDL (mg/dL)	<100	165	58.8	1.733	0.188
	≥100	116	50.9		
Dyslipidemia	Normal	66	21.7	0.604	0.437
	Dyslipidemia	216	78.3		
Metabolic syndrome	Normal	141	48.2	5.704	0.017
	Metabolic syndrome	136	62.5		
BMI^{*} (kg/m^2)	<25	107	47.7	4.042	0.044
	≥25	170	60.0		
Hypertension	Normal	93	43	9.883	0.002
	Hypertension	193	62.7		
Diabetes Mellitus	Normal	137	50.4	3.043	0.081
	Diabetes mellitus	145	60.7		

BMI^{*}: Body Mass Index; WC^{β}: Waist Circumference; $WHR^{\ddagger}$: Waist Hip Ratio; n: number.