Original Article

Pandemic of Vitamin D Deficiency: Cardiometabolic Concern or Skeletal Biochemical Abnormality?

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Abstract

Context: Biochemical Vitamin D deficiency is said to be present universally in recent times. However, its effect is more profound in modulation of anthropometric and biochemical risk factors of various chronic metabolic disorders rather than its influence on bone mineral abnormalities. The present study was undertaken to compare various anthropometric and biochemical parameters including basic bone mineral biochemistry in various strata of Vitamin D status. **Materials and Methods:** A population based study was done in the rural area of West Bengal comprising 405 people (initially targeted 400) to look for various anthropometric and biochemical parameters. **Results:** Anthropometric metabolic markers like BMI, WC, waist to height ratio and biochemical parameters like total cholesterol, LDL, TG, insulin, ALT, FPG were statistically significantly higher in vitamin D deficient (<20 ng/ml) (n = 228) subjects compared to Vitamin D non-deficient subjects (≥20 ng/ml) (n = 177) which persisted even after adjustment for BMI except for FPG. The difference was similarly present when severely Vitamin D deficient (<10 ng/ml) (n = 39) subjects were compared to Vitamin D sufficient subjects (≥30 ng/ml) (n = 38) and persisted after adjustment for BMI except for FPG. However, WHR, blood pressure (both systolic and diastolic), HbA1c, HDL, AST, Uric acid, freeT4, TSH, HOMA-IR were not different in both the above-mentioned comparisons. Metabolic syndrome was statistically significantly lower in vitamin D non-deficient subjects. Though iPTH was statistically significantly higher in the low vitamin D cohorts in both the comparisons, bone mineral markers like serum calcium, phosphorus and alkaline phosphatase were not different even when severely vitamin D deficient subjects were compared to vitamin D sufficient subjects. **Conclusion:** Pandemic of vitamin D deficiency is more likely to be associated with cardio-metabolic risk factors than biochemical bone mineral abnormality.

Keywords: Anthropometry, lipid disorders, liver disease, metabolic syndrome, vitamin D deficiency

Introduction

Vitamin D is historically known as a prohormone that regulates the bone mineral metabolism. When its serum level goes below a critical level (which is not clearly defined) several diseases related to decreased bone formation occurs which depends upon age of the patient and other factors. The biochemical hallmarks of these bone mineral problems are hypophosphatemia, low/compensated calcium level, and raised alkaline phosphatase, and elevated intact PTH level. Numerous literature of past two decades, inform us about a pandemic of Vitamin D deficiency. The deficiency is found in upto 90 percent of general population and includes almost all age groups, all ethnic groups and all socio economic strata independent of sunlight exposure. Even in a tropical country like India the situation is not much different. This pandemic of biochemical Vitamin D deficiency has provoked international professional organisation to publish guidelines which defines a serum level less than 20 ng/ml to be regarded as Vitamin D deficiency.[1] A level more than 30 ng/ml is accepted as a state of Vitamin D sufficiency.[1] The level between 20-30 ng/ml is customarily taken as the state of insufficiency.[2] Though not accepted by all, this range of insufficient Vitamin D is likely to be associated with elevation of intact PTH level without any clinical manifestation (Secondary hyperparathyroidism). On the contrary population data from IOM (Institute of Medicine) suggests the level of Vitamin D linked to EAR (Estimated average requirement) of 400 IU/day is around 16 ng/ml.[3]

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RDA (Recommended daily allowance) (i.e., 97th percentile value of Vitamin D intake) is about 600 IU/day and has its mean corresponding Vitamin D value of 20 ng/ml.[3] These cut offs did not take account of the possible extra skeletal manifestations of Vitamin D deficiency.

Despite this global biochemical Vitamin D deficiency, the bone mineral problems are not increasing to a similar proportion. Rather, observational studies are flooded with the information that this Vitamin D deficiency is associated with several extra-skeletal manifestations and is also associated with several anthropometric and biochemical cardio metabolic risk factors. In this background we looked at the biochemical effects of this so called Vitamin D deficiency along with major bone mineral metabolism markers as well as various anthropologic and biochemical cardio metabolic risk factors in an Indian rural population. We also evaluated the association of Vitamin D deficiency with metabolic syndrome by standard criteria.

Materials and Methods

We undertook a population based observational study to compare the metabolic health (anthropologic and biochemical) between Scheduled Tribe population and non Scheduled Tribe population in underdeveloped rural areas in the District of Birbhum, West Bengal, India. The results presented herein are part of the data collected in the aforementioned study. Clearance from the Institutional Ethics committee of Institute of Post Graduate Medical Education and Research was obtained.

Four hundred and five individuals (adult males and non-pregnant females) (initially targeted 400) including all ethnicity/caste were included in the study to make an appropriate representation of rural West Bengal.

Subjects were included in the study only if they agreed to give written informed consent and did not have any definite documented chronic infective or inflammatory illness. All patients had history of adequate exposure to sun and no history of pharmacological vitamin D supplementation.

We collected blood samples for biochemical tests in fasting state. Anthropometric data including height, weight, waist circumference, blood pressure were measured using standard methods. Body mass index, waist hip ratio and waist to hip ratio were then calculated. History of addiction, including tobacco and alcohol was documented.

Blood samples drawn were allowed to clot and serum was separated by centrifuging on site and samples were immediately sent for biochemical examination at a NABL (National Accreditation Board for Testing and Calibration Laboratories) accredited laboratory of West Bengal. Samples were appropriately transported on dry ice. Calcium, phosphorus, intact PTH, 25 hydroxy Vitamin D, creatinine, albumin and alkaline phosphatase levels were estimated as a part of skeletal mineral metabolism indicator. Additionally other metabolic parameters e.g., FBS, HbA1c, fasting serum insulin, lipid profile, uric acid, free T4, TSH, ALT, AST were also measured. Specifically Vitamin D and intact PTH measurement were done by Chemiluminiscence (Immulite-1000) method and measurement of calcium, phosphate and alkaline phosphatase were done by spectophotometry.

Insulin resistance was calculated by using HOMA 2 IR calculator, based on computer derived software. The IDF consensus[4] worldwide definition of the metabolic syndrome (IDF METS) included central obesity as a mandatory criteria (defined as waist circumference ≥90 cm for men and ≥80 cm for women as ethnicity specific values for Asians) plus any two of the following four factors: (i) raised triglyceride level ≥150 mg/dL or specific treatment for this lipid abnormality (ii) reduced HDL cholesterol <40 mg/dL in males and <50 mg/dL in females, or specific treatment for this lipid abnormality (iii) raised blood pressure with systolic BP ≥130 mm Hg or diastolic BP ≥85 mm Hg, or treatment of diagnosed hypertension iv) raised fasting plasma glucose (FPG) ≥100 mg/dL, or previously diagnosed type 2 diabetes.

All analyses were conducted using SAS 9.4 (SAS Institute). The continuous data are presented as mean ± standard deviation (if normally distributed) or median (inter-quartile range) (if skewed), and categorical variables are presented as proportions. The comparison between the normally distributed continuous variables was done by student's unpaired t-test and comparison between continuous variables which were not normally distributed was done by Mann-Whitney U test. Categorical variables were compared by Chi square test.

Results

There were 405 individuals who were included in the study of whom 205 persons (50.62%) were from tribal population and 200 persons (49.38%) were from non-tribal population. Of those 405 persons, 232 were female (57.28%) and 173 were male (42.72%). (Range was 18-68 years). The mean (±SD) age was 38.53 ± 11.74 years. The mean (±SD) weight was 53.89 (±11.89) Kg, BMI was 22.32 (±4.54) Kg/m2, Waist Hip Ratio was 0.87 (±0.10).

Using the current definition, the number and proportion of persons with Vitamin D sufficiency (≥30 ng/ml) was 9.38% (38/405), Vitamin D insufficiency (≥20- 29.9 ng/ml) was 34.32%(139/405), Vitamin D deficiency (<20 ng/ml) was 56.29% (228/405) and severe Vitamin D deficiency (<10 ng/ml) was 9.62% (39/405). The corresponding median (with IQR) of intact PTH level was 42.3ng/ml (IQR 33.6-75.05), 48 ng/ml (IQR 34.10-63.98), 54.7 ng/ml (IQR 36.95-81.5) 61.5 ng/ml (IQR 37.5-87.9) respectively for Vitamin level ≥ 30 ng/ml, ≥ 20- 29.9 ng/ml, 10- 19.9 ng/ml, <10 ng/ml respectively.

We first divided the study population into two groups as Vitamin D deficient ($n = 228$) and Vitamin D non-deficient ($n = 177$) based on accepted definition of deficiency as <20 ng/ml.

Table 1 summarizes the results of comparison of various normally distributed parameters between Vitamin D deficient and Non-deficient Groups.

Table 2 summarizes the results of comparison of various parameters not normally distributed between Vitamin D deficient and Non-deficient Groups.

Subsequently we compared the two subset of the study population as Severely Vitamin D deficient (n = 39) and Vitamin D sufficient (n = 38) based on a cut off level of Vitamin D as <10 ng/ml and ≥30 ng/ml respectively.

Table 3 summarizes the results of comparison of various normally distributed parameters between Vitamin D severely deficient and Vitamin D sufficient Groups.

Table 4 summarizes the results of comparison of various parameters (not normally distributed) between Vitamin D severely deficient and Vitamin D sufficient Groups.

As vitamin D deficiency is associated with increased adiposity and adiposity *per se* can alter almost all findings, we analysed all relevant parameters after adjustment of BMI except the anthropometric parameters of obesity.

Discussion

It is an established fact that Vitamin D is a prohormone that serves as an endocrine regulator of serum calcium/phosphate metabolism. Vitamin D deficiency leading to clinical bone mineral problems are almost always associated with biochemically low phosphate, high alkaline phosphatase (ALP) but serum calcium is maintained at a low normal level until the Vitamin D level is very low. In last few decades with the advent of Vitamin D assay, Vitamin D deficiency has been reported from all corners of the world and this deficiency is reported irrespective of age, sex, race, socio economic condition, physical activity, sun exposure, season changes etc. More and more information are coming forward in relation to the extra-skeletal manifestation of Vitamin D deficiency. However bone mineral problems are probably not increasing to the same extent. On the contrary, several anthropometric and biochemical cardio-metabolic risk factors including metabolic

Table 1: Comparison of various normally distributed parameters between Vitamin D deficient and non deficient groups

Variables	Mean±SD		*P*	
	Vitamin D deficient (<20 ng/ml) (n=228)	Vitamin D non deficient (≥20 ng/ml) (n=177)	Unadjusted	Adjusted for BMI
Systolic BP (mmHg)	124.5±12.8	125.4±14.4	NS	NS
Diastolic BP (mmHg)	80.2±6.79	80.2±7.2	NS	NS
Waist (cm)	78.3±12.88	74.4±11.36	0.001	-
BMI (kg/m^2)	23.26±4.9	21.14±3.6	<0.001	-
Waist/Height	0.50±0.08	0.48±0.07	<0.001	-
Waist Hip Ratio	0.89±0.10	0.87±0.09	NS	-
FPG (mg/dL)	114±43.6	106±25.7	0.03	NS
HbA1c (%)	5.79±1.2	5.6±0.9	NS	NS
Cholesterol (mg/dL)	181±41	163±38	<0.001	0.002
HDL (mg/dL)	46±47	14.6±11.7	NS	NS
LDL (mg/dL)	109±33	97±29	<0.001	0.025
Uric Acid (mg/dL)	4.28±1.4	4.25±1.2	NS	NS

P<0.05 considered as statistically significant by Student's unpaired *t*-test

Table 2: Comparison of various parameters not normally distributed between Vitamin D deficient and non-deficient groups

Variables	Vitamin D deficient (<20 ng/ml) (n=228)		Vitamin D non deficient (≥20 ng/ml) (n=177)		*P*	
	Median	IQ Range	Median	IQ Range	Unadjusted	Adjusted for BMI
ALT (U/L)	44	33-58	39	31-51	0.008	0.02
AST (U/L)	28.5	23-38	29	24-37	NS	NS
ALP (U/L)	104	83-125	96	84.5-118	NS	NS
Serum Calcium (mg/dL)	9.4	9.1-9.7	9.3	9.1-9.6	NS	NS
Serum Phosphorus (mg/dL)	3.2	3.0-3.6	3.3	3.0-3.7	NS	NS
iPTH (pg/ml)	54.9	37-82.5	48.9	34.1-66.7	0.019	0.007
TG (mg/dL)	123	91-163	95	71-119	<0.001	<0.001
Insulin (mU/L)	9.6	5.8-13.9	6.2	4.1-9.6	<0.001	<0.001
Free T4 (ng/dL)	1.03	0.93-1.15	1.04	0.91-1.16	NS	NS
TSH (μU/ml)	2.50	1.65-3.85	2.32	1.62-3.51	NS	NS
HOMA-IR	2.67	1.59-4.09	2.04	1.23-3.33	0.003	NS

P<0.05 considered as statistically significant by Mann Whitney test

Table 3: Comparison of various normally distributed parameters between severely Vitamin D deficient and Vitamin D sufficient groups

Variables	Mean±SD		*P*	
	Vitamin D severely deficient (<10ng/ml) (*n*=39)	Vitamin D sufficient (≥30 ng/ml) (*n*=38)	Unadjusted	Adjusted for BMI
Systolic BP (mmHg)	127±13.4	126±13.2	NS	NS
Diastolic BP (mmHg)	82±6.2	80±6.5	NS	NS
Waist (cm)	81.5±13.5	75±12.1	0.039	-
BMI (kg/m^2)	23.66±3.9	21.27±3.7	0.009	-
Waist/Height	0.52±0.08	0.48±0.07	0.059	-
Waist Hip Ratio	0.91±0.14	0.87±0.09	NS	-
FPG (mg/dL)	122±51	105±28	0.06	NS
HbA1c (%)	6.04±1.3	5.7±1.08	NS	NS
Cholesterol (mg/dL)	193±42.5	157±37	<0.001	0.003
HDL (mg/dL)	49±24.2	47.3±11.7	NS	NS
LDL (mg/dL)	114±37.7	91±28.3	0.003	0.046
Uric Acid (mg/dL)	4.2±1.4	4.3±1.08	NS	NS

P<0.05 considered as statistically significant by Student's unpaired *t*-test

Table 4: Comparison of various not normally distributed parameters between severely Vitamin D deficient and Vitamin D sufficient groups

Variables	Vitamin D severely deficient (<10 ng/ml) (*n*=39)		Vitamin D sufficient (≥30 ng/ml) (*n*=38)		*P*	
	Median	IQ Range	Median	IQ Range	Unadjusted	Adjusted for BMI
ALT (U/L)	44	37-63	40	27-52	0.048	0.040
AST (U/L)	25	21-36	30	25-41.5	NS	NS
ALP (U/L)	106	82-136	95	83-120	NS	NS
Serum Calcium (mg/dL)	9.5	9.2-9.8	9.35	9.1-9.5	NS	NS
Serum Phosphorus (mg/dL)	3.2	3.0-3.7	3.3	3.0-3.8	NS	NS
iPTH (pg/ml)	61.5	37.5-88.0	51.5	31.3-74.3	0.005	0.001
TG (mg/dL)	136	88-190	93	69-144	0.006	0.022
Insulin (mU/L)	9.11	5.9-15.3	4.7	3.4-8.6	0.001	0.049
Free T4 (ng/dL)	1.06	0.95-1.23	1.02	0.89-1.13	NS	NS
TSH (µU/ml)	2.11	1.62-3.12	1.87	1.32-2.95	NS	NS
HOMA-IR	2.24	1.35-4.19	2.21	1.31-3.68	NS	NS

P<0.05 considered as statistically significant by Mann Whitney test

syndromes have also been reported to be associated with Vitamin D deficiency.

Lupton JR[5] *et al.* reported data of US adults (*n* = 20,360) of their lipid profile. Deficient serum 25(OH) D (<20 ng/mL) was associated with significantly lower HDL (-5.1%) and higher total cholesterol (+9.4%), directly measured LDL (+13.5%), VLDL (+19.0%) and TG (+26.4%) when compared with the optimal group (≥ 30 ng/ml).

Potolitsyna *et al.*[6] found a relationship between the serum 25 OH vitamin D and lipid parameters in residents of the North European Russia and reported significant negative correlations especially with LDL (r = –0.307, *P* = 0.007). Though TG was also negatively correlated, this was not statistically significant. Ponda MP[7] *et al.* reported that compared to vitamin D deficient patients (<20 ng/ml), those with optimal levels (≥30 ng/ml) had lower mean total cholesterol (-1.9 mg/dl [95% CI (-1.2, -2.7 mg/dl)]; *P* <.0001), lower LDL (-5.2 mg/dl [95% CI (-4.5, -5.8 mg/dl)]; *P* <.0001), higher HDL (+4.8 mg/dl [95% CI (4.5, 5.0 mg/dl)]; *P* <.0001), and lower triglycerides (-7.5 mg/dl [95% CI (-6.2, -8.7 mg/dl)]; *P* <.0001). Patel *et al.*[8] studied 120 healthy premenopausal women (20–45 year) from Gujrat, India and documented that serum 25(OH) D concentrations had a significant inverse correlation with total cholesterol (r = −0.202, *P* = 0.027), TG (r = −0.284, *P* = 0.002) and LDL (r = −0.184, *P* = 0.044) and positive correlation with HDL (r = 0.250, *P* = 0.006). Mashahit *et al.*[9] reported that serum 25(OH) D were inversely associated with high TG and low HDL in both diabetics and control groups. Ray Chaudhuri J *et al.*[10] reported that deficiency of 25-hydroxyvitamin D was significantly associated with dyslipidemia (*P* = 0.0001) in Indian population. Study from Womack Army Medical Center,[11] North Carolina in 3,053 cases reported that vitamin D was significantly positively

correlated with HDL in all after controlling for age, gender and military status. Vitamin D concentrations were negatively associated with total cholesterol and LDL in veterans only.

Cheng S *et al.*[12] reported from data of 4,095 third generation study participants of the Framingham Heart Study, who had at least one parent in the offspring cohort, between 2002 and 2005. In multivariable-adjusted regression models, 25(OH) D was inversely associated with, waist circumference, and serum insulin ($P < 0.005$ both). Study by McGill *et al.*[13] from New Zealand, reported a cross-sectional study of 250 overweight and obese adults of different ethnicities and found that there were modest inverse associations of vitamin D3 with body weight (r = -0.21, $P = 0.0009$), BMI (r = -0.18, $P = 0.005$), waist (r = -0.14, $P = 0.03$), and HbA1c (r = -0.16, $P = 0.01$). Multivariable regression carried out separately for BMI and waist showed a decrease of 0.74 nmol/l ($P = 0.002$) in vitamin D3 per 1 kg/m^2 increase in BMI and a decrease of 0.29 nmol/L ($P = 0.01$) per 1 cm increase in waist.

Analysis by Rocha LM *et al.*[14] in a cross-sectional study of 106 adults of both genders vitamin D deficiency had higher triglycerides, VLDL, fasting blood glucose, insulin, glycated hemoglobin, BMI, waist circumference, and HOMA-IR than those of the vitamin D sufficient group ($P < 0.05$)

Marwaha RK *et al.*[15] also reported that serum 25(OH) D levels were negatively correlated with BMI (r -0.128, P 0.05). Again, level of vitamin D had a significant correlation with waist circumference ($P < 0.02$) and waist-to-hip ratio (WHR) ($P < 0.007$) in patients with polycystic ovarian syndrome from North Iran.[16] Vitamin D serostatus was inversely associated with the development of adiposity in school-age children.[17] Another study[18] on 66 white Spanish women aged 20–35 years reported that the body weight, BMI, and waist circumference of the high Vitamin D subjects were smaller than those recorded for the low vitamin D subjects (68.6 ± 4.2 kg, 26.0 ± 1.3 kg/m^2, and 79.4 ± 3.4 cm compared to 76.2 ± 9.8, 28.6 ± 3.2 kg/m2, and 86.2 ± 9.3 cm, respectively; $P < 0.05$). The hip circumference and the waist/hip ratio however were similar in both groups.

Vitamin D deficiency is common among patients with liver diseases. A growing body of evidence connects vitamin D with hepatic disease. How vitamin D status can affect liver function is poorly understood. Skaaby *et al.*,[19] from a general population based study suggested that the risk of having a high level of ALT, AST, or GGT tended to be higher for lower vitamin D levels, although this was not statistically significant. However in another study[20] Vitamin D insufficiency was not associated with the presence of NAFLD as assessed by validated non-invasive prediction models.

Vitamin D deficiency is associated with metabolic syndrome. In the study by Mitri *et al.*[21] including 1959 US adults, after multivariate adjustment, participants in the highest tertile of 25OHD had lower prevalent metabolic syndrome (OR 0.62; 95%CI 0.45-0.84), smaller WC (waist circumference), higher HDL, and lower fasting plasma glucose compared to participants in the lowest tertile of 25OHD. Higher plasma 25OHD concentration was associated with greater insulin sensitivity and lower insulin secretion. In a meta-analysis[22] including 18 relevant (16 cross-sectional and1 case control studies and 1 nested case control) it was concluded that vitamin D levels were associated with a risk of metabolic syndrome in cross sectional studies but not in longitudinal studies. The pooled odds ratio of metabolic syndrome per 25 nmol/L increment in the serum 25(OH) D concentration was 0.87 (95% CI 0.83–0.92, I2 = 85%), based on 16 cross-sectional studies.

In a cross-sectional study[23] of 239 overweight and obese, sedentary postmenopausal women without diabetes (83 black, 156 white) 25(OH) D was inversely related to fasting glucose, fasting and 2-h insulin, HOMA-IR, visceral abdominal fat, percentage fat, PTH, and triglycerides. Low 25(OH) D3 levels was also seen to be associated inversely with total adiposity, metabolic syndrome and hypertension in a cohort of caucasian children and adolescents.[24]

On the contrary, in a study from Turkey,[25] presence of metabolic syndrome was not associated with presence of vitamin D deficiency. Also, Grimnes *et al.* from a randomized controlled trial[26] using hyperglycemic clamp technique on 52 subjects documented that Vitamin D supplementation to apparently healthy subjects with insufficient serum 25(OH) D levels does not improve insulin sensitivity or secretion or serum lipid profile.

In our study from a rural part of West Bengal, India, we found mixed results. Statistically favourably lower value in Vitamin D non-deficient (≥20 ng/ml) subjects in clinical measures of obesity like BMI ($P < 0.001$), Waist Circumference ($P = 0.001$), Waist to height ratio ($P < 0.001$) were found when compared to Vitamin D deficient (<20 ng/ml) subjects. This difference was also found in similar direction when the comparison was done between Vitamin D sufficient and severely Vitamin D deficient subjects, for example, for BMI ($P = 0.009$), for Waist Circumference ($P = 0.039$), for Waist to Height ratio ($P = 0.049$). The strength of significance is lower in the second instance probably because of lower sample size in the second comparison. However waist to hip ratio was not different between the groups in either comparison.

With regards to the lipid parameters, total cholesterol, LDL, triglyceride were also favourably lower value in Vitamin D non-deficient subjects when compared to Vitamin D deficient subjects ($P < 0.001$ for all). After adjustment for BMI the difference still persisted with statistical significance [total cholesterol ($P = 0.002$), LDL ($P = 0.025$), TG ($P < 0.001$)]. This difference was also found, as expected similarly, when the comparison was between Vitamin D sufficient and severely Vitamin D deficient [total cholesterol ($P < 0.001$), LDL ($P = 0.003$), TG ($P = 0.006$)]. After adjustment for BMI the difference persisted with statistical significance [total cholesterol ($P = 0.003$), LDL

($P = 0.046$), TG ($P = 0.022$)]. However we could not find any statistically significant difference in HDL between the groups in either comparison.

Among liver enzymes, only ALT was statistically significantly higher in Vitamin D deficient subjects compared to non deficient subjects (unadjusted $P = 0.008$, adjusted for BMI $P = 0.020$). The difference was present when severely deficient compared to the Vitamin D sufficient groups (unadjusted $P = 0.048$, adjusted for BMI $P = 0.04$). However AST and ALP were not different in Vitamin D deficient or severely deficient compared to the Vitamin D non-deficient or sufficient groups respectively.

Fasting blood sugar was statistically significantly higher in Vitamin D deficient subjects compared to non-deficient subjects but after adjustment for BMI, it was not significant. While comparing fasting blood sugar between severely Vitamin D deficient and Vitamin D sufficient subjects also, it was statistically significantly higher in the first group. However after adjustment for BMI, it was not significant.

Again, in our study blood pressure (both systolic and diastolic), HbA1c, uric acid, free T4, TSH were not different in Vitamin D deficient/severe deficient compared to the Vitamin D non-deficient/sufficient groups.

Serum insulin also was statistically significantly higher in Vitamin D deficient subjects compared to non-deficient subjects ($P < 0.001$) both for unadjusted, adjusted for BMI analysis). The difference was present when severely deficient group was compared to the Vitamin D sufficient groups (unadjusted $P = 0.001$, adjusted for BMI $P = 0.049$).

Analysing the IDF METS between respective groups, we found 24% (55/228) of the Vitamin D deficient had IDF METS compared to 11.3% (20/117) subjects with vitamin D non-deficient subjects and this difference was statistically significant ($P = 0.001$ in Chi Square test). However the same comparison between severely Vitamin D deficient subjects [30.8% (12/39)] with vitamin D sufficient subjects [13.2% (5/38)] was not significant probably due to small number of subjects in the second comparison. On the contrary HOMA-IR was not different in Vitamin D deficient/severe deficient compared to the Vitamin D non-deficient/sufficient groups respectively after adjustment for BMI.

Among the bone mineral parameters, iPTH level was statistically significantly higher in Vitamin D deficient subjects compared to non-deficient subjects (54.9 vs 48.9) (unadjusted $P = 0.019$, adjusted for BMI $P = 0.007$). The difference was, as expected, more strongly present when severely deficient subjects were compared to the Vitamin D sufficient subject (68.16 vs 44.9) (unadjusted $P = 0.005$, adjusted for BMI $P = 0.001$). However serum calcium, phosphate and alkaline phosphatase levels were not different in Vitamin D deficient subjects and Vitamin D non-deficient subjects or even when severely Vitamin D deficient subjects were compared to the Vitamin D sufficient subjects.

Conclusion

Pandemic of vitamin D deficiency is likely to be associated with cardio-metabolic risk rather than biochemical bone mineral abnormality.

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Conflicts of interest

There are no conflicts of interest.

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