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Original Article

Internal Medicine Section

Correlation of 25-Hydroxy Vitamin D and Serum Lipid Profile amongst Asymptomatic Adults in Mumbai City: A Cross-sectional Study

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ABSTRACT

Introduction: Deficiency of 25-Hydroxy Vitamin D (25-OH Vitamin) is prevalent globally. Vitamin D and cholesterol metabolism are known to be linked with each other. Few International studies have attempted to relate low Vitamin D level and altered serum lipid levels. However, Indian studies are lacking, hence there is a need to conduct the studies in Indian population.

Aim: To study the correlation of the serum Vitamin D level with lipid profile amongst asymptomatic Indian adults in a tertiary care hospital, Mumbai, India.

Materials and Methods: This cross-sectional study was conducted in SevenHills Hospital, Mumbai, Maharashtra, India (tertiary care hospital), from December 2016 to August 2017. A total of 243 asymptomatic adults, visiting the wellness clinic for routine assessment of health status were randomly selected. Study participants were divided into two groups based on Vitamin D levels. Group A (n=139) with Vitamin D level <20 ng/mL, group B (n=104) with Vitamin D ≥20 ng/mL. Group B was further segregated into sub group B1 (n=60) with Vitamin D level ≥20 ng/mL to <30 ng/mL and sub group B2 (n=44) with Vitamin D level ≥30 ng/mL. Fasting blood samples were collected to measure levels of serum Vitamin D and lipid profile. The measured values of Vitamin D and serum lipids were statistically analysed for any significant relationship using Chi-square test and Unpaired t-test and Pearson's correlation.

Results: Mean age of the participants of group A was 39.94±11.59 years and group B was 47.78±11.53 years. The difference in gender distribution and average BMI of both groups was not statistically significant (p-value=0.8599 and p-value=0.4497, respectively). On comparison of group A and group B2, average High Density Lipoprotein Cholesterol (HDL-C) level was comparatively higher amongst group B2 (52.18±11.87 mg/dL vs 45.81±12.76 mg/dL; p-value=0.0038) and average Triglyceride (TG) level was higher amongst group A (104.58±70.35 mg/dL vs 129.38±64.34 mg/dL; p-value=0.0308). There was no statistically significant linear correlation found between lipid profile parameters and Vitamin D.

Conclusion: In present study, no significant correlation between Vitamin D deficiency and serum lipid profile was found. However, a statistically significant difference was found in average levels of HDL-C and TG amongst adults with adequate Vitamin D and those with Vitamin D deficiency.

Keywords: Dyslipidaemia, Healthy adults, Prevalence, Vitamin D deficiency

INTRODUCTION

Vitamin D deficiency is globally prevalent and is endemic in India [1]. The prevalence of Vitamin D ranges from 70%-100% in various geographical regions, ethnic groups, and socio-economic strata [1]. Besides the known skeletal effects of Vitamin D deficiency there are various extra-skeletal associations of Vitamin D deficiency that have been found. The association of 25-hydroxy Vitamin D (Vitamin D) deficiency with atherosclerosis [2], myocardial infarction, and stroke, has been reported [3,4].

Vitamin D is derived from 7-dehydrocholesterol in the skin upon irradiation from UV rays. 7-dehydrocholesterol is part of the metabolic pathway that controls the synthesis of cholesterol in human cells [5]. The possible interplay between Vitamin D metabolism and cholesterol metabolism can be explained by theories that involve the feedback mechanisms and interactions involving the Vitamin D metabolites, receptor and various enzymes of the cholesterol metabolism pathway [5]. These possible mechanisms include driving of Sterol Regulatory Element Binding Protein mediated feedback; suppression of 3-hydroxy-3-methyl-glutaryl-coenzyme-A reductase and Vitamin D receptor mediated CYP7A1 activity induction [5]. Therefore; it is reasonably pertinent to examine the association, if any, between Vitamin D deficiency and dyslipidaemia.

Studies conducted in China [6], and the middle east [7] found that low levels of Vitamin D were associated with increased Total Cholesterol (TC), Low Density Lipid Cholesterol (LDL-C), and Triglycerides (TG) in the study participants. However, there are very few studies done on Indian subjects [8,9]. The study conducted by Chaudhuri J et al., [8] in 2011 on urban population including 150 residents of Hyderabad, found that Vitamin D deficiency was associated with dyslipidaemia. Another observational study of 400 participants was conducted on rural population of West Bengal by Mukhopadhyay P et al., [9]. The study concluded that TC, LDL and TG were significantly higher in the deficient Vitamin D group.

However, it is known that rural and urban population have different lifestyles in terms of diet and activity. This can impact the prevalence of co-morbidities in them. A systematic review by de Groot R et al., analysed the difference in lipid profiles of urban vs rural population and found a higher prevalence of high LDL, TC and TG in urban population compared to rural [10]. Thus, the authors believe that there is need of another study on urban population. So far, there is no study on the association of Vitamin D and lipid profile conducted in western India. The present study, to the best of authors' knowledge, is the first cross-sectional study on correlation of serum Vitamin D levels and lipid profile in metropolitan city of Mumbai with a large and diverse sample size of 243 participants.

MATERIALS AND METHODS

This cross-sectional study was conducted in SevenHills Hospital, Mumbai, Maharashtra, India (tertiary care hospital), from December 2016 to August 2017. The approval was obtained by the Ethics

Committee of the Hospital (Reg.No. ECR/679/Inst/MH/2014). Participants were included in the study after informed written consent was obtained.

Inclusion criteria: Healthy adults ≥18 years of age, without any apparent illness and who consented for the study were included in the study.

Exclusion criteria: Persons taking drugs acting/modifying lipid metabolism like statins, vitamin D supplements, patients on antiepileptics, antituberculosis, and antiretroviral medication were excluded from the study. Pregnant or lactating ladies, those diagnosed with chronic thyroid, hepatic and renal disorders were also excluded [11].

Sample size calculation: Sample size of minimum 88 participants for each group of sufficient and deficient Vitamin D was calculated from the formula: $n1=n2=(z1-\alpha/2+z1-\beta)^2 *p1(1-p1)+p2(1-p2)/(p1-p2)^2$.

where,

n1=sample size for group A i.e. Vitamin D <20 ng/dL; n2=sample size for group B i.e. Vitamin 25 D ≥20 ng/dL.

α=probability of type I error (usually 0.05);

β=probability of type II error (taken as 0.1);

the power of the study was considered here as 90%;

z=critical Z value for a given α or β.

critical value for $Z\alpha$ two tailed was 1.96,

critical value for $Z\beta$ two tailed was 1.282.

Here p1 was 30.7% and p2 was 54.2%

Thus, p1-p2=-23.5% substituting the values in the formula [12]:

$n1=n2=(1.96+1.282)^2$ (0.542 (1-0.542)+0.307 (1-0.307)/(23.5) 2=87.736~90

Convenience non probability sampling method was used for sampling method.

Study participants were divided into two groups based on Vitamin-D levels:

- **Group A** (n=139): Vitamin D <20 ng/mL (Vitamin D deficient group)
- **Group B** (n=104): Vitamin D ≥20 ng/mL (Vitamin-D non deficient group)

Group B was further segregated into subgroups as per Endocrine Society clinical practice guidelines [13]:

Subgroup B1 (n=60): Vitamin D level ≥20 to <30 ng/mL (Vitamin D insufficient subgroup)

Subgroup B2 (n=44): Vitamin D level ≥30 ng/mL (Vitamin D sufficient subgroup)

Components of serum lipids in all groups/subgroups were compared with serum Vitamin D levels for statistically significant association.

Study Procedure

Medical history and demographic data of participants was recorded on predesigned proforma. Details recorded were age, gender, past medical illness, and anthropometric data such as height and weight; was recorded with study participants wearing light clothes, without footwear. Body Mass Index (BMI) was also calculated.

A sample of 10 mL peripheral fasting venous blood was collected in a plain tube. Blood samples were centrifuged at 2500 rpm for 10 minutes. Separated serum was loaded on Roche Cobas-6000 auto-analyser [14] for estimation of Vitamin D and serum lipid components [15]. Dyslipidaemia was defined when one or more of lipid components exceeded the upper limits of laboratory normative values; TC >200 mg/dL, LDL-C >130 mg/dL, HDL-C <40 mg/dL, VLDL-C >30 mg/dL, and TG >150 mg/dL (as per adult treatment panel-ATP III criteria) [16]. Details of various test used to assess biochemical parameters used in the present study are as described in [Table/Fig-1].

Parameters	Test of measurement	Normal range
Vitamin D (25 hydroxy Vitamin-D)	Electro-Chemiluminescence Immunoassay (ECLIA) technique	Interassay and intra-assay Coefficient of Variation (CV) for 25-OH Vitamin D was 7.54% and 5.67% respectively. Vitamin D Deficiency <20 ng/mL Vitamin D insufficiency: 20-30 ng/mL Normal range >30-100 ng/mL [13]
Serum total cholesterol, High-Density Lipoprotein (HDL) Cholesterol, and triglyceride levels	Homogenous enzymatic colourimetric test	TC-<200 mg/dL [16] Normal HDL C >40 mg/dL in men and >50 mg/dL in women [16] Normal triglycerides: <150 mg/dL [16]
Low-density lipoprotein (LDL) cholestrol concentration	1. Calculated using Friedewald equation [15] for TG levels less than 400 mg/dL. 2. When triglyceride levels were >400 mg/dL; estimated by direct method [14] on Roche Cobas 6000 analyser using homogenous enzymatic colourimetric test.	LDL cholesterol <100 mg/dL (Optimal 100-129 mg/dL) [16]
Very Low Density Lipoprotein (VLDL) cholesterol	Calculated using the formula TG/5	VLDL <30 mg/dL[16]

[Table/Fig-1]: Details of tests for various biochemical parameters studied.

STATISTICAL ANALYSIS

Data was recorded, tabulated, and statistically analysed in Microsoft excel office 16. Chi-square test was used to test the significance of association between tabulated values of data and qualitative, categorical data. Two-tailed Unpaired t-test was used to compare differences between mean of quantitative measurements. Pearson's Correlation analysis was applied to assess the relation of Vitamin D (independent variable) with each component of the serum lipids (dependent variables) in each of the two groups. A p-value of <0.05 was considered statistically significant.

RESULTS

The 243 participants of the study were divided into three groups. Group A had 77 (55.4%) males, 62 (44.6%) females and Group B had 57 (54.8%) males, 47(45.2%) females. Both groups were comparable for gender distribution (p-value=0.8599). Mean age of the participants in group A (39.94±11.59 years) were significantly lesser than group B (47.78±11.53 years; (p-value <0.0001). Vitamin D deficiency was thus observed more amongst younger age group. The BMI in group A was (27.12±7.34 kg/m^2) and in group B was (27.75±4.92 kg/m^2). The average BMI of both groups was statistically comparable (p-value=0.4497).

Prevalence of dyslipidaemia amongst participants of group A was 90 (64.75%) vs 62 (58.65%) in group B. This was statistically comparable (p-value=0.4135). Prevalence of dyslipidaemia in group B1 was 32 (53.33%) vs 29 (65.9%) in group B2. On comparison; prevalence was comparable in group B1 and B2 (p-value=0.2779) [Table/Fig-2].

Groups	Dyslipidaemia (n, %)	p-value (Chi-square test)
Group A (n=139)	90/139 (64.75%)	0.4135
Group B (n=104)	61/104 (58.65%)	
Subgroup B1(n=60)	32/60 (53.33%)	0.2779
Subgroup B2 (n=44)	29/44 (65.9%)	

[Table/Fig-2]: Prevalence of dyslipidaemia amongst group A, B B1 and B2 participants. p-value <0.05 was considered statistically significant

Average levels of individual lipid components (HDL, LDL, TG, TC and VLDL) in group A and group B participants were comparable using Unpaired t-test analysis (p-value for LDL=0.1518, p-value for HDL=0.4003, p-value for VLDL=0.6081, p-value for TG=0.5407, p-value for TC=0.7650, respectively) [Table/Fig-3].

Lipid profile	Group A (ng/mL)	Group B (ng/mL)	p-value
Low Density Lipoprotein (LDL) (mg/dL)	108.5±28.7	102.54±35.9	0.1518
High Density Lipoprotein (HDL) (mg/dL)	45.81±12.76	47.21±12.89	0.4003
Very Low-Density Lipoprotein (VLDL) (mg/dL)	25.52±14	26.54±14.12	0.6081
Triglyceride (TG) (mg/dL)	129.38±64.34	134.82±68.05	0.5407
Total Cholesterol (mg/dL)	180.53±41.61	177.51±39.8	0.7650
Vitamin D (ng/mL)	10.57±5.25	32.15±11.14	**<0.001**

[Table/Fig-3]: Comparison of lipid components' levels in group A and group B participants.
p-value <0.05 was considered statistically significant

On comparison of group A and group B1, there was no significant difference between the average levels of HDL, LDL, TG, TC and VLDL between both the groups. Comparatively lower levels of HDL Cholesterol (p-value=0.0038) and higher levels of Triglyceride (p-value=0.0308) was observed amongst group A participants (Vitamin D deficient group was HDL-45.81±12.76 mg/dL; TG was 129.38±64.34 mg/dL) when compared with those of subgroup B2 (Vitamin D Sufficient subgroup HDL was 52.18±11.87 mg/dL; TG was 104.58±70.35 mg/dL). This was statistically significant (p-value=0.0038 for HDL, p-value=0.0308 for TG). The observed intra group B differences (group B1 vs group B2) among individual lipid component levels between subgroup B1 and subgroup B2 were statistically not significant [Table/Fig-4].

On further analysis, there was no statistically significant linear correlation (direct or inverse) amongst any lipid profile parameter and Vitamin D on analysing with Pearson's correlation test. There was a negative correlation found between Vitamin D and LDL (r-value= -0.1211, p-value= 0.0596), TG (r-value=-0.0029, p-value= 0.97536) and TC (r-value=-0.0657, p-value= 0.3149) but was not statistically significant [Table/Fig-5].

Lipid profile	Group A (ng/mL)	Subgroup B1 (ng/mL)	Subgroup B2 (ng/mL)	p-value (Unpaired t-test)		
				Group A vs B1	Group A vs B2	Group B1 vs B2
LDL-C (mg/dL)	108.5±28.7	106.93±34.55	104.09±37.23	0.74	0.4110	0.6894
HDL-C (mg/dL)	45.81±12.76	48.01±13.63	52.18±11.87	0.276	**0.0038**	0.1069
VLDL-C (mg/dL)	25.52±14	24.76±12.60	28.95±15.86	0.718	0.1721	0.1365
Triglyceride (mg/dL)	129.38±64.34	130.83±66.65	104.58±70.35	0.8854	**0.0308**	0.0554
Total cholesterol (mg/dL)	180.53±41.61	182.63±39.38	177.24±39.77	0.7403	0.6447	0.4938
Vitamin D (ng/mL)	10.57±5.25	25±3.33	63.9±10.6	**<0.001**	**<0.001**	**<0.001**

[Table/Fig-4]: Comparison of lipid components levels in Group A, subgroup B1 and subgroup B2 participants.
p-value <0.05 was considered statistically significant

Parameters to be correlated with Vitamin D	r-value	p-value (Pearson's Correlation)
LDL	-0.1211	0.0596
HDL	0.099	0.12378
VLDL	0.0652	0.3165
Triglyceride	-0.0029	0.97536
Total cholesterol	-0.0657	0.3149

[Table/Fig-5]: Correlation analysis between vitamin D and lipid profile parameters.
¥: using Pearson's Correlation Analysis

DISCUSSION

The current cross-sectional observational study on asymptomatic adults, show 57.2% subjects had Vitamin D deficiency and 24.69% subjects had Vitamin D insufficiency. Thus, 81.89% asymptomatic participants in th study had less than adequate level of Vitamin D (Vitamin D <30 ng/mL). Details regarding gender and age distribution of study population is further discussed in Hinduja ARA et al., [17].

Dyslipidaemia are known to carry high-risk of atherosclerosis and cardiovascular morbidities [18]. In this study, dyslipidaemia was observed in 152 (62.55%) of 243 participants-122 (61.31%) participants with combined Vitamin D deficiency and insufficiency (group A and B1), and in 30 (65.9%) participants having adequate levels of Vitamin D (group B2). The observed prevalence of dyslipidaemia in the two groups (combined Vitamin D deficient and insufficient) group and Vitamin D sufficient group was statistically not significant (p-value=0.393). Prevalence of dyslipidaemia in group A (Vitamin D deficient) and sub group B2 (Vitamin D sufficient) was also observed to be similarly not significant. The observed proportion of dyslipidaemia amongst study participants is higher than reported by Gupta R et al., in their review article, stating high total cholesterol levels in the Indian population, ranging between 25-30% amongst urban and 15-20% amongst rural population [19]. Gupta R et al., [19] have also pointed to progressive increase of TC, LDL-C and TG levels over a 20 year period. Faridi KF et al., have reported moderate increase in risk of dyslipidaemia in Vitamin D deficient subjects in a prospective five years study [20]. A recent study conducted in Nepal by Nepal R et al., found that in patients with acute coronary syndrome, the mean Vitamin D levels were lower for patients with dyslipidaemia [21]. Observed lack of association of dyslipidaemia with low (deficient and insufficient) levels of Vitamin D in the present study; is in contrast to study of Chaudhuri J et al., who reported higher prevalence of dyslipidaemia (54.2) in vitamin D deficient population compared to those having sufficient Vitamin D levels (30.7%) [8].

Current study observed higher mean HDL-C levels in participants with adequate Vitamin D when compared with those of Vitamin D deficient participants (p-value=0.0038) and lower TG levels amongst participants with adequate Vitamin D levels when compared with those of Vitamin D deficient participants (p-value=0.0308). Like the current study other international studies [7,20,22,23] have also reported significant differences in the serum levels of HDL [22,23] and TG levels [23] for those with adequate level of Vitamin D when compared to those with Vitamin D deficiency. Amongst the Indian studies published so far, higher levels of serum triglyceride observed amongst Vitamin D deficient adult participants has also been reported by Chaudhuri J et al., [8]. The observed statistically significant lower serum triglyceride levels amongst people with adequate Vitamin D in the present study has also been corroborated by these studies. However, significantly elevated LDL cholesterol amongst Vitamin D deficient individuals reported by Chaudhuri J et al., was not observed in current study [8]. Comparison of the present study to the various similar national and international studies available are presented in [Table/Fig-6] [6-8,20,22-29].

Author and year of study	Study place	Study design and sample size	Study population	Prevalence of dyslipidaemia	Lipid profile findings		Correlation analysis
					TC, TG, LDL, VLDL	HDL	
Present study, 2016-2017	Mumbai	Cross-sectional study (n=243)	Inclusion: Age more than 18 years (also included geriatric population). Exclusion: CKD, CLD, thyroid disorders, medications affecting lipid profile and those on vitamin D supplementation	Equal in deficient and sufficient group	TG significantly higher in deficient group. Rest not significant.	HDL significantly higher in sufficient group.	Not significant
Doddamani S and Shetty P (2019) [24]	Bengaluru	Cross-sectional study (n=100)	20-60 years, healthy participants	Not applicable	TC and LDL significantly higher in deficient group. Rest not significant.	Not significant	Direct significant correlation of HDL in deficient group.
Annapurna K and Swarnalatha PK [25] (2018)	Kannur	Cross-sectional study (n=30)	18-20 years female 1st year medical and dental undergraduate students of ACME	Not applicable	Not significant	Not significant	Not applicable
Biswas M et al., [26] (2021)	Manipal	Cross-sectional study (n=219)	More than 18 years adults	Not applicable	Not significant	Low in deficient group for males. (significant)	Not significant
Anantharamakrishnan B and Benansia J [27] (2020)	Bengaluru	Retrospective study (n=500)	IT employees	Not applicable	LDL cholesterol was significantly higher among deficient participants.	Median HDL-cholesterol was significantly lower in deficient participants.	LDL negative correlation, TC and VLDL had weak positive correlation with Vitamin D
Chaudhari J et al., [8] (2011-2012)	Hyderabad	Cross-sectional study (n=150)	Asymptomatic adult patient attendees.	More in deficient than sufficient group.	Elevated mean TC, LDL, VLDL and TG levels in deficient group; significant.	Low HDL-C levels in deficient group (significant)	Not applicable
Al Quaiz AM et al., [7] (2014-2015)	Riyadh, Saudi	Cross-sectional study (n=1717)	Saudi, male and female participants aged 30-75 years were recruited from 18 randomly selected.	Not applicable	High TG levels in women are associated with vitamin D deficiency.	Low levels of HDL cholesterol in men with deficient Vitamin D	The risk (OR) of low HDL levels in association with Vitamin D deficiency was 2.1 times more in males and 1.3 times more in females. A significant OR of having high TG in association with Vitamin D deficient females.
Guan C et al., [6] (2011-2012)	Lanzhou China	Cross-sectional study (n=10038)	Individuals aged 40-75 years.	Deficient group had higher prevalence of dyslipidaemia.	Average TG, TC, LDL was significantly higher in deficient group.	Not significant	Inverse significant correlation for TG, LDL, TC with Vitamin D. Low Vitamin D associated with the risk of onset of dyslipidaemia (logistical regression analyses.)
Faridi KF et al., [20] (1993-1998)	United States America	Longitudinal study (n=13039)	57±6 years average age 57% women, 24% black.	Not applicable	Participants with Vitamin D deficiency had significantly higher LDL, non HDL, and TC/HDL.	Participants with Vitamin D deficiency had significantly lower HDL	Modestly increased risk for incident dyslipidaemia amongst deficient participants. No correlation analysis.
Alkhatatbeh MJ et al., [22] (2016-2017)	Irbid, Jordan	Cross-sectional study (n=105)	Inclusions: Jordan residents with chest pain (cardiac cause ruled out) Exclusions: Patients with CKD, CLD, Myocardial Infarction, acute coronary syndrome, arrhythmias, angina, heart failure and individuals on vitamin D supplements in past 3 months.	Not significant	LDL, TC, TG not significant	HDL was significantly higher in subjects with sufficient vitamin D	Vitamin D was positively correlated with HDL.
Tosunbayraktar G et al., [23] (2013)	Turkey	Cross-sectional study (n=90)	Inclusions: Individuals aged 18-63 years with diverse BMI. Exclusion: any kind of medicines, vitamins/ minerals. Pregnant/ lactating women, or any co-morbidities.	Not applicable	Participants with sufficient vitamin D had lower TG.	Participants with sufficient vitamin D had higher HDL	Not significant

Elmi C et al., [28] (2017-2018)	United States of America	Cross-sectional study (n=100)	Patients aged 18-80 years. Participants were excluded if they were diagnosed of CLD, familial hypercholesterolemia, active cancer or pregnancy. Patients on statin included.	Not applicable	Patients with Vitamin D deficiency have significantly higher level of LDL, TG, ApoB and ApoB/A ratio compare with patients have normal Vitamin D	Patients with normal Vitamin D level have significantly higher level of HDL.	Correlation study shows that Vitamin D level is negative correlated with TC, LDL, TG, ApoB and ApoB/A ratio and positive correlated with HDL.
Jeenduang N and Sangkaew B [29] (2022)	Southern Thailand	Cross-sectional study (n=726)	Exclusion criteria for subjects were the presence of chronic disease, thyroid disease, renal or hepatic disease, the use of hormone replacement therapy or lipid lowering agents, and drug abuse.	Not applicable	TC, TG, LDL, were significantly higher in hypovitaminosis D in women. The prevalence of high TG was significantly higher in hypovitaminosis D in women.	The prevalence of reduced was higher in Vitamin D deficiency in women.	Multivariate logistic regression analysis showed that the odds ratio of high TG and low HDL were significantly lower in vitamin D sufficiency in women Serum 25(OH)D levels were negatively correlated with (TC),TG and LDL in women.

[Table/Fig-6]: Comparison of various studies with present study [6-8,20,22-29].
HDL: High density lipid; LDL: Low density lipid; TG: Triglyceride; TC: Total cholesterol; VLDL: Very low density lipid

The current observational study on asymptomatic adult participants has established no significant linear correlation (Pearson's correlation) of serum lipid components with low levels of Vitamin D. This is finding is corroborated by studies of Doddamani S and Shetty P [24], Annapurna K and Swarnalatha PK [25] and Tosunbayraktar G et al., [23]. However, observed statistically significant differences between average triglyceride levels and HDL-C levels amongst Vitamin D deficient and Vitamin D sufficient adults, is an interesting finding of the study.

Limitation(s)

Impact of dietary preferences and other metabolic variables (such as parathyroid hormone, calcium and phosphorus level) had not been factored in the study. Thus, observed findings of the study cannot be generalised.

CONCLUSION(S)

Average triglyceride levels were lower and average HDL-C levels were higher in adults with adequate Vitamin D. Differences observed in other serum lipid components amongst adults of these two groups were not statistically significant. No statistically significant correlation (direct or inverse) could be established for serum TC, VLDL-C and LDL-C with serum Vitamin D levels in this observational study. We suggest, that to generalise the observed causal relationship between Vitamin D and serum lipid levels; suitably stratified randomised multicentric study across distributed geography of the country with large sample size with supplementation should be undertaken.

Authors contribution: This study was a part of PG thesis conducted at SevenHills Hospital under the guidence of AA and DC. AA and DC involved in the inception of the topic, supervision of analysis and drafting of the first version of the manuscript. HW and DP were involved in scripting the manuscript.

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