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Vitamin D Deficiency and its Relation to Lipid Profile

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ABSTRACT

The article explained the relation between deficiency in vitamin D and increase parameters of lipid profile in the serum. Therefore, correction of vitamin D deficiency will lower the lipid profile parameters and so protect the heart from diseases.

Vitamin D deficiency and its relation to lipid profile

Background: Vitamin D deficiency is considered as a major public health problem all over the world. Vitamin D acts as a hormone with multi-functions. The main source of vitamin D is solar UV radiation, which converts 7-dehydrocholesterol to pro-vitamin D which is modified to vitamin D given normal skin temperature. Vitamin D deficiency is a common disorder presents in all ages and in both genders. Vitamin D plays an important role in modulating the immune response to infections and reduction inflammatory response. Vitamin D deficiency has a genetic predisposition. There is a correlation between low 25-hydroxyvitamin D levels and dyslipidemia, so correction of vitamin D deficiency is important for treating disturbance in lipid profile. Repletion of 25-hydroxy vitamin D levels raised serum calcium level and decrease parathyroid hormone levels.

Materials: The study was carried out in a clinical Lab Al-Safowa in Cairo , Egypt on blood samples taken from 39 female patients, in the period from October 2019 to May 2020. Patients aged between (25-45) years old, all suffering from vitamin D deficiency indicated by unclear bony pain . The blood samples were estimated for lipid profile by fasting serum samples using colorimetric method and vitamin D estimation by ELIZA. The results were analyzed using SPSS (T-Test). **Results:** There were significant correlation between vitamin D deficiency and hypercholesterolemia and increase LDL levels($P<0.05$) but insignificant correlation between vitamin D deficiency and HDL and TG (significant P value > 0.05).

Conclusions: Vitamin D deficiency is correlated with increase in LDL, cholesterol. **Recommendation:** It is important to correct vitamin D deficiency to treat hyperlipidemia and so protection from cardiovascular diseases.

Aim of the work: to explain the relation between deficiency in serum level of vitamin D and disturbance in lipid profile.

KEYWORDS: Hyperlipidemia, Vitamin D deficiency, Triglycerides , LDL , HDL

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INTRODUCTION

Vitamin D is an essential dietary component for its biological effects occur only as a consequence of its metabolism into a family of daughter metabolites. **(1)** Vitamin D is well known for its important role in the maintenance of bone mineral density. However, vitamin D also has an important "non-classic" modulatory effect on the innate and adaptive immune system.**(2)** Research carried out recently indicates that vitamin D deficiency has an effective influence in many non-skeletal diseases **(3)** such as hypertension **(4)** , CVD **(5)** and **(6)**, type 1 and 2 diabetes, immune disorders, osteoporosis, and cancers **(7)** and increase liability to bacterial infection specially upper respiratory tract infection ***(8)***. Vitamin D has both genomic and non-genomic pathways, which directly and indirectly affects insulin secretion, β-cell function , and insulin resistance ***(9)*** and ***(10)***. Researchers have proved that

vitamin D is essential for normal endothelial function, blood pressure control, increased vascular resistance, and prevention of CVD. The effect of vitamin D on regulation of the lipid profile is one of the suggested mechanisms for explanation of relationship between vitamin D deficiency and CVD ***(11)*.**

Epidemiology of Vitamin D deficiency

The prevalence of vitamin D deficiency is 50% in the elderly ***(12)***, affecting near of half of adults American population ***(13)*** and about 30% of adults in Europe ***(14)***, with increased occurrence in either high- or low-latitude countries. ***(15) and (16)***. In Saudi Arabian population, vitamin D deficiency is nearby 60% of the population. The studies on the population and the different diagnostic methodology were used to prove the deficiency of vitamin D in Saudi Arabian population in spite of high sun drop on the earth ***(17)***. The results accentuated the importance of treating vitamin D deficiency in the general population ***(18).***

Genetic Predisposition of vitamin D deficiency

It was proven that problem of high prevalence of low vitamin D levels depended on genetic predisposition by single nucleotide polymorphism ***(19).***

Action of vitamin D

Vitamin D and calcium metabolism are closely related, but it can also influence several processes by the expression 900 genes. It may also affect the lipid concentrations through its effects on insulin sensitivity and is associated with metabolic syndrome ***(20)***.

Vitamin D influences mineral metabolism through suppressing parathyroid hormone (PTH) production and increasing gut calcium absorption ***(21)***. Adequate calcium intake and use of calcium supplements, have become a fundamental plan in the treatment and prevention of osteoporosis ***(22)***. Vitamin D sterols is the corner stone in protection against hypocalcaemia ***(23).*** Active form of vitamin D, 1,25-dihydroxyvitamin D (1,25 OH) D is a hormone that regulates gene expression in multiple signaling pathways, including bone mineral density and affecting immune function ***(24).***

Higher demands of vitamin D are during adolescence, pregnancy and lactation, and in some other diseases. Minimum serum level of 25(OH)D necessary to maintain good health is 30 ng/mL. In the absence of sunlight exposure and with daily oral intake of 600 IU vitamin D to compensate decrease in vitamin D level, very few people would reach serum 25(OH)D level above 30 ng/mL. Lighter-skin color need additional 1000 IU daily but those with darker skin and the elderly, require a minimum of 2000IU/ day to maintain serum 25(OH)D levels over 30 ng/mL ***(25).*** Vitamin D has an immuno-modulatory effect, modulates the expression of antimicrobial peptides such as cathelicidin, and influences the inflammatory cascade. Many studies tried to explore the relationship between vitamin D deficiency and the incidence and severity of infection in adults and children. Respiratory diseases were the main focus of these studies, although there is recent evidence that vitamin D deficiency is associated with systemic infection ***(26)***.

It was proved that optimal circulating 25(OH) D concentration of (30 ng/mL) is needed to prevent upper respiratory tract infections , enhance innate and mucosal immunity and bring about anti-inflammatory actions, possibly by the induction of regulatory T cells and the inhibition of pro-inflammatory cytokine production ***(27).***

Relation between vitamin D and lipid profile

Studying the effects of supplemental vitamin D3 on circulating lipids have been observed. Changes in levels of circulating lipids, including cholesterol and triglycerides were observed after daily supplementation of 1.0 g elemental calcium and 400 IU vitamin D3 for 5y ***(28).*** Canadian Health Measures Survey showed that plasma Hydroxy-vitamin D25 is inversely correlated with triglycerides and cholesterol. Hyper-cholestremic mices when treated by vit D, reduced the levels of plasma and liver cholesterol by increasing the presence of the hepatic-protein Cyp7a1 ***(29).***

Elevated low-density lipoprotein (LDL)cholesterol and decreased high-density lipoprotein (HDL) cholesterol levels are independent risk factors for adverse cardiovascular event ***(30)***.

It was proved the associating of normal lipid profile with high 25(OH)D levels. Correlations between higher 25(OH)D levels and lower total cholesterol, lower LDL cholesterol, higher HDL cholesterol, and lower triglycerides were proved. However, another studies showed that increasing 25 (OH) D levels from the deficient to sufficient range had a regulatory effect on the lipid profile increased total and HDL cholesterol but no change in LDL cholesterol and triglycerides ***(31)***.

Some epidemiological studies suggested an inverse association between circulating levels of 25(OH) D and cardiovascular risk biomarkers ***(32) and (33)***, but other studies have not supported the benefit of 25(OH) D supplementation to improve the blood lipid profile ***(34) and (27)***. Vitamin D can be affected by environmental factors, such as exposure to ultraviolet light and consumption of foods rich in fat-soluble vitamin D (e.g., oily sea fish, meat, and eggs), so raising vitamin D level can be done by these sources ***(34)***.

Hypo-vitaminosis D was shown to be associated not only with adverse effects on TG, total cholesterol, and LDL-cholesterol and HDL-cholesterol concentrations but also lowered insulin secretion and sensitivity in a study of healthy people from several racial and ethnic groups ***(35)***. It has been proposed that vitamin D deficiency was related to different cardiovascular disorders through its effects on endothelial function, blood pressure control and increased vascular resistance ***(36)***.It was found that vitamin D improved serum level of Triglycerides, total cholesterol and LDL in patients with DM type 2 ***(37)***.

On the other hand, Calcium and vitamin D3 shown to reduce blood triglycerides but did not change the level of blood cholesterol**.** These effects were not seen with vitamin D3 alone, indicating that calcium is the main factor responsible for the observed changes ***(38)*****.**

The effect of physical exercise on regulating lipid profile and vitamin D

Exercises, when accompanied by vitamin D supplementation, lead to a significant decrease in blood total cholesterol in young, well-trained people. It is observed a small drop in LDL and a significant one in HDL cholesterol were found after vitamin D supplementation. Some previous studies proved that 25- OH-D was inversely associated with insulin, insulin resistance, and lipid profile ***(39)***. In addition, serum (25-OH-D) level was inversely correlated with the LDL-C / HDL-C ratio and TG values in Japanese men, independent of the visceral fat area and cardiorespiratory fitness ***(40)***.

Regular exercise has been associated with an improved lipid profile in young and old subjects ***(41)***. Athletes are considered as lower blood cholesterol LDL, and higher HDL concentration compared to non-athletes ***(42)***.

Vitamin D and lipid profile in pediatrics

It was found that higher serum 25(OH)D is related to a more satisfactory lipid profile in the pediatric age group ***(43)***. Vitamin D is known to be essential for bone metabolism, and low serum 25(OH)D levels increase the risk of rickets, osteomalacia, and osteopenia ***(44)***.

METHODS

The patients were 39 females aged between 25 45 ears old who came to internal medicine out patients clinic complaining from generalized bony pain . They didn't receive any treatment or supplementations. Their blood samples were investigated for many biochemical parameters included; serum lipid profile (Cholesterol- Triglycerides- LDL-HDL) by colorimetric methods and vitamin D is estimated by ELIZA in El-Safowa clinical Lab in Cairo, Egypt .

-Blood samples are collected from patients and serum samples were obtained after centrifuged at 2000 rpm for 10 minutes.

-Blood sample 15 ml was taken from the patients under sterile conditions.

-Separation by centrifugation at 3000 rpm/10 min for obtaining serum sample.

I- Lipid profile include:

1- Cholesterol estimation by enzymatic method ***(45)*****.**

2-HDL and triglycerides were estimated by enzymatic method (***46)***.

3-LDL was estimated by enzymatic method ***(47)***.

4- Triglycerides was estimated by enzymatic method ***(45)***.

-All were estimated by automated sysmex analyzer.

II-Vit D estimation was also done By ELISA Technique Catalog Number KA1168

RESULTS

The results are analyzed by SPSS.

Parameters	**Range**	**Mean± SD**
Vitamin D	6 – 20.4	12.97 ± 4.07
Cholesterol	130 – 320	226.55 ± 46.22
LDL	89 – 208	120.13 ± 30.81
HDL	39 – 65	44.20 ± 4.32
Triglycerides	107 – 180	137.71 ± 18.82

	Vit D	
	r	P
Triglycerides	- 0.272	0.099
HDL	0.126	0.449
LDL	- 0.501	0.001*
Cholesterol	- 0.529	0.001*

r: Pearson correlation

* significant p value < 0.05

DISCUSSION

Vitamin D is a fat-soluble vitamin which is produced in the body by exposure of skin to ultraviolet light from the sun. There are many foods and other dietary supplements are the main sources of vitamin D. Vitamin D was considered as important factor for musculoskeletal health, but recently, it is proved that it is also important for maintenance of health other systems, the prevention of malignancies and protection against infections. Also, vitamin D plays an important role in regulation of endothelial function, blood pressure control, increased vascular resistance, and protection against CVD. The regulatory effect of vitamin D on the lipid profile explains the relationship between vitamin D deficiency and CVD ***(15)***.

In this study results showed that a significant relationship between serum levels of 25(OH) D and lipid profile especially LDL and Cholesterol. There was a significant correlation between vitamin D deficiency and increase in LDL and cholesterol levels (P< 0.05) but there is insignificant correlation between vitamin D deficiency and HDL and TG (P>0.05).

Ford and colleagues, 2005 in their NHANES III study, found a negative association between serum levels of 25(OH) D and TG in patients with hypertriglyceridemia. However, this relationship was not observed with regard to HDL cholesterol in healthy subjects ***(48)***. This agree with the present results that low serum vit D is associated with normal TG and normal upper limit of HDL.

Rejnmark and colleagues, 2009 performed a study on healthy postmenopausal women who had been treated with anti-cholestremic drugs, in which vitamin D, TG, and LDL levels were measured at baseline and after treatment**.** In this study the anti-cholestremic drugs showed no effect on vitamin D status, while there were a decrease the serum levels of TG and LDL***(49)***.Some results suggest that serum

concentration of TG is inversely associated with serum level of 25(OH) D. In contrast, ***Chiu, 2004*** showed no relationship between serum levels of 25(OH) D and TG or HDL cholesterol in healthy subjects ***(4)***. That agree with the present results.

All studies reported an inverse association between serum levels of 25(OH) D and Cholesterol and LDL ***(50)***. ***Wang and colleagues,2009*** showed a significant decrease in serum LDL and Cholesterol in those given vitamin D supplements. It was proved that vitamin D has both direct and indirect effects on modification of the lipid profile through increasing the activity of lipoprotein lipase in adiposity ***(51)***. Correction of serum 25(OH)D is associated with modifications in lipid profile ***(52)*** and vice versa ***(53)***.

In addition to vitamin D, calcium is suggested to have a reduction effect on lipids levels by decrese in fatty acid absorption via the formation of insoluble calcium–fatty complexes in the gut. By decreased absorption of fat, particul arly saturated fatty acids, it is expected that serum levels of total and LDL cholesterol will be reduced ***(54)***. Calcium can increase the conversion of cholesterol to bile acids due to its ability to bind with bile salts ***(55).*** However, the effect of enteric calcium on lipid absorption is very limited, and it does not have a significant effect on lipid profiles ***(56)*** and ***(57)***.

CONCLUSIONS

Serum concentration of 25-hydroxyvitamin D is generally used for evaluating vitamin D status and has been shown to be correlated inversely to hyperlipidemia with the risks of cardiovascular disorders and hence increase mortality rate. So, the importance of treatment with vit D supplementation in vitamin D deficiency and insufficiency is important to correct high levels of LDL and cholesterol and protection from cardiovascular disorders.

RECOMMENDATIONS

1. Adequate vitamin D intake in cases of deficiency or insufficiency is important to treat and protect against cardiovascular disease either in previous healthy persons or in diabetics.
2. Adequate calcium intake and maintenance of an optimal vitamin D level are important for treating and prophylaxis against postmenopausal osteoporosis in women and men older than 50 years.
3. Daily vitamin D supplements about 800 IU per day, can reduce the risk of fracture and protect the body from cardiovascular disorders through controlling lipid dyslipidemia.
4. Serum 25-(OH) D level should be tested to continuous evaluation to vitamin D deficiency or insufficiency.
5. Serum 25-(OH)D level above 20 ng/mL is proper for prophylaxis against osteoporosis. More increase in a serum 25-(OH)D level is strong helpful for management of osteoporosis ,fractures, cardiovascular disorders and regulation of blood glucose level.

LIST OF ABBREVIATIONS

UV: Ultraviolet
CVD: Cardiovascular Diseases
HDL: High Density Lipoprotein
LDL: Low Density Lipoprotein
TG: Triglycerides
DM: Diabetes Miletus
BMD: Bone Mass Density

DECLARATION

ETHICAL APPROVAL

Non-applicable

CONSENT TO PARTICIPANTS

Consent is taken from all patients.

CONSENT TO PUBLICATION

Non-applicable

DATA AVAILABILITY

The data used to support the findings of this study are included within the article.

COMPETING OF INTEREST

There is no conflict of interest with publication.

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AUTHOR CONTRIBUTION

All the authors share in the following steps: Conception of the research, Statistical analysis, Data collection, Revision and Editing.

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REFERENCES

I. Bikle DD.(2014): Vitamin D metabolism, mechanism of action, and clinical applications. Chem Biol. 2014; 21:319–329.
II. Cameron F.G., Peter M.M. and Adit A.G.(2013): The Role of vitamin D in prevention and Treatment of infection. Inflammation Allergy Drug Targets. 11;12:239-245.
III. Heaney RP (2004): Functional indices of vitamin D status and ramifications of vitamin D deficiency. Am J Clin Nutr.;80(6):1706S–1709S.
IV. Chiu KC, Chu A, Go VLW, Saad MF (2004): Hypo-vitaminosis D is associated with insulin resistance

and β cell dysfunction. Am J Clin Nutr.;79(5):820–825.

V. Michos ED, Melamed ML (2008): Vitamin D and cardiovascular disease risk. Curr Opin Clin Nutr. ;11(1):7–12.

VI. Wang TJ, Pencina MJ, Booth SL, Jacques PF, Ingelsson E, Lanier K, Benjamin EJ, D'Agostino RB, Wolf M, Vasan RS. (2008): Vitamin D deficiency and risk of cardiovascular disease. Circulation. ;117(4):503–511.

VII. Holick MF (2006): High prevalence of vitamin D inadequacy and implications for health. Mayo Clin Proc.; 81:353–373.

VIII. Dimitra Z ,Anna C and Alexandros M.(2019):The association between Vitamin D status and infectious diseases of the respiratory system in infancy and childhood.Hormones;18:353-363.

IX. Zeitz U, Weber K, Soegiarto DW, Wolf E, Balling R, Erben RG (2003): Impaired insulin secretory capacity in mice lacking a functional vitamin D receptor. FASEB J.;17(3):509–51.

X. Delvin EE, Lambert M, Levy E, O'Loughlin J, Mark S, Gray-Donald K, et al. (2010): Vitamin D status is modestly associated with glycemia and indicators of lipid metabolism in French-Canadian children and adolescents. J Nutr.; 140(5):987–91.

XI. Nemerovski CW, Dorsch MP, Simpson RU, Bone HG, Aaronson KD, Bleske BE. (2009): Vitamin D and cardiovascular disease. J Hum Pharmacol Drug Ther. ;29(6):691–708.

XII. Pilz S, Marz W, Wellnitz B, Seelhorst U, Fahrleitner-Pammer A, Dimai HP, et al (2008): Association of vitamin D deficiency with heart failure and sudden cardiac death in a large cross-sectional study of patients referred for coronary angiography. J Clin Endocrinol Metabol.; 93(10):3927–35.

XIII. Al Mheid I, Patel R, Murrow J, Morris A, Rahman A, Fike L, et al (2011): Vitamin D status is associated with arterial stiffness and vascular dysfunction in healthy humans. J Am Coll Cardiol.;58(2):186–92.

XIV. Zakeri H (2011): Vitamin D, deficiency prevalence in summer compared to winter in a city with high humidity and a sultry climate. Women.;94:96.

XV. Saedisomeolia A, Taheri E, Djalali M, Moghadam AM, Qorbani M (2014): Association between serum level of vitamin D and lipid profiles in type 2 diabetic patients in Iran. J Diabetes Metab Disord.;13(1):1.

XVI. Kelishadi R, Farajzadegan Z, Bahreynian M (2014): Association between vitamin D status and lipid profile in children and adolescents: a systematic review and meta-analysis. Int. J. Food Sci Nutr.;65(4):404–10.

XVII. Haneen Al-Alyani, Haifa A. Al-Turki, Omar N. Al-Essa, Fawaz M. Alani and Mir Sadat-Ali (2018):Vitamin D deficiency in Saudi Arabians: A reality or simply hype: A meta-analysis (2008–2015). J Family Community Med. 2018 Jan-Apr; 25(1): 1–4.

XVIII. AlQuaiz MA, Kazi A, Youssef RA, Alshehri M and Aldarweyshi SA(2020): Association between standardized vitamin 25(OH)D and dyslipidemia: a community-based study in Riyadh, Saudi Arabia. Environmental Health and Preventive Medicine,25:(4):2020. Open access ID1674.

XIX. Mir-Sadat A.,Haifa A.,Mohammed A(2016): Genetic influence on circulating vitamin D among Saudi Arabian.Saudi Med J.;37:966-1001.

XX. Vitezova A, Zillikens MC, van Herpt TT, Sijbrands EJ, Hofman A, Uitterlinden AG, Franco OH, Kiefte-de JongJC (2015): Vitamin D status and metabolic syndrome in the elderly: The Rotterdam Study. Eur J Endocrinol 172: 327. –335.

XXI. De Luca HF (2004): Overview of general physiologic features and functions of vitamin D. Am J Clin Nutr.;80(6 Suppl):1689S–1696S.

XXII. Compston J, Bowring C, Cooper A, et al (2013): Diagnosis and management of osteoporosis in postmenopausal women and older men in the UK: National Osteoporosis Guideline Group (NOGG). Maturitas ; 75:392-6.

XXIII. Horst RL , Goff JP and Reinhardt TA. (2003): Role of vitamin D in calcium homeostasis and its use in prevention of bovine peri-parturient paresis. Acta Vet Scand Suppl; 97:35-50.

XXIV. Dixon BM, Barker T, McKinnon T, Cuomo J, Frei B, Borregaard N, Gombart AF.(2012): Positive correlation between circulating cathelicidin antimicrobial peptide (hCAP18/LL-37) and 25hydroxyvitamin D levels in healthy adults. BMC Res Notes; 5:575.

XXV. Bischoff –Ferrari HA, Willett WC, Orav EJ, et al (2012): A pooled analysis of vitamin D dose requirements for fracture prevention N Eng.J.Med.;367:40-9.

XXVI. Kempker JA, Martin GS. Vitamin D and Sepsis(2013): From Associations to Causal Connections. Inflamm. Allergy Drug Targets.; 12(4):003.

XXVII. He CS, Aw Yong XH, Walsh NP, Gleeson M.(2016): Is there an optimal vitamin D status for immunity in athletes and military personnel? Exerc Immunol Rev.;22:42–64.

XXVIII. Rajpathak SN, Xue X, Wassertheil-Smoller S, Van Horn L, Robinson JG, Liu S, et al (2010): Effect of 5 y of calcium plus vitamin D supplementation on change in circulating lipids: results from the

Women's Health Initiative. Am J Clin Nutr.;91(4):894–9.

XXIX. Chow EC, Magomedova L, Quach HP, Patel R, Durk MR, Fan J, Maeng HJ, Irondi K, Anakk S, Moore DD, Cummins CL, Pang KS (2014): Vitamin D receptor activation down-regulates the small heterodimer partner and to lower cholesterol increases CYP 1059-1048:146. Gastroenterology.

XXX. Superko HR (2009): Advanced lipoprotein testing and sub-fractionation are clinically useful. Circulation.;119.:2383–2395.

XXXI. Martins D, Wolf M, Pan D, Zadshir A, Tareen N, Thadhani R, Felsenfeld A, Levine B, Mehrotra R, Norris K (2007): Prevalence of cardiovascular risk factors and the serum levels of 25-hydroxyvitamin D in the United States: data from the Third National Health and Nutrition Examination Survey. Arch Intern Med.167:1159–1165.

XXXII. Wang H, Xia N, Yang Y, Peng D-Q (2012): Influence of vitamin D supplementation on plasma lipid profiles: a meta-analysis of randomized controlled trials. Lipids Health Dis2012;11(1):1.

XXXIII. Ponda MP, Huang XX, Odeh MA, Breslow JL, Kaufman HW (2012): Vitamin D may not improve lipid levels: a serial clinical laboratory data study. Circulation.;126:2707.

XXXIV. John WG, Noonan K, Mannan N, Boucher BJ. (2005): Hypo-vitaminosis D is associated with reductions in serum apolipoprotein AI but not with fasting lipids in British Bangladeshis. Am J Clin Nutr.;82(3):517–22.

XXXV. Grimnes G, Figenschau Y, Almås B, Jorde R (2011): Vitamin D, insulin secretion, sensitivity, and lipids result from a case-control study and a randomized controlled trial using hyperglycemic clamp technique. Diabetes.;60(11): 2748–57.

XXXVI. Alam U, Najam O, Al-Himdani S, Benoliel S, Jinadev P, Berry J, et al (2012): Marked vitamin D deficiency in patients with diabetes in the UK: ethnic and seasonal differences and an association with dyslipidemia. Diabet Med.29(10):1343–5.

XXXVII. Tina J,Aziz A,Asfhin B ,Plumx M.(2016): Effects of vitamin D on serum lipid profile in patients with type 2 DM: A meta-analysis of randomized controlled trials. Clinical Nutrition; 35:1259-1268.

XXXVIII. Chai W, Cooney RV, Franke AA, Bostick RM (2013):Effects of calcium and vitamin D supplementation on blood pressure and serum lipids and carotenoids: a randomized, double-blind, placebo-controlled, clinical trial Epidemiol 570-564: 23Ann.

XXXIX. Garcia-Bailo B, Da Costa LA, Arora P, Karmali M, ElSohemy A, Badawi A (2013): Plasma vitamin D and biomarkers of cardiometabolic disease risk in adult Canadians, 2007–2009. Prev Chronic Dis 10: E91.

XL. Sun X, Cao ZB, Tanisawa K, Ito T, Oshima S, Ishimi Y, Tabata I, Higuchi M. (2015): Associations between theSerum 25(OH)D Concentration and Lipid Profiles in Japanese Men. J Atheroscler Thromb 22: 355–362.

XLI. Zorba E, Cengiz T, Karacabey K (2011): Improves body composition, blood lipid profile, Fitness and excersie serum insulin levels in obese children. J Sports Med Phys Fitness. Exercise train 51: 664–669.

XLII. Zanella AM, Nakazone MA, Pinhel MA, Souza DR (2011) :Lipid profile, apolipoprotein A-I and oxidative stress in professional footballers, sedentary individuals, and their relatives. Arq Bras Endocrinol Metabol 55: 121–126.

XLIII. Kelishadi R, Farajzadegan Z, Bahreynian M (2014): Association between vitamin D status and lipid profile in children and adolescents: a systematic review and meta-analysis. Int J Food Sci Nutr.;65(4):404–10.

XLIV. Sonja Soininen, Aino-Maija Eloranta, Anna Viitasalo, Geneviève Dion, Arja Erkkilä, Virpi Sidoroff, Virpi Lindi, Anitta Mahonen, Timo A Lakka (2018): Serum 25-hydroxyvitamin D, Plasma Lipids, and Associated Gene Variants in Prepubertal Children. The Journal of Clinical Endocrinology & Metabolism; DOI: 10.1210/jc.2018-00335.

XLV. Burtis CA, Ashwood ER (2001); editors. Tietz Fundamentals of Clinical Chemistry, 5th ed. Philadelphia, PA: WB Saunders:480–5.

XLVI. Young DS (2001). Effects of disease on Clinical Lab. Tests, 4thed.AACC.

XLVII. EA (1987); Lipids, lipoprotein, and apolipoprotein. In: NW Tietz, ed. Fundamentals of clinical chemistry, 3 rd ed. Philadelphia: WB Saunders;pp:448.

XLVIII. Ford ES, Ajani UA, McGuire LC, Liu S (2005): Concentrations of serum vitamin D and the metabolic syndrome among US adults. Diabetes Care. ;28:1228–1230.

XLIX. Rejnmark L, Vestergaard P, Heickendorff L, Mosekilde L (2009): Simvastatin does not affect vitamin D status, but low vitamin D levels are associated with dyslipidemia: results from a randomised, controlled trial. Inte J Endocr. Volume 2010 (2010), Article ID 957174, 6 pages.

L. Jorde R, Grimnes G (2011): Vitamin D and metabolic health with special reference to the effect of vitamin D on serum lipids. Prog Lipid Res.;50(4):303–12.

LI. Wang JH, Keisala T, Solakivi T, Minasyan A, Kalueff AV, Tuohimaa P (2009): Serum cholesterol and expression of ApoAI, LXR [beta] and SREBP2

in vitamin D receptor knock-out mice. The J Steroid Biochem. ;113(3–5):222–226.

LII. Jorde R, Figenschau Y., Emaus N. and Grimnes G (2010): High serum 25-hydroxyvitamin D concentration are associated with favorable serum lipid profile. Eroupean Journal of Clinical Nutrition;64:1457-64.

LIII. Li Y, Tong CH, Radcliff J, Rowland CM, Bare LA, McPhaul MJ and Devlin JJ (2021) : Association of changes in lipid levels with changes in vitamin D levels in a real-world setting. Nature. Open access. Article Nunber 11, Article number: 21536 (2021)

LIV. Christensen R, Lorenzen JK, Svith CR, Bartels E, Melanson E, Saris W, Tremblay A, Astrup A (2009): Effect of calcium from dairy and dietary supplements on Faecal fat excretion: a meta-analysis of randomized controlled trials. Obes Rev.;10(4):475–486.

LV. Vaskonen T, Mervaala E, Sumuvuori V, Seppnen-Laakso T, Karppanen H. (2002): Effects of calcium and plant sterols on serum lipids in obese Zucker rats on a low-fat diet. Brit J Nutr. ;87(03):239–245.

LVI. Vitezova A, Zillikens MC, van Herpt TT, Sijbrands EJ, Hofman A, Uitterlinden AG, Franco OH, Kiefte-de Jong JC (2015): Vitamin D status and metabolic syndrome in the elderly: The Rotterdam Study. Eur J Endocrinol 172: 327. –335.

LVII. Reid IR, Mason B, Horne A, Ames R, Clearwater J, Bava U, Orr-Walker B, Wu F, Evans MC, Gamble GD. (2002): Effects of calcium supplementation on serum lipid concentrations in normal older women: A randomized controlled trial. Am J Med. ;112(5):343–347.