Association of Serum Vitamin-D and Omentin-1 Levels in Post-Menopausal Female with Coronary Artery Disease

Shazia Nazar[1], Afshan Mehboob[2], Sara Rafique[3]

Abstract

Objective: The objective of the present study was to investigate the association between serum vitamin-D (calcidiol, D2) and omentin-1 levels in pre- and post-menopausal female patients with coronary artery disease (CAD).

Methods: This cross-sectional, case-based study was conducted in cardiac ward of Civil Hospital Karachi during July 2016 to June 2017. Total 110 diagnosed female patients of coronary artery disease were included randomly in the study, out of which, 42 women were pre-menopausal, whereas, 68 post-menopausal. Diagnosis was based upon coronary angiography. Serum Vitamin-D and omentin-1 levels were determined by using enzyme linked immunosorbent essay (ELISA) in Dr. Abdul Qadeer Khan Institute of Biotechnology and Genetic Engineering (KIBGE). Serum vitamin-D concentrations were classed as sufficient (≥ 30 ng/mL); deficient (10 to< 29 ng/mL); and insufficient (<10 ng/mL). Data was analyzed by SSPS version 16.

Results: From our study we observed significant low levels of serum vitamin-D and omentin-1 in pre- and post-menopausal females of coronary artery disease, however, severe deficiency of Vitamin-D (<10 ng/L) was more associated with post-menopausal females. Vitamin-D deficiency (<30ng/L) was found in 82.72% (n=96) of CAD females, moreover; 46.36% (n=51) patients were found with severe vitamin-D deficiency placed in group I, 40.90% (n=45) patients were found with moderate deficiency (17.09 ± 4 ng/mL) in group II, whereas only 12.72% (n=14) had optimal serum vitamin-D levels placed in group III. Serum vitamin-D (calcidiol, D2) level was associated positively with omentin-1 in CAD patients after adjustment for potential confounding variables; basal metabolic rate, waist circumference, blood pressure and lipid profile in multivariable linear regression analysis.

Conclusion: Within the limits of the study, we concluded that low levels of vitamin-D and omentin-1 are associated with both pre and post-menopausal females with prevalent coronary artery disease (CAD). Further investigations are required in different ethnic groups and populations to confirm the findings.

Keywords: vitamin D, omentin-1, coronary artery disease

IRB: Approved by the ethical committee of DR. A.Q. Khan Institute of Biotechnology and Genetic Engineering. Ref No. KIBGE/ICE/106/30/05/16. Dated: 30th May 2016.

Citation: Nazar S, Mehboob A, Rafique S. Association of Serum Vitamin-D and Omentin-1 Levels in Post-Menopausal Female with Coronary Artery Disease. [Online]. Annals ASH KMDC 2020;25:

(ASH & KMDC 25(2):76;2020)

Introduction

Menopause is an usual phenomenon characterized by decrease function of ovaries and cessation of menstrual periods for at least 12 months[1]. Studies have revealed the transition from a low to a higher risk of coronary artery disease CAD in post-menopausal women is related to hormonal variations. These modifications in the metabolic profile causes changes in configuration and distribution of adipose tissue and promote the development of atherosclerotic plaque[2].

Omentin-1 is a 34-kDa, anti-inflammatory, circulating adipocytokine, has been considered to have a significant role in endothelial dysfunction, atherosclerosis and myocardial remodeling[3]. Omentin-1 exhibits its anti-inflammatory role by hindering tissue necrosis alpha (TNF-alpha) factor that is a pro-inflammatory cytokine. It activates activated B cells in endothelial cells via nuclear factor kappa-

[1-2]Department of Physiology,
Dow University of Health Sciences
[3]Department of Physiology,
Jinnah Medical and Dental College

Correspondence: Dr. Shazia Nazar
Department of Physiology,
Dow University of Health Sciences
Email: adrshazia@gmail.com

Date of Submission: 15th October 2019
Date of Acceptance: 26th August 2020

light-chain. Omentin-1 also activates protein Kinase (5'AMP) that inhibits expression of vascular adhesion molecule E-selectin[4].

Vitamin D (sun vitamin), is a fat soluble vitamin. It has two major types; ergo-calcidiol (vitamin D2), found in plants and chole-calciferol (vitamin D3), found in fish, oil or synthesized by the skin when exposed to sunlight from the precursor molecule 7-dehydrocholesterol[5]. In addition to fundamentals hare in calcium metabolism, bone health and mineral homeostasis, now the role of vitamin D in endocrine system has been established. Studies have shown its involvement in immune system and increasing or decreasing expression of certain cytokines[6]. Similarly, it is also involved in the development of athermatous plaque by enhancing the lipid uptake via monocytes/ macrophage system and their conversion into foam cells[7]. Several research studies have suggested the association of coronary artery disease (CAD) and vitamin-D insufficiency via metabolic functions, insulin sensitivity, and endothelial dysfunctions[8-9]. The presence of the

Table 1. Comparison of clinical, demographic and anthropometric characteristics of study population

Study variables	Female Patients of CAD (n= 110) Pre menopause n=42	Post menopause n=68	P value
Age (year)	41.54 ± 7.82	56.70 ± 4.90	<0.001*
BMI (kg/m2)	36.8 ± 3.28	34.03 ± 5.67	0.182
WC(cm)	39.09 ± 5.0	36.12 ± 6.67	0.122
SBP (mmHg)	129.54 ± 7.22	150.21 ± 10.00	<0.001*
DBP (mmHg)	84.27± 7.24	93.09 ± 12.34	<0.001*
FBS (mg/dl)	109.43 ± 16.72	102 ± 9.32	0.018
TC (mg/dL)	188.26 ± 18.39	187 ± 11.0	0.011
TG (mg/dL)	113.15 ± 13.36	99 ± 11.09	0.003*
HDL (mg/dL)	38.73 ± 4.14	40.22 ± 8.02	0.109
LDL (mg/dL)	123.31 ± 16.01	130.86 ± 11.54	0.021
Vit D(mg/dL)	22.08 ± 5.98	19.73 ± 6.05	0.001*
Omentin-1(ng/dL)	409 ± 32.09	320 ± 43.09	0.001*

Data is expressed in terms of mean±SD, BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; FBS, fasting blood sugar; TC, total cholesterol; TG, triglycerides; HDL-c, high-density lipoprotein cholesterol; LDL-c, low--density lipoprotein cholesterol; (*) indicates a significant difference between groups, P≤0.001.

Table 2. Pearson's correlations between serum vitamin D with omentin-1 and different cardio-metabolic risk factors in CAD patient

Study Variables	Premenopausal females with CAD (n=42)				Postmenopausal females with CAD (n=68)			
	Group I n =9	Group II n =25	Group III n=8	P-value	Group I n =42	Group II n =20	Group III n =6	P-value
BMI (kg/m^2)	0.152	0.122	0.109	0.233	0.021	0.056	0.032	0.019
WC (cm)	-0.220	-0.269	-0.241	0.021	-0.034	-0.076	-0.042	0.001*
DBP (mmHg)	0.076	0.093	0.066	0.826	00.67	0.098	0.067	0.201
SBP (mmHg)	0.058	0.058	0.058	0.058	0.054	0.054	0.048	0.345
TC (mg/dL)	-0.782	-0.081	-0.430	0.750	0.021	0.032	0.054	0.001*
TG (mg/dL)	-0.323	-0.317	-0.317	0.006	0.034	0.093	0.067	0.001*
LDLC (mg/dL)	-0.001	-0.012	-0.018	0.084	0.078	0.067	0.070	0.253
HDL-C (mg/dL)	0.141	0.119	0.142	0.023	0.024	0.054	0.050	0.001*
FBS (mg/dL)	0.099	0.108	0.110	0.091?	0.063	0.043	0.034	0.450
Omentin-1 (ng/mL)	0.054*	0.068*	0.073*	0.001*	0.051	0.083	0.067	0.001*

BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; FBS, fasting blood sugar; TC, total cholesterol; TG, triglycerides; HDL-c, high-density lipoprotein cholesterol; LDL-c, low--density lipoprotein cholesterol; (*) indicates a significant difference between groups, P≤0.01

Table 3. Multiple linear regression analysis for the association between vitamin D (independent variable), omentin-1(dependent variable)in CAD patients

	Model1OR(CI)	Model2OR(CI)	Model3OR(CI)	Model4OR(CI)
Pre-menopausal females with CAD				
V≤it D (30ng/mL)	3.45 (1.59-7.64)	3.98 (1.54-7.79)	3.90 (1.7-8.66)	3.23 (1.44-7.24)
P value	0.002	0.002	0.001	0.003
Postmenopausal females with CAD				
V≤it D (30ng/mL)	3.05 (1.29-5.44)	3.19 (1.39-5.64)	3.56 (1.41-5.39)	3.09 (1.28-5.32)
P value	0.002	0.003	0.004	0.004

Model 1 is unadjusted, 2=adjusted for anthropometric parameters,3= adjusted for biochemical parameters,
4= adjusted for all studied parameters; CI= confidence interval
P<0.01 is significant

vitamin-D receptors in adipose tissue and pre-adipocytes discloses a direct role for vitamin-D in regulating adipocytokine gene expression. Active form of vitamin-D involve in inhibition of pro-inflammatory adipocytokines production whereas stimulates anti-inflammatory adipocytokines secretion from the adipose tissues through decrease expression of the nuclear factor Kappa-B (NF-κB). Concurrently, vitamin-D deficiency accelerates CAD progression through enhanced chronic inflammation byactivation of protein KPNA[4] which in turns stimulate the activation of inflammatory factor called nuclear factor kappa-B (NF-κB). These are the novel outcomes provide knowledge about beneficial preventive and pharmacological effects of vitamin-D supplementation in CAD[10-11].

Understanding the influence of menopause on CAD risk remains indescribable, and the correlation of serum vitamin-D concentrations with omentin-1 is far less been studied within CAD post-menopausal females. So the aim of this study is to determine the association of vitamin-D with serum omentin-1 concentrations and other cardio metabolic risk factors in female patients of CAD.

Patients and Methods

This cross-sectional study was conducted from July 2016 to June 2017, after obtaining approval from ethical board committee of concerned institutes. Total 110 diagnosed female patients of coronary artery disease were included in the study out of which 42 were pre-menopausal while 68 were postmenopausal. Open-epi software was used to calculate the sample size. The diagnosis of CAD was made on the basis of electrocardiographic (significant Q waves >2 mm, ST depression >2mm and T-wave inversion in more than one ECG leads), history of chest pain for more than 30 minutes, positive Troponin-I test (> 0.01ng/ml). Moreover, the patients with more than 50% obstruction of one or more major coronary arteries declared by angiography were considered the patients of CAD. The females with the history of regular menstrual cycle and not using oral contraceptives, not pregnant or lactating within the previous year were considered as premenopausal candidates, whereas, inclusion criteria for post-menopausal females was cessation of menstruation for at least 12 months and were not on hormone replacement therapy. The females with acute infections, malignancy, valvular heart disease, liver disease (ALT > 58 units/L), renal disorders (Creatinine> 1.5 mg/dl) were excluded from study. Subjects on anti-inflammatory drugs and vitamin D supplements were also excluded.

The information about study variables including age, exercise, socioeconomic status, consumption of junk food, smoking status, family history of heart disease, hypertension, diabetes mellitus, use of anti-hyperlipidemic, anti-diabetic, antihypertensive drugs; were collected through Proforma, designed for the research.

Anthropometric parameters including body mass index (BMI), waist circumference (cm), height (feet), and weight (kg) were measured. The BMI was calculated by the formula (kg/m^2).

There was collection of 5 ml venous blood from brachial artery of patients after overnight fasting between 8:00 am to 9:00 am in vacationers containing EDTA, then centrifuged for 5 min, plasma was separated and frozen at -80 C in sterile Eppendorf till the day of essay. Enzyme-linked immunosorbent assay (ELISA) was used to measure serum omentin-1 concentrations (Bio Vender, USA).

The serum vitamin-D concentration was measured by automatic direct electro-chemiluminescence immunoassay (Roche Diagnostics). The lower limit of measurement was 3.9 mg/dl.

According to serum vitamin D status, participants were categorized in 3 groups:

Group (I); vitamin-D insufficient = 0.9-9.0 ng/mL
Group (II); vitamin-D deficient = 10-29 ng/mL
Group (III); vitamin-D sufficient ≥30 ng/mL

Statistical analysis of results was conducted with SPSS version 16 (Chicago, USA). Unpaired t-test was the statistical method used for comparing quantitative variables among groups. All variables were presented in mean ± SD. Pearson's correlation was used to observed the relationship between serum vitamin D,omentin-1 and cardio-metabolic risk factors in CAD. Multivariable linear regression was used to analyze the relationship of vitamin D and omentin-1 with adjustment for other study parameters like; age, basal metabolic rate, waist circumference, systolic and diastolic blood pressures, lipid profile and blood sugar.

Results

Total of 110 females with CAD were included in the study. The average age of premenopausal females (n=42) was (41.54 ± 7.82) while that of postmenopausal females (n=68) was (56.70 ± 4.90) years. Vitamin D deficiency (<30 ng/mL) was found in 87.27 % (n= 96) patients. Mean serum omentin-1 level was (409 ± 32.09, 409 ± 32.09, 320 ± 43.09 ng/ mL) in both groups respectively. No significant differences were observed in three subgroups of cases of CAD with respect to age, body mass index (BMI), waist circumference, fasting blood glucose, total cholesterol, HDL-C, values. However, serum omentin-1, TG and blood pressure values showed significant difference between pre and postmenopausal females (Table 1).

Table 2 is demonstrating significant positive correlation between vitamin D levels and serum omentin-1 levels in both pre and post-menopausal females. Negative correlations was found between serum vitamin D levels and WC, TC, TG, LDL-C, although, were not significant in premenopausal females. However, negative correlations between vitamin D and WC, TG and HDL-c was found to be statistically significant in post-menopausal women.

In multivariable regression analysis four models were made to confirm the association between omentin-1 (dependent variable) and vitamin D (independent variable). In both pre and post-menopausal females with CAD, we found Positive association between omentin-1 and vitamin D levels in unadjusted model 1. After controlling for biophysical parameters (BMI, WC, SBP and DBP) in model 2 and biochemical parameters in model 3, strong correlation was found between omentin-1 and vitamin D. After further controlling all studied parameters in model 4 significant correlation was still found (Table 3).

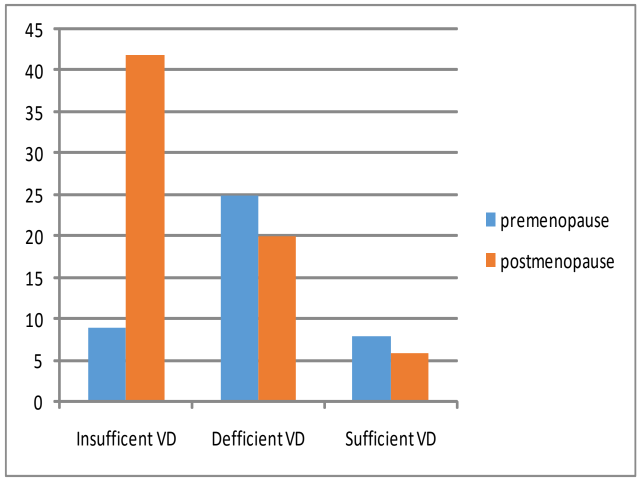

Fig 1. Comparison between level of vitamin D deficiency in postmenopausal females with CAD and premenopausal females. X-axis is showing vitamin-D status, Y-axis is representing number of participants.

Discussion

In the present study we aimed to determine the association between vitamin D and serum omentin-1 levels in female CAD patients. The outcomes of our study revealed that there is a strong relationship between serum vitamin D (calcidiol, D2) and omentin-1 levels. Low serum levels of calcidiol (D2) were found with decrease secretion of omentin-1 in both pre- and post-menopausal female patients of CAD. These results agreed with the research study piloted by Dikker et al., who observed the calcidiol (D2) and omentin-1 levels in postmenopausal females. Increased omentin-1 levels were observed in women with normal vitamin D levels. A positive correlation betweencalcidiol (D2) levels and omentin-1 was found in all groups made according to vitamin D serum concentrations[12]. Another study conducted by Zorlu et al; discovered the negative relationship between calcidiol (D2) and omentin-1 serum levels in healthy female volunteers[13]. Fazelianet al. have compared omentin-1 levels and vitamin D, before- and after-treatment, in female patients of type 2 diabetes mellitus. He observed significantly raised omentin-1 levels with high levels of vitamin D[14]. Very few studies have been conducted to assess the relationship between vitamin D and omentin-1, however; literature has given the association between vitamin D and other adipokines. Maggi S et al., observed increased serum leptin levels with vitamin D therapy in the type 2 diabetic patients[15]. Similarly, Gangloffet al; observed the positive correlation between vitamin D and leptin in young males with central obesity[16]. Mohammad S Met al. worked on another adipokine adiponectin in diabetic patients and found high vitamin D levels with high adiponectin values[17]. Some studies have shown the positive correlation of vitamin D with interlukin-10 which is an anti-inflammatory cytokine while negative correlation with pro-inflammatory cytokine interleukin-6[18-20]. These studies have demonstrated the vital role of Vitamin D in adipocytokines production via adipocytes in different disease. Researches have been done to explain the mechanisms of action of vitamin D on adipokines secretion and it is It is suggested that vitamin D receptors are present on adipose cells and they might alter the expression of adipocytokine genes[21].

Low serum vitamin D concentrations have been found to associate with abnormal lipid profile. Diabetes mellitus and cardiovascular diseases often accompanied by abnormal levels of TC, LDL-c, HDL-c and TG[22]. Ford et al, revealed negative correlation between serum vitamin D concentrations and Triglycerides in healthy males[23]. Moreover, wang et al. has given data about negative association of vitamin D with TC, LDL-c and TG and positive with HDL-c[24]. High LDL-c and TG, with low HDL-c have observed in our samples of CAD, however, the statistically significant negative correlation between serum vitamin D and TG and LDL-c were only found in post-menopausal females of CAD.

It is important to note that in current study, although, we found positive and negative relationship between serum vitamin D and different anthropometric and biochemical parameters in CAD female patients, but all the results were not significant.

Conclusion

The current study has concluded that there is a negative correlation between vitamin-D and omentin-1 serum levels with coronary artery disease in post-menopausal females. Our data also suggests that deficiency of both studied markers might be an appropriate diagnostic tool for CAD assessments. This would promote the earlier identification and treatment of CAD, which is an important part of CAD management in postmenopausal women, however, further study is needed on large sample size to confirm the findings.

References

1. Brinton RD, Yao J, Yin F, Mack WJ, Cadenas E. Perimenopause as a neurological transition state. Nat Rev Endocrionol 2015 ;11:393-399. [DOI: 10.1038/nrendo.2015.82]
2. Pardhe BD, Ghimire S, Shakya J, Pathak S, Shakya S, Bhetwal A, Khanal PR, Parajuli NP. Elevated cardiovascular risks among postmenopausal women: a community based case control study from Nepal. Biochem Res Int 2017; 12: 16-20. [DOI: 10.1155/2017/3824903]
3. Du Y, Ji Q, Cai L, Huang F, Lai Y, Liu Y, Yu J, Han B, Zhu E, Zhang J, Zhou Y. Association between omentin-1 expression in human epicardial adipose tissue and coronary atherosclerosis. Cardiovasc Diabetol 2016;15:90-98. [DOI: 10.1186/s12933-016-0406-5]
4. Nazar S, Zehra S, Azhar A. Association of single Nucleotide Missence Polymorphism Val109Asp of Omentin-1 gene and coronary artery disease in Pakistani population: Multicenter study. Pak J Med Sci 2017;33:1128-1138. [DOI: 10.12669/pjms.335.13110]
5. Karonova T, Belyaeva O, Jude EB, Tsiberkin A, Andreeva A, Grineva E, Pludowski P. Serum 25 (OH) D and adipokines levels in people with abdominal obesity. biology Steroid Biochem Mol Biol 2018;175:170-6.[DOI:10.1016/j.jsbmb.2016.09.005]
6. Iqbal S, Khan FZ, Sharafat S. Estimation of vitamin D deficiency among patients of a tertiary care hospital of Karachi, Pakistan. Rawal Medical Journal 2019;44:248-53. Available from: https://www.rmj.org.pk/index.php?mno=1060. Accessed on: 19 August 2020.
7. Dozio E, Briganti S, Vianello E, Dogliotti G, Barassi A, Malavazos AE, Ermetici F, Morricone L, Sigruener A, Schmitz G, Romanelli MC. Epicardial adipose tissue inflammation is related to vitamin D deficiency in patients affected by coronary artery disease. Nutr Metab Cardiovasc Dis 2015;25:267-73. [DOI:10.1016/j.numecd.2014.08.012].
8. Verdoia M, Schaffer A, Barbieri L, Di Giovine G, Marino P, Suryapranata H, De Luca G, Novara Atherosclerosis Study Group. Impact of gender difference on vitamin D status and its relationship with the extent of coronary artery disease. Nutr Metab Cardiovasc Dis 2015;25:464-70. [DOI: 10.1016/j.numecd.2015.01.009]

9. Pérez-Hernández N, Aptilon-Duque G, Nostroza-Hernández MC, Vargas-Alarcón G, Rodríguez-Pérez JM, Blachman-Braun R. Vitamin D and its effects on cardiovascular diseases: a comprehensive review. Korean medicine Intern Med 2016 ;31:1018-24. [DOI:10.3904/kjim.2015.224]

10. Ragab D, Soliman D, Samaha D, Yassin A. Vitamin D status and its modulatory effect on interferon gamma and interleukin-10 production by peripheral blood mononuclear cells in culture. Cytokine 2016;85:5-10. [DOI: 10.1016/j.cyto.2016.05.024]

11. Mousa A, Naderpoor N, Johnson J, Sourris K, De Courten MP, Wilson K, et al. Effect of vitamin D supplementation on inflammation and nuclear factor kappa-B activity in overweight/obese adults: a randomized placebo-controlled trial. Sci Rep 2017;7:15154-60. [DOI: 10.1038/s41598-017-15264-1]

12. Dikker O, Bekpinar S, Ozdemirler G, Uysal M, Vardar M, Atar S, et al. Evaluation of the Relation Between Omentin-1 and Vitamin D in Postmenopausal Women With or Without Osteoporosis. Exp Clin Endocrinol Diabetes. 2018 ;126:316-20. [DOI: 10.1055/s-0043-120110].

13. Zorlu M, Kiskac M, Cakirca M, Karatoprak C, Güler EM, Çelik K, et al. Cikrikcioglu MA, Kocyigit A. Evaluation of the relation between vitamin d and serum omentin and Vaspin levels in women. Exp Clin Endocrinol Diabetes 2016;124:440-3. [DOI: 10.1055/s-0042-108853]

14. Fazelian S, Paknahad Z, Khajehali L, Kheiri S, Amani R. The effects of supplementation with vitamin D on inflammatory biomarkers, omentin, and vaspin in women with type 2 diabetes: A randomized double blind placebo controlled clinical trial. Journal of food biochemistry 2018;42:e12631. Available from: https://www.researchgate.net/publication327039231_The_effects_of_supplementation_with_vitamin_D_on_inflammatory_biomarkers_omentin_and_vaspin_in_women_with_type_2_diabetes_A_randomized_double-blind_placebo-controlled_clinical_trial. Accessed on: 19 August 2020. [DOI: 10.1111/jfbc.12631]

15. Maggi S, Siviero P, Brocco E, Albertin M, Romanato G, Crepaldi G. Vitamin D deficiency, serum leptin and osteoprotegerin levels in older diabetic patients: an input to new research avenues. Acta Diabetol 2014;51:461-9. [DOI:10.1007/s00592-013-0540-4]

16. Gangloff A, Bergeron J, Lemieux I, Tremblay A, Poirier P, Alméras N, et al. Relationships between circulating 25 (OH) vitamin D, leptin levels and visceral adipose tissue volume: results from a 1-year lifestyle intervention program in men with visceral obesity. Int J Obes 2019; 29:1-10. [DOI: 10.1038/s41366-019-0347-7]

17. Mohammadi SM, Eghbali SA, Soheilikhah S, Ashkezari SJ, Salami M, Afkhami-Ardekani M, et al. The effects of vitamin D supplementation on adiponectin level and insulin resistance in first-degree relatives of subjects with type 2 diabetes: a randomized double-blinded controlled trial. Electronic physician 2016;8:2849-55. [DOI: 10.19082/2849]

18. Izadi A, Aliasghari F, Gargari BP, Ebrahimi S. Strong association between serum Vitamin D and Vaspin Levels, AIP, VAI and liver enzymes in NAFLD patients. Int J Vitam Nutr Res 2020;23: 122-8. [DOI:10.1024/0300-9831/a000443]

19. Hayes CE, Acheson ED. A unifying multiple sclerosis etiology linking virus infection, sunlight, and vitamin D, through viral interleukin-10. Medical hypotheses 2008;71:85-90. Avaialble from: https://europepmc.org/article/med/18387750. Accessed on: 19 August 2020. [DOI:10.1016/j.mehy.2008.01.031]

20. Guven MA, Coskun A, Ertas IE, Aral M, Zenc?rc? B, Oksuz H. Association of maternal serum CRP, IL-6, TNF-?, homocysteine, folic acid and vitamin b12 levels with the severity of preeclampsia and fetal birth weight. Hypertension in pregnancy 2009;28:190-20. Available from: https://www.tandfonline.com/doi/abs/10.1080/10641950802601179. Accessed on: 19 August 2020. [DOI:10.1080/10641950802601179].

21. Antwi J, Huffman F, Sullivan S. Relationship of serum Vitamin D concentrations with Adipokines and Cardiometabolic risk among non-Hispanic black type 2 diabetic and non-diabetic subjects: a cross-sectional study. BMC nutrition 2018;4:50. Available from: https://bmcnutr.biomedcentral.com/articles/10.1186/s40795-018-0259-2. Accessed on: 19 August 2020. [DOI: 10.1186/s40795-018-0259-2].

22. Faridi KF, Zhao D, Martin SS, Lupton JR, Jones SR, Guallar E, Ballantyne CM, Lutsey PL, Michos ED. Serum vitamin D and change in lipid levels over 5 y: The Atherosclerosis Risk in Communities study. Nutrition 2017;38:85-93. Available from: https://europepmc.org/article/med/28526388. Accessed on: 19 August 2020. [DOI:10.1016/j.nut.2017.01.008].

23. Vajdi M, Farhangi MA, Nikniaz L. Diet-derived nutrient patterns and components of metabolic syndrome: a cross-sectional community-based study. BMC Endocrine Disorders 2020;20:1-3. Available from: https://bmcendocrdisord.biomedcentral.com/articles/10.1186/s12902-020-0547-0. Accessed on: 19 August 2020. [DOI:10.1186/s12902-020-0547-0]