ORIGINAL ARTICLE

PATTERN OF DYSLIPIDAEMIA AND ITS ASSOCIATION WITH HYPOVITAMINOSIS D IN TYPE 2 DIABETES MELLITUS

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Background: Macrovascular atherosclerosis is an important long-term complication of type 2 diabetes mellitus. Concurrent dyslipidaemia acts as an additional risk factor for these complications. Hypovitaminosis D has been associated with adverse cardiovascular events. These modifiable risk factors of cardiovascular disease are inter-related. In the presence of an increasing incidence of type 2 diabetes mellitus and its associated metabolic abnormalities and widespread vitamin D deficiency in Pakistan, this association needs to be investigated. The purpose of our study was to determine the pattern of dyslipidaemia and its association with low vitamin D levels in South Asian diabetics. **Methods:** The study was designed as a quantitative cross-sectional study. It was conducted at the Department of Medicine, Sir Syed College of Medical Sciences and Hospital, Karachi from January to June 2014. A total of 168 adult consecutive patients with type 2 diabetes mellitus of both the genders were included. Data was collected and analysed using SPSS-20.0. The association of dyslipidaemia with vitamin D status was computed through Chi-square test. **Results:** We found that dyslipidaemia is highly prevalent in patients with type 2 diabetes mellitus in Pakistan. High total cholesterol, LDL cholesterol and triglycerides show significant association with vitamin D deficiency. **Conclusion:** In order to decrease the development of diabetic complications aggressive management of hyperglycaemia and dyslipidaemia is required. Vitamin D supplementation may play a dual role in these situations.

Keywords: Dyslipidaemia; Type 2 diabetes mellitus; Vitamin D; Hypovitaminosis D

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INTRODUCTION

Cardiovascular mortality is the foremost reason of death the world over.[1] The most common cause being ischemic heart disease. In South Asia cardiovascular mortality is increasing exponentially. There are many causes of this increase including population growth, a larger aging population and inadequate control of modifiable etiological factors.[2]

Atherosclerosis plays key role in ischemic heart disease. There are many risk factors for development of atherosclerosis. The modifiable risk factors include obesity, smoking, lack of exercise, dyslipidaemia, diabetes mellitus, hypertension etc. Multiple risk factors, from the above-mentioned list for ischemic heart disease are present in the type 2 diabetic patient.[3]

One of these is dyslipidaemia which is a known metabolic abnormality in type 2 diabetes. Different patterns of dyslipidaemia are associated with this disease. The commonest being a raised triglyceride level and reduced HDL levels, although increased LDL levels have also been found to be associated with type 2 diabetes mellitus. Among the lipid fraction high LDL and low HDL have been known to predict cardiovascular disease. Triglycerides are also now implicated to contribute towards cardiovascular risk independantly.[4]

Thus, diabetes mellitus and its associated dyslipidaemia both contribute to cardiovascular mortality. Diabetes is an independent risk factor for cardiovascular disease. The presence of dyslipidaemias has an additive effect on the macrovascular complications of diabetes including coronary heart disease and cerebrovascular disease. Many risk factors are associated with atherosclerosis among these altered lipid profile plays an important role. Dyslipidaemia is not only a metabolic feature of diabetes mellitus but is also independently associated with hypovitaminosis D.[5,6]

A modifiable factor which contributes to both diabetes mellitus and dyslipidaemia is hypovitaminosis D. Deficiency of vitamin D is widely prevalent worldwide. It is interesting to note that vitamin D is associated with not only with its well-known skeletal and muscular effects but its deficiency is also associated with multiple illnesses. Vitamin D receptors are found on a number of cells including pancreatic islet cells, adipose tissue, cardiac muscle, skeletal muscle, bone cells and other 36 different cells. Hypovitaminosis D plays an aetiological role in the development of atherosclerotic risk factors. It is postulated to play a role in hypertension, diabetes mellitus, dyslipidaemias, metabolic syndrome, endothelial inflammation, cardiac muscle hypertrophy and cardiac failure. Acute coronary syndrome has been

found to be related to vitamin D deficiency. It is also related to increased risk of major adverse cardiovascular events.[7]

Vitamin D deficiency has been documented to produce diabetes mellitus and it is also known to play a role in the development of dyslipidaemia. The relationship with diabetes is said to be due to its action on insulin resistance, pancreatic beta cell dysfunction and metabolic syndrome.[8]

As hypovitaminosis D has been reported in all atherosclerotic conditions like acute coronary syndrome, cerebrovascular accident (CVA), congested cardiac failure (CCF) and peripheral vascular disease. Vitamin D levels are inversely associated with prevalence of hypertension, diabetes mellitus, increased triglycerides and obesity.[9–11]

Diabetes has acquired epidemic proportions worldwide and especially in developing countries,[12] The objective of this study is to evaluate the pattern of dyslipidaemia and its association with hypovitaminosis D in patients with type 2 diabetes.

MATERIAL AND METHODS

This was a cross-sectional study conducted in the Department of Medicine of a secondary care centre in a low socioeconomic area of Karachi namely Sir Syed Hospital, Sir Syed College of Medical Sciences, from January 2014 to July 2014. This study was approved by the ethical committee of the institution. The sample was collected through non-probability convenient sampling. All adult patients of both genders coming to the Medical Out-patient Department fulfilling the criteria for type 2 diabetes mellitus were included in the study. The exclusion criteria included acute illnesses, chronic liver or kidney disease, pregnancy and patients on medication which changed vitamin D metabolism. Patients were included in the study after taking their informed consent.

Patients were diagnosed to have diabetes mellitus if they fulfilled any of the following: WHO (World Health Organization) OGTT (oral glucose tolerance test) criteria, HbA1c criteria, a known history of diabetes and use of diabetes medication. Type 2 diabetes mellitus was diagnosed when the patient fulfilled diagnostic criteria after 35 years of age irrespective of treatment and also if treated with diet or oral hypoglycaemic drugs irrespective of age at diagnosis. A structured *pro forma* was filled regarding the demographic data, treatment and complications of the disease. The laboratory investigations included: fasting and random blood glucose. HbA1c levels were also recorded for glycaemic control. Haemoglobin A1c was measured, by automated high-performance Liquid chromatography analyser (Bio_RadDiamat, Milan, Italy); The upper limit of normal for our laboratory was 5.8%. The subject was labelled to have satisfactory control of diabetes if the level of HbA1c was 7 or below 7. And was labelled unsatisfactory when the level of HbA1c was above7%.

Vitamin D levels were measured at baseline as serum 25(OH) D by high-performance liquid chromatography. The subject was labelled as vitamin D deficient if the levels of vitamin D were below 20 ng/ml, insufficient when the levels were 21–30 ng/ml and sufficient when vitamin D levels were >30 ng/ml. A cut off point of <30 ng/ml of 25(OH) D was used to classify patients as on low vitamin D status.[7,13]

Total lipid profile was estimated after a twelve hour fast. Total cholesterol, LDL, HDL and triglyceride fractions of the lipid profile were assessed. Dyslipidaemia was defined as derangement of any single fraction of lipid profile. A total cholesterol above 200 mg/dl was considered abnormal while LDL was considered abnormal if the level was above 130mg/dl, for triglycerides, the cut off point was 150 mg/dl and HDL level below 40 mg/dl was labelled as dyslipidaemic.

Data was entered and analysed on SPSS version 20.0. Mean±SD was computed for quantitative variables like age, duration of diabetes, fasting and random blood sugar level, HbA1c levels, lipid profile, and 25-hydroxy vitamin D levels. Categorical variables were described as frequencies and percentages. These variables included gender, level of glycaemic control (satisfactory and unsatisfactory), therapeutic agents used, presence of complications, presence of dyslipidaemia and status of vitamin D level. Relationship of dyslipidaemia with the glycaemic control and that of dyslipidaemia with vitamin D status was analysed through Chi-square test. *p*-value of ≤0.05 was considered statistically significant.

RESULTS

In our study 168 patients with type 2 diabetes mellitus were enrolled. They had a mean age of 46.7±12 years. The patients had been diagnosed with diabetes for a mean duration of 7±4.4 years. Most of the patients (62%) had poor glycaemic control. The glycaemic indices were much above the desired range with a fasting blood glucose of 170±64.6 and a random blood glucose of 261±86.9 while HbA1c was 8.3±2.28. Most of the patients were deficient in vitamin D (80%) while only 5.5% of the patients had vitamin D levels within the sufficient range.

The fasting lipid profile showed mean total cholesterol 192±45, mean LDL 119.6±33.5, mean HDL 38.2±13.5 and mean triglycerides 186.25±76.3. The other characteristics of the subjects revealed that 70% of the patients had a complication caused by diabetes mellitus. Around 83% of the patients were taking oral anti diabetic agents only, 15% were taking oral agents along with insulin while 2.4% were taking only insulin.

The characteristics of the studied population according to glycaemic control are enumerated in table-1. The lipid profile showed low HDL 35.6±12.0 and high triglycerides 194.6±86.7 in patients with poor glycaemic control. Vitamin D3 levels were lower in patients with poor glycaemic control. (Table-1). The relationship of different characteristics of the patients according to their vitamin D status is shown in Table-2. While age shows that patients with sufficient vitamin D levels had a higher mean age. Females showed lower vitamin D levels as compared to males. Fasting and random blood glucose levels were higher in patients with low vitamin D levels as was HbA1c. Also, total cholesterol, LDL cholesterol and serum triglycerides were higher in patients with hypovitaminosis D. HDL was the only lipid fraction which was higher in patients with insufficient vitamin D levels. (Table-2)

The relationship of vitamin D status with the lipid profile is shown in table-3. This shows a strong association of vitamin D deficiency with total cholesterol, LDL and serum triglycerides. Majority of the subjects who had high cholesterol were deficient in vitamin D (62.2%). Patients with the LDL fraction high were also significantly deficient in vitamin D (p-value <0.05); while patients with high triglycerides were also vitamin D deficient (p-value<0.01).

Table-1: Characteristics of subjects according to glycaemic control

Variable		Good glycaemic control	Poor glycaemic control
Age		42±12	49±11
Gender	Male	36% (23)	51% (53)
	Female	64% (41)	49% (51)
Duration of diabetes		6.4±0.5	7.5±4.6
Fasting blood sugar		124.5±20	198±67
Random blood sugar		217±53.6	288±93.23
Hba1c		6.4±0.5	9.5±2.1
Total cholesterol		191.79±47.13	193.05±44.07
LDL		118.71±32.1	119.19±34.57
HDL		42.31±14.69	35.59±12.01
Triglyceride		172.82±53.53	194.6±86.71
Vitamin D level		17.2±7.8	11.7±7
Vitamin D3 levels	Deficient	71.4% (45)	86.5% (90)
	Insufficient	19% (12)	10.5% (11)
	Sufficient	9.5% (6)	3% (3)
Presence of complications	Yes	64% (41)	74% (77)
	No	36% (23)	26% (27)
Type of therapeutic agent	Oral only	89.1% (57)	78.8% (82)
	Oral +insulin	9.45% (6)	18.3% (19)
	Insulin only	1.6% (1)	2.9% (3)

Table-2: Characteristics of subjects according to vitamin D status

Variable		Deficient	Insufficient	Sufficient
Age (years) mean± SD		46.1±12	47±11	52.7±14.5
Gender	Male %(number)	42.2% (57)	47.8 (11)	77.8 (7)
	Female %(number)	57.8% (78)	52.2 (12)	22.2 (2)
Duration of diabetes (years) mean±SD		7.3±4.4	5.9±4.5	6±3
Fasting blood sugar (mean±SD)		179±66	141.7±44.7	112.3±25.3
Random blood sugar (mean±SD)		274.6±84	217±88.8	168.6±28
Hba1c (mean±SD)		8.6±2.3	7.76±2.1	6.4±1
Total cholesterol (mean±SD)		200±42	170±45	146±37.7
LDL (mean±SD)		122±32	112±38	98±32
HDL (mean±SD)		38±14	40.5±12	34.66±6.4
Triglyceride (mean±SD)		195±79	149±46.5	151.77±57
Vitamin D level (mean±SD)		10.76±4.3	22.78±2.1	35.5±3.7
Glycaemic control	Satisfactory % (number)	33.3 (45)	52.2 (12)	66.7 (6)
	Unsatisfactory % (number)	66.7 (90)	47.8 (11)	33.3 (3)
Presence of complication	Yes % (number)	69.9 (94)	78.3 (18)	55.6 (5)
	No % (number)	30.4 (41)	21.7 (5)	44.4 (4)
Type of therapeutic agent	Oral only %(number)	14.8 (20)	17.4 (4)	11.1 (1)
	Oral +Insulin % (number)	83.7 (113)	73.9 (17)	88.9 (8)

Table-3: Relationship of vitamin D status with lipid profile indices

Lipid profile		Vitamin D status			p-value
		Deficient percentage(number)	Insufficient percentage(number)	Sufficient percentage(number)	
Total cholesterol	<200	37.3 (50)	73.9 (17)	88.9 (8)	0.00
	>200	62.2 (84)	26.1 (6)	11.1 (1)	
LDL	<130	24.4 (33)	34.8 (8)	66.7 (6)	0.019
	>130	74.8 (101)	65.2 (15)	33.3 (3)	
HDL	<40	63.6 (84)	47.8 (11)	77.8 (7)	0.69
	>40	36.4 (48)	52.2 (12)	22.2 (2)	
Triglyceride	<150	26.1 (35)	56.5 (13)	55.6 (5)	0.005
	>150	73.3 (99)	43.5 (10)	44.4 (4)	

DISCUSSION

Type 2 diabetes is responsible for more than 90% of all cases of diabetes in most countries and therefore the major health burden worldwide is because of the rising prevalence of type 2 diabetes mellitus.[14] The increasing prevalence of obesity, diabetes mellitus, hypertension, dyslipidaemia and cardiovascular disease in the developing countries reflect urbanization and change of lifestyle in these countries.[15] Metabolic abnormalities manifest systemically as the complications of diabetes mellitus with macro and microvascular involvement.[16] The best known metabolic effect of diabetes mellitus is hyperglycaemia which occurs as a result of disturbed carbohydrate metabolism. Many risk factors are associated with it. Cardiovascular disease is an important cause of mortality and morbidity in patients who have diabetes mellitus.[17]

In our study we have researched the association between glycaemic control and its effect on the lipid profile. We have also clarified the relationship between low vitamin D levels and lipid profile. Dyslipidaemia was seen in a majority of patients in our study. These lipid abnormalities were greater in patients with unsatisfactory glycemic control. The dyslipidaemia was also significantly associated with hypovitaminosis D. Dyslipidemias should be treated in the patient with type 2 diabetes mellitus. The treatment will include lifestyle modification, better glycemic control, pharmaceutical therapy directed against the abnormal lipid fraction and interestingly maybe vitamin D supplementation. The increased atherogenicity of dyslipidaemia in diabetes may well be due to its multifactorial causation.

Longer duration of diabetic illness and lack of medication compliance are considered important factors responsible for poor glycemic control in type II diabetics. Uncontrolled DM was frequently noted in our patients. Our study compared patients with type 2 diabetes mellitus having good or poor glycaemic control. It shows that patients with diabetes who had poor glycaemic control as defined by a HbA1c of more than 7.0 have higher total cholesterol, LDL cholesterol, and triglycerides; and lower HDL cholesterol than patients who had a good glycemic control.

Prevalence of dyslipidemia in type II diabetics is variable. Some form of dyslipidaemia was noted in at least 49% of type 2 diabetics in an Iranian study.[13] While 94% of diabetic patients in a Pakistani study which evaluated dyslipidaemia in type 2 diabetics revealed dyslipidaemia.[14] Most common pattern of dyslipidaemia in type 2 DM is elevated triglyceride level, decreased HDL cholesterol levels, and a preponderance of smaller and denser LDL particles.[15,16] Some studies have shown that increased triglyceride levels along with high LDL cholesterol and low levels of HDL are all associated with diabetes mellitus and these play an important role in development of atherosclerotic plaques. In a local study high triglycerides, low HDL, high total cholesterol and high LDL cholesterol were seen in the given order of prevalence in diabetic patients. Similar results are seen in other studies.[14]

In our population people do not take their health seriously especially chronic illnesses which require long-term lifestyle modification and medication. This needs motivation on the patients' part and re-enforcement of health education regarding their illness on the health personnel's part. Almost 62% of the subjects in our study had poor glycaemic control. Poor glycaemic control. In studies from Saudi Arabia, Jordan, and Kuwait 73%, 65.1%, and 66.7% patients respectively had poor glycaemic control. Similar figures have been noted in studies conducted in UK as well.[17]

Association between atherogenicity in plasma with HbA1c is already known. Correlation exists between glycemic control and dyslipidemia in type 2 DM patients. In local studies dyslipidemia were more frequent in poorly controlled diabetics compared to diabetics with good glycemic control.[18]

Vitamin D has garnered a lot of attention recently because of its role in many disease processes. Vitamin D deficiency is a common phenomenon worldwide. It has been found to be deficient in 55–80% of the population in different regions of the world. Vitamin D deficiency has been observed in regions which receive less sunlight especially extremes of the hemispheres, but has also been observed in tropical regions. Other factors which contribute to its deficiency are an increasing age, darker skin tone, air pollution, use of sunscreen and a sedentary indoor lifestyle, increased body coverings, obesity, malnutrition, malabsorption, renal and hepatic diseases and use of certain drugs like steroids, antiepileptic and certain antiviral drugs.[8–10]

Many studies have highlighted the role of vitamin D in multiple cardiovascular risk factor development. Its role development of type 2 diabetes mellitus, metabolic syndrome and hypertension and coronary heart disease are well-documented.

The role of vitamin D in diabetes mellitus is also well-documented. Its deficiency increases the risk of development of type 2 diabetes mellitus and worsens glycaemic control through beta cell dysfunction and insulin resistance. These effects are produced through its action on calcium metabolism and vitamin D receptor activation which are present on pancreatic beta cells, liver cells and adipocytes.[19]

In our study the levels of vitamin D in type 2 diabetic patients was found to be deficient or insufficient in a large majority of cases (80.4% and 13.7% respectively). We observed no significant relationship between low 25-hydroxyvitamin D levels and subjects with gender, duration of diabetes, presence of diabetic complications or the anti-diabetic agent being used, while glycaemic control and presence of dyslipidaemia was significantly associated vitamin D deficiency. Another local study has shown a significant relationship of hypovitaminosis D with a higher a mean serum glucose level.[20]

A European study revealed hypovitaminosis D related significantly to prevalence of type 2 diabetes and poorer glycaemic control in the study population.[21]

Total cholesterol levels show a markedly significant relationship to hypovitaminosis D in diabetic patients in our study, this is similar to an Indian study where the mean total cholesterol was higher in participants who had deficient vitamin D than in those subjects who were sufficient in vitamin D. Similar results have been obtained in Europe, North America and Asia.[6,12] Our study showed no association of HDL with serum 25-hydroxy vitamin D levels. This was in contrast with an Indian study which showed significantly lower levels of high-density lipoprotein in subjects with deficiency of 25-hydroxyvitamin D. Similar relationship was observed in other studies.[21]

This conflicting result is not readily explainable. The subject population differed in the respect that in our study only type 2 diabetics were assessed. As mentioned earlier low HDL levels were significantly related to poor glycaemic control (*p*-value<0.01). But when analysed with relationship to vitamin D levels HDL was higher in patients with insufficient vitamin D. This may be because total cholesterol and LDL are related to increase BMI while HDL has more of an association with physical activity. Patients with a high BMI have a higher body fat content. Obesity is directly related to hypovitaminosis D as it is postulated that vitamin D being a fat-soluble vitamin may be sequestered in the fat compartment of the body. Thus, both total cholesterol and LDL cholesterol will be high in patients with hypovitaminosis D.

The LDL fraction of lipid profile also significantly related to low vitamin D levels in our study. This finding is supported by the results of other studies.[21]

We also found a significant relationship between deficiency of 25-hydroxyvitamin D and high triglycerides. This finding is duplicated in other studies.[12] Two main mechanisms have been postulated to be responsible for hypertriglyceridemia associated with vitamin D deficiency. Firstly, vitamin D leads to increase in serum calcium by enhancing intestinal calcium absorption. This process will then lead to reduction in serum triglycerides through decreased production of triglycerides from the liver. Second mechanism could be that vitamin D has a suppressive effect on serum PTH concentration. As plasma post heparin lipolytic activity is reduced by elevated PTH concentration, low serum PTH may reduce serum triglycerides due to increased peripheral removal. Apart from the above, two other mechanisms have also been implicated. Vitamin D may regulate triglyceride metabolism by causing the expression of VLDL cholesterol receptors in some types of cell resulting in removal of triglycerides from the circulation.

Satisfactory diabetic control and treatment of dyslipidaemias associated with diabetes will lead to reduction of risk of development of coronary artery disease. Supplementation with vitamin D can help in achieving these goals.

CONCLUSION

Keeping in view the high prevalence of hypovitaminosis D in the diabetic population under review multiple metabolic abnormalities were associated with it. There was an inverse relationship of different fractions of lipid profile with vitamin D levels.

Dyslipidaemia was also associated with unsatisfactory glycaemic control in our patients. In order to control and prevent the complications of diabetes mellitus a multipronged and tailored management is required for every diabetic patient.

AUTHORS' CONTRIBUTION

FB: Concept, data collection, literature search, statistical analysis, final write-up. ZUK: literature search, data collection. NK: literature search, data collection. ZS: concept, review and correction of manuscript.

REFERENCES

1. Lozano R, Naghavi M, Foreman K, Lim S, Shibuya K, Aboyans V, *et al*. Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet 2012;380(9859):2095–128.
2. Roth GA, Forouzanfar MH, Moran AE, Barber R, Nguyen G, Feigin VL, *et al*. Demographic and Epidemiologic Drivers of Global Cardiovascular Mortality. N Engl J Med 2015;372(14):1333–41.
3. Alexander CM, Landsman PB, Teutsch SM, Haffner SM. NCEP-defined metabolic syndrome, diabetes, and prevalence of coronary heart disease among NHANES III participants age 50 years and older. Diabetes 2003;52(5):1210–4.

4. Ginsberg HN. Identification and treatment of hypertriglyceridemia as a risk factor for coronary heart disease. Curr Cardiol Rep 1999;1(3):233–7.
5. Karhapää P, Pihlajamäki J, Pörsti I, Kastarinen M, Mustonen J, Nuemela O, *et al*. Diverse associations of 25-hydroxyvitamin D and 1,25-dihydroxy-vitamin D with dyslipidaemias. J Intern Med 2010;268(6):604–10.
6. Auwerx J, Bouillon R, Kesteloot H. Relation between 25-hydroxyvitamin D3, apolipoprotein A-I, and high density lipoprotein cholesterol. Arterioscler Thromb 1992;12(6):671–4.
7. Hollick MF. Vitamin D deficiency. N Engl J Med 2007;357(3):266–81.
8. Lips P. Vitamin D deficiency and secondary hyperparathyroidismin the elderly: consequences for bone loss and fractures and therapeutic implications. Endocr Rev 2001;22(4):477–501.
9. Harinarayan CV, Joshi SR. Vitamin D status in India—its implications and remedial measures. J Assoc Physicians India 2009;57:40–8.
10. Islam MZ, Akhtaruzzaman M, Lamberg-Allardt C. Hypovitaminosis D is common in both veiled and nonveiled Bangladeshi women. Asia Pac J Clin Nutr 2006;15(1):81–7.
11. Pittas AG, Dawson-Hughes B, Li T, Van Dam RM, Willett WC, Manson JE, *et al*. Vitamin D and calcium intake in relation to type 2 diabetes in women. Diabetes Care 2006;29(3):650–6.
12. Martins D, Wolf M, Pan D, Zadshir A, Tareen N, Thadhani R, *et al*. 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 2007;167(11):1159–65.
13. Nakhjavani M, Esteghamati AR, Esfahanian F, Heshmat AR. Dyslipidaemia in type 2 diabetes mellitus. Acta Med Iran 2006;44(2):111–8.
14. Gilani SY, Bibi S, Ahmed N, Shah SR. Gender differences of dyslipidaemia in type 2 diabetics. J Ayub Med Coll Abbottabad 2010;22(3):146–8.
15. Mooradian AD. Dyslipidaemia in type II diabetes mellitus. Nat Clin Pract Endocr Metab 2009;5(3):150–9.
16. Eckel RH. Diabetic Dyslipidaemia and Cardiovascular Risk. Curr Diab Rep 2008;8(6):421–3.
17. Khattab M, Khader YS, Al-Khawaldeh A, Ajlouni K. Factors associated with poor glycemic control among patients with type 2 diabetes. J Diabetes Complications 2010;24(2):84–9.
18. Khurram M, Gul H, Rahman F, Khar HTB, Faheem M. Lipid Abnormalities in Patients with Type 2 Diabetes. J Rawalpindi Med Coll 2013;17(2):167–8.
19. Pittas AG, Lau J, Hu FB, Dawson-Hughes B. The role of vitamin Dand calcium in type 2 diabetes. A systematic review and meta-analysis. J Clin Endocrinol Metab 2007;92(6):2017–29.
20. Chaudhuri JR, Mridula KR, Anamika A, Boddu DB, Misra PK, Lingaiah A, *et al*. Deficiency of 25-Hydroxyvitamin D and Dyslipidemia in Indian Subjects. J Lipids 2013;2013:623420.
21. Cigolini M, Iagulli MP, Miconi V, Galiotto M, Lombardi S, Targher G. Serum 25-hydroxyvitamin D3 concentrations and prevalence of cardiovascular disease among type 2 diabetic patients. Diabetes Care 2006;29(3):722–4.
22. Wang TJ, Pencina MJ, Booth SL, Jacques PF, Ingelsson E, Lanier K, *et al*. Vitamin D deficiency and risk of cardiovascular disease. Circulation 2008;117(4):503–11.

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