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Original article

Vitamin D and Metabolic Health: A Study of Lipid and Glucose Profiles in Benghazi, Libya

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Vitamin D, 25(OH)D Deficiency, Dyslipidemia, Diabetes, Lipid Parameters, Fasting Blood Glucose (FBG), HbA1c.

ABSTRACT

Vitamin D is an essential fat-soluble vitamin and it acts in the body like a steroid hormone with a multitude of functions. Vitamin D deficiency is common in Benghazi, Libya especially among females and in the older age groups. Recent reports have found that hypo 25-(OH) D is associated with many diseases. The relationship between vitamin D status and dyslipidemia and diabetes is unclear. The objective of this study was to investigate the role of vitamin D level in all lipid parameters, fasting blood glucose and cumulative blood glucose levels in Libyan adult sample. Clinical investigatory data of (110) random subjects was obtained from Alrazi laboratory in Benghazi, Libya over a four-month period. The mean concentration of TC, VLDL-C, TG levels, FBG and (Hb1AC) levels were higher in (25(OH)D) deficient group, when compared to subjects with sufficient 25(OH)D group. While the mean concentration of HDL-C and LDL-C were lower in deficient group. A higher percentage of subjects who had high TG, VLDL, FBG and low HDL in 25(OH)D deficient group in compare to sufficient group. While, a lesser percentage of subjects who had high TC and LDL in 25(OH)D deficient group in compare to sufficient group. However, there are a statistically significant correlation of 25(OH)D deficiency and overall elevation of all lipid parameters serum levels, concurrent elevation of VLDL and triglycerides and concurrent elevation of VLDL and FBG. Our results may indicate that there is a negative correlation between vitamin D deficiency and high TG, VLDL, FBG and positive correlation with TC and LDL and HDL.

Introduction

Vitamin D is an essential fat-soluble vitamin [1]. Also, it acts in the body like a steroid hormone with a multitude of functions [2]. The main source of vitamin D in humans (>80%) is derived from sunlight, whereas the remaining percentage is acquired via dietary supplementation. However, because vitamin D receptors have been found in various tissues including the brain, prostate, breast, colon, pancreas, and immune cells [3], it's also considered as a modulator of immune system functions [4], anti-inflammatory activity [5], reduce resistance of insulin [6], and suppress rennin-angiotensin system [7].

Vitamin D deficiency is common worldwide and has become an important public health problem in many countries, Vitamin D deficiency is common in female in all age groups and among overweight and obese Libyan females living in the Eastern region of the country. Vitamin D deficiency was highest in adult, then late adult and children age group consequently [8].

Also, according other study vitamin D deficiency is common in Benghazi, Libya especially among females and in the older age groups [9]. Several studies were performed to evaluate the level of this vitamin and according to their results, higher levels of vitamin D is associated with a better health status [10]. Vitamin D deficiency is defined as a serum 25-hydroxyvitamin vitamin D(25(OH)D) level of less than 50 nmol/L (20 ng/Ml) [11].

A number of factors influence the blood level of vitamin D in humans. First, Diet, in addition, various health conditions affect vitamin D's bioavailability; whereas, gastrointestinal disorders limit its absorption, renal and liver diseases can prevent activation of the parenteral vitamin D or impair the conversion of vitamin D into its active form [12, 13]. Additionally, other research study shown the Vitamin D level is associated with other potential factors (age, BMI, gender) [14,15]. Dyslipidemia and diabetes are considered as a major risk factor for cardiovascular disease [16]. Vitamin D deficiency has been linked to

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the onset of diabetes. The relationship between vitamin D status and dyslipidemia and diabetes is unclear. However, some studies suggest association between vitamin D and dyslipidemia and high blood glucose as vitamin D might play a role in the regulation of cholesterol biosynthesis and may inhibit synthesis and secretion of triglyceride and insulin [17]. Additionally, many observational studies showed that low levels of vitamin D may be associated with hyperlipidemia [18, 19]. Therefore, in our study, we investigating a relationship between vitamin D level and dyslipidemia and high blood glucose in all age and both gender of Libyan adult sample.

Method

Sample collection

Clinical investigatory data from 110 random subjects were obtained from Alrazi Laboratory in Benghazi, Libya, over a four-month period. The clinical data included: fasting blood glucose, HbA1c (Glycated hemoglobin), lipid profile (including total cholesterol (TC), low density lipoprotein (LDL) cholesterol, high-density lipoprotein (HDL) cholesterol, very low-density lipoprotein (VLDL) cholesterol, and triglycerides), vitamin D; 25(OH)vitamin D (calcidiol).

In this study, the subjects were categorized into three groups according to serum vitamin D level. Group one containing subjects with sufficient vitamin D level considered as control group (>30ng/ml), group two containing subjects with insufficient vitamin D level (20-30ng/ml), and group three containing subjects with deficient vitamin D level (200mg/dl, >130mg/dl, 30mg/dl, >150mg/dl respectively. These values used as reference to diagnosis dyslipidemia according to National Cholesterol Education Program (US), 2020).

Data interpretation

According to WHO criteria: A fasting blood sugar level less than 100 mg/dL (5.6 mmol/L) is normal. A fasting blood sugar level from 100 to 125 mg/dL (5.6 to 6.9 mmol/L) is considered prediabetes. If it's 126 mg/dL (7 mmol/L) or higher on two separate tests indicated for diabetes. While, HbA1C level of 6.5% or higher on two separate tests indicates that you have diabetes. 5.7 and 6.4 % indicates prediabetes. Below 5.7 is considered normal. 14 2.2.

Statistical analysis

The statistical analysis was performed using statistical package for social science (SPSS. version 21). The categorical variables were measured using descriptive statistics including frequencies, percentage. The data are expressed as mean ± standard deviation (SD). The association between vitamin 25(OH)D levels (dependent variable) and lipid profiles (independent variable) were estimated using both two sample T test and chi-square test. The level of significant with a p-value of less than 0.05 was considered statistically significant for all tests.

Results

A total of 110 subjects' clinical investigatory data has been collected. Few above half of the subjects were male 57(51.8%) and the rest were female (53, 48.2%). The distribution of respondents according to the four following age groups, more than 40, 40-50, 51-60 and more than 60 years, was 34(30.9%), 39(35.5%), 21(19.1%) and 16 (14.5%) respectively as shown in (Figure 1). The number of subjects [n(%)] in each groups according to serum 25(OH)D levels was 26 (23.64%), 36 (32.73%), and 48 (43.64%) sufficient group, insufficient group, and deficient group respectively. The number of subjects [n (%)] with the abnormal levels of cholesterol, triglycerides, LDL, HDL, VLDL, glucose and HbA1c was [48(43.6%), 59(53.6%), 68(61.8%), 13 (11.8%) 67 (60.9%), 14(12.7%) and 22 (20%)] respectively. While, the number of subjects [n(%)] with the normal levels of the same variables was [62(56.4%),51(46.4%), 42(38.2%), 97(88.2 %), 43(39.1%),37(33.6%) and 26(23.6%)]

Patients younger than 40 years were vitamin D deficient more than those older than 50 years. However, there is no statistically significant difference between age and serum level of vitamin D in all groups (p=0.295). There is no statistically significant difference in vitamin D level (p=0.861) between male and female (Figure1).

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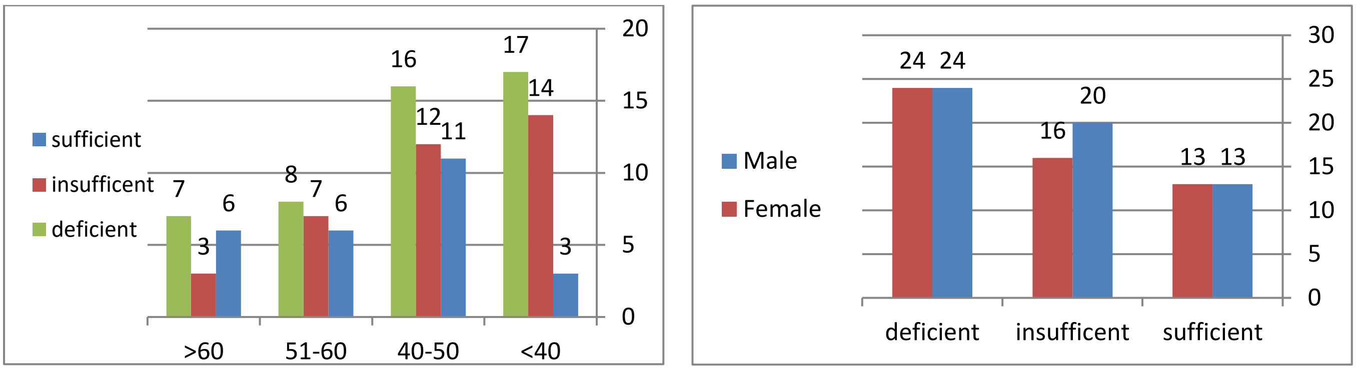

Figure 1. Age group (Left) and gender (Right) correlation with serum 25(OH)D levels.

In the 25(OH) D deficient group, the mean concentration of cholesterol, triglycerides, LDL, HDL, VLDL, glucose and Hb1Ac were (193.77mg/dl), (164.04mg/dl), (107.56mg/dl), (53.37mg/dl), (32.8mg/dl), (111.35mg/dl) and (6.21%) respectively. While, in the sufficient group the mean concentrations of cholesterol, triglycerides, LDL, HDL, VLDL, glucose and Hb1Ac were (193.07mg/dl), (139.80mg/dl), (112.46mg/dl), (54.42mg/dl), and (31.46mg/dl), (109.68mg/dl), (6.10%) respectively (Figure 2). The difference in mean of cholesterol, triglycerides, LDL, and HDL VLDL glucose and HbA1c between sufficient and deficient groups is not statistically significant, P>0.05

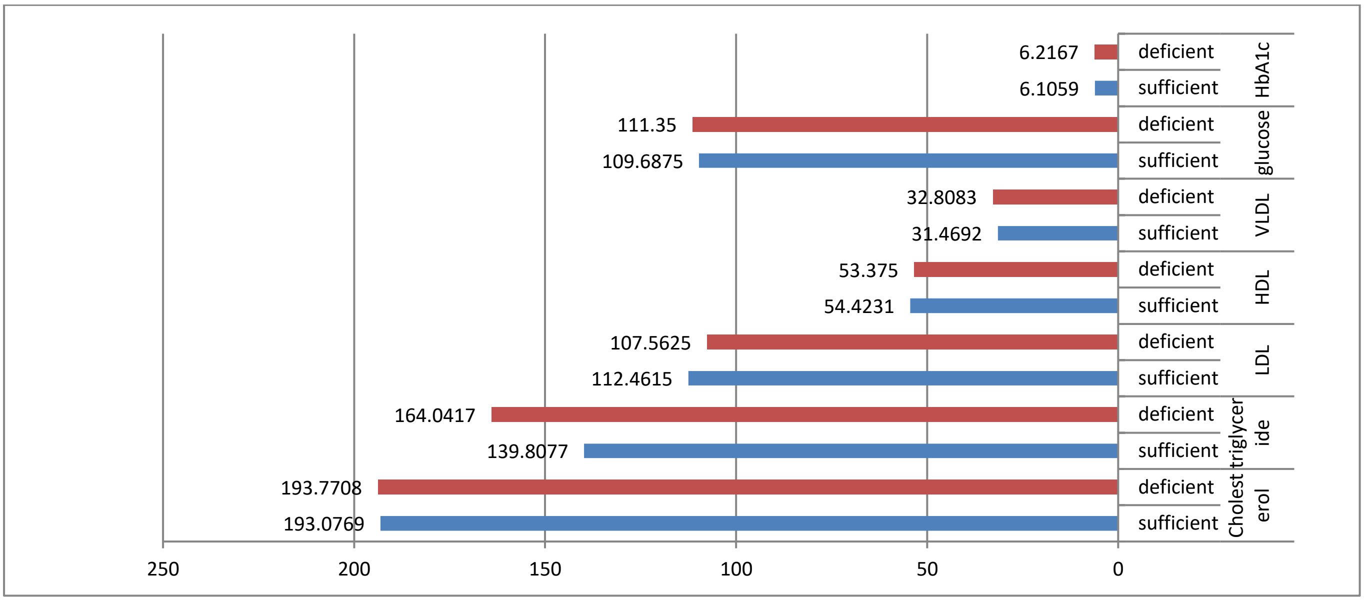

Figure 2: Correlation between vitamin D deficiency and mean concentrations of lipid profile, fasting and cumulative blood sugar

In the Figure 3 below, association test (Chi square) of 25(OH) D levels and total serum cholesterol, showed that 26 subjects who are deficient 25(OH)D had high cholesterol level in compare to 14 sufficient 25(OH)D had high cholesterol level. While, there 28 who were 25(OH)D deficient had normal cholesterol level in compare to 12 sufficient 25(OH)D with normal cholesterol level. However, statistically there is no significant difference in cholesterol levels between 25(OH) D levels (p=0.471).

In the Figure 4 below, association test (Chi square test) of 25(OH) D levels and triglyceride showed that there were 29 deficient 25(OH) D subjects who had high triglyceride serum level in compare to 14 sufficient 25(OH) D subjects who had high triglyceride level. While, there are 19 subjects who were deficient 25(OH) D with normal triglyceride level in compare to 12 sufficient 25(OH) D who had normal triglyceride level. However, there was no statistically significant correlations between 25(OH) D levels and total triglycerides level(p=0.348).

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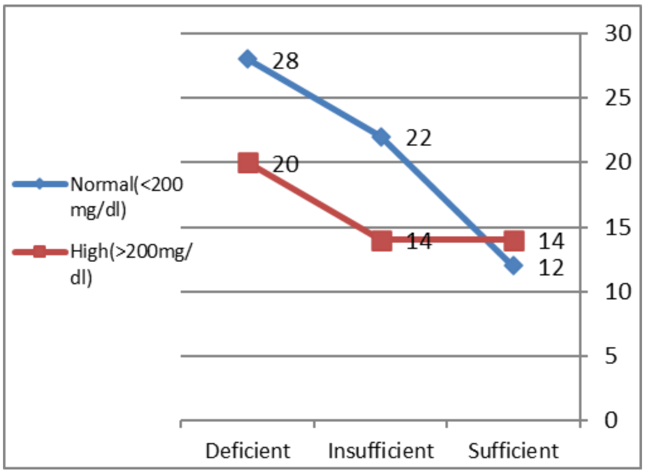

Figure 3: 25(OH) D levels and total serum cholesterol correlation

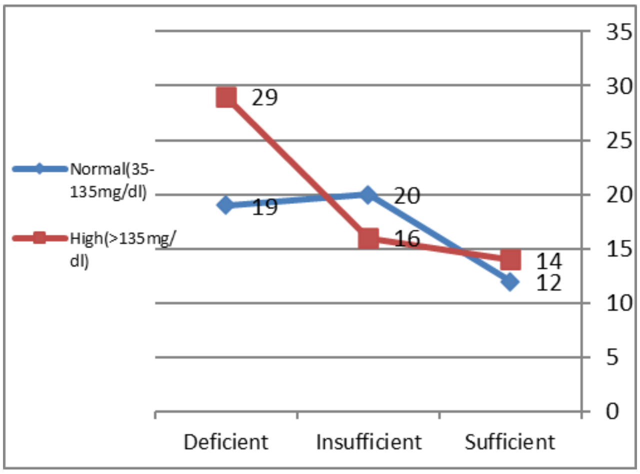

Figure 4. 25(OH) D levels and total serum triglyceride correlation

In the Figure 5 below, association test (Chi square) of 25(OH) D levels and LDL levels showed that there were 26 deficient 25(OH) D who had high LDL levels in compare to 20 sufficient 25(OH) D who 12 22 28 14 14 20 0 5 10 15 20 25 30 Deficient Insufficient Sufficient Normal(200mg/dl) 12 20 19 14 16 29 0 5 10 15 20 25 30 35 Deficient Insufficient Sufficient Normal(35-135mg/dl) High(>135mg/dl) 21 had high LDL level. While there were 22 deficient 25(OH) D who had normal LDL level in compare to 6 sufficient 25(OH) D who had normal LDL level. However, there was no statistically significant correlations between 25(OH) D levels and total LDL level. (P=0.156).

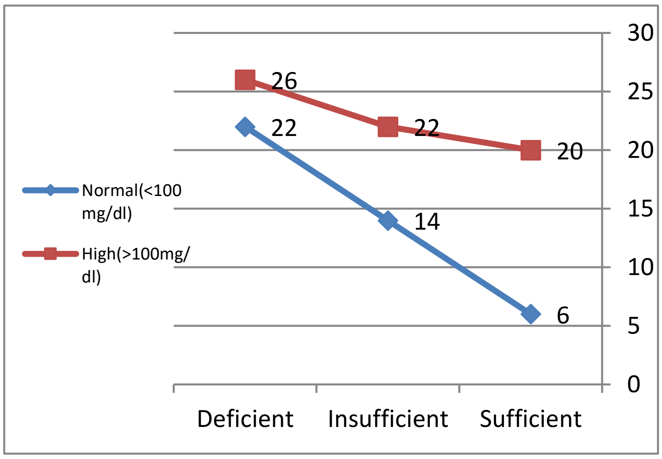

Figure 5. 25(OH) D levels and serum LDL correlation

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In the Figure 6 below, association test (Chi square) of 25(OH) D deficiency and HDL levels showed that there were 9 deficient 25(OH) D who had low HDL level in compare to 2 sufficient 25(OH) D who had low HDL level. While, there were 39 deficient 25(OH) D who have normal HDL level in compare to 24 sufficient 25(OH) D who had normal HDL level. However, there was no statistically significant correlations between 25(OH) D levels and HDL level(p=0.136)

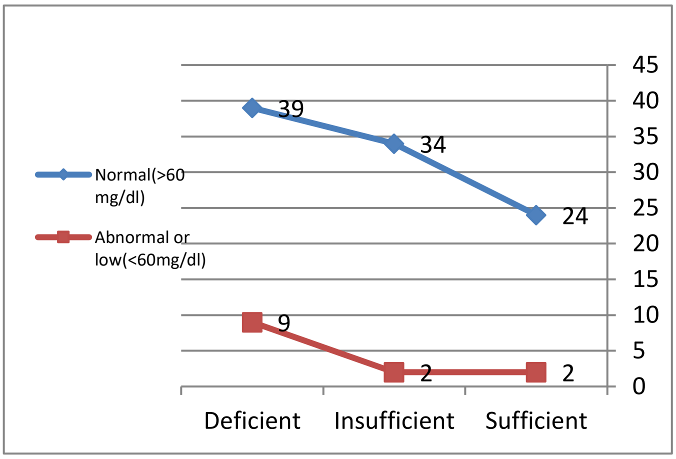

Figure 6: 25(OH) D levels and total serum HDLcorrelation

In the Figure 7 below, association test (Chi square) of 25(OH) D levels and VLDL levels showed that there were 33 deficient 25(OH) D who had high VLDL levels in compare to 16 sufficient 25(OH) D who had high VLDL level. While there were 15 deficient 25(OH) D who had normal VLDL level in compare to 10 sufficient 25(OH) D who had normal VLDL level. There were no statistically significant correlations between 25(OH) D levels and total LDL level. (p= 0.218).

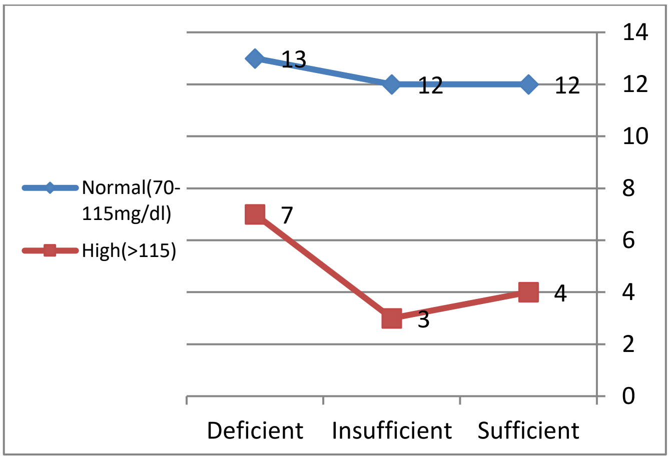

Figure7: 25(OH) D levels and serum VLDL correlation

In the Figures 8 below, association test (Chi square) of 25(OH)D levels and fasting serum glucose level showed that there were 7 deficient 25(OH) D who had high fasting serum glucose in compare to 4 sufficient 25(OH)D who had high glucose level. While there were 13 deficient 25(OH)D who had normal glucose level in compare to 12 sufficient 25(OH) D who had normal glucose level. There were no statistically significant correlations between 25(OH) D levels and glucose (p=0.595).

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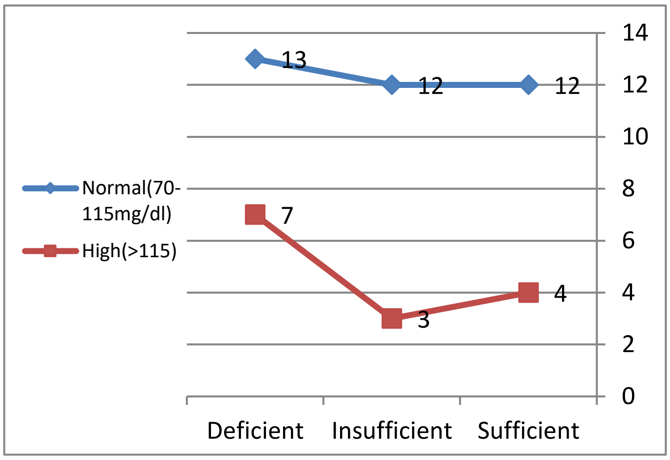

Figure 8:25(OH) D levels and total glucose level correlation

In Figure 9, 48.27% of deficient 25(OH) D subjects had concurrent elevation of both serum VLDL and triglycerides in compare to 24.13% sufficient 25(OH) D subjects had concurrent elevation of both serum VLDL and triglycerides and the correlation was statistically significant (p= 0.01). While, in Figure 10, 44.44% of deficient 25(OH) D subjects had dyslipidemia (all lipid parameters were elevated) in compare to 33.33% sufficient 25(OH) D subjects and the correlation was statistically significant (p= 0.057).

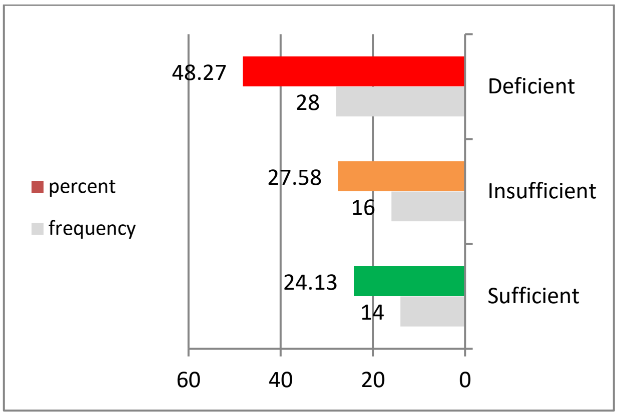

Figure 9: 25(OH) D levels correlation with dyslipidemia

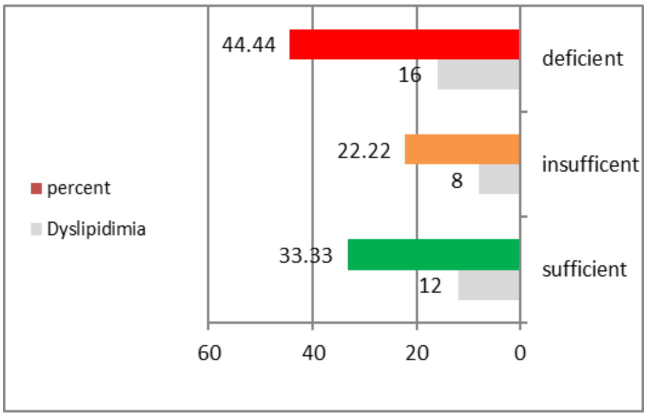

Figure 10: 25(OH) D levels correlation with (VLDL +Triglycerides)

In figure20, 53.8% of deficient 25(OH)D subjects had concurrent high serum VLDL and (FBG) in compare to 23.07% of sufficient 25(OH)D subjects had concurrent high serum VLDL and (FBG), While, 8.33% of deficient 25(OH)D subjects had concurrent normal serum VLDL and (FBG) and 33.33% sufficient 25(OH)D had normal levels. However, the correlation was statistically significant (0.001).

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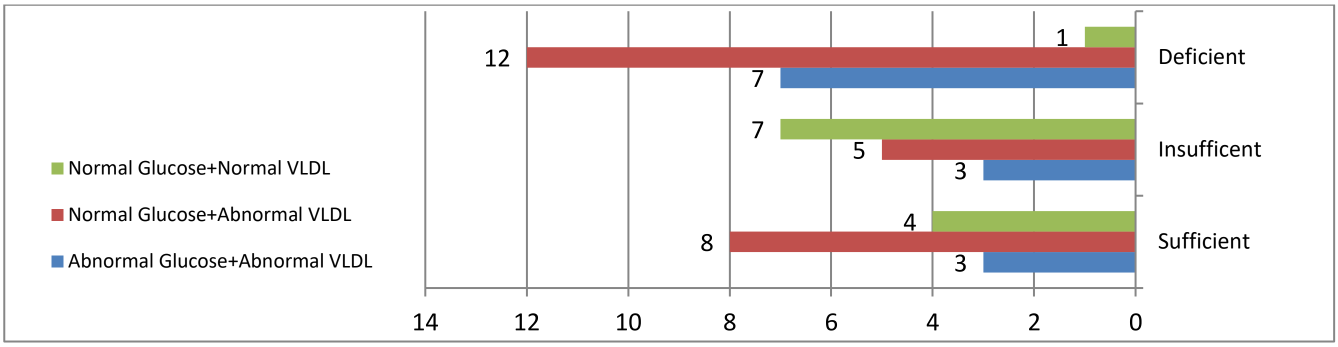

Figure 11: 25(OH) D levels correlation with concurrent serum VLDL and fasting blood glucose

Discussion

The effect of low vitamin D on human health is important to study. In this study, the effect of different levels of vitamin D on the level of all lipid parameters, cumulative and fasting blood glucose were investigated. A greater proportion of our subject have deficient 25(OH) D (n=48, 43.6%) while, sufficient and insufficient group were (n=26, 23.6%), (n=36, 32.7%) respectively. Many studies found high prevalence of 25(OH)D deficiency. A meta-analysis study found that prevalence of vitamin D deficiency is high in African populations especially in newborn babies, women, and urban populations [20]. A study was comparable to our results as the percent of 25(OH)D sufficient group, insufficient 25(OH)D group, and deficient group was 43 (33.9%), 38 (29.9%), and 46 (36.2%) respectively. [21]. While a study found that 58.34% of patients had 25(OH)D deficiency and 41.66% of them had 25(OH)D sufficiency and insufficiency combined [22]. Another study found that 25(OH)D deficiency was ascertained in 83.3% of their subjects. Regarding association of 25-Hydroxyvitamin D and Gender [11]. This study showed an equal distribution of 25(OH)D levels in both genders, Similar reports with equal distribution amongst both sexes were observed by other studies [11, 22, 23] from Saudi and Pakistan respectively. However, other study [1] established more prevalence in women than in men. The most likely reason may be due to poor outdoor activity, 25 increased bone turnovers after the age of 40 in women [23]. Whereas, in other study found the prevalence of vitamin D deficiency is highest among men in compare to women [25].

Regarding the correlation of 25(OH)D and age, it has been found that high number of subjects who are 25(OH)D deficient in age group below 40 years compare to other age groups. However, there is no statistically significant association between 25(OH)D and age group. This result supports previous studies that concluded young adults aged 18 to 29 years have an equal to greater risk of vitamin D insufficiency than do older adults [26]. In addition, many studies support that vitamin D deficiency are more prevalent in the elderly population [27, 28].

Aging affects the formation of 1,25-dihydroxyvitamin D, production of 1,25(OH)2D is reduced by 50% as a result of an age-related decline in renal function. The results of our study showed that, the mean concentration of TC, VLDL-C, TG, FBG and (HbA1C) were higher in (25(OH)D) deficient group when compared to subjects with sufficient 25(OH)D group. While the mean concentration of HDL-C and LDL-C were lower in deficient group when compared to sufficient group. However, there is no statistically significant difference between lipid parameters, FBG and HbA1c concentrations in the two 25(OH)D levels. Furthermore, subjects in this study were divided into three groups, 25(OH)D deficient group, insufficient and the sufficient group and then cross tabulated with their lipid and fasting blood glucose 26 levels by chi square test. The results showed that a higher percentage of subjects who were 25(OH)D deficient and had high TG, VLDL, FBG and low HDL in compare to sufficient subjects who had had high TG, VLDL, FBG and low HDL. While, a lesser percentage of subjects who were 25(OH)D deficient and had high TC and LDL in compare to sufficient group with the same high levels. That may indicate that there is a negative correlation between vitamin D deficiency and high TG, VLDL and FBG and positive correlation with TC, LDL and HDL. However, the correlations statistically were not significant. Many studies have examined the relationship between serum levels of 25(OH)D and lipid profiles.

Some findings indicate a negative but non-significant relationship between serum levels of 25(OH)D and triglycerides (TG) in diabetic patients [29]. Other studies found positive correlations with total cholesterol and negative correlations with triglycerides [1]. Elevated TG and reduced HDL-C decreased significantly in vitamin D sufficient men compared to deficient men, whereas in women, no significant differences in dyslipidemia incidences were observed between sufficient and deficient groups. Additional findings suggest elevated total cholesterol, LDL-C, VLDL-C, triglyceride levels, and low HDL-C levels are significantly associated with 25(OH)D deficiency compared to subjects with normal 25(OH)D levels [30]. A meta-analysis based on cross-sectional data showed that the majority of the study results indicate that serum 25-hydroxy-

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D is directly associated with serum HDL-C and inversely related to TC, LDL, and TG [31]. Another meta-analysis of randomized controlled trials by Jafari et al. (2016) demonstrated that vitamin D improved serum levels of TC, TG, and LDL in patients with Type2 diabetes but changes of serum HDL was not satisfactory [32].

Table 1. Summary of different studies correlate 25(OH)D with lipid profile and blood glucose levels.

Study, year	Article	Subject	Association with serum 25(OH)D level
Chiu *et al.* (2004) [33]	Hypovitaminosis D is associated with insulin resistance and β cell dysfunction	126	A negative correlation of 25(OH)D concentration with total cholesterol and LDL –C was observed and no interaction of 25(OH)D concentrations with TG and HDL
Fernandez, & Webb, (2008). [34]	The LDL to HDL cholesterol ratio as a valuable tool to evaluate coronary heart disease risk.	-	Showed the relation between serum 25(OH)D and serum TC, HDL-C and LDL-C. were a high serum 25(OH)D concentration is associated with a desirable lipid profile with low serum TAG concentration and a low LDL-C/HDL-C ratio [14]
Jorde, *et al.*(2010) [35]	High serum 25 hydroxy-vitamin D concentrations are associated with a favorable serum lipid profile.	27 158	There is a cross-sectional association between serum 25(OH)D and serum lipids, and a longitudinal association over 14 years between serum 25(OH)D and TG.
Gaddipati *et al.*, (2011) [36]	The relationship of vitamin D status to cardiovascular risk factors and amputation risk in veterans with peripheral arterial disease.	1435	suggested that serum vitamin D levels were negatively correlated with total cholesterol, triglycerides and LDL-C and positively correlated with HDL-C in Americans
Moy, *et al.*, (2011) [37]	High prevalence of vitamin D insufficiency and its association with obesity and metabolic syndrome among Malay adults in Kuala Lumpur, Malaysia.	380	Vitamin D insufficiency is independently associated with younger age, female sex and greater abdominal obesity. Vitamin D insufficiency is also associated with Metabolic Syndrome.
Baker, *et al.*, (2012) [38]	Vitamin D, Metabolic Dyslipidemia, and Metabolic Syndrome in Rheumatoid Arthritis.	499	In conclusion, vitamin D deficiency was associated with the metabolic syndrome and dyslipidemia in rheumatoid arthritis, suggesting a potential role in cardiovascular disease risk.
Chaudhuri, *et al.*, (2013) [30]	Deficiency of 25-Hydroxyvitamin D and Dyslipidemia in Indian Subjects.	150	They established that low levels of 25-hydroxyvitamin D were independently associated with dyslipidemia. Hence 25-hydroxyvitamin vitamin D deficiency endangers this population for an early onset of cardiovascular and cerebrovascular diseases.
Saedisomeolia *et al.*, (2014) [29]	Association between serum level of vitamin D and lipid profiles in type 2 diabetic patients in Iran	108	Indicates that there is a negative, but non-significant, relationship between serum levels of 25(OH) D and that of TG in diabetic patients.
Tosunbayraktar, *et al.*, (2015) [39]	Low serum 25(OH)D levels are associated to higher BMI and metabolic syndrome parameters in adult subjects in Turkey	90	In conclusion, low serum 25(OH)D levels appear to be associated with obesity, visceral obesity, hypertriglyceridemia, insulin resistance, and metabolic syndrome in obese patients.
Wang *et al.*, (2016) [1]	The Associations of Serum Lipids with Vitamin D Status	1475	Found that there are a positive correlation with total cholesterol, while there are a negative correlation with triglycerides.
Lupton, *et al.* (2016) [40]	Deficient serum 25-hydroxy vitamin D is associated with an atherogenic lipid profile: The Very Large Database of Lipids (VLDL-3) Study	20,360	Despite inconclusive evidence from clinical trials, there remains strong evidence in the literature that 25(OH)D is inversely associated with LDL-C and TG and directly associated with HDL-C.

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Saeidlou, *et al.*, (2017) [11]	Seasonal variations of vitamin D and its relation to lipid profile in Iranian children and adults	541	Vitamin D is different between the two seasons regardless of gender variations. Its status showed some significant relationship with some lipid profiles (cholesterol, LDL, and HDL) during the two seasons.
Shahriari, *et al.*, (2018) [41]	The Effect of Vitamin D Supplementation in Overweight or Obese Type 2 Diabetic Patients with Vitamin D Deficiency and Dyslipidemia	60	This study indicates that eight weeks supplementation of vitamin D may improve lipid, glycemic and inflammatory indices in overweight or obese T2D patients with vitamin D deficiency and dyslipidemia
Kim, & Jeong, (2019) [23]	Relationship between Vitamin D Level and Lipid Profile in Non-Obese Children.	243	The results of this study partially confirmed the negative association between 25(OH)D level and lipid profile, including TG level and TG/HDL-C ratio.
Alsamghan, *et al.* (2020) [42]	Effect of Hypovitaminosis D on Lipid Profile in Hypothyroid Patients in Saudi Arabia	400	Hypovitaminosis D are known as independent risk factors for the development of CVD hypovitaminosis D, are correlated with total cholesterol, triglycerides, and low-density lipoprotein in Saudi patients.
AlQuaiz *et al.* (2020). [11]	Association between standardized vitamin 25(OH)D and dyslipidemia: a community-based study in Riyadh, Saudi Arabia	1717	

Vitamin D affects glucose metabolism as several reports support the hypothesis that vitamin D influences the pathways of pancreatic β--cell dysfunction, insulin resistance. Both vitamin D receptors and CYP27B1 (1-αhydroxylase), the key enzyme regulating the conversion of 25(OH)D into its active form, 1,25(OH)2D3) are expressed in the pancreatic β-cells. Thus, vitamin D action in the pancreatic β-cells seems to be exerted directly via binding of vitamin D to vitamin D receptors. An invitro study showed that 1,25(OH)2D3 can induce insulin biosynthesis in rat pancreatic islet cells and facilitate the conversion of pro-insulin to insulin [43, 44. 45]. Vitamin D may help protect beta cells in the pancreas that produce insulin, and thus preserve their function [46].

Conclusion

Despite the difference statistically was non-significant, the mean concentration of TC, VLDL-C, TG, FBG and (HbA1C) levels were higher in (25(OH)D) deficient group, when compared to subjects with sufficient 25(OH)D group. While the mean concentration of HDL-C and LDL-C were lower in deficient group. In addition, A higher percentage of subjects who had high TG, VLDL, FBG and low HDL in 25(OH)D deficient group in compare to sufficient group. While, a lesser percentage of subjects who had high TC and LDL in 25(OH)D deficient group in compare to sufficient group. However, there are a statistically significant correlation of 25(OH)D deficiency and elevated serum levels of all lipid parameters together, concurrent elevation of VLDL and triglycerides and concurrent elevation of VLDL and FBG. That may indicate that there is a negative correlation between vitamin D deficiency and high TG, VLDL, FBG and positive correlation with TC and LDL and HDL.

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Conflicts of Interest

The authors declare no conflicts of interest**.**

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الملخص

فيتامين د هو فيتامين أساسي قابل للذوبان في الدهون ويعمل في الجسم كهرمون ستيرويدي مع مجموعة من الوظائف المتعددة. يعتبر نقص فيتامين د شائعًا في بنغازي، ليبيا، خاصة بين الإناث وفي الفئات العمرية الأكبر. أظهرت التقارير الحديثة أن انخفاض مستوى فيتامين د يرتبط بالعديد من الأمراض. العلاقة بين حالة فيتامين د واضطرابات الدهون ومرض السكري غير واضحة. الهدف من هذه الدراسة هو التحقيق في دور مستوى فيتامين د في جميع معايير الدهون، سكر الدم الصائم ومستويات سكر الدم التراكمي في عينة من البالغين الليبيين. تم الحصول على بيانات من (110) مواضيع عشوائية من مختبر الرازي في بنغازي، ليبيا، في فترة أربعة أشهر. كانت التركيزات المتوسطة للكوليسترول الكلي، والكوليسترول منخفض الكثافة جدًا، ومستويات الدهون الثلاثية ، وسكر الدم الصائم ومستويات الهيموجلوبين السكري أعلى في مجموعة نقص فيتامين د مقارنة بالمجموعة التي لديها مستوى كافٍ من فيتامين د. بينما كانت التركيزات المتوسطة للكوليسترول عالي الكثافة والكوليسترول منخفض الكثافة أقل في المجموعة التي تعاني من نقص فيتامين د. كما كانت نسبة أعلى من الأفراد الذين يعانون من ارتفاع الدهون الثلاثية، الكوليسترول منخفض الكثافة جدًا، سكر الدم الصائم وانخفاض الكوليسترول عالي الكثافة في مجموعة نقص فيتامين د مقارنة بالمجموعة التي لديها مستوى كافٍ. في حين كانت النسبة أقل من الأفراد الذين يعانون من ارتفاع الكوليسترول الكلي والكوليسترول منخفض الكثافة في مجموعة نقص فيتامين د مقارنة بالمجموعة الكافية. ومع ذلك، توجد علاقة ارتباط ذات دلالة إحصائية بين نقص فيتامين د وارتفاع جميع معايير الدهون في المصل، وارتفاع متزامن في الكوليسترول منخفض الكثافة جدًا والدهون الثلاثية، وارتفاع متزامن في الكوليسترول منخفض الكثافة جدًا وسكر الدم الصائم. قد تشير نتائجنا إلى وجود علاقة سلبية بين نقص فيتامين د وارتفاع الدهون الثلاثية ، الكوليسترول منخفض الكثافة جدًا ، سكر الدم الصائم ، وعلاقة إيجابية مع الكوليسترول الكلي والكوليسترول منخفض الكثافة والكوليسترول عالي الكثافة.

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