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Correlation of Vitamin D3 Levels and Lipid Profiles in Menopausal Patients

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Abstract

Background : It is known that during menopause process, estrogen levels fall, triggering variety of pathological conditions such as vitamin D deficiency. Vitamin D has been shown to play a role in lipid metabolism, therefore its deficiency causes a more atherogenic lipid profile.

Aim: This study aims to determine the correlation between vitamin D3 levels and lipid profiles in postmenopausal patients.

Methods : This study is an observational analytic study with a cross-sectional research design conducted at the Universitas Sumatera Utara Hospital starting from July 2022 until the number of samples is met. The examination results of vitamin D3 levels and lipid profiles were obtained from laboratory examinations by taking blood samples. If data is normally distributed, then data is analyzed using Pearson Correlation Test. If data is not normally distributed, then data is analyzed using Spearman Correlation Test..

Results : Based on Pearson correlation test, it was found that there was a significant correlation between vitamin D3 levels and total cholesterol (p = 0.002), LDL (p = 0.007), and triglycerides (p = 0.000) levels but not significant with HDL (p = 0.074). Analysis with Chi-Square test showed that there was a significant relationship between vitamin D3 levels and cholesterol levels (p = 0.036), LDL levels (p = 0.033) and triglyceride levels (p = 0.036) but also not significant with HDL (p = 0.159) levels.

Conclusion: In postmenopausal patients, vitamin D3 levels had a significant relationship with lipid profiles that included total cholesterol, LDL, and triglyceride levels but did not have a significant relationship with HDL levels.

Keywords: Menopause, Vitamin D3, total cholesterol, LDL, LDL, triglycerides**INTRODUCTION**

Demographic data shows that every year, 25 million women worldwide experience menopause.[1] The mean age of menopause woman in Indonesia is found to be 50.5 years.[2] In Indonesia, on 2025, it is estimated that there will be 60 million menopausal women. Along with increasing women life expectancy to 70.43 years in 2014 and 73.77 years in 2025, it can be predicted that majority of women will experience menopause symptoms more than 30 years after going through menopause and spend about a third of their life with a state of estrogen deficiency that has an impact on various health problems that affect their quality of life.[3]

During menopause, decreased estrogen levels will cause changes in body composition, including increased fat mass, resulting in an increased vitamin D deficiency risk. Vitamin D deficiency can worsen quality of life and diseases that occur during menopause.[4] Changes in lipid metabolism begin during late phase of menopause. Levels of total cholesterol, LDL, triglycerides, and lipoproteins peak during menopausal transition and early postmenopausal stages. Postmenopausal women with higher estradiol levels had lower total and LDL cholesterol levels, whereas women with low FSH levels also had high total and LDL cholesterol levels.[5]

A meta-analysis study reported that vitamin D can reduce levels of LDL cholesterol, triglycerides, or total cholesterol. The study found vitamin D had a synergistic effect with cholesterol drugs.[6] Research by Srimani showed that prevalence of metabolic syndrome was 46% in postmenopausal women, whereas in postmenopausal women with metabolic syndrome, 53% had vitamin D deficiency.[7] Significant differences in 25-hydroxyvitamin-D were found in postmenopausal women. There was a significant difference in 25-hydroxyvitamin-D in postmenopausal women with and without vitamin D deficiency who had an increased lipid profile.[8]

Research conducted by Chon et al in 2013 concluded that plasma vitamin D concentration was positively associated with HDL-C (p = 0.003). Lower vitamin D was associated with a more atherogenic lipid profile, which is a major risk factor for progression to coronary artery atherosclerosis.[9] Hypovitaminosis D is associated with an increased risk of metabolic syndrome, central obesity, and hypertriglyceridemia in postmenopausal women. Total cholesterol and triglyceride levels were significantly higher in hypovitaminosis D than in adequate vitamin D group (p < 0.05).[10]

Estrogen increases activity of enzyme responsible for activating vitamin D, so a decrease in estrogen levels during menopausal transition can lead to vitamin D deficiency. Vitamin D deficiency can increase levels of LDL cholesterol, triglycerides, and total cholesterol. Based on these facts, researchers consider it is important to examine "The Correlation of Vitamin D3 Levels and Lipid Profiles in Menopausal Patients."

MATERIAL AND METHODS

This is an observational analytic study with a cross-sectional research design conducted at Universitas Sumatera Utara Hospital starting from July 2022 until number of samples is met. The sample was selected using consecutive sampling method, with number calculated using numerical-numerical correlative analytic formula.

The sample in this study were postmenopausal women who came for treatment at Universitas Sumatera Utara Hospital who met the inclusion criteria, namely women aged > 50 years, met the menopause criteria, spontaneous cessation of menstruation for at least 12 consecutive months, willing to be research subjects after receiving informed consent, never received hormone replacement therapy, and not included in exclusion criteria, namely patients with liver and kidney disease, other systemic diseases, and damaged blood serum. Through history-taking and physical examination, data on characteristics (age, education, occupation, duration of menopause, and BMI) were obtained. The results of the examination of vitamin D3 levels and lipid profiles were obtained from laboratory examinations by taking blood samples.

Statistical Analysis

In this study, data were collected, coded, cleaned, and tabulated, and statistical analysis was performed using SPSS computer program and presented in form of tables, narrations, and pictures. If the data is normally distributed, then data is analyzed using Pearson Correlation Test. If data is not normally distributed, then data is analyzed using Spearman Correlation Test..

RESULTS

This study was followed by 32 post-menopausal women at USU Hospital who met the inclusion criteria. Subjects aged between 50 – <55 years amounted to 16 subjects (50%) and those aged 56 – <60 years also amounted to 16 subjects (50%). Based on Body Mass Index (BMI) examination, most of subjects showed that nutritional status of normal weight was 16 subjects (50%). The most common subject education is senior high school as much as 12 subjects (56.3%). Most of subjects experienced menopause 5 years ago, which amounted to 20 subjects (62.5%). A total of four subjects (12.5%) each work indoors and outdoors.

Table 1. Demographic Characteristics of Menopausal Patients

Demographic Characteristics	n = 32
Age, n (%), years old	
50 – <55	16 (50)
56 – <60	16 (50)
BMI	
Underweight	2 (6,3)
Normoweight	16 (50)
Overweight	12 (37,5)
Obesity	2 (6,3)
Education, n (%)	
Elementary School	8 (25)
Junior High School	8 (25)
Senior High School	12 (37,5)
University	4 (12,5)
Menopause, duration [n (%)], years	
< 5	20 (62,5)
6 – < 10	12 (37,5)
Occupation, n (%)	
Indoors	4 (12,5)
Outdoors	4 (12,5)
Unoccupied	24 (75)

Vitamin D3 Levels and Lipid Profile of Menopausal Patients

Subjects mean vitamin D3 level was 16.54 ng/mL, with lowest level of 7 ng/mL and highest level of 26.8 ng/mL. A total of 20 subjects (62.5%) had vitamin D3 deficiency with vitamin D3 levels <20 ng/mL and 12 subjects (37.5%) had vitamin D3 insufficiency with vitamin D3 levels of 20–29 ng/mL. The mean total cholesterol level was 192.99 mg/dL with lowest level of 101.2 mg/dL and highest level of 231 ng/mL. A total of 25 subjects (78.1%) showed total cholesterol levels of >200 mg/dL and as many as 7 subjects (21.9%) showed total cholesterol levels of <200 mg/dL.

Mean LDL levels was 131 mg/dL with lowest level of 55 mg/dL and highest level of 156 mg/dL. A total of 27 subjects (84.4%) showed LDL levels >100 mg/dL and as many as 5 subjects (15.6%) showed LDL levels < 100 mg/dL. Mean HDL levels was 29 mg/dL with lowest level of 25 mg/dL and highest level of 40 mg/dL. A total of 29 people (90.6%) showed HDL levels <40 mg/dL and as many as 3 people (9.4%) showed HDL levels > 40 mg/dL. Mean Triglyceride levels was 190.46 mg/dL with lowest level of 62 mg/dL and highest level of 369 mg/dL. A total of 25 subjects (78.1%) had triglyceride levels > 150 mg/dL and 7 subjects (21.9%) had levels <150 mg/dL.

Table 2. Vitamin D3 Levels and Lipid Profile of Post-Menopausal Patients

Variable	n = 32
Vitamin D3, ng/mL	
Mean (SD)	16,54 (6,18)
Median (Min – Max)	17,1 (7 – 26,8)
< 20 ng/mL	20 (62,5)
≥ 20 – 29 ng/mL	12 (37,5)
Total Cholesterol, mg/dL	
Mean (SD)	192,99 (37,91)
Median (Min – Max)	206,2 (101,2 – 231)
≥ 200 mg/dL	25 (78,1)
< 200 mg/dL	7 (21,9)
LDL, mg/dL	
Mean (SD)	131 (28,98)
Median (Min – Max)	142 (55 – 156)
≥ 100 mg/dL	27 (84,4)
< 100 mg/dL	5 (15,6)
HDL, mg/dL	
Mean (SD)	29 (4,79)
Median (Min – Max)	27 (25 – 40)
< 40 mg/dL	29 (90,6)
≥ 40 mg/dL	3 (9,4)
Triglycerides, mg/dL	
Mean (SD)	190,46 (70,91)
Median (Min – Max)	184 (62 – 369)
> 150 mg/dL	25 (78,1)
≤ 150 mg/dL	7 (21,9)

Using Pearson correlation test, it was found that there was a significant correlation between vitamin D3 levels and total cholesterol (p = 0.002). Vitamin D3 levels also showed a significant correlation with LDL levels (p = 0.007). HDL levels didn't show a significant correlation with Vitamin D3 levels (p = 0.074). Furthermore, vitamin D3 levels showed a significant correlation with triglyceride levels (p = 0.000).

Table 3. Correlation of Vitamin D3 Levels and Lipid Profile in Post-Menopausal Patients

Lipid Profile	Vitamin D3	
	p value	r value
Total cholesterol	0.002 [a]	-0,516 [a]
LDL	0,007 [a]	-0,466 [a]
HDL	0,074 [a]	-0,320 [a]
Triglyceride	0,000 [a]	-0,597 [a]

[a]Pearson correlation

Table 4. Correlation of Vitamin D3 Levels and Total Cholesterol in Post-Menopausal Patients

Lipid Profile	Vitamin D3 Levels		p value*
	< 20 ng/mL	≥ 20 – 29 ng/mL	
≥ 200 mg/dL	18 (90)	2 (10)	0,036*

Total cholesterol	**< 200 mg/dL**	2 (10)	5 (41,7)	

**Chi-Square*

Table 5. Correlation of Vitamin D3 Levels and LDL in Post-Menopausal Patients

Lipid Profile		Vitamin D3 Levels		p value*
		< 20 ng/mL	**≥ 20 – 29 ng/mL**	
LDL	**≥ 100 mg/dL**	19 (95)	8 (66,7)	0,033*
	< 100 mg/dL	1 (5)	4 (33,3)	

**Chi-Square*

Table 6. Correlation of Vitamin D3 Levels and HDL in Post-Menopausal Patients

Lipid Profile		Vitamin D3 Levels		p value*
		< 20 ng/mL	**≥ 20 – 29 ng/mL**	
HDL	**< 40 mg/dL**	17 (85)	12 (100)	0,159*
	≥ 40 mg/dL	3 (15)	0 (0)	

**Chi-Square*

Table 7. Correlation of Vitamin D3 Levels and TG in Post-Menopausal Patients

Lipid Profile		Vitamin D3 Levels		p value*
		< 20 ng/mL	**≥ 20 – 29 ng/mL**	
TG	**≥ 150 mg/dL**	18 (90)	7 (58,3)	0,036*
	< 150 mg/dL	2 (10)	5 (41,7)	

**Chi-Square*

Analysis with Chi-Square test showed that there was a significant relationship between vitamin D3 levels and cholesterol levels (p = 0.036), LDL levels (p = 0.033) and triglyceride levels (p = 0.036) but also not significant with HDL (p = 0.159) levels.

DISCUSSIONS

Perimenopausal and postmenopausal women are more at risk for vitamin D deficiency because aging and increased fat mass lead to decreased blood levels of vitamin D. In addition, proper physical activity and sun exposure are necessary for vitamin D synthesis in the skin, and amount of vitamin D in body decreases with age, especially during menopause. Therefore, some of cardiovascular disease causes in perimenopause and menopause are related to decreased concentrations of ovarian hormones during and after menopause. Dyslipidemia is a major risk factor for cardiovascular disease and atherosclerosis. Previous reports have shown that metabolic syndrome prevalence in postmenopausal women is 41.5%.[11]

Because it reflects a person's cumulative sun exposure and dietary vitamin D intake, serum 25(OH)D is widely regarded as best biochemical indicator of vitamin D status. Identifying circulating levels of 25-OH-D is important for diagnosis and monitoring of vitamin D deficiency. Deficiency of vitamin D levels in human blood is defined as <20 ng/ml, insufficiency defined as 21-29 ng/ml and adequate vitamin D levels as 30 -100 ng/ml.[7]

Mean vitamin D3 level of study subjects was 16.54 ng/mL, with lowest level of 7 ng/mL and highest level of 26.8 ng/mL. In this study, there were no study subjects with adequate levels of vitamin D3. A total of 20 subjects (62.5%) had vitamin D3 deficiency with vitamin D3 levels <20 ng/mL and 12 subjects (37.5%) had vitamin D3 insufficiency with vitamin D3 levels of >20–29 ng/mL. The study conducted by Joshi et al. demonstrated vitamin D status among postmenopausal women, 80% of study subjects had vitamin D deficiency, 14.8% had insufficiency, and only 5.2% had optimal vitamin D levels (p = 0.004), indicating that vitamin D deficiency was associated with patient age. One study conducted in South India on vitamin D status among postmenopausal women and women in reproductive age group showed a similar prevalence. Postmenopausal women show vitamin D deficiency and insufficiency was 70% and 23% of postmenopausal women. Another study also reported that 52.37% of postmenopausal women were vitamin D deficiency. This clearly indicates that low vitamin D levels in old age are due to reduced capacity of aging skin to synthesize vitamin D effectively.[12]

Vitamin D is considered a modulator of immune system function; it has anti-inflammatory effects; reduces insulin resistance; and suppresses renin-angiotensin system. In a study conducted by Kumari et al., vitamin D

deficiency occurred in 37.80% of perimenopausal and 51.21% of postmenopausal women, and vitamin D insufficiency was reported in 2.43% of perimenopausal and 6.09% of postmenopausal women. Only 2.43% of perimenopausal women with deficient serum vitamin D levels.[13] Capatina et al. found a significantly high prevalence of patients with Vitamin D insufficiency in study group which was 91.9% of cases (114 women) had serum 25OHD levels < 30 ng/ml, 74.8% of cases with vitamin D deficiency (92 cases) and 17.1% of cases with vitamin D insufficiency (21 cases) and only 8.1% (10 cases) with vitamin D sufficiency.[14]

In this study found mean total cholesterol level was 192.99 mg/dL with lowest level of 101.2 mg/dL and highest level of 231 ng/mL. A total of 25 subjects (78.1%) showed total cholesterol levels of >200 mg/dL and as many as 7 subjects (21.9%) showed total cholesterol levels of <200 mg/dL. Mean LDL levels was 131 mg/dL with lowest level of 55 mg/dL and highest level of 156 mg/dL. A total of 27 subjects (84.4%) showed LDL levels >100 mg/dL and as many as 5 subjects (15.6%) showed LDL levels < 100 mg/dL. Mean HDL levels was 29 mg/dL with lowest level of 25 mg/dL and highest level of 40 mg/dL. A total of 29 people (90.6%) showed HDL levels <40 mg/dL and as many as 3 people (9.4%) showed HDL levels > 40 mg/dL. Mean Triglyceride levels was 190.46 mg/dL with lowest level of 62 mg/dL and highest level of 369 mg/dL. A total of 25 subjects (78.1%) had triglyceride levels > 150 mg/dL and 7 subjects (21.9%) had levels <150 mg/dL.

Research conducted by Kostecka et al. In 2022, mean total cholesterol was 221.5 +42.95 mg/dl, HDL fraction cholesterol was 68+17.44 mg/dl, LDL fraction was 130.1+35.1 mg/dl, and triglycerides were 110.8+82.82 mg/dl. The median total cholesterol was 218.6 mg/dl. The highest triglyceride levels measured were 1024 mg/dl and median 92.9 mg/dl, respectively. There is a weak negative correlation between serum vitamin D levels and total cholesterol (rho = -0.14; p = 0.05), LDL cholesterol (rho = -0.16; p=0.026), and triglycerides (rho = -0.22; p = 0.002). Only HDL cholesterol (p = 0.067) and glucose levels did not show a statistically significant correlation.[15]

Vitamin D is required for optimal calcium absorption, so it is also important for bone health. In patients with vitamin D deficiency, no more than 15% of calcium is absorbed from food, whereas in people with vitamin D sufficiency, 30–80% of calcium is absorbed from food. The study conducted by Narula et al. showed that based on the examination of serum 25-hydroxy vitamin D levels in all patients, vitamin D deficiency was found (serum 25-OH vit. D = 5–20 ng/ml) in 118 of 190 subjects (62%), and severe vitamin D deficiency (serum 25-OH vit D = 5 ng/ml) in four subjects (2.1 percent of subjects). Total cholesterol was 178 + 41 mg%, triglycerides were 130 +60 mg%, HDL was 47 +13 mg%, LDL was 117 +45 mg%, and VLDL was 33 +26 mg% in postmenopausal women.[16]

Vitamin D is known to prevent cardiovascular disease, hypertension, diabetes, and osteoporosis. Vitamin D deficiency is reported to cause secondary hyperparathyroidism due to increased PTH in blood, causing diabetes, increased blood pressure, accelerated atherosclerosis, and cardiovascular calcification. Women with vitamin D deficiency have a lower hip-to-waist ratio, higher body lipoprotein density, and a higher body mass index. elevated triglycerides, PTH, and higher fasting blood glucose. Dietary intake of calcium and vitamin D was found to be lower in vitamin D deficiency group.[17]

In a parallel, randomized, placebo-controlled trial by Moghassemi, 76 healthy postmenopausal women experienced vitamin D deficiency (defined as 25-[OH]D level < 75 nmol/L) and were randomly assigned to receive 2000 IU of vitamin D3 supplementation once daily (n = 38) or placebo (n = 38). After 12 weeks, there were no significant differences in fasting blood sugar, lipid profile, or blood pressure between groups (P > 0.05).[18]

In a study conducted by Chon et al., it was found that results of triglycerides increase and HDL decrease were due to serum 25OHD levels increasement. In several studies, triglycerides were generally found to be elevated in postmenopausal women compared to premenopausal women, and cardioprotective features in women were found to decrease after menopause with significant HDL-C decrease. Although the mechanism underlying association between vitamin D status and dyslipidemia is not well known, one animal study reported that plasma vitamin D concentration was positively associated with HDL-C (p = 0.003), concluding that lower vitamin D was associated with decreased vitamin D levels. The lipid profile is more atherogenic, which is a major risk factor for progression to coronary artery atherosclerosis.[9]

Correlation of Vitamin D3 Levels and Lipid Profile in Post-Menopausal Patients

Based on Pearson correlation test done in this study, it was found that there was a significant correlation between vitamin D3 levels and total cholesterol (p = 0.002), LDL (p = 0.007), and triglycerides (p = 0.000) levels but not significant with HDL (p = 0.074). Analysis with Chi-Square test showed that there was a significant relationship between vitamin D3 levels and cholesterol levels (p = 0.036), LDL levels (p = 0.033) and triglyceride levels (p = 0.036) but also not significant with HDL (p = 0.159) levels.

This is in accordance with a study conducted by Jeenduang et al in 2020, who conducted a study on 340 postmenopausal women and found that total cholesterol levels and triglyceride levels were significantly higher in

hypovitaminosis D compared to adequate vitamin D levels subjects (p=0.05). The prevalence of metabolic syndrome, central obesity, and hypertriglyceridemia in hypovitaminosis D was significantly higher than in adequate vitamin D levels subjects (p =0.05). In a multivariable logistic regression model, hypovitaminosis D was associated with improved lipid profiles (OR 1.85; 95% CI 1.12–3.04, p = 0.015), central obesity (OR 2.41; 95% CI 1.20–4.85, p = 0.014), and hypertriglyceridemia (OR 1.91; 95% CI 1.12–3.26, p = 0.018) compared with adequate vitamin D levels subjects. Serum vitamin D concentrations were significantly lower in lipid profile enhancement group than in the low lipid profile group (p = 0.016) and decreased with an increasing number of lipid profile components (p = 0.034).[10]

Although the mechanism by which lower vitamin D levels improve lipid profiles in postmenopausal women is unknown, previous research has shown that decreased estrogen levels after menopause reduce 25(OH)D synthesis, active vitamin D metabolite 1a,25-dihydroxyvitamin D [1,25(OH)2D], and vitamin D receptor expression. In fact, the biologically active form of vitamin D, 1,25(OH)2D, plays an important role in controlling many physiological processes. For example, renin-angiotensin system, angiogenesis, thrombogenesis, insulin sensitivity, immunomodulation, cell proliferation, cell cycle control, bone metabolism, and muscle function bind to vitamin D receptors, which regulate expression of more than 900 genes in several cell types. As a result, decreased 25(OH)D and 1,25(OH)2D levels, as well as decreased expression of vitamin D receptors during menopause, can increase the risk of hypertension, type 2 diabetes, cardiovascular disease, and metabolic syndrome. A previous study also reported a synergistic effect of vitamin D deficiency and estradiol (E2) on improving lipid profiles in postmenopausal women.[10]

Although the mechanism by which vitamin D affects lipid levels remains unclear, several mechanisms have been proposed. First, vitamin D can affect serum lipids by increasing intestinal calcium absorption and resulting increase in serum calcium. Increased levels of calcium can reduce hepatic triglyceride formation, intestinal secretion and absorption of fatty acids. Second, serum calcium can increase excretion of fecal fat and bile acid secretion and then lower cholesterol levels. Third, low serum 25(OH)D concentrations are associated with elevated parathyroid hormone concentrations. Hyperparathyroidism triggers lipogenesis in adipocytes, decreased lipolysis, decreased lipoprotein lipase activity, decreased peripheral triglyceride clearance, and activation of microsomal triglyceride transfer protein, leading to increased triglycerides. Fourth, vitamin D deficiency was found to be associated with impaired cell function and insulin resistance, leading to increased triglyceride levels and decreased HDL levels. Finally, vitamin D can regulate lipid levels through increased expression of VLDL receptor gene.[19]

Menopause is an important transition period in a woman's life as well as an increased need for vitamin D. Menopause is also associated with an increased risk of obesity and a shift to an increased distribution of abdominal fat with associated increased health risks. Age is an important factor in determining vitamin D skin synthesis. Aging affects several steps of vitamin D metabolism because aging of the skin has reduced the efficiency of synthesizing vitamin D when exposed to sunlight. Therefore, postmenopausal women are more prone to vitamin D deficiency due to inevitable aging process coupled with obesity.[12]

The systematic review and meta-analysis conducted by Liu et al. showed that administration of vitamin D in postmenopausal women can cause changes in lipid profiles, especially in terms of lowering triglycerides and HDL. However, administration of vitamin D did not significantly change total or LDL cholesterol levels. Administration of vitamin D has an impact on HDL concentrations, namely vitamin D increases HDL in postmenopausal women, especially in women who are overweight. Although HDL is one of the factors that play a role in reducing cardiovascular risk, recent studies have shown that incidence of cardiovascular events is higher in subjects with both low and high HDL concentrations.[11]

Decreased triglyceride values may be associated with increased serum vitamin D status in women. In addition, there are studies showing that increased triglyceride concentrations are associated with several polymorphisms in the vitamin D receptor gene, which may also explain why vitamin D is more effective in reducing triglycerides in postmenopausal women at lower doses..[11] Vitamin D deficiency was associated with serum triglyceride levels among Kashmiri women (4.8 ± 3.1) versus women living in Jammu (8.3 ± 2.9) and this difference was statistically significant (p=0.001) indicating that Vitamin D deficiency is associated with cardiovascular risk. Vitamin D levels decrease proportionally with increasing triglyceride levels. Vitamin D deficiency is associated with increased TNF-α and Interleukin-6 leading to inflammation and cardiac hypertrophy.[12]

Triglyceride levels can be reduced by taking vitamin D to improve lipid profile as a risk factor for coronary heart disease in postmenopausal women. The effect of giving vitamin D to lower LDL levels, increase HDL levels, and reduce total cholesterol clinically is unknown. In addition, supplementation with vitamin D decreased triglycerides significantly, especially in postmenopausal women with hypertriglyceridemia at onset.[20]

Vitamin D can inhibit the synthesis and secretion of triglycerides through stimulation of intestinal calcium absorption. Increased intestinal calcium levels may reduce intestinal fatty acid absorption due to formation of insoluble calcium-fat complexes. Serum LDL levels decrease with decreased absorption of fats, especially saturated fatty acids. In addition, calcium can increase conversion of cholesterol into bile acids and thereby reduce cholesterol levels. Other studies have shown that high levels of parathyroid hormone (PTH) can lead to increased triglycerides and that higher concentrations of 25(OH)D suppress serum PTH levels. Therefore, vitamin D can affect triglyceride concentrations by regulating PTH levels. In addition, previous studies have shown strong evidence that vitamin D deficiency may be associated with impaired β-cell function and insulin resistance which can affect lipoprotein metabolism and lead to increased triglyceride levels and decreased HDL levels. In addition, vitamin D has been found to be involved in lipid metabolism such as bile acid synthesis in the liver, suggesting that vitamin D may affect lipid regulation directly.[21]

In women, estrogen deficiency results in increase abdominal obesity. Similarly, previous studies have shown that hypovitaminosis D is associated with obesity. The mechanism underlying the inverse relationship between vitamin D and obesity may be the accumulation of vitamin D in adipose tissue because vitamin D is fat-soluble. Therefore, level of vitamin D serum is low and then causes a decrease in its bioavailability of obese subjects. However, it is not clear whether lower vitamin D levels are simply due to obesity. It is possible that obesity may be a consequence of low vitamin D levels. Some evidence has supported the role of vitamin D in the prevention of obesity. In vitro studies show that 1,25(OH)2D inhibits adipogenesis and promotes apoptosis in adipocytes of mouse cell line 3T3-L1.[10,21]

In Song et al study. The results were compared with highest quartile serum 25-(OH)D group (19.9-55.9 ng/ml), odds ratio for metabolic syndrome in lowest group (4.2-9.7 ng/ml).) was 2.44 [95% confidence interval (CI)=1.32-4.48], in low concentration group (9.8-14.1 ng/ml) was 2.20 (95% CI=1, 24-3.90), and in moderate level group (14.3-19.8 ng/ml) was 1.81 (95% CI=1.02–3.20). Low serum 25-(OH)D levels are significantly associated with presence of metabolic syndrome and several metabolic components, particularly high triglyceride levels and blood pressure in postmenopausal women.[22]

In women, there was a link between serum 25(OH)D and LDL ($p = 0.01$) and total cholesterol ($p = 0.001$). Each 10 nmol/L increase in 25(OH)D concentration was associated with a 0.25 mmol/L decrease in LDL and a 0.39 mmol/L decrease in total cholesterol.[21] Vitamin D supplementation for elderly women has been shown to increase muscle enzymes oxidative citrate synthase and 3-hydroxyacyl-CoA-dehydrogenase, which are markers of improved muscle function. Another cardiac protective effect of vitamin D is lipid regulation, in which association between vitamin D deficiency and lipid profile is negative. The positive correlation between 25(OH)D and HDL and the inverse correlation of 25(OH)D with triglycerides was consistent with increase in intimal media thickness seen in subjects with carotid plaque in The Northern Manhattan Study.[23]

Vitamin D can inhibit various aspects of inflammation, which has been established as the main mechanism of atherosclerosis. In this study, vitamin D may inhibit the inflammatory response to cardiovascular injury and that, in cases with vitamin D deficiency, vitamin D administration may reduce development of atherosclerotic plaques and plaque rupture.[24] A 10 ng/mL increase in 25(OH)D was associated with a 1.279 mmol/L decrease in TGs, a 0.047 mmol/L decrease in TC, a 0.119 atherogenic index of plasma (AIP), and a 0.102 mmol/L increase in HDL-C (all $p < 0,05$). In contrast, a positive association between 25(OH)D and HDL-C was found in female participants, with every 10 ng/mL increase in 25(OH)D associated with an increase of 0.060 mmol/L HDL-C ($p = 0.006$). [25]

Vitamin D decreases proliferation of purified T h1 (helper) cells and also cytokines production which involved in lipogenesis and lipolysis. Interferon-γ; Th1 cell cytokines have been determined to control lipid inflammation. Other Th1 cell products such as TNF-α were found to induce lipogenesis and induce lipolysis in mice. In addition, 1,25(OH)2D3 has been reported to inhibit expression of uncoupling adipocyte protein 2, leading to stimulation of lipogenesis and inhibition of lipolysis. In addition, vitamin D downregulates nuclear factor-kB activity, increases interleukin (IL)-10 production, and decreases IL-6, IL-12, which reduces inflammation. An increase in vitamin D levels from 20 to 30 ng/ml was associated with an increase in total and HDL cholesterol, but did not change LDL and triglyceride levels.[24]

CONCLUSION

In postmenopausal patients, vitamin D3 levels had a significant relationship with lipid profiles that included total cholesterol, LDL, and triglyceride levels but did not have a significant relationship with HDL levels.

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