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Vitamin D supplementation influences the serum lipid profile in the Jordanian population with vitamin D deficiency

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ABSTRACT

Purpose: To evaluate the association between vitamin D supplementation and changes in lipid profile in a Jordanian population with vitamin D deficiency.

Methodology: A total of 95 participants, comprising 35 females aged 15-73 years, were recruited for this prospective investigation and administered vitamin D supplements. Blood specimens were examined for lipid profile characteristics and 25(OH)D3 amounts. Vitamin D supplementation protocole involved the weekly dosing of a single tablet containing 50,000 IU of cholecalciferol for the first four weeks, and bi-weekly medication for the final four weeks.

Findings: Before intervention, vitamin D, calcium, total cholesterol, high-density lipoprotein (HDL), decreased low-density lipoprotein (LDL), and triglyceride (TG), had no statistical difference between males and females (p=0.231, 0.111, 0.331, 0.821, 0.271, and 0.371, respectively). A noteworthy decrease in serum total cholesterol levels (194±22 mg/dL to 187±19 mg/dL, p<0.05) was noted after vitamin D administration. Although there was a non-significant trend towards LDL cholesterol levels (107±18 mg/dL to 98±15 mg/dL), as well as TG levels (135±26 mg/dL to 128±17 mg/dL), these changes were not statistically significant. Conversely, there was a minor and insignificant rise in the levels of HDL cholesterol (55±13 mg/dL to 57±12 mg/dL). Post intervention, lipid profile parameters correlated positively with vitamin D (r=0.77 for total cholesterol, 0.84 for TG, 0.80 for HDL, and 0.29 for and LDL) with a significant difference (p<0.001, <0.001, <0.001, and 0.004, respectively).

Conclusion: Vitamin D may influence certain aspects of lipid metabolism, but broader conclusions regarding overall lipid profile improvement should be made cautiously.

Practical implications: Future studies should assess the long-term effects of vitamin D supplementation on lipid profile parameters.

KEYWORDS

Micronutrients, cardiovascular prevention, lipid metabolism, nutritional intervention.

INTRODUCTION

Vitamin D, or calciferol, is a fatty-soluble vitamin that is stored in several foods. It is made up of substances that are essential to the body's mineral balancing and to the healthy growth and strength of bones and teeth[1].

The body produces vitamin D internally through the skin and externally through food, which are the main supply of vitamin D in humans. The cholesterol metabolic mechanism is the main process of endogenous synthesis, which is activated by ultraviolet B (UVB) radiation and results in the conversion of 7-dehydrocholesterol into cholecalciferol (vitamin D3)[2]. The human body obtains vitamin D from exogenous sources such as food and supplements. Egg yolk, fortified milk, and fatty fish are dietary natural sources of vitamin D which supply the body with absorbable vitamin D3 and ergocalciferol (vitamin D2)[3]. After being consumed or supplemented, vitamin D is quickly metabolised in the liver to produce 25-hydroxyvitamin D (25(OH)D), the main form that circulates and acts as a precursor to the hormone that is actually produced. The physiologically active sort of vitamin D, 1,25-dihydroxyvitamin D (1,25(OH)2D), is then produced in the kidneys by a second hydroxylation process involving 25(OH)D. Parathyroid hormone (PTH) affects this conversion procedure, which is

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characterised by a half-life of roughly three weeks for 25(OH)D and eight hours for 1,25(OH)2D. It also shows a substantially higher blood level (>100 times larger) than the active hormone[4].

Upon the injection of loading dosages, vitamin D2 and vitamin D3 both had the same effectiveness in raising serum 25(OH)D concentrations. However, in the context of long-term supplementation, cholecalciferol (vitamin D3) is considered a more practical and convenient option due to its longer shelf life, improved stability, and reduced risk of degradation[4]. Serum concentrations of 25-hydroxyvitamin D3 (25(OH)D3) are commonly measured to assess a person's vitamin D status, even though this molecule is an inactive precursor that needs more hydroxylation to become biologically active. This is due to the fact that 25(OH)D3 has a high degree of stability and a longer half-life, making it a reliable indicator of vitamin D concentrations[5].

By aiding in the uptake of calcium from the gastrointestinal system and encouraging its upcoming integration into bone tissue, vitamin D is essential for maintaining phosphorus and calcium balance. Furthermore, vitamin D is necessary for the health of bones since it controls the mechanisms behind bone formation, maintenance, and enhancing, maintaining the normal amounts of phosphorus and calcium in the body[6]. Research has shown that vitamin D induces the production of antibodies by immune cells, thereby enhancing the overall immune response and boosting immune-mediated resistance. A comprehensive review of over 500 studies has consistently demonstrated vitamin D immune health regulating function, underscoring its significance in modulating immune function and promoting immune competence[7]. The favourable impacts of vitamin D on the body's skeletal system, particularly its capacity to preserve joint and muscle relaxation and its function in promoting the health of the breasts[8], and prostate[9], have been demonstrated by several research. Additionally, vitamin D has been demonstrated to have a good impact on psychological condition, most likely by modulating the hypothalamic-pituitary-adrenal axis and regulating mood-related neurotransmitters[10].

There are many different types of vitamin D supplementation, such as single-entity or multivitamin solutions, and some formulas incorporate vitamin D and calcium to meet particular dietary requirements[11]. To cater to the diverse requirements of different patient populations, vitamin D-based products are offered in various formats, including capsules, tablets, liquids, and sublingual tablets. Particularly, since vitamin D3 is more effective at preserving the ideal amounts of vitamin D in the human body than vitamin D2, it is recommended for supplementation. Improved health indicators are made possible by the human body's more effective intake and digestive processes of vitamin D3[12].

The inconsistent reported results across various groups are one of the major gaps in the current evidence on the connection between vitamin D prescription and alterations in lipid profiles. According to certain research, vitamin D may help with lipid digestion[13]. Others, however, have not discovered any meaningful connection[14]. Furthermore, Western populations have been the subject of the majority of earlier studies[15], with little investigations been out in Middle Eastern nations, such as Jordan, where food and lifestyle choices are major causes of vitamin D insufficiency. Furthermore, little is known about how the consumption of vitamin D impacts various lipid components in persons with serious deficiencies, including HDL and LDL.

To fill in these discrepancies, a Jordanian group with a diagnosis of vitamin D deficiencies was included in the current prospective trial, which included a clearly defined regimen of vitamin D supplementation. To guarantee sufficient replacement of vitamin D levels in a brief amount of time, the investigation used a standardised high-dose supplemental strategy (50,000 IU weekly for the first four weeks, followed by bi-weekly delivery). The research sought to shed further light on the relationship between vitamin D and lipid absorption by comparing alterations to lipid profiles prior to and following administration. To increase the validity of the results, the research also took into account contributory factors including age, sex, BMI, and pre-existing metabolic disorders. Additionally, an extensive age spectrum of male and female volunteers were included in the research, which increased its representativeness of the entire population. Additionally, the strength of these connections was determined by doing a correlation study between vitamin D values and particular lipid markers, which offers a more thorough understanding of how vitamin D affects lipid digestion. In order to clarify any potential correlations between these factors, the current study set out to examine any possible associations that might exist between lipid profiles and serum vitamin D levels in a sample of Jordanian people.

The research questions guiding this study were as follows:

1. Does vitamin D supplementation significantly alter serum lipid profile parameters (total cholesterol, HDL, LDL, and triglycerides) in individuals with vitamin D deficiency?
2. Is there a statistically significant correlation between serum vitamin D levels and lipid profile parameters following supplementation?
3. Does vitamin D supplementation lead to sex-specific differences in lipid profile changes among Jordanian individuals?
4. How does high-dose vitamin D supplementation compare to previously reported lower-dose regimens in terms of lipid profile improvement?

The structure of this paper follows a systematic approach to presenting the research. The introduction outlines the significance of vitamin D in various physiological functions, par-

ticularly its role in lipid metabolism. It also highlights the gaps in existing literature and the rationale for conducting this study in a Jordanian population. The methodology section details the study design, participant recruitment, inclusion and exclusion criteria, data collection methods, and statistical analysis used to assess the impact of vitamin D supplementation on lipid profiles. The results section presents the demographic characteristics of the participants, baseline and post-supplementation biochemical parameters, and statistical analyses illustrating the changes in lipid profile and their correlation with vitamin D levels. In order to emphasise similarities and differences and investigate potential reasons behind the observed changes, the findings were compared with previous research in the discussion section. The study's practical ramifications are also discussed, along with suggestions for therapeutic practice and future lines of inquiry. The conclusion, which highlights the possible advantages of vitamin D administration in enhancing lipid profiles and identifies areas for additional research, wraps up the main outcomes.

LITERATURE REVIEW

A thorough analysis of the body of research is necessary to determine the degree and clinical significance of the association between vitamin D insufficiency and lipid control, given the prevalence of this condition worldwide. Adequate vitamin D quantities were linked to favourable lipid profiles in prospective and interventional trials, while insufficient vitamin D amounts were linked to unfavourable blood lipid trends[16].

The implications of vitamin D level on blood lipids in Chinese people were examined in a retrospective study involving 1475 subjects. The incidence of dyslipidaemias (fewer HDL-C, increased TG, and increased atherogenic index of plasma (AIP)) was linked to decreased 25(OH)D levels in males, though higher TC and LDL-C were linked to higher 25(OH)D levels in females[17].

Vitamin D status were discovered to be inversely correlated with TC, TG, and LDL cholesterol in a Polish cohort research[16]. By examining the levels of 25(OH)D and different lipid fractions in 20,000 people, a strong association between an atherogenic lipid composition and vitamin D insufficiency was discovered[18]. Additionally, vitamin D levels, supplementation, and their relationship to the lipid profile have been assessed in additional meta-analyses[19-21]. Vitamin D decreased TG levels and was linked to an increase in HDL cholesterol and, surprisingly, an increase in LDL cholesterol, according to a meta-analysis of eight randomised controlled trials (RCTs) investigating the impact of vitamin D intake on cholesterol levels[19]. The implications of vitamin D administration on TG, TC, LDL cholesterol, and HDL cholesterol were assessed in an expanded meta-analysis of 10 RCTs. The results showed that vitamin D administration raised HDL cholesterol values. However, the scientists discovered that vitamin D administration and TG, TC, and LDL cholesterol had a statistically noteworthy inverse relationship[21]. TG, TC, LDL, and HDL cholesterol levels were all considerably reduced and HDL cholesterol concentrations were raised in a far larger meta-analysis that assessed the combined effect of vitamin D administration on these levels in up to 81 RCTs[20].

TC, TG, and HDL-C are all improved by calcium and vitamin D co-supplementation, according to a systematic review and meta-analysis of thirteen trials[22].

According to an umbrella examination and meta-analyses, a dose of vitamin D may be useful as a complementary treatment to control lipid profile levels, particularly in those who are vitamin D deficient[23].

Given the quantity of studies, the variety of interventions and results, and the methodological calibre of the research, these results should be considered cautiously. Thus, considering that vitamin D insufficiency is common around the world and that vitamin D is said to have positive effects on lipid profiles (Table 1).

MATERIAL AND METHODS

Study design

Prospective intervention study without a control group (pre-post), designed to evaluate changes in the lipid profile after vitamin D supplementation and its association with serum levels of 25(OH)D.

Study settings

The current study was conducted among participants attending the internal medicine clinics at Tohama Medical Center in Zarqa City, Jordan, from September 25, 2023, to August 22, 2024.

Study populations

The study comprised 95 individuals, including 35 women, aged 15–73 years, who received vitamin D supplementation. The wide age range was intentionally included to reflect the real-world prevalence of vitamin D deficiency across various age groups in the Jordanian population, thereby enhancing the generalizability of the findings, and determined by statistical criteria according to a formula. The sample size calculation utilized a two-sided test where the β value is 0.2 and the α value is 0.05.

Inclusion Criteria

The research included patients who were undergoing vitamin D supplementation as part of their regimen. Respondents were chosen from among nonsmoking individuals who sought care at Tohama Medical Center's internal medicine clinics in Zarqa City, Jordan.

Table 1.

Reference	Setting	Study design	Population	Aim	Findings
(24)	UK	A systematic review literature	19 RCTs	To clarify the contradiction between the encouraging results of observational investigations and the depressing outcomes of interventional trials.	Healthy individuals are prone to spend more time outside and adopt healthier dietary habits, therefore elevated serum vitamin D levels could not be an indicator of good health but rather its result.
(19)	UK	A meta-analysis	9 RCTs	Investigating how vitamin D administration affects the lipid balance.	Vitamin D decreased TG levels and was linked to higher HDL and, surprisingly, lower LDL cholesterol amounts.
(18)	USA	Retrospective study	20,000 participants	Measuring the concentrations of different lipid components and 25(OH)D.	Vitamin D insufficiency and an atherogenic lipid inventory are significantly correlated.
(16)	Poland	Cohort study	637 patients	To evaluate how 25(OH)D affects the composition of lipids and the degree of coronary atherosclerosis.	A negative correlation between TC, TG, and LDL cholesterol and vitamin D amounts.
(17).	Chinese	Retrospective study	1475 participants	To look into how Chinese people' serum lipid levels are affected by their vitamin D status.	Male's reduced 25(OH)D levels were linked to dyslipidaemias (lower HDL-C, raised TG, and increased AIP), while female's increased TC and LDL-C were linked to elevated 25(OH)D values.
(20)	Canada	A meta-analysis	81 RCTs,	Assessing how vitamin D supplements affect TG, TC, LDL cholesterol, and HDL cholesterol collectively	Vitamin D dramatically raised HDL cholesterol amounts while lowering TG, TC, and LDL cholesterol values.
(21)	Iran	A meta-analysis	10 RCTs	Assessing how vitamin D administration affects TG, TC, LDL, and HDL cholesterol.	TG, TC, and LDL cholesterol have a substantially negative relationship with vitamin D intake.
(22)	Iran	A systematic review and meta-analysis	Thirteen studies	Although co-supplementing calcium and vitamin D is popular and often utilised, RCTs have produced conflicting findings on its effect on the blood lipid profile.	Co-supplementing with calcium and vitamin D improves TC, TG, and HDL-C.
(23).	Iran	An Umbrella Review of Meta-Analyses	25 meta-analyses	To look into how vitamin D administration affects the lipid profile's elements: TG, TC, HDL, and LDL cholesterol.	Supplementing with vitamin D may be a useful adjuvant treatment for controlling lipid profile levels, particularly in those who are vitamin D deficient.
The current study	Jordan	Prospective investigation	95 participants	To examine whether lipid profiles and amounts of vitamin D in a Jordanian population, to examine the associations between these biochemical parameters and identify any significant relationships.	Vitamin D supplementation has a significant effect on lipid profile improvemet

Exclusion Criteria

Participants who currently smoked or showed a history of smoking were excluded from the study. Furthermore, the research excluded people with any medical conditions that would have impacted the study's results, including hypertension, diabetes, cardiovascular illness, or kidney or liver disease. Additionally, participants in the current study were not permitted to register during pregnancy or breastfeeding, had just undergone bariatric surgery, or had lost a significant amount of weight (>10% of their body weight) in the previous six months.

Data collection

Each participant provided written and informed consent to participate in the study following a five-minute interview. The study collected information on medical and laboratory testing, in addition to demographic characteristics like age, sex, and BMI. Specifically, the following parameters were assessed: vitamin D, calcium, total cholesterol, HDL, LDL, TG levels, and changes in vitamin D serum levels after treatment.

Laboratory Measurements

An automated analyser, the Cobas e411 (Roche Diagnostics GmbH, Mannheim, Germany), was used for all laboratory testing, which is a validated and reliable instrument for measuring lipid profile parameters and 25-hydroxyvitamin D3 (25(OH)D3) levels. Following a 14-hour fast, blood specimens were taken, and they were centrifuged at 4000 g for 10 minutes after having been permitted to clot at room temperature for ten to fifteen minutes. Following that, the samples were examined right away for 25(OH)D3 amounts and lipid profile characteristics. All laboratory tests were performed at Teryaq Alrohh Medical Laboratory in Zarqa, Jordan.

Follow-up Measurements

After a 90-day period, the same laboratory tests were repeated to evaluate the impact of taking supplements of vitamin D.

Definitions

The normal reference ranges for the lipid profile parameters assessed in this study were as follows: 150–200 mg/dL for total cholesterol, 50–200 mg/dL for TGs, 35–65 mg/dL for HDL, and 50–150 mg/dL for LDL.

As per the criteria set forth by the National Cholesterol Education Program and the National Lipid Foundation[25], The following lipid profile parameters should be at optimal levels: LDL < 100 mg/dL, with a value between 100 and 129 mg/dL regarded above optimal; total cholesterol < 200 mg/dL; total cholesterol TGs < 150 mg/dL; HDL > 40 mg/dL for females and > 50 mg/dL for males.

Intervention

In the current study, patients were employed a regimen of oral cholecalciferol supplementation to achieve a satisfactory serum level of 25-hydroxyvitamin D (25(OH)D). A weekly dose of 50,000 IU was utilised for the first four weeks, followed by bi-weekly administration of a single tablet. Serum 25(OH)D concentrations increased as a statistically significant consequence of this regimen, exceeding 20 ng/mL in all participants. Interestingly, the treatment successfully raised 25(OH)D levels beyond this threshold, even though about 45% of the trial participants had severe vitamin D deficiency (serum levels of 25(OH)D < 10 ng/mL prior to supplementation).

Ethical approval

The subjects underwent all procedures in accordance with the research committee of the institution's ethical guidelines of jadra University (Approval number: PHAR -02/11/2020).

Statistical analysis

The study's findings were displayed as means ± standard deviations (SDs). Statistical analyses were conducted using SPSS for Windows 20.0 (SPSS Inc. Headquarters, Chicago, Illinois, USA) and Microsoft Excel 2010. In determining the degree of significance, a conventional threshold of $P < 0.05$ was employed, indicating that any observed differences or associations were deemed statistically significant.

Paired sample t-tests were the main statistical method used for comparing the lipid profile metrics prior to and following vitamin D administration. This test was selected because it is useful for assessing the impact of vitamin D supplementation on lipid absorption since it can potentially used to analyse continuous data from the same subjects at two different times. Significant correlations between these biochemical indicators were also found by using the Pearson correlation approach to investigate the links between serum vitamin D amounts and lipid characteristics. The assumptions of normality were verified before applying parametric tests.

This work fills a gap in earlier research that lacked standardised dose or follow-up lengths by introducing a regulated supplementing protocol and follow-up term (90 days), which strengthens the proof of vitamin D's possible impact on lipid metabolism in the Jordanian population.

RESULTS

Demographic characteristics among the studied participants

95 patients attending the internal medicine clinics at Tohama Medical Center in Zarqa City in Jordan from September 25, 2020, to August 22, 2021, were included in this study and screened for serum lipid profile and 25(OH)D3 levels. Among those patients, 35 (36.85%) were women. The

age of patients ranged from 15 to 73 years with a mean age of 42.17 ± 12.25 years. The mean BMI among participants was 24.43 ± 2.82 kg/m^2 (Table I).

Table I. Features of the demographics of the studied patients (n=95)

Variable	Parameter	N=95
Age	Mean ± SD	42.17 ± 12.25
	IQR (min-max)	42 (15-73)
Sex	Male	60 (63.15%)
	Female	35 (36.85%)
BMI (kg/m^2)	Mean ± SD	24.43 ± 2.82
	IQR (min-max)	25 (18-31)

IQR: interquartile range, BMI: body mass index, max: maximum, min: minimum, SD: standard deviatin. Data presented as means and standard deviations, numbers, and frequencies. P-value: is the value of significane among parameters. P is considered significant if it recorded <0.05.

Table II presents the frequency of vitamin D insufficiency among participants before intervention, stratified by sex. The results show that no significant differences were found between sexes in any of the parameters analyzed (p>0.05).

Table III shows the laboratory data before intervention among males and females. It was found that no significant differences were found between sexes in any of the parameters analyzed (p>0.05). No significant changes were observed in HDL, LDL, or TG (p>0.05).

When cholesterol levels were compared at pre and post-treatment, a noteworthy drop in total cholesterol levels (194±22 vs. 187±19 mg/dL, respectively, p< 0.05), a non-significant decrease in LDL (107±18 vs. 98±15 mg/dL respectively) and TG concentration levels (135±26 vs. 128±17 mg/dL respectively), and slight non-significant increase in HDL levels (55±13 vs. 57±12 mg/dL respectively) were observed as presented in Table IV.

Association between vitamin D and lipid metabolism post-intervention among the studied patients

Table V and figure 1 show the correlation between vitamin D and lipid profile parameters among participants. It

Table II. Vitamin D deficiency according to sex among participants before intervention

Variable	Parameter	Males N=63	Females N=32	Total N=95	p-value
25(OH)DR3R levels	Deficient (<20 ng/mL)	40 (63.50%)	25 (78.12%)	65 (68.40%)	0.541
	Insufficient (20–30 ng/mL)	15 (23.80%)	1 (3.12%)	16 (16.80%)	0.031
	Sufficient (>30 ng/mL)	8 (12.70%)	6 (18.75%)	14 (14.70%)	0.151

Data presented as numbers and frequencies. P-value: is the value of significane among males and females' groups. P is considered significant if it recorded <0.05.

Table III. Laboratory data before intervention

Parameters	Patients	Males	Females	p-value
Vitamin D (mg/dL)	11.76 ± 2.90	12.78 ± 9.43	10.38 ± 9.57	0.231
Calcium (mg/dL)	9.30 ± 0.60	9.31 ± 0.19	9.23 ± 0.25	0.111
Total cholesterol (mg/dL)	194 ± 22	195.68 ± 5.82	194.43 ± 6.45	0.331
HDL (mg/dL)	55 ± 13	55.20 ± 2.29	55.09 ± 2.65	0.821
LDL (mg/dL)	107 ± 18	109.18 ± 24.38	104.57 ± 6.19	0.271
TG (mg/dL)	135 ± 26	135.43 ± 5.23	136.43 ± 5.24	0.371

Data demonstrated as means and standard deviations. The normal reference ranges for the measured parameters are as follows: Vitamin D: 20–40 mg/dL; Calcium: 8.5–10.5 mg/dL; Total cholesterol: 150–200 mg/dL; High-density lipoprotein (HDL): 35–65 mg/dL; Low-density lipoprotein (LDL): 50–150 mg/dL; and Triglycerides (TG): 50–200 mg/dL.

Table IV. Changes in laboratory data levels pre- and post-treatment parameters

Parameters	Pre-intervention	Post-intervention	p-value
Vitamin D (mg/dL)	11.76±2.90	48.70±9.30	0.038
Calcium (mg/dL)	9.30±0.60	9.50±0.70	
Total cholesterol (mg/dL)	194±22	187±19	
HDL (mg/dL)	55±13	57±12	
LDL (mg/dL)	107±18	98±15	
TG (mg/dL)	135±26	128±17	

HDL, high-density lipoprotein; LDL, low-density lipoprotein; SD: standard deviation; TG: Triglycerides. Data demonstrated as means and standard deviations.

was found that total cholesterol (Figure 1), TG (Figure 2), HDL (Figure 3), and LDL (Figure 4) levels correlated positively with vitamin D post intervention (r=0.77, 0.84, 0.81, and 0.29, respectively) with a significant difference (p<0.001, <0.001, <0.001, and =0.004, respectively).

DISCUSSION

As a fat-soluble vitamin, vitamin D functions both as a hormone and a nutrition. Its major purpose is to make it easier for calcium and phosphorus to be absorbed and retained, which is essential for bone formation and rehabilitation. Moreover, an abundance of research

Table V. Correlation between vitamin D and lipid profile markers post-intervention among the studied patiients

Variable	Parameter	Ca	Total cholesterole	TG	HDL	LDL
Vitamin D	r-value	0.00	0.77**	0.84**	0.80**	0.29**
	p-value	0.991	<0.001	<0.001	<0.001	0.004

**, Significant correlation at <0.01. HDL, high-density lipoprotein; LDL, low-density lipoprotein; TG: Triglycerides.

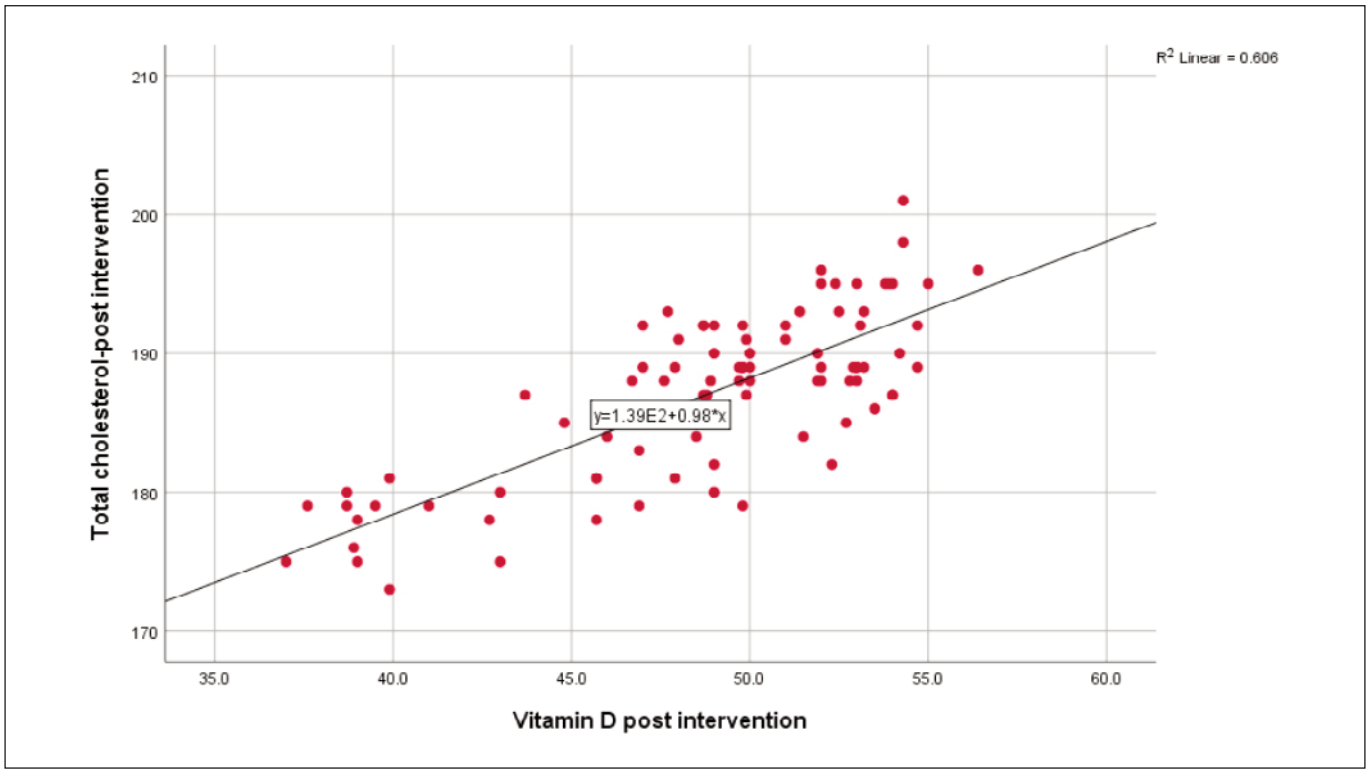

Figure 1. Correlation between vitamin D and Total cholesterol metabolism post-intervention among the studied patients

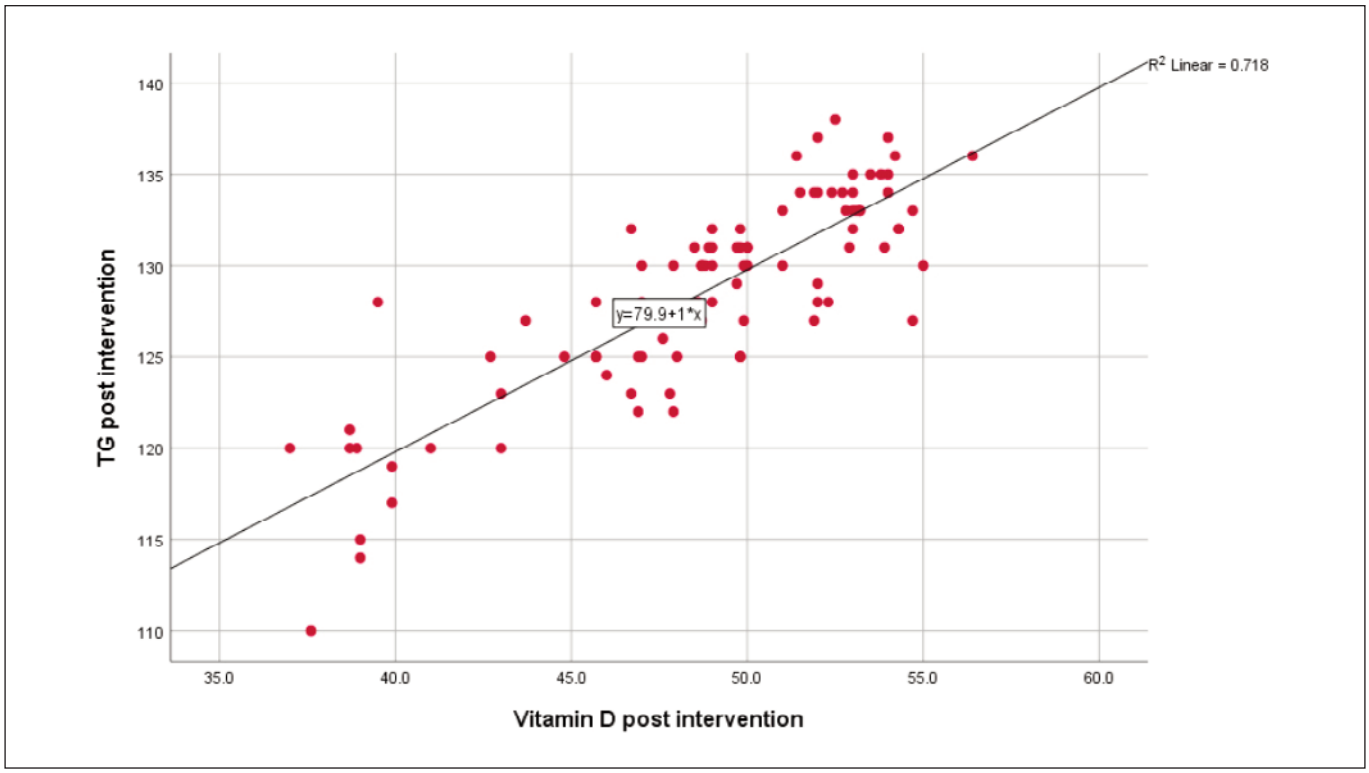

Figure 2. Correlation between vitamin D and TG metabolism post-intervention among the studied patients

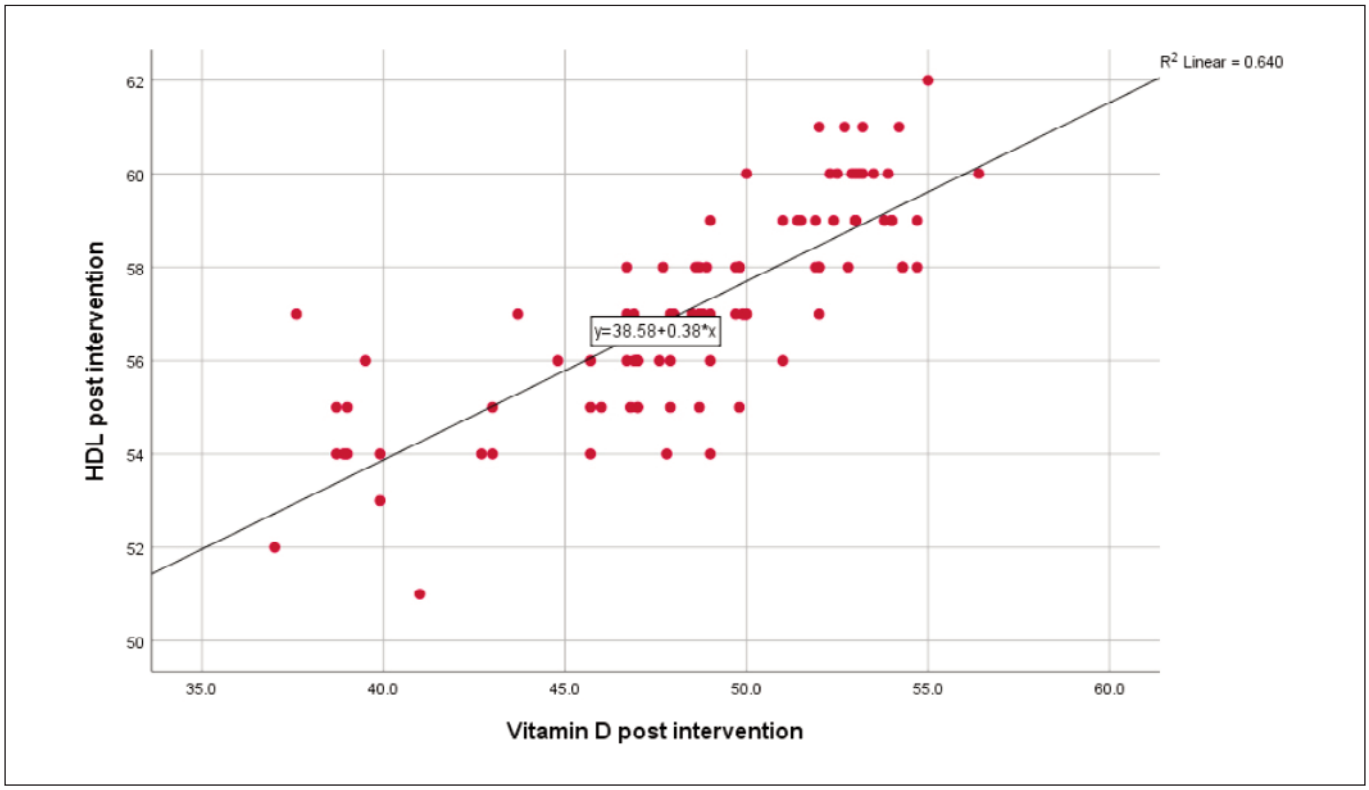

Figure 3. Correlation between vitamin D and HDL metabolism post-intervention among the studied patients

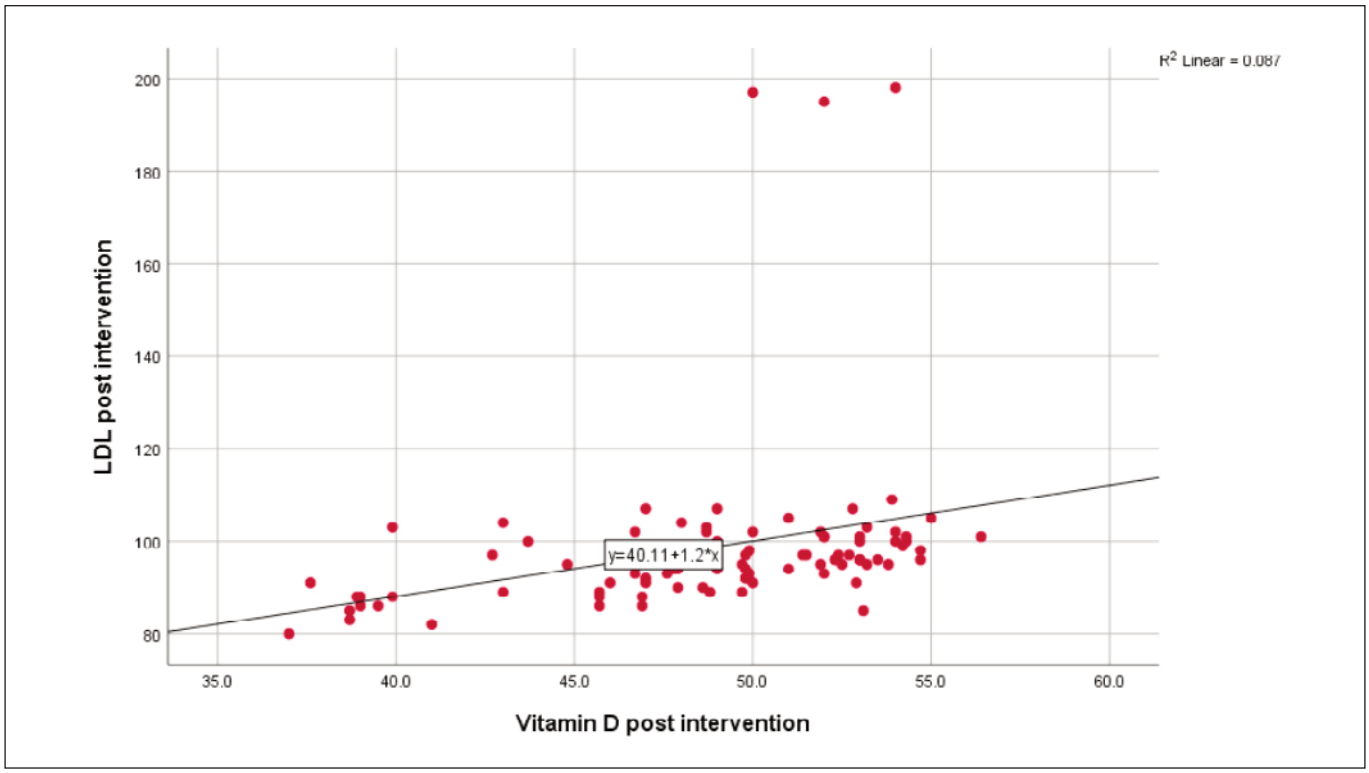

Figure 4. Correlation between vitamin D and LDL metabolism post-intervention among the studied patients

has indicated that vitamin D exhibits supplementary biological functions, like preventing the formation of malignant cells, regulating immunological responses, and diminishing inflammation. Researchers have demonstrated that vitamin D could be important for more than just bone metabolism because it has receptors in a variety of tissues and organs[26].

Because 25(OH)D is stable in the blood, measuring it can precisely represent serum vitamin D amounts and offer a thorough evaluation of vitamin D status. A number of strategies can be used to raise serum 25(OH)D levels to an appropriate level[17]. Once 25-hydroxyvitamin D (25(OH)D, the precursor form of vitamin D, is converted by a number of enzyme processes into 1,25-dihydroxyvitamin D, the physiologically active component of the pigment. But because of its longer half-life, 25(OH)D is the main form of vitamin D that is in circulation and provides a sensitive and accurate measure of serum vitamin D levels and status[17]. All subjects in the current study had significantly elevated blood 25(OH)D levels above 20 ng/mL as a result of receiving 50,000 IU of oral cholecalciferol once a week.

Increased calcium levels have been demonstrated to have effects beyond those previously mentioned, such as, promoting the transformation of cholesterol into bile acids[27]. In addition, the release of parathyroid hormone (PTH) may not be inhibited by vitamin D. It has been discovered that elevated PTH levels promote lipogenesis, which increases calcium input into adipocytes. On the other hand, elevated PTH levels are linked to a reduction in lipolytic activity, which raises TG values. Consequently, with relation to increased amounts of vitamin D, it is hypothesised that decreased PTH levels could lead to decreased TG levels by boosting lipolytic activity and peripheral elimination. Elevated PTH levels have also been connected to a rise in bone turnover and the subsequent release of calcium from the bone. It has been demonstrated that vitamin D influences lipoprotein metabolism, resulting in lowered hepatic TG production and secretion and elevated expression of the very low-density lipoprotein (VLDL-C) receptors. Thus, it has been discovered that elevated vitamin D levels raise HDL-C levels while lowering TG and VLDL-C values[28].

There is a clear and substantial association between the roles of vitamin D and amounts of lipid level[29]. Vitamin D is essential for controlling the metabolising process of calcium, which reduces the uptake of intestinal fatty acids and raises intestinal calcium levels. This decrease in the uptake of fat can then lead to a fall in cholesterol concentrations. Moreover, it has been demonstrated that elevated calcium concentrations promote the liver's conversion of cholesterol into bile acids, which in turn lowers cholesterol concentrations[30].

The results of the current study showed a slightly higher level of HDL cholesterol and a significantly lower level in total cholesterol, along with an insignificant reduction in LDL cholesterol and TG concentrations. While some of these results

are in line with earlier research, there are clear variations in other lipid profile-related metrics[29].

A meta-analysis of 41 RCTs totalling 3434 respondents were incorporated into the research; 1699 of the subjects received vitamin D supplements, whereas 1735 people received a placebo. In contrast to HDL cholesterol, which showed no discernible change, the meta-analysis showed that vitamin D administration considerably reduced serum levels of total cholesterol, LDL cholesterol, and TG. According to the results, vitamin D administration could be an advantageous supplemental therapy for individuals who have vitamin D deficiency and higher lipid metabolism level, both of which raise the chance of developing heart disease[31].

In contrast to the current findings, a thorough meta-analysis of 21 RCTs with a total of 80,000 individuals discovered no connection between vitamin D administration and significant cardiovascular incidents, which disagreed with the current findings[32].

Because of the variety of experimental approaches used in previous investigations, the effects of vitamin D on lipid profiles have not been conclusively shown. A statistically significant correlation was seen between alterations to lipid levels and the treatment of 2,000 IU of vitamin D3 daily for 18 months in 92 patients who had a mean blood amounts of 25(OH)D of 13 ng/mL. In particular, there was no change in the concentrations of TG or HDL cholesterol, although there was a drop in the amounts of total and LDL cholesterol. Additionally, after 18 months of therapy, the injection of vitamin D3 increased blood levels of 25(OH)D by a mean of 8 ng/mL [5].

Vitamin D administration showed a good correlation with lipid profile measures in the current investigation. Additionally, vitamin D has been shown to promote the liver's conversion of cholesterol into bile acids, which may possibly have an effect on cholesterol concentrations. To clarify the underlying biology, further investigation is required to ascertain the particular processes driving these effects[33]. Vitamin D has a complex interaction with lipid metabolism since it affects how calcium is absorbed and decreases the uptake of intestinal fatty acids, which in turn affects cholesterol levels indirectly[34].

In contrast to the current study, the findings of a meta-analysis evaluating the impact of vitamin D supplements on blood lipid management revealed that vitamin D therapy significantly decreased TG in comparison to control or placebo therapy ($P < 0.001$)[35].

Strength

There are advantages and disadvantages to the current investigation. The study's prospective design, which permits the investigation of vitamin D administration's effects on lipid parameters measures, is one of its most noteworthy strengths. Additionally, the study's large sample size, comprising both male and female participants, enhances the generalizability of the results. Furthermore, the utilization of a standardized protocol for vitamin D supplementation ensures consistency in the treatment.

Limitations

However, the study also exhibits several limitations. The study was notably limited in its relevance to different groups by the fact that it was only carried out in one centre. Furthermore, the effects of vitamin D supplementation over time on lipid profile measures were not examined in this investigation. Furthermore, the potential interactions between vitamin D supplementation and other medications or health conditions were not assessed.

CONCLUSIONS

Our research showed that vitamin D therapy led to a considerable drop in total cholesterol amounts and insignificant alteration in the amounts of TG and LDL, while HDL levels exhibited a slight increase, suggesting a beneficial effect on cardiovascular disease. The concept that high serum vitamin D levels could be an effect of healthy living rather than its cause, as healthy people may participate in outdoor activities and adopt better food habits, can be used to explain the conflicting findings between the encouraging and depressing results. Vitamin D may influence certain aspects of lipid metabolism, but broader conclusions regarding overall lipid profile improvement should be made cautiously. Current intervention studies could clarify the possible advantages of vitamin D administration and pinpoint the demographic most likely to gain from this treatment.

Implications

- Given the high prevalence of vitamin D deficiency in the Jordanian population, integrating vitamin D supplementation into public health policies may contribute to better cardiovascular health outcomes.
- The study reinforces the importance of adequate sun exposure, dietary intake, and supplementation to maintain optimal vitamin D levels, potentially reducing the burden of cardiovascular diseases associated with dyslipidemia.
- Awareness campaigns targeting healthcare providers and the general population about the broader metabolic benefits of vitamin D supplementation could encourage preventive measures against lipid abnormalities.

Future researches

1. Future studies should evaluate the influence of vitamin D administration over a prolonged period on lipid profile parameters.

2. Future studies should include a diverse group of participants, including patients with different health conditions and medications.
3. Future studies should investigate the optimal dosage and the period of vitamin D administration for improving lipid profile parameters.
4. To determine how vitamin D supplementation affects the prognosis of cardiovascular disease in individuals with vitamin D insufficiency, more research is required.

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