MINISTRY OF EDUCATION AND TRAINING
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STUDY OF THE RELATIONSHIPS BETWEEN SERUM 25 HYDROXY VITAMIN D CONCENTRATION AND SOME RELATED FACTORS IN TYPE 2 DIABETES PATIENTS

SUMMARY OF DOCTORAL THESIS

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Reviewer 1:

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ABBREVIATION LIST

1,25 $(OH)_2$ D	: 1,25 dihydroxy Vitamin D
25(OH)D	: 25 hydroxy vitamin D
ADA	: American Diabetes Association
CKD	: Chronic kidney disease
DR	: Diabetes duration
eGFR	: Estimated glomerular filtration rate
FPG	: Fasting plasma glucose
Go	: Fasting Glucose
HDL-C	: High-density lipoprotein Cholesterol
HOMA-IR	: Homeostatic Model Assessment for Insulin Resistance
HOMA-%B	: Homeostatic Model Assessment for β-cell function
Hs-CRP	: High-sensitivity CRP
IDF	: International Diabetes Federation
IFG	: Impaired fasting glucose
IL	: Interleukin
Io	: Fasting Insulin
IR	: Insulin resistance
KDIGO	: Kidney Disease Improving Global Outcomes
LDL-C	: Low-density lipoprotein Cholesterol
Mean diff	: Mean difference
PG	: Plasma glucose
PSLD	: Polish Society of Laboratory Diagnostics
PoLA	: Polish Lipid Association
PTH	: Parathyroid hormon
REF	: Reference
TC	: Total Cholesterol
TG	: Triglyceride
UVB	: Ultraviolet B
VIF	: Variance Inflation Factors
WC	: Waist circumference

INTRODUCTION

Vitamin D is an important microelement and its known function is to regulate calcium and phosphorus in the body with the main storage form is 25 hydroxy vitamin D, vitamin D deficiency has been shown to cause osteoporosis, joint degeneration, myasthenia gravis…

In addition to the known traditional functions, vitamin D has gradually been found to be related to other diseases such as metabolic diseases, cardiovascular diseases, tumors, infectious diseases... and one of the relationships between vitamin D and metabolic diseases is being focused on is the link between vitamin D and type 2 diabetes.

Many studies have pointed out that vitamin D deficiency is common in people with diabetes. The relationship between vitamin D and type 2 diabetes is listed through many mechanisms, such as: 1,25 can regulate inflammatory cells, affect the process of inflammatory immune response, reduce the immune damage of islet cells, enhance the expression of insulin receptor RNA, and enhance the ability of insulin receptor to carry glucose...

In addition to the influence of blood glucose, recent studies have also pointed out that vitamin D is related to some risk factors of diabetes, such as obesity, lipid metabolism disorder, insulin resistance, physical exercise…

Studies have shown that, overweight and obese people are high-risk groups for vitamin D deficiency the higher the BMI, the lower the vitamin D concentration. The disorder of lipid metabolism, which is related to obesity and type 2 diabetes, has also been proved to be related to vitamin D deficiency. Vitamin D has also been proved to be related to some common diseases of diabetes patients, such as hypertension and diabetes nephropathy.

Up to now, the world's research on vitamin D concentration and vitamin D deficiency in patients with type II diabetes is still expanding, However, in Vietnam, there has been no study on the influence of vitamin D on type 2 diabetes patients and the relationship between vitamin D deficiency and some factors such as blood glucose control, lipid metabolism disorder and insulin resistance... thereby supporting a more specific assessment of the risk of vitamin D deficiency and supporting the care and treatment of type 2 diabetes patients.. Therefore, we proceed with the topic **"**Study of the relationships between serum 25 hydroxy vitamin D concentration and some related factors in type 2 diabetes patients**"** with two objectives:

1. Determination of serum levels of 25 hydroxyvitamin D and prevalence of vitamin D deficiency in patients with type 2 diabetes。

2. Analyzing the related factors of serum 25 hydroxyvitamin D deficiency in type 2 diabetes patients..

Scientific contribution of the study :

Nursing and treatment of patients with diabetes is increasingly comprehensive, besides the traditional factors treated with medical intervention, the influence of microelements such as vitamins, especially vitamin D, on the effectiveness of treatment and the risk of progression of diabetes are being studied intensively at present.

Existing studies have not yet clarified the causal relationship between vitamin D and type 2 diabetes, there are still differences in study results between different regions of the world; genetics, physical condition, eating and living habits affect both metabolic disorders and 25(OH)D levels in the body. The study will contribute to strengthening the relationship between vitamin D and type 2 diabetes through analysis and evaluation on Vietnamese people.

Practical contribution of the study:

Identifying the risk of vitamin D deficiency for type 2 diabetes patients in Hue - Vietnam.

Identify groups of diabetic patients at high risk of vitamin D deficiency for supplementation consideration.

Identify some factors associated with vitamin D deficiency in type 2 diabetes patients, thereby enhancing treatment options.

DISSERTATION PROPOSAL STRUCTURE

Dissertation has 124 pages with 4 chapters, 51 tables, 4 pictures, 4 diagrams, 2 charts, 152 references (Vietnamese: 6, English: 146). Introduction: 3 pages. Overview: 33 pages. Subjects and research methods: 20 pages. Results: 31 pages. Discussion: 33 pages. Conclusion: 2 pages. The study limitations: 1 page. Recommendations: 1 page.

Chapter 1
OVERVIEW

1.1. TYPE 2 DIABETES OVERVIEW

1.1.1. Epidemiology of diabetes

According to the International Diabetes Federation (IDF), there are 537 million people aged 20-79 with diabetes worldwide in 2021, expected to reach 643 million by 2030. According to the survey results conducted by the Viet Nam ministry of health in 2015, in the age group of 18-69, the national rate of diabetes is 4.1%, of which the rate of diagnosed diabetes is 31.1%, the rate of undiagnosed diabetes is 69.9%.

1.1.2. Diabetes diagnostic criteria

- According to ADA 2020, a patient is diagnosed with diabetes when: FPG ≥7,0 mmol/L or 2-h PG ≥11,1 mmol/L in glucose tolerance test or A1C ≥ 6,5% or blood glucose any ≥11,1 mmol/L.+ clear clinical symptoms (heavy drinking, polyuria, unexplained weight loss). The first 3 criteria require 2 successful tests.

1.2. Relationship between vitamin D and type 2 diabetes

1.2.1. Vitamin D overview

1.2.1.1. Structure, absorption and metabolism of vitamin D

Vitamin D consists of a group of fat-soluble seco-sterols found in certain foods such as cod liver oil, fish fat, mushrooms, egg yolks and liver. Two important forms are vitamin D3 - which is synthesized in the skin. of vertebrates by the action of solar ultraviolet radiation on 7-dehydrocholesterol and vitamin D2 - produced by UV radiation from ergosterol, which occurs in fungi and higher plants. After entering human body, vitamin D is attached to the vitamin D binding protein and transported to the liver and converted to 25 hydroxyvitamin D, then 25(OH)D is converted in the kidney to 1,25 $(OH)_2$ D - active form of vitamin D.

1.2.1.2. Function of vitamin D

The role of vitamin D in calcium metabolism: 1,25 $(OH)_2$ D, PTH, and calcitonin are the 3 main hormones involved in the regulation of calcium and phosphorus in the body**.**

Other functions: The vitamin D receptor was discovered to be present in many organs and cells that are not involved in the regulation of calcium and phosphorus such as pancreas, breast, macrophages, vascular endothelial cells From then on, vitamin D has been discovered to have many other functions such as regulating insulin secretion, regulating blood pressure through the RAS system, regulating immunity, inhibiting cancer cells...

1.2.1.3. 25 hydroxy vitamin D levels and vitamin D deficiency

According to the American Endocrine Society, the concentration of 25(OH)D corresponding to vitamin D insuficiency and deficiency is 20-29 ng/ml and less than 20 ng/ml, respectively. The prevalence of vitamin D deficiency in the US, Australia and New Zealand has been reported to be 27%-32%, in Vietnam, according to research by Huong T.T. Nguyen et al., in the North, the prevalence of vitamin D deficiency in men is 16% and in women is 30%

1.2.1.4. Factors affecting body vitamin D

-Factors affecting skin exposure to ultraviolet light, the amount of melanin and 7-dehydrocholesterol in the skin

-Gastrointestinal diseases - affect the absorption of vitamin D in the intestine, liver disease - affect the hydroxylation of vitamin D and reduce the production of vitamin D transporters, kidney disease - reduce the production of 1,25 $(OH)_2$ D

1.2.2. Relationship between vitamin D and type 2 diabetes

1.2.2.1. Common risk factors of vitamin D and type 2 diabetes

-*Seasonal factors*: winter is a period when it is more difficult for diabetes patients to control blood glucose, and they are also more prone to the risk of vitamin D deficiency.

-*Gender and race*: women are more likely to suffer from type 2 diabetes and vitamin D deficiency than men. Blacks are at greater risk of type 2 diabetes and vitamin D deficiency than whites

-*Nutritional factors*: studies have shown that people who consume less milk or dairy products (high vitamin D content) have a higher risk of type 2 diabetes.

1.2.2.2. Mechanism of effect of vitamin D on blood glucose regulation

Effect of vitamin D on pancreas β Cellular influence

-1,25 (OH) 2D binding vitamin D receptor in pancreas β cells to affect insulin secretion

- Vitamin D balances intracellular and extracellular β Cell calcium concentration , thereby affecting insulin secretion.

- Studies have shown that 1,25 (OH) 2D can regulate the maturation and function of inflammatory cells, thus affecting the process of inflammatory immune response and reducing the effect of immune response on pancreas β cell.

Effect of vitamin D on insulin action

- 1,25 $(OH)_2$ D can improve the glucose uptake capacity of human cells

- Carriers with a vitamin D receptor restriction enzyme Fok I cleavage site gene defect have higher fasting blood insulin levels than carriers without the cleavage site defect gene.

- Vitamin D improves insulin action in target organs through calcium balance

- 1,25 $(OH)_2$ D inhibits adipocyte differentiation and reduces peripheral insulin resistance. Vitamin D deficiency leads to secondary PTH elevation. PTH is also an insulin resistance inducer

1.2.3. Some factors related to vitamin D in diabetic patients

1.2.3.1. Obesity and Vitamin D

Overweight and obese people usually lack physical activity and outdoor activities, have short UV exposure time, and have reduced endogenous vitamin D levels.

Obese people have lower levels of 25(OH)D because of the large amount of vitamin D stored in adipose tissue. With the increase of body volume, the volume of tissues and vitamin D target organs also increased, resulting in the decrease of serum 25(OH)D concentration.

1,25 (OH) 2D inhibits c/ebp β The results showed that vitamin D was involved in inhibiting adipocyte differentiation and directly stimulating mRNA expression and leptin secretion

1.2.3.2. Dyslipidemia and vitamin D

Clinical studies have shown that 25(OH)D levels are negatively correlated with TC, TG and LDL-C, although the lipid profiles involved in each study are different.

Vitamin D supplementation research shows that vitamin D supplementation can improve TG, TC, LDL-C and HDL-C.

1.2.3.3. Hypertension, diabetic nephropathy and vitamin D

Vitamin D plays a role in regulating the activities of RAAS system and minimizing the progression of diabetes nephropathy and hypertension. Vitamin D is also involved in protecting endothelial function, which plays a very important role in delaying the progression of renal failure and hypertension.

Clinical studies have shown the related efficacy of paricanxitol in reducing urinary albumin creatinine ratio (UACR) in patients with diabetes.

Chapter 2
SUBJECTS AND METHODS

2.1. STUDY SUBJECTS

214 type 2 diabetes patients were examined and treated in the internal medicine clinic, the Department of internal medicine and endocrinology of Hue University of Medicine and Pharmacy hospital, and the Department of general internal medicine and geriatrics of Hue central hospital.

2.1.1. Inclusion criteria

Patients with diabetes were diagnosed according to the ada2020 standard and had some type 2 diabetes symptoms according to the Canadian Diabetes Association. The 214 patients who participated in the study were all patients who had been diagnosed with type 2 diabetes and received maintenance treatment with hypoglycemic drugs.

2.1.2. Research duration

From august 2020 to july 2021.

2.1.3. Exclusion criteria

Age <18 years old, refused to participate in the study, suffered from liver disease, gastrointestinal diseases affecting vitamin absorption, took vitamin D supplements, had a history of severe burns, was pregnant, and the patient had a history of type 1 diabetes

2.2. RESEARCH METHODS

- Research method: Descriptive Cross-Sectional method.
- Sample size: use the formula $n = z^2_{(1-\alpha/2)} \frac{p(1-p)}{d^2}$

+n: Minimum reasonable sample size. Z: Expected confidence value, corresponding to the expected confidence level of 95%. z = 1.96.

+p: According to Mohammed a.alhewishel et al., the vitamin D deficiency rate in type 2 diabetes patients was 89.68%, p=0.897, d=0,05; The sample size was calculated as at least 142 patients.

2.3. RESEARCH CONTENTS

2.3.1. Characteristics of the study objects:

- Gender, age, age at diagnosis of diabetes.

2.3.2. Clinical variables

2.3.2.1. Blood pressure

Hypertension was diagnosed according to Vietnam Heart Association in 2018 standard. The systolic blood pressure was ≥ 140mmHg, the diastolic blood pressure was ≥ 90mmHg or the patient was previously diagnosed as hypertension.

2.3.2.2. BMI

BMI = Weight (kg)/ (height)^2 (m^2)

BMI classification based on WHO BMI classification for Asians

2.3.2.3. Waist circumference

- The patient is defined as abdominal obesity when the waist circumference is ≥90cm in men and ≥80cm in women according to WHO waist circumference standards for Asians.

2.3.2.4. Treatment plan

Divided into two groups: oral drug treatment group and oral drug combined with insulin or insulin alone treatment group.

2.3.2.5. Physical activity

Patients are noted to have a good physical activity regime when: moderate exercise with 30 minutes/time of exercise with a frequency of ≥5 times/week slightly increases heart rate according to Heather M Campbell's study.

2.3.2.6. Diabetes duration

Using the 10-year cutoff according to the study by author Zelin Li.

Divided into 2 groups: group with diabetes detection time of 10 years or less and group over 10 years

2.3.3. Subclinical variables

Patient preparation: the patient explained before the test, fasted at breakfast, and collected venous blood and urine in the morning**.**

The serum 25(OH)D concentration test, hsCRP test, blood lipid index, fasting insulin, fasting blood glucose, HbA1C, creatinine , urea and microalbuminuriawere carried out on the automatic immunohistochemical system of the Biochemistry Department of hue Central Hospital and the laboratory of Hue University of Medicine and Pharmacy hospital.

2.3.3.1. Serum 25 hydroxyvitamin D concentration

-According to the data of American endocrine society in 2011, vitamin D deficiency is determined when the concentration of 25(OH)D is less than 30 ng / ml

-The subjects were divided into two groups: vitamin D deficiency group with 25(OH)D concentration <30 ng/ml and non vitamin D deficiency group with 25(OH)D concentration >30 ng / ml.

2.3.3.2. High sensitive C-reactive protein (hs-CRP)

- Select the hsCRP cut-off point with CV risk >3mg/l according to AHA

2.3.3.3. **Blood lipid index*:***

- Lipid index classification based on psld/pola recommendations

- TC uses the critical point of 5mmol/l, TG uses 1.7mmol/l, LDL-C uses 2.6mmol/l; When HDL-C was <1 mmol/l for men and <1.2mmol/l for women, HDL-C was lower.

- TC/HDL ratio: calculated as total cholesterol /HDL cholesterol ratio. According to the study of Susanna calling, when TC/HDL>5, patients are classified as high TC/HDL

2.3.3.4. **Fasting blood insulin**

-Reference value: 2.6 – 24.9 IU/mL according to Vietnam Ministry of Health

2.3.3.5. Fasting blood glucose

- The cut-off point was selected based on the diagnostic criteria for fasting blood glucose in diabetic patients of ADA 2020: Go<7mmol/l.

2.3.3.6. HbA1c quantification

- The cut-off point selected was based on the ADA 2020 diabetes control criteria: HbA1c <7%.

2.3.3.7. Assessment of insulin resistance by HOMA-IR

+ HOMA- IR = GxI/22,5

+ Cut-off point::HOMA-IR≤3,04 according to study of Sihoon Lee

2.3.3.8. Evaluation of pancreatic beta cell function by HOMA-%B

+ HOMA-%B=20 x Io (µU/ml) /(Go (mmol/l) -3,5)

+ Cut-off point: HOMA-%B>48,9% According to the study of Elsafty

2.3.3.9. ***Estimated glomerular filtration rate***

The estimated glomerular filtration rate was calculated according to the 2009 CKD-EPI formula

Classification of chronic kidney disease stages according to KDIGO 2012

2.3.3.10. Quantification of blood urea

Reference value::1,7- 8,3 mmol/L according to Vietnam Ministry of Health

2.3.3.11. Quantification of microalbuminuria

Microalbuminuria increases: random urine microalbumin>20mg/l according to the study of Nikolai C. Hodel (2021).

2.4. METHODS OF DATA PROCESSING

- Data processing with statistical software SPSS version 22.0

- Qualitative variables are presented as percentages.

- Use t-test to compare 2 means of normally distributed variables, Mann-Whitney test to compare 2 means if the variable is not normally distributed, Chi-squared statistic to compare 2 ratio.

- To investigate the correlation between parameters, we calculate the correlation coefficient r with 95% confidence interval.

- The risk is evaluated by odds ratio， tested by Z test

- Draw the ROC curve, determine the cut-off value, sensitivity, and density predictive model of vitamin D deficiency

2.5. RESEARCH ETHICS

- We conducted the study with the consent of the University of Medicine and Pharmacy - Hue University and the Hospital of Hue University of Medicine and Pharmacy, Hue Central Hospital. The study design was developed and documented in the research protocol and approved by the scientific and ethical committee.

- The subjects participating in the study were clearly explained about the purpose and content of the research implementation, only those subjects who voluntarily participated in the study were included in the study, if they do not agree, we will remove them from the study.

-25(OH)D, hsCRP and microalbuminuria tests were used in this study, and the study participants did not need to bear any expenses.

Chapter 3
RESEARCH RESULTS

We studied 214 type 2 diabetes patients from August 2020 to July 2021. The results are as follows:

3.1. 25(OH)D CONCENTRATION, VITAMIN D DEFICIENCY PREVALENCE OF TYPE 2 DIABETES PATIENTS

Table 3.1. The average concentration of 25(OH)D and the rate of vitamin D deficiency and of the study sample

Groups	25 (OH)	n (%)
All patients	28,74 ± 7,39 *ng/ml*	214 (100,0)
Vitamin D deficiency	24,22 ±3,99 *ng/ml*	132 (61,7)
Vitamin D sufficiency	36,02 ± 5,56 *ng/ml*	82 (38,3)

Table 3.2. Prevalence of vitamin D deficiency by gender and diabetes duration

Vitamin D / Characteristics	Deficiency		Sufficiency		Sum	p
	n	%	n	%		
Male	41	51,9	38	48,1	79	**0,024**
Female	91	67,4	44	32,6	135	
Diabetes duration ≤10 years	81	55,1	66	44,9	147	**0,003**
Diabetes duration > 10 years	51	76,1	16	23,9	67	

Table 3.3. The average concentration of 25(OH)D by gender and diabetes duration

Variables	Classification	n	25(OH)D *ng/ml)*	Mean diff. (95%CI)	p
Gender	Male	79	30,51 ± 7,60	ref	
	famale	135	27,71 ± 7,09	-2,81 (-4,84- -0,78)	**0,007**
Diabetes duration *(year)*	≤10	147	29,54 ± 7,55	ref	
	> 10	67	26,99 ± 6,76	-2,55 (-4,68 - -0,43)	**0,019**

3.2 RELATIONSHIP BETWEEN 25(OH)D CONCENTRATION, VITAMIN D DEFICIENCY AND SOME RELATED FACTORS IN TYPE 2 DIABETES PATIENTS

3.2.1. Factors affecting the risk of vitamin D deficiency in type 2 diabetes patients

3.2.1.1. Some factors related to 25(OH)D concentration and vitamin D deficiency in type 2 diabetes patients

Table 3.4. Relationship between BMI, waist circumference, lipid index, hsCRP and vitamin D deficiency

Vitamin D / Characteristics	Deficiency		Sufficiency		Sum	p
	n	%	n	%		
BMI <18,5	1	14,3	6	85,7	7	**<0,001**
BMI 18,5-<23,0	51	48,6	54	51,4	105	
BMI 23-<25	38	88,4	5	11,6	43	
BMI ≥25	42	71,2	17	28,8	59	
Abdominal obesity	95	70,9	39	29,1	134	**<0,001**
Non Abdominal obesity	37	46,2	43	53,8	80	
Nomal TC	74	52,9	66	47,1	140	**<0,001**
High TC	58	78,4	16	21,6	74	
Nomal TG	55	56,1	43	43,9	98	0,124
High TG	77	66,4	39	33,6	116	
Nomal HDL-C	60	58,8	42	41,2	102	0,412
Low HDL-C	72	64,3	40	35,7	112	
Nomal LDL-C	50	60,2	33	39,8	83	0,681
High LDL-C	81	61,8	50	38,2	131	
Nomal TC/HDL	95	58,6	67	41,4	162	0,106
High TC/HDL	37	71,2	15	28,8	52	
hsCRP ≤3 *mg/l*	93	57,8	68	42,2	161	**0,04**
hsCRP >3 *mg/l*	39	73,6	14	26,4	53	

Table 3.5. Relationship between BMI, waist circumference, lipid indexs and hsCRP and 25(OH)D concentration

Variables	Classification	n	25(OH)D *(ng/ml)*	Mean diff. (95%CI)	p
BMI	<23	112	30,79 ± 7,59	Ref	
	≥23	102	26,49 ± 6,49	-4,31 (-6,21 - 2,39)	**<0,001**
Abdominal obesity	No	80	31,25 ± 7,94	ref	
	Yes	134	27,25 ± 6,63	-4,01 (-6,00 – 2,01)	**<0,001**
TC	Nomal	140	29,80 ± 7,51	ref	
	High	74	26,74 ± 6,78	-3,07 (-5,12- - 1,01)	**0,004**
TG	Nomal	98	29,99 ± 7,48	ref	
	High	116	27,69 ± 7,18	-2,30 (-4,28 - -0,32)	**0,023**
HDL- C	Nomal	102	29,64 ± 7,70	ref	
	Low	112	27,92 ± 7,03	-1,72 (-3,70 – 0,27)	0,089
LDL-C	Nomal	83	28,87 ± 7,88	ref	
	High	131	28,66 ± 7,09	2,18 (-1,72 - 6,08)	0,271
TC/HDL	Nomal	162	29,43 ± 7,64	ref	
	High	52	26,60 ± 6,15	-2,83 (-5,13 - -0,54)	**0,016**
hsCRP *(mg/l)*	≤3	161	29,44 ± 7,38	Ref	
	>3	53	26,63 ± 7,08	-2,78 (-5,10 – 0,47)	**0,016**

Table 3.6. Association between fasting blood glucose, HOMA-IR and vitamin D deficiency

Vitamin D / Characteristics	Deficiency		Sufficiency		Sum	p
	n	%	n	%		
Go <7 *mmol/l*	36	49,3	37	50,7	73	**0,007**
Go ≥7*mmol/l*	96	68,1	45	31,9	141	
IR	29	46	34	54	63	**0,022**
Non IR	66	65,3	35	34,7	101	

Table 3.7. Relationship between Go, HbA1c, HOMA-IR with 25(OH)D concentration

Variables	Classification	n	25(OH)D *(ng/ml)*	Mean diff.(95%CI)	p
Go *(mmol/l)*	<7	73	30,74 ± 8,59	ref	
	≥7	141	27,71 ± 6,48	-3,02 (-5,09 - 0,96)	**0,004**
HbA1c *(%)*	<7	87	30,54 ± 7,59	ref	
	≥7	127	27,51 ± 7,02	-3,03 (-5,02- -1,04)	**0,003**
HOMA-IR	IR	63	31,37 ± 8,03	ref	
	Non IR	101	28,43 ± 7,36	-3,64 (-5,61- -0,53)	**0,017**

Table 3.8. Relationship between physical activity habits and diabetes treatment regimens with vitamin D deficiency

Characteristics \ Vitamin D	Vitamin D deficiency		Vitamin D sufficiency		Sum	P
	n	%	n	%		
Good Physical activity	95	58,3	68	41,7	163	0,067
Not good Physical activity	37	72,5	14	27,5	51	
Oral	95	57,9	69	42,1	164	**0,041**
Insulin	37	74,0	13	26,0	50	

Table 3.9. Relationship between physical activity habits and diabetes treatment regimen with 25(OH)D concentration

Variables	Classification	n	25(OH)D *(ng/ml)*	Mean diff. (95%CI)	p
Physical activity	Good	163	29,31 ± 7,63	ref	
	Not good	51	26,93 ± 6,29	-2,38 (-4,70 - -0,06)	**0,044**
Treatment	Oral	164	29,56 ± 7,74	Ref	
	Insulin	50	26,06 ± 5,36	-3,50 (-5,80 - -1,18)	**0,003**

3.2.1.2 Some factors correlated with 25(OH)D concentration

Table 3.10. Correlation between 25(OH)D concentration and some related factors

Variables	r/rho	p
BMI *(kg/m^2)*	-0,176	**0,010**
WC *(cm)*	-0,045	0,513
TC *(mmol/l)*	-0,186	**0,006**
TG *(mmol/l)*	-0,198	**0,004**
HDL-C *(mmol/l)*	0,058	0,401
LDL-C *(mmol/l)*	-0,045	0,510
TC/HDL	-0,176	**0,010**
HsCRP (*mg/l*)	-0,141	**0,039**
Io* *(µIU/mL)*	-0,170	**0,012**
Go *(mmol/l)*	-0,231	**0,001**
HbA1c (%)	-0,217	**0,001**

3.2.1.3 Factors affecting 25(OH)D concentration

Table 3.11. Effect of some anthropometric factors and disease on 25(OH)D concentration

Variables	β*	KTC 95%		p	VIF
Age	0,003	-0,081	0,087	0,942	1,184
Diabetes duration	-0,146	-0,296	0,004	0,057	1,061
Gender (female)	-2,520	-4,611	-0,429	**0,018**	1,090
BMI	-0,482	-0,902	-0,063	**0,024**	1,686
WC	0,049	-0,103	0,200	0,527	1,791
Hypertension	0,889	-1,402	3,179	0,445	1,133
R^2	0,085 ; **p*=0,005**				

Table 3.12. Effect of lipid index on 25(OH)D concentration

Variables	Regression coefficient	KTC 95%		p	VIF
TG	-1,067	-1,594	-0,540	0,000	1,111
HDL-C	-0,891	-4,086	2,303	0,583	1,191
LDL-C	-0,362	-1,376	0,653	0,483	1,205
LDL/HDL	-0,019	-0,506	0,467	0,937	1,226
R^2	0,075; **p*=0,003**				

Table 3.13. Effect of HbA1C, Go on 25(OH)D concentration

Variables	Regression coefficient	KTC 95%		p	VIF
HbA1C	-0,553	-1,326	0,220	0,160	1,713
Go	-0,391	-0,788	0,007	0,054	1,713
R^2	0,07; **p*=0,001**				

3.2.1.4. Multivariable model predicts vitamin D deficiency risk

Table 3.14. Multivariable model predicts vitamin D deficiency risk

Variables		Simplified model			
		OR	KTC 95%		p
Gender	Male				
	Female	2,062	1,068	3,984	**0,031**
Diabetes duration	≤10 years				
	> 10 years	2,238	1,086	4,609	**0,029**
BMI	<23				
	≥23	4,992	2,546	9,749	**0,000**
TC	Nomal				
	High	3,346	1,644	6,810	**0,001**
Go	<7mmol/l				
	≥ mmol/l	2,285	1,173	4,452	**0,015**

The model has a sensitivity of 78,79%; specificity 62,20%; positive predictive value 77,04%, negative predictive value 64,56%

3.2.1.5. Differences in the risk of vitamin D deficiency between male and female, overweight and obese patients, and non overweight and obese patients

Table 3.15. Differences in risk factors of vitamin D deficiency in 2 gender

	Male				Female			
Variables	**OR**	**KTC 95%**		**p**	**OR**	**KTC 95%**		**p**
BMI < 23	1				1			
BMI ≥ 23	5,435	1,855	15,922	**0,002**	5,573	2,141	14,510	**<0,001**
TC nomal	1				1			
TC high	2,711	0,840	8,755	0,095	4,712	1,742	14,404	**0,002**
Go <7 mmol/l	1							
Go ≥7 mmol/l	2,439	0,836	7,118	0,103				
Oral	1							
Insulin	5,190	1,233	21,854	**0,025**				
DR≤10years					1			
DR>10 years					5,010	1,742	14,404	**0,003**

Table 3.16. Differences in risk factors of vitamin D deficiency in overweight and obese patients and non overweight and obese patients

Variables	**BMI <23 kg/m²**				**BMI ≥23.0 Kg/m²**			
	OR	**KTC 95%**		**p**	**OR**	**KTC 95%**		**p**
TC Nomal	1				1			
TC High	3,754	1,424	9,899	**0,008**	10,278	1,843	57,326	**0,008**
HbA1c <7%	1							
HbA1c ≥7%	3,726	1,345	10,381	**0,011**				
Oral	1							
Insulin	6,259	1,859	21,076	**0,003**				

3.2.2. Effects of vitamin D deficiency and 25(OH)D level on some research factors in type 2 diabetes patients

3.2.2.1. Differences of some research indexes between vitamin D deficiency patients and non vitamin D deficiency patients

Table 3.17. Difference of lipid index and hsCRP between vitamin D deficiency and non vitamin D deficiency patients

Vitamin D / Characteristics	Vitamin D deficiency	Vitamin D sufficiency	p
BMI *(kg/m²)*	23,92 ± 2,92	22,94 ± 3,05	**0,020**
WC *(cm)*	86,07 ± 6,74	87,38 ± 9,50	0,279
TC *(mmol/l)*	4,72 ± 1,20	4,25 ± 0,98	**0,002**
TG *(mmol/l)*	1,91 (1,33-2,76)	1,65 (1,24-2,18)	0,064
HDL-C*(mmol/l)*	1,12 (0,97-1,31)	1,09 (0,98-1,32)	0,902
LDL-C *(mmol/l)*	2,97 ±1,13	2,74 ± 0,89	0,101
TC/HDL	4,01 (3,35-5,10)	3,58 (2,90-4,70)	**0,035**
HsCRP *(mgl/l)*	1,58(0,75-3,37)	1,29(0,60-2,15)	0,111

Table 3.18. Difference of Go, HbA1c, HOMA-IR and HOMA -% B between vitamin D deficiency and non vitamin D deficiency patients

Vitamin D / Characteristics	Vitamin D deficiency	Vitamin D sufficiency	p
Go *(mmol/l)*	8,11 (6,91-11,24)	7,24 (6,24-8,79)	**0,004**
HbA1c *(%)*	7,58 (6,62-9,23)	7,10 (6,40-8,16)	**0,040**
HOMA-IR	6,84 (0,63-80,75)	4,34 (0,68-20,1)	**0,031**
HOMA-%B	82,51(7,43-448,6)	80,63 (6,34-569,77)	0,541

3.2.2.2. Effect of 25(OH)D level and vitamin D deficiency on some research factors in patients with type 2 diabetes

Table 3.19. Effect of vitamin D deficiency on some related factors in type 2 diabetes patients

Variables		OR	KTC 95%		p
BMI	<23	1			
	≥23	**4,196**	2,302	7,649	**0,000**
Abdominal obesity	No	1			
	Yes	**2,831**	1,591	5,037	**0,000**
TC	Nomal	1			
	High	**3,233**	1,696	6,164	**0,000**
HsCRP	≤3	1			
	>3	**2,037**	1,026	4,045	**0,042**
Go	<7mmol/l	1			
	≥7mmol/l	**2,193**	1,228	3,419	**0,008**
HOMA-IR*	Non IR	1			
	IR	**2,211**	1,162	4,205	**0,016**

Table 3.20. Effect of 25(OH)D concentration on some related factors in type 2 diabetes patients

Variables		OR	KTC 95%		p
BMI	<23	1			
	≥23	**0,914**	0,875	0,955	**0,000**
Abdominal obesity	No	1			
	Yes	**0,926**	0,888	0,965	**0,000**
TC	Nomal	1			
	High	**0,940**	0,900	0,981	**0,005**
TG	Nomal	1			
	High	**0,958**	0,922	0,995	**0,025**
TC/HDL	Nomal	1			
	High	**0,944**	0,900	0,990	**0,017**
HsCRP	≤3	1			
	>3	**0,944**	0,901	0,990	**0,018**
Go	<7mmol/l	1			
	≥7mmol/l	**0,946**	0,909	0,984	**0,006**
HbA1c	<7%	1			
	≥7%	**0,946**	0,910	0,983	**0,005**
HOMA-IR	Non IR	1			
	IR	**0,934**	0,897	0,973	**0,001**

Chapter 4
DISCUSSION

4.1. 25(OH)D CONCENTRATION, VITAMIN D DEFICIENCY PREVALENCE OF TYPE 2 DIABETES PATIENTS

Our results showed that among 214 patients, 132 were vitamin D deficient, accounting for 61.7%, and 82 were vitamin D sufficient, accounting for 38.3%. The average concentration of 25(OH)D in the study group was 28.74 ± 7.39 ng/ml, and our vitamin D deficiency rate was lower than that in the Georgios Papadakis study (85.9%) and the alhewishel study (89.69%). This difference may be due to the different illumination time, the UBV ray level reaching different geographical points and the different living habits of Vietnamese people and other countries.

Difference of 25 (OH) D concentration and prevalence of vitamin D deficiency in different genders: due to less physical activity and outdoor activities, women have a higher risk of vitamin D deficiency than men, and testosterone is also positively correlated with vitamin D concentration. Our study showed that the vitamin D deficiency rate was 52.6% in male patients and 66.9% in female patients, $p<0,05$; The concentration of 25(OH)D in male patients was also higher than that in female patients, $p=0,013$. Our results are similar to those of Zelin Li and Kaili Yang

.The difference of 25(OH)D concentration and vitamin D deficiency rate in different duration of diabetes: our study shows that patients with diabetes lasting for 10 years and >10 years have diabetes. The vitamin D deficiency rates were 55.1% and 76.1% respectively; The concentration of 25(OH)D was 29.54 ± 7.55 and 26.99 ± 6.76, respectively, $p<0,05$. This correlation may be due to the longer the duration of the disease, the more complications of diabetes, which is also a related factor of vitamin D deficiency. Our results are similar to the study of Yosuf Abdullah Salih and of Christel

4.2. RELATIONSHIP BETWEEN 25(OH)D CONCENTRATION, VITAMIN D DEFICIENCY AND SOME RELATED FACTORS IN TYPE 2 DIABETES PATIENTS

4.2.1. Factors affecting the risk of vitamin D deficiency in patients with type 2 diabetes

4.2.1.1. Some factors related to 25(OH)D concentration and vitamin D deficiency in type 2 diabetes patients

The relationship between overweight and obesity, abdominal obesity, lipid index, hsCRP and vitamin D deficiency and 25(OH)D concentration

Our results show that the vitamin D deficiency rate and 25(OH)D level of overweight and obese patients are lower than those of non obese and non obese patients; Our results are similar to those of Syed Yasir Hussain Gilani and Gradillas-García A.

The rate of vitamin D deficiency in patients with high TC was 78.4%; 58% with normal TC; $p<0,05$。 The mean 25(OH)D levels of high Tc patients, high Tg patients and high TC / HDL patients were statistically significantly lower than those of low TC, low Tg and TC / HDI patients. Our results are similar to those of Yosuf Abdullah Salih, Kaili Yang and Chao-Wu Xiao.

Recent studies have shown that patients with low 25(OH)D levels have higher CRP than patients with high 25(OH)D levels, and hsCRP levels are significantly negatively correlated with 25(OH)D levels. Our study also showed similar results: Patients with hsCRP ≤ 3 had a higher VD deficiency rate and a lower 25(OH)D level than those with hsCRP > 3 ($p < 0,05$).

Relationship of insulin level, fasting blood glucose and HbA1c with vitamin D deficiency and 25(OH)D level

Studies have shown that activated vitamin D participates in the regulation of Go and Io through different pathways.

Relationship between fasting blood glucose and vitamin D: Our study showed that patients with Go < 7mmol /l had a higher VD deficiency rate, and the average 25(OH)D concentration was lower than patients with Go ≥ 7mmol /l, p < 0,01; Our results are similar to those of Hussain Darraj et al..

Relationship between HbA1c and vitamin D: The prevalence of VD deficiency in patients with HbA1c < 7 was 55.2%; 66.1% of patients with HbA1c ≥ 7%; p=0,105. The mean 25(OH)D concentration of patients with HbA1c < 7% was 30,54 ± 7,59, and that of patients with HbA1c ≥ 7% was 27.51 ± 7.02mmol/l; p=0,003. Our results are consistent with Hussain Darraj et al.

Relationship of insulin resistance, pancreatic beta cell function with vitamin D deficiency and 25(OH)D levels

Vitamin D improves insulin resistance through many different mechanisms, and clinical studies have also shown that it is related to insulin resistance index (HOMA-IR).

Our study shows that patients with insulin resistance according to HOMA-IR index have higher VD deficiency rate and lower 25(OH)D level compared with patients without insulin resistance. Our results are similar to those of Chao Wu Xiao and Elham Ehrampoush.

Relationship of physical activity habits, treatment regimen with vitamin D deficiency and 25(OH)D concentration

Relationship between physical activity and vitamin D:

Physical activity is a factor to improve body VD. Our results show that the average 25(OH)D concentration of patients with good physical activity is higher than that of patients with poor physical activity; p=0,044. Our results are similar to those of Elham Ehrampoush et al

Relationship between diabetes treatment regimen and vitamin D:

Patients treated with insulin are long-term patients with many complications of diabetes, which is also factors related to VD deficiency in diabetes patients. Our study shows that patients treated with insulin have higher VD deficiency rate and lower 25(OH)D level than patients treated with oral drugs alone, p < 0,05.

4.2.1.2. **25(OH)D concentration correlated factors**

In our study, there was a statistically significant negative correlation between 25(OH)D concentration and BMI (p = 0,01); r = -0176, our results are similar to those of Kaili Yang et al. and Malgorzata Gorska-Ciebiada et al. The study of Eman S. Arafat showed that 25(OH)D concentration was correlated with body mass index and waist circumference. This difference may be due to the fact that Eman S. Arafat only studied female diabetes patients and race, and the individual conditions of patients were different.

25(OH)D concentration was negatively correlated with TC, TG and TC / HDL ratio (p < 0,01); Our results are similar to those of Liu Yaqiong, Yogita Dhas and Kaili Yang. Regarding the TC / HDL ratio, no study has evaluated the correlation between 25(OH)D concentration and TC / HDL ratio. However, the study of Chao Wuxiao and Marisa Censani showed that the lower the concentration of 25(OH)D, the higher the TC / HDI ratio.

For Go, HbA1c and Io index: 25(OH)D concentration has a statistically significant negative correlation with Go, Io and HbA1c. Our results are consistent with those of Essam h Jiffri and Yosria E..

There was a statistically significant negative correlation between 25(OH)D concentration and hsCRP (p = 0,018); r = -0.162, our results are similar to those of Malgorzata Gorska Ciebiada.

4.2.1.3. Some factors affecting 25(OH)D concentration

Effects of anthropometric factors and disease on 25(OH)D concentration

Multivariable regression model including the factors: age, duration of diabetes, sex, BMI, waist circumference, hypertension showed that gender, BMI had a statistically significant independent impact on the concentration of 25(OH)D. The results of our study are similar to studies by Hussain Darraj and by Maria Creusa Rolim.

Our Multivariable regression model shows that diabetes duration has an impact on the 25(OH)D concentration with p=0,051, Manal S. Fawzy's study on diabetic patients also gave similar results with p=0,544, the cause may be because the treatment regimen, treatment adherence and patient's diet are not the same in each country, leading to heterogeneous results.

Effect of lipid indexs on the 25(OH)D concentration

The multivariate regression analysis including TC, TG, LDL-C and LDL/HDL ratio: only TG had a statistically significant independent effect on 25(OH) concentration D. Our results are similar to the results of Kaili Yang and Sushant Pokhrel's research.

Effect of HbA1C, Go on 25(OH)D concentration

Go concentration has a negative effect on the concentration of 25(OH)D with p=0,054. Yogita Dha's study also gave similar results with a very significant p, showing that Go has a certain effect on the body's vitamin D status.

4.2.1.4. Multivariable model predicts vitamin D deficiency risk

Our prediction of vitamin D deficiency was similar to other studies.

Regarding gender, our model showed that the risk of vitamin D deficiency in female patients was 2,062 times higher than that in male patients, p = 0,031. Our results are similar to Hussain darraj.

For BMI, our study showed that patients with BMI ≥ 23 kg/m2, the risk of vitamin D deficiency was 4,992 times higher than patients with BMI less than 23 with high statistical significance, our results similar to studyl of Maria Creusa Rolim

In terms of the duration of diabetes, our model shows that the risk of vitamin D deficiency is 2,238 times higher in patients with diabetes diagnosed for more than 10 years than in patients with diabetes diagnosed for less than 10 years. Our results are similar to study of. Thuraya A. Alaidarous et al.

For total cholesterol, the regression analysis of Sushant Pokhrel showed that TC concentration had a negative effect on 25(OH)D concentration, this result was similar to our result.

For Go, our study showed the following results: compared with patients with Go <7mmol/l, patients with Go ≥7mmol/l had a 2,285 times higher risk of vitamin D deficiency with p=0,015; this result is similar to multivariate model results in the study of Sushant Pokhrel

Our model predicted the risk of vitamin D deficiency with a sensitivity of 78,79% and a specificity of 62,20%; the positive predictive value was 77,04%; the negative predictive value was 64,56%, the area under the curve = 0,780, and the predictive level was good.

4.2.1.5. Differences in the risk of vitamin D deficiency between men and women, overweight and obese patients, and non overweight and obese patients

Differences in risk factors for vitamin D deficiency in 2 gender

In male and female patients, overweight and obesity increased the risk of vitamin D deficiency than non overweight and obese patients; the risk of vitamin D deficiency in male patients was 6,416 times that in male patients and 4,727 times that in female patients (p < 0,05). For TC index, the risk of vitamin D deficiency in female patients with high blood TC concentration is higher than that in male patients. The risk of vitamin D deficiency in female patients with diabetes detection time > 10 years is higher than that in female patients with diabetes diagnosis ≤ 10 years. The risk index OR = 5.01

For male patients, insulin treatment was associated with a 5.19-fold higher risk of vitamin D deficiency with p = 0,025.

At present, there is no similar study to analyze the multiple regression of the risk of vitamin D deficiency in two groups of male and female diabetes patients.

Differences in risk factors for vitamin D deficiency in overweight and obese patients, and non overweight and obese patients

In overweight and obese and non overweight and obese patients, high blood TC are associated with the risk of vitamin D deficiency. However, overweight and obese patients have a higher risk of vitamin D deficiency than non overweight and obese patients

In non-overweight and obese patients, high HbA1c factors and insulin treatment as a risk factor for vitamin D deficiency, the risk was 3,726 times higher for patients with HbA1c ≥7% and 6,259 times higher for insulin treatment patients .

At present, there is no similar study to analyze the multivariate regression of the risk of vitamin D deficiency in overweight and obese diabetes patients.

4.2.2. Effects of vitamin D deficiency and 25(OH)D level on some research factors in type 2 diabetes patients

4.2.2.1. Differences of some research indexes between vitamin D deficiency patients and non vitamin D deficiency patients

Differences in BMI and lipid index between vitamin D deficiency and non vitamin D deficiency patients:

Our study shows that the average BMI and median TC / HDL ratio of patients with VD deficiency are higher than those without VD deficiency (p < 0,05). Our results are similar to those of Surya Prakash Bhatt, Xiao Chaowu and Kaili Yang.

Differences in Io, Go, HbA1c and HOMA-IR between patients with and without vitamin D deficiency:

Our results showed that the median Go of VD deficient patients was 8.11mmol/l; 7.24mmol/l in patients without vitamin D deficiency; p=0,004. Our results are similar to those of Nuria Alcubierre and Salome Sadat Salehi.

The median HbA1c of VD deficiency patients was 7,53% and 7,1% of patients without VD deficiency; p=0,047. Our results are similar to those of Salome Sadat Salehi and Essam H Jiffri.

The median HOMA-IR of VD deficiency and non VD deficiency patients was 6,84 and 4,34, respectively; p=0,031. Our results are similar to those of Chao Wu Xiao and Elham Ehrampoush.

4.2.2.2 Effects of vitamin D deficiency and 25(OH)D levels on some research factors in type 2 diabetes patients

For overweight, obesity and dyslipidemia: vitamin D deficiency has also been shown to increase the risk of overweight, obesity and dyslipidemia. Our study shows that vitamin D deficiency is associated with an increased risk of overweight and obesity, abdominal obesity and high TC, and the increased level of 25(OH)D is also associated with an increased risk of overweigh and obesity, abdominal obesity, high blood TC and high blood TG in patients with type 2 diabetes. Our results are consistent with those of Maria Creusa Rolim, Ying Xiao and Dan Jin.

For fasting blood glucose and HbA1C: studies have shown that vitamin D can improve blood glucose through a variety of mechanisms. Our study showed that vitamin D deficiency was significantly associated with the risk of high Go levels, while improving 25(OH)D levels were associated with reducing the risk of high Go and high HbA1c levels, $p < 0,05$. Our results are similar to those of Abdullah Salih and Hussain darraj.

For hsCRP: our study showed that vitamin D deficiency was significantly associated with an increased risk of hsCRP, while improvements in 25(OH)D levels were significantly associated with improvements in hsCRP. Our results are similar to those of Hyemi Lee and Dan Jin

CONCLUSION

By investigating the serum 25 hydroxy vitamin D levels of 214 patients with type 2 diabetes, we reached the following conclusions:

1. 25 hydroxyvitamin D concentration, vitamin D deficiency prevalence of type 2 diabetes patients with vitamin D deficiency

-The vitamin D deficiency rate of type 2 diabetes patients was 61,7%, and the average concentration of 25 hydroxyvitamin D in the study group was 28,74 ± 7,39 ng / ml.

-The average concentration of 25 hydroxyvitamin D in female patients with type 2 diabetes was 27,71 ± 7,09 ng/ml, lower than that in male patients (30,51 ± 7,60 ng/ml) with $p<0,01$.

- The rate of vitamin D deficiency in female patients with type 2 diabetes was 67,4%, which was higher than that in male patients (51,9%)， $p<0,05$.

- The average concentration of 25 hydroxyvitamin D of type 2 diabetes patients with diabetes duration ≤10 years was 26.99 ± 6.76ng/ml lower than that in patients with diabetes duration <10 years (29.54 ± 7.55ng/ml), p<0,05.

- The vitamin D deficiency rate of patients with type 2 diabetes duration > 10 years was 76,1% which higher than patients with type 2 diabetes duration ≤ 10 years (55,1%), p <0,05.

2. Some related factors of vitamin D deficiency in type 2 diabetes patients

2.1. Factors affecting the risk of vitamin D deficiency in patients with type 2 diabetes:

-Overweight and obesity, abdominal obesity, high TC, high TG, hsCRP>3mg/l, Go ≥ 7 mmol/l, HbA1C ≥ 7%, insulin resistance according to HOMA-IR index and poor physical activity in patients with type 2 diabetes are associated with low levels of 25 hydroxyvitamin D and high prevalence of vitamin D deficiency

-Female gender s, more than 10 years of diabetes history, overweight and obesity, high TC and Go levels have positive effects on the risk of vitamin D deficiency. The multivariate model predicted the risk of vitamin D deficiency, including: the sensitivity of the above factors was 78,79%, and the specificity was 62,20%; Area under the curve = 0,780.

-Compared with male patients, the duration of diabetes > 10 years and high blood TC increase the risk of vitamin D deficiency in female patients. In non overweight and obese patients, high HbA1c and insulin maintenance therapy increased the risk of vitamin D deficiency, while in overweight and obese patients, high blood TC increased the risk of vitamin D deficiency.

2.2. Effects of vitamin D deficiency on some research factors:

-The BMI, TC, TC / HDL, Go, HbA1c and HOMA-IR of patients with vitamin D deficiency were significantly higher than those without vitamin D deficiency.

-Vitamin D deficiency was associated with increased risk of obesity, abdominal obesity, high blood TC, hsCRP > 3mg/l, Go ≥ 7mmol/l, and insulin resistance according to HOMA-IR index.

-Elevated 25 hydroxyvitamin D levels were associated with decreased risk of overweight and obesity, abdominal obesity, high TC, TG, TC/Hdl, Go, hsCRP, and insulin resistance according to HOMA-IR index.

STUDY LIMITATIONS

-Vitamin D has too many influencing factors, so it is impossible to exclude all or study some factors that are difficult to quantify, such as the impact of sunlight on the skin or the comprehensive analysis of the patient's diet.

-This study did not collect the control group in the healthy population, so it is impossible to compare the prevalence of vitamin D deficiency in type 2 diabetes patients and healthy people in the same study.

- The association between 25 hydroxyvitamin D levels and chronic kidney disease cannot be found to be reasonable, because the number of patients with stage 4 or higher CKD is too small.

RECOMMENDATION

Based on the results of this study, we propose the following suggestions:

-It is necessary to measure 25 hydroxyvitamin D levels in patients with diabetes. In particular, if the patient has one of the following factors: female patients, lack of physical exercise, overweight and obesity, dyslipidemia, poor blood sugar control, and the patient's diabetes detection time over 10 years.

-Vitamin D deficiency should be considered to be a risk factor for overweight and obesity, dyslipidemia and poor blood glucose control in patients with type 2 diabetes.

-To further study the long-term consequences of vitamin D deficiency in patients with type 2 diabetes, and to study the adjuvant treatment for patients with vitamin D deficiency diabetes.

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