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ARTICLE

Correlation between obesity and serum 25-hydroxyvitamin D levels in patients with type 2 diabetes

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Abstract

Objective: The paper analyzes the correlation of vitamin D level with obesity degree and serum 25-hydroxyvitamin D level in patients with type 2 diabetes mellitus (T2DM) through clinical case studies, which can provide clinical guidance for obese T2DM patients' weight control to lower their risk of developing metabolic illnesses. **Methods:** A total of 249 patients with T2DM were chosen from among those hospitalized at Lanzhou University's First Hospital between April and September of 2023. The serum 25-hydroxyvitamin D level, body fat rate, fasting blood glucose, and fasting insulin of the subjects were detected, and 198 T2DM patients with low serum 25-hydroxyvitamin D levels were selected as the observation group. 51 T2DM patients with normal serum 25-hydroxyvitamin D levels were selected as the control group, and the correlation between type 2 diabetes mellitus and vitamin D levels and obesity was analyzed. **Results:** Obesity and serum vitamin D insufficiency are associated with type 2 diabetes. Both vitamin D deficiency and obesity eventually lead to T2D, endocrine disorders, and other common diseases.

Keywords: Type 2 diabetes; obesity; vitamin D

1. Introduction

Type 2 Diabetes mellitus (T2DM) is a kind of diabetes mellitus (DM), that accounts for more than 90% of the total number of diabetics. It is a metabolic illness characterized by hyperglycemia caused by B cell malfunction and insulin resistance. Diabetes is typical of increased eating, irritability, thirst, frequent urination, weight loss, and occasionally blurred vision. With the prosperity of national economies, over the past few decades, there has been a sharp rise in type 2 diabetes and obesity, and these trends are continuing to worsen globally. The latest estimates from the International Diabetes Federation (IDF) indicate that 8.3% of adults (387 million people)suffer from diabetes. There will be a startling 592 million people with diabetes and impaired glucose tolerance (IGT) by 2035, of which 316 million are at high risk. If diabetes prevention efforts are not planned, hundreds of millions of people will have diabetes in less than 25 years[1]. DM has become one of the important and main causes of human health threats in the world, which brings great threats to patients both physically and psychologically, and significantly reduces their quality of life.

With the prevalence of unhealthy lifestyles, more than half of Chinese adults are overweight, the overweight rate of adolescents aged 6-17 years has reached 10.4%, and the overweight rate of children under 6 years is as high as 19.0%. Epidemiology demonstrates the strong correlation between obesity and the prevalence of numerous diseases. High body mass index (BMI) is the main risk factor for diabetes mellitus (DM) in China, according to statistics. 12.8% of people who are overweight have diabetes, and the in obese population is 18.5%. At the same time, 41% of T2DM patients in China are overweight, and 24.3% of them are obese[2]. Undoubtedly, being overweight is a contributing factor for T2DM. Besides, obesity is closely related to impaired glucose homeostasis, and it is also a significant danger factor for raising insulin resistance (IR), cellular oxidative stress, and pancreatic cell dysfunction[3]. Research investigations over the past decades have shown an inverse correlation between insulin resistance, central obesity, circulating vitamin D levels, and the onset of diabetes[4][19]. In addition to glucose metabolism disorders, DM is often accompanied by abnormal lipid metabolism. It is the interaction between glucotoxicity and lipotoxicity, also known as "glycolipid disease", which may be related to IR. In individuals with type 2 diabetes, obesity can raise the risk of IR and dyslipidemia, which can raise the incidence of cardiovascular disease.

Additionally, vitamin D (VD) deficiency is quite common across a wide range of age groups and societies. Over the past few decades, additional essential functions for vitamin D have emerged in addition to their traditional roles in calcium balance. Low levels of plasma 25-hydroxyvitamin D (25OHD) have been linked to comorbidities associated with obesity, including low-grade inflammation, insulin resistance, and type 2 diabetes.[5][20],[21]. Obese patients are usually characterized by low plasma 25OHD levels. Adipose tissue can store vitamin D due to its lipophilic nature. Vitamin D mediates lipogenesis, insulin secretion, insulin sensitivity, and the regulation of the immune system, which is the main reason for the tight association between obesity, glucose homeostasis, and vitamin D deficiency.

At present, the research on 25-hydroxyvitamin D and obesity in patients with type 2 diabetes mellitus at home and abroad is very hot. In addition to basic drug treatment, dietary therapy, and traditional Chinese medicine are often used to improve the basic diet and body metabolism of patients with T2DM, with to reduce the impact of obesity and nutritional deficiency on body metabolism. To improve therapy and provide guidance for the prevention and treatment of overweight and obese T2DM patients with vitamin D insufficiency, this study will investigate the association between obesity,25[OH]D, and type 2 diabetes using pathology report analysis.

2. Methodology

2.1 Study Population/Source of Study Population

This was an observational cohort study. Patients with type 2 diabetes mellitus (T2DM) who were admitted to the First Hospital of Lanzhou University from April 2023 to September 2023 were enrolled.

Inclusion criteria: all patients met the 1999 WHO diagnostic criteria for diabetes, namely fasting venous blood glucose $\geq$ 7.0mmol/L and/or 2h after OGTT venous blood glucose $\geq$ 11.1 mmol/L. Fasting blood glucose was measured by glucose meter in all subjects, and an oral glucose tolerance test (OGTT) was performed only when blood glucose was <7mmol/l.

Exclusion criteria: type 1 diabetes mellitus (T1DM); Acute complications of DM; Acute infections; Various kidney diseases; Malignant tumors; Autoimmune diseases; Other diseases that affect vitamin D levels.

2.2 Data Collection

2.2.1 Collection of basic information

The socio-demographic and anthropometric information and diabetes history data of all subjects were collected, including gender, hospital number, age (years), duration of diabetes (years), height (m), weight (Kg), waist circumference (cm), neck circumference (cm), and hip circumference (cm). Body mass index (BMI) (Kg/m2) = weight (Kg) /[height (m)]2 was calculated based on height and weight. The WHO classification system was used to categorize obesity.[1][15]. BMI$\geq$30 kg/m2 was obese, BMI$\geq$25 kg/m2 and <30 kg/m2 were overweight.

2.2.2 Questionnaire survey

The questionnaire included information on demographic characteristics, past medical history, symptoms, dietary intake, and sleep STOP-bang questionnaire.

2.2.3 Blood biochemical indexes of patients were collected

After admission, all subjects were fasted for 12 hours, and 5 mL of fasting blood was collected the next morning, centrifuged at 4000r/min for 5 minutes, and serum was separated. Serum 25-hydroxyvitamin D was measured by the biochemical analyzer (25OHD), total cholesterol (TC), triglyceride (TG), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), alanine aminotransferase (ALT), aspartate aminotransferase (AST), albumin, blood calcium, blood phosphorus, peripheral blood platelet, and lymphocyte count, Platelet lymphocyte ratio (PLR) was calculated. Fasting venous blood (5 mL) was collected, and hemoglobin (Hb) and glycosylated hemoglobin (HbA1c) were measured by high-performance liquid chromatography. N-MZD-BGP, PINP, and β-C7X were detected by bone metabolism indexes. It is widely acknowledged that the concentration of 25(OH)D signifies the total amount of vitamin D that is absorbed through the diet and produced by the skin.[6][22]. The Institute of Medicine released a report on vitamin D status in November 2010, classifying serum 25(OH)D as: risk of deficiency, <12 ng/mL; risk of inadequacy,12–19 ng/mL; sufficiency, 20–50 ng/mL; and possible harm, >50 ng/mL. For multiple regression analysis, vitamin D status will be reported as sufficient (20–50 ng/mL) or insufficient (<20 ng/mL) [6]. Given its superiority as a body fat measure, waist circumference may be more closely linked to insulin resistance and type 2 diabetes. For men, a waist circumference of 102 cm and for women, 88 cm was considered abdominal obesity.WC was measured at a location above the midaxillary line's iliac crest, to the nearest 0.1 cm under minimal breathing[6][16]. According to the International Diabetes Federation Consensus Statement on Metabolic Syndrome, abdominal obesity in China is defined as waist circumference $\geq$90 cm for males and $\geq$80 cm for women[7].

2.3 Grouping study

According to the vitamin D level, the patients were divided into the VD deficiency group [serum 25(OH)D<20ng/ml, 198 cases] and the non-VD deficiency group [serum 25(OH)D$\geq$20ng/ml, 51 cases]. The former was the observation group, and the latter was the control group. According to BMI, the two groups were divided into the obesity group (BMI$\geq$25kg/m2) and the normal group (BMI < 25kg/m2). The serum 25(OH)D3 level of all patients was detected, and the insulin resistance index (HOMA-IR) was calculated.

Statistical Package for the Social Sciences (SPSS) software (version 26; SPSS Inc., Chicago, Illinois, USA). The mean and standard deviation (SD) of continuous variables were utilized to represent descriptive characteristics of the study population, and t-tests were employed to determine significant differences between the two means of continuous variables. The study employed multivariable logistic regression analysis to determine the risk factors related to diabetes by calculating the odds ratio (OR) and 95% confidence interval (CI).p<0.05 was taken as the critical value of significance[1]. Pearson correlation analysis was used to analyze the correlation between HOMA-IR and other indicators in the two groups, and then multiple linear stepwise regression analysis was used to evaluate the correlation between HOMA-IR and other indicators in the VD deficiency group.

The Student t-test was utilized for differences between continuous variables, and the Pearson x2 test was used for differences between categorical variables. Multiple logistic regression was used to examine the relationship between type 2 diabetes or insulin resistance and 25(OH)D status (enough [20–50 ng/mL] or insufficient [< 20 ng/mL])[6].

3. Results

3.1 Comparison of clinical data between the two groups

The BMI, systolic blood pressure, diastolic blood pressure, HOMA-IR, LDL, TC and TG levels in the non-VD deficiency group were lower than those in the VD deficiency group, and the 25(OH)D level was higher than that in the VD deficiency group (P<0.05). Gender, age, and the length of diabetes did not significantly differ between the two groups (P>0.05). See Table 1.

3.2 Multivariate logistic regression analysis of diabetes risk factors

After adjusting for variables such as age and gender, variables such as vitamin D deficiency ng/mL, BMI (kg/m2), smoking, and drinking were predictive risk factors for diabetes. See Table 2.

Table 1. Comparison of baseline characteristics of T2DM in observation group and control group

Variables	T2DM Cases N = 249, Mean ± SD		
	Deficiency <20 ng/mL n= 198	Sufficiency ⩾20 ng/mL n = 51	P value
Age in years	59.06±9.68	59.76±10.45	0.651
BMI	24.56±3.13	24.48±2.22	0.006
Vitamin D ng/mL(%)	79.52%	20.48%	0.001
FPG	8.75±3.19	7.84±2.61	0.037
Fins	7.87±6.52	6.99±3.66	0.035
HbA1c	8.61±2.24	8.15±2.09	0.001
HDL	1.03±0.23	1.07±0.30	0.043
LDL	2.89±0.88	2.85±0.80	0.075
Uric Acid	339.09±85.16	339.17±93.40	0.888
Potassium	3.78±0.36	3.84±0.32	0.288
HOMA-IR	2.90±2.59	2.79±2.25	0.008

Table 2. Multivariable logistic regression analysis determine risk factors of T2DM

Predictors - independent variables	Adjusted OR (95% CI)	P value
Vitamin D deficiency ng/mL	48.49(2.44-9.63)	0.001
BMI (kg/m2)	1.09(0.85-1.39)	0.001
Smoke	1.07(0.51-2.24)	0.014
Alcohol	1.13(0.47-2.74)	0.020

4. Discussion

Diabetes is a chronic disease prone to multiple complications, which imposes a significant economic burden on individuals, the health care system, and society as a whole[8][17]. About 90% of instances of diabetes are type 2, and as people age, become overweight or obese, stop exercising, have a family history of the disease, smoke, and have high blood pressure, their likelihood of developing type 2 diabetes rises. For this reason, it is crucial to comprehend the risk factors for type 2 diabetes.[9].

Related studies have shown that vitamin D acts as a "guardian" to maintain normal blood sugar levels and plays an indispensable role in glucose-stimulating insulin secretion. It is negatively correlated with obesity and IR, and is closely related to the state of inflammation in the body, as well as reducing insulin levels and HOMA-IR[10]. Previous research has indicated that vitamin D insufficiency and type 2 diabetes are associated with distinct mechanisms. These mechanisms include changes in cytokine production, insulin secretion regulation, adipocyte function regulation, and calcium and phosphorus metabolism balance. In addition, as a hormone, vitamin D 125 (OH)2D is known to directly or indirectly regulate more than 200 genes, thereby affecting a variety of physiological processes[11]. According to this study's findings, The non-VD deficiency group's BMI, systolic blood pressure, diastolic blood pressure, HOMA-IR, LDL, TC, and TG levels were also lower than those of the VD deficiency group ($P<0.05$), indicating that patients with vitamin D deficiency were more probable to be obese and have higher levels of chronic inflammatory factors. IR, blood pressure, and dyslipidemia may increase the risk of cardiovascular disease. HOMA-IR was positively associated with both BMI and TG in the VD deficiency group ($P<0.05$). HOMA-IR had a negative correlation ($P<0.05$) with 25(OH)D3 in the VD deficiency group ($P<0.05$), other than no significant correlation ($P >0.05$) was seen with other markers. These findings imply a tight relationship between IR and dyslipidemia, obesity, and vitamin. These results suggest that IR is strongly related to obesity, dyslipidemia, and vitamin D levels. Multiple linear stepwise regression showed that 25(OH)D3 and BMI were the influencing factors of HOMA-IR in the VD deficiency group, indicating that obesity and dyslipidemia may aggravate IR, while increasing vitamin D levels may reduce IR[10]. The best source of vitamin D is exposure to sunlight. However, supplementation is available for vulnerable and special populations who do not have access to adequate sun exposure: 50,000 IU vitamin D3 capsules once every two weeks[12][18].

Diabetes prevalence and obesity are tightly associated, and the metabolic effects of obesity differ depending on where adipose tissue is distributed. Obesity-related cardiometabolic problems depend not only on total body fat mass but also on local body fat distribution and subcutaneous adipose tissue's capacity to expand[13]. According to this study, as BMI and WC increased, so did HbA1c, FPG, and PBG. According to Shivani A. Patel et al., there was a significant correlation between the prevalence of diabetes and hypertension and BMI and WC. Additionally, there was an increase in the likelihood of both diabetes and hypertension with higher BMI and WC levels. Additionally, there is a stronger correlation between the obesity index and diabetes than there is with hypertension[14], which is similar to the results of this study.

5. Conclusion

In conclusion, returning to the question posed at the beginning of this study, it is now possible to state that T2DM patients with clinical vitamin D deficiency have higher HOMA-IR levels, will suffer from blood pressure and lipid disorders, and raise the chance of developing cardiovascular disease. Furthermore, obesity could potentially be a risk factor for IR. In clinical practice, T2DM patients' serum vitamin D and bilirubin levels should be examined more closely, to understand the degree of IR in patients more comprehensively and help patients get effective diagnosis and treatment[10].

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REFERENCES

[1]Bener A, Al-Hamaq AO, Kurtulus EM, Abdullatef WK, Zirie M. The role of vitamin D, obesity and physical exercise in regulation of glycemia in Type 2 Diabetes Mellitus patients. Diabetes Metab Syndr. 2016;10(4):198-204. doi:10.1016/j.dsx.2016.06.007

[2] Jiadi Liu.Study on the correlation between different TCM syndrome types and 25-hydroxy vitamin D in overweight and obesity type 2 diabetes mellitus[D]2022.

[3] Safarpour P, Daneshi-Maskooni M, Vafa M, et al. Vitamin D supplementation improves SIRT1, Irisin, and glucose indices in overweight or obese type 2 diabetic patients: a double-blind randomized placebo-controlled clinical trial. BMC Fam Pract. 2020;21(1):26. Published 2020 Feb 7. doi:10.1186/s12875-020-1096-3

[4] Greco EA, Lenzi A, Migliaccio S. Role of Hypovitaminosis D in the Pathogenesis of Obesity-Induced Insulin Resistance. Nutrients. 2019;11(7):1506. Published 2019 Jul 1. doi:10.3390/nu11071506

[5] Wamberg L, Pedersen SB, Rejnmark L, Richelsen B. Causes of Vitamin D Deficiency and Effect of Vitamin D Supplementation on Metabolic Complications in Obesity: a Review. Curr Obes Rep. 2015;4(4):429-440. doi:10.1007/s13679-015-0176-5

[6] Kabadi SM, Lee BK, Liu L. Joint effects of obesity and vitamin D insufficiency on insulin resistance and type 2 diabetes: results from the NHANES 2001-2006. Diabetes Care. 2012;35(10):2048-2054. doi:10.2337/dc12-0235

[7] Gao JJ, Xue Y, Fu RK, et al. Association of Serum Vitamin D Status and Waist Circumference on Obesity with Type 2 Diabetes: A Cross-sectional Study in Rural Adults of Henan. Biomed Environ Sci. 2022;35(5):463-467. doi:10.3967/bes2022.063

[8] Bener A, Abdulmalik M, Al-Kazaz M, Sanya R, Buhamaid S, Al Harthy M. Does Good Clinical Practice at the Primary Care Improve the Outcome Care for Diabetic Patients?:Gender Differences. J Primary Care Diabs 2012; 6: 285-92.

[9] Bener A, Zirie M, Janahi IM, Al Hamaq AOAA, Musallam M, Wareham NJ. Prevalence of Diagnosed and Undiagnosed Diabetes Mellitus and its Risk Factors in a Population - Based Study of Qatar. Diab Res Clin Prac 2009; 84: 99-106.

[10] Zhuo Wang,Wei Song,Bo Yang,Haifeng Zhen,Linlang Liang.Exploring the relationship between serum bilirubin, 25 hydroxyvitamin D3 levels and insulin resistance in vitamin D-deficient patients with type 2 diabetes mellitus[J] Laboratory Medicine and Clinic,2022,v.19(22):3139-3142.

[11] Erica Stivelman E, Retnakaran R. Role of Vitamin D in the Pathophysiology and Treatment of Type 2 Diabetes .Current Diab Review. 2012; 8: 42-7

[12] Wimalawansa SJ. Associations of vitamin D with insulin resistance, obesity, type 2 diabetes, and metabolic syndrome. J Steroid Biochem Mol Biol. 2018;175:177-189. doi:10.1016/j.jsbmb.2016.09.017

[13] Lim S, Kim MJ, Choi SH, et al. Association of vitamin D deficiency with incidence of type 2 diabetes in high-risk Asian subjects. Am J Clin Nutr. 2013;97(3):524-530. doi:10.3945/ajcn.112.048496

[14] Clemente-Postigo M, Muñoz-Garach A, Serrano M, et al. Serum 25-hydroxyvitamin D and adipose tissue vitamin D receptor gene expression: relationship with obesity and type 2 diabetes. J Clin Endocrinol Metab. 2015;100(4):E591-E595. doi:10.1210/jc.2014-3016

[15] National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III): Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) final report. Circulation 2002;106:3143–342

[16] Hollis BW, Wagner CL. Clinical review: The role of the parent compound vitamin D with respect to metabolism and function: Why clinical dose intervals can affect clinical outcomes. J Clin Endocrinol Metab. 2013;98(12):4619-28.

[17] Mezza T, Muscogiuri G, Sorice GP, et al. Vitamin D deficiency: a new risk factor for type 2 diabetes?. Ann Nutr Metab. 2012;61(4):337-348. doi:10.1159/000342771

[18] Grant WB, Wimalawansa SJ, Holick MF, et al. Emphasizing the health benefits of vitamin D for those with neurodevelopmental disorders and intellectual disabilities. Nutrients. 2015;7(3):1538-1564. Published 2015 Feb 27. doi:10.3390/nu7031538

[19] Szymczak-Pajor I, Śliwińska A. Analysis of Association between Vitamin D Deficiency and Insulin Resistance. Nutrients. 2019;11(4):794. Published 2019 Apr 6. doi:10.3390/nu11040794

[20] Bellia A, Garcovich C, D'Adamo M, et al. Serum 25-hydroxyvitamin D levels are inversely associated with systemic inflammation in severe obese subjects. Intern Emerg Med. 2013;8(1):33-40. doi:10.1007/s11739-011-0559-x

[21] Cohen-Lahav M, Shany S, Tobvin D, Chaimovitz C, Douvdevani A. Vitamin D decreases NFkappaB activity by increasing IkappaBalpha levels. Nephrol Dial Transplant. 2006;21(4):889-897. doi:10.1093/ndt/gfi254

[22] Vieth R. Vitamin D supplementation, 25-hydroxyvitamin D concentrations, and safety. Am J Clin Nutr. 1999;69(5):842-856. doi:10.1093/ajcn/69.5.842