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Serum vitamin D levels are correlated with cholesterol in individuals with type 2 diabetes mellitus and overweight

Níveis séricos de vitamina D estão correlacionados com o colesterol de indivíduos com diabetes mellitus tipo 2 e excesso de peso

Abstract

Introduction: vitamin D (25OHD) plays an important role in carbohydrate and lipid metabolism. Vitamin D deficiency is frequently found in individuals with metabolic disorders. It is necessary to identify how serum levels of 25OHD correlate with these indicators in individuals with type 2 diabetes mellitus (T2DM) and excess weight. *Objective*: to analyze the correlation between 25OHD and body composition, anthropometric, and biochemical indicators in individuals with T2DM and excess weight. *Métodos:* cross-sectional study conducted at the University Hospital of Florianópolis, Brazil, in individuals with T2DM and excess weight. Body composition was determined by dual-energy X-ray absorptiometry. Anthropometric data were measured by standardized techniques. Biomarkers were analyzed from a serum sample. The correlation between 25OHD and the outcomes was verified using Spearman's correlation. *Results:* 20 individuals with 35 to 75 years old, of which 55% were female. Preserved muscle compartments were observed according to the appendicular muscle mass index, along with a high percentage of body fat in both sexes. Fifty percent of the individuals had vitamin D deficiency and 75% used supplementation. An inverse correlation was observed between 25OHD and total cholesterol (r= -0.52; p= 0.02) and non-HDL-c (r= -0.47 p= 0.04). *Conclusion:* The 25OHD levels are associated with the lipid profile of individuals with type 2 diabetes and overweight, showing an inverse correlation.

Keywords: Diabetes Mellitus. Type 2. Overweight. Obesity. Vitamin D. Cholesterol.

Resumo

Introdução: A vitamina D (25OHD) exerce importante papel no metabolismo dos glicídios e lipídios; entretanto, sua deficiência é frequentemente encontrada em distúrbios metabólicos. Torna-se necessário identificar como os níveis séricos de 25OHD se correlacionam com esses indicadores em indivíduos com diabetes mellitus tipo 2 (DM2) e excesso de peso. *Objetivo*: Analisar a correlação entre a 25OHD e os indicadores de composição corporal, antropométricos e bioquímicos de indivíduos com DM2 e excesso de peso. *Métodos*: Estudo transversal conduzido no Hospital Universitário de

Florianópolis/SC em indivíduos com DM2 e excesso de peso. A composição corporal foi determinada por absorciometria de raio-x de dupla energia; os dados antropométricos aferidos por técnicas padronizadas; e os biomarcadores analisados por amostra sérica. A correlação entre a 25OHD e os desfechos foi verificada com o uso da correlação de Spearman. ***Resultados***: 20 indivíduos com idades entre 35 e 75 anos, sendo 55% do sexo feminino. Constataram-se compartimentos musculares preservados de acordo com o índice de massa muscular apendicular e elevado percentual de gordura em ambos os sexos. Cinquenta por cento dos indivíduos apresentaram deficiência de vitamina D e 75% utilizavam suplementação. Observou-se correlação inversamente proporcional entre a 25OHD e o colesterol total (r= -0.52 e p valor= 0.02) e não HDL-c (r= -0.47 e p valor= 0.04). ***Conclusão***: Há associação entre os níveis de 25OHD e o perfil lipídico de indivíduos com DM2 e excesso de peso, evidenciando uma correlação inversa.

Palavras-chave: Diabetes Mellitus Tipo 2. Sobrepeso. Obesidade. Vitamina D. Colesterol.

INTRODUCTION

Diabetes mellitus (DM) is a highly prevalent chronic disease considered a global public health problem that affects approximately 537 million people worldwide. Its main characteristic is hyperglycemia resulting from the insufficient production or ineffective action of insulin.[1] The development of type 2 diabetes (T2D) is associated with the presence of excess weight, characterized by an elevated body mass index (BMI) (≥ 25 kg/m²), including both overweight and obesity.[2]

Excess weight affects glycemic metabolism by influencing insulin resistance through the intensification of pro-inflammatory signaling, increased glucolipotoxicity, and the maintenance of a state of lipolysis.[3,4] The interrelationships between T2D and excess weight are widely investigated, as their simultaneous occurrence leads to metabolic changes that establish an interdependent cycle among adipose tissue, glycemic control, and, consequently, insulin resistance.[5]

Due to the physiological and metabolic changes of T2D, studies are investigating its relationship with serum micronutrient levels in the health-disease process.[6] Among micronutrients, vitamin D stands out because its deficiency is common in individuals with endocrine disorders, such as type 2 diabetes (T2D) and obesity,[7] since the serum level of 25-hydroxyvitamin D (25OHD) is lower in cases of excess weight, reflecting fat distribution, extracellular fluid, and muscle mass.[8]

Vitamin D plays a protective role, reducing insulin resistance, glycemia, and glycated hemoglobin.[9] However, despite its beneficial effect, individuals with T2D frequently show low 25OHD levels, which can lead to a dysregulation of the lipid profile, including a reduction in high-density lipoprotein (HDL-c) and an increase in total cholesterol and triglyceride levels.[10] Considering the importance of vitamin D for carbohydrate and lipid metabolism, it is necessary to identify its relationship with the carbohydrate and lipid profile in individuals with excess weight and T2D, given that there is an interdependence.[11,12]

Considering the above, this article aims to analyze the correlation between serum 25OHD levels and the biochemical markers, body composition indicators, and anthropometric data of individuals with T2D and overweight who are followed up at an outpatient clinic.

METHODS

Study design and sample

A cross-sectional study with a quantitative approach, conducted with baseline data of a randomized clinical trial, registered on the platform Clinical Trials n° NCT05418179. Data collection was carried out at the diabetes mellitus outpatient clinic of the Endocrinology and Metabolism Service of the University Hospital of the Federal University of Santa Catarina, located in Florianópolis, Santa Catarina, Brazil. The sampling process occurred by temporal saturation. The sample consisted of individuals followed by the outpatient clinic who met the inclusion criteria during the initial screening, which was conducted by the researchers based on physical and electronic medical record data, and who agreed to participate in the study by signing the Informed Consent Form. Data was collected between 2021 and 2023. For the analysis, data from the participants' baseline, before the start of the randomized clinical trial intervention, were used.

Inclusion criteria were: adults (35 to 75 years) diagnosed with type 2 diabetes (T2D) for at least 1 year (≥ 1 year); of both sexes; with BMI between 25.00 kg/m² and 39.99 kg/m²; glycated hemoglobin (HbA1c) ≤ 9.0% and; using metformin, either alone or in combination with other anti-diabetic drugs for T2D treatment.

The exclusion criteria were determined by the need to specify the study population of the randomized clinical trial, which used probiotics in its intervention. Participants were excluded if they had: intestinal

diseases or a history of previous gastrointestinal surgeries, food intolerances or allergies with a previous medical diagnosis, a glomerular filtration rate < 30 ml/min/1.73 m², inflammatory diseases, or immunodeficiencies. A diagnosis of autonomic neuropathy with gastrointestinal involvement, such as diabetic gastroparesis, diabetic enteropathy, or colonic hypomotility. Used anti-inflammatory drugs or antibiotics, or were hospitalized up to one month before or during the study. Regular use of laxatives, opioid narcotic analgesics, or appetite suppressants.

In addition, the following were excluded from the study: current or previous users (up to 1 month) of prebiotics, probiotics, synbiotics, or products enriched with these dietary supplements; individuals intolerant to prebiotics, probiotics, or synbiotics; pregnant or lactating women; individuals who were following a nutritionist-guided diet for weight loss or gain up to 1 month before the study, or who were currently following unusual diets; those who consumed alcohol (> 1 drink/day or 14 g of alcohol for women and > 2 drinks/day or 28 g of alcohol for men); illicit drug users and smokers; individuals who had a change in hypolipidemic and/or anti-diabetic drugs in the 3 months prior to the research.

This study was approved by the Research Ethics Committee of the University, No. 4.800.072. The study followed the principles established in the Declaration of Helsinki and in Resolution No. 466 of 2012 of the National Health Council.[13]

General and demographic data collection

Personal and clinical data to characterize the individuals were collected from medical records and confirmed using a structured questionnaire with self-reported answers from the participants. Data related to sex, age, supplementation used, and the presence of a menstrual period for females were collected. Regarding the supplements used, prescriptions in the electronic medical record were consulted (active ingredient, dose, and dosage) and then cross-referenced with the patient's report to confirm consumption and identify the use of other non-prescribed supplements. The presence or absence of a menstrual period was determined by the date of the last menstruation or a menopause diagnosis.

Anthropometric measurements

The assessment of nutritional status was determined using data on body weight, height, BMI, and waist circumference (WC), according to the World Health Organization (WHO).[14,15] To obtain the parameters, a calibrated electronic scale (Welmy®) with a capacity of 300 kg and an accuracy of 50 g was used, along with a stadiometer attached to the platform with a capacity of 2 m and an accuracy of 0.5 cm, and a non-stretchable measuring tape (Sanny®) with an accuracy of 0.1 cm. Two measurements were taken; if the difference was ≤ 1 cm, the average was calculated, and if > 1 cm, the measurement was repeated.

With the measured obtained and/or calculated, the classification was as follows: a waist circumference (WC) > 88 cm for women and > 102 cm for men indicates a very high risk for cardiovascular diseases.[16]

Body composition

Body composition was determined using dual-energy X-ray absorptiometry (DXA) (Lunar Prodigy Advance, GE Healthcare – Diegem, Belgium) to estimate bone mineral density (BMD), bone mineral content (BMC), lean mass, and body fat (in kg and %). The DXA measurement was performed by a trained technician according to the manufacturer's guidelines (GE Healthcare), with the device calibrated daily before the start of the assessments. For the procedure, participants were instructed to be fasting, barefoot, in light clothing, and without metallic objects, in addition to removing belts, jewelry, and piercings. Participants were positioned lying on their back on the equipment table, keeping their arms and legs away from their body and remaining completely still for 10 to 15 minutes (the average full-body scan time). Appendicular muscle mass

(AMM) was calculated by summing the muscle mass of each participant's arms and legs. The appendicular muscle mass index (AMMI) was estimated by the ratio of AMM to height squared (AMM/height²),[17] with an adequate lean mass level classified as > 5.5 kg/m² for women and > 7 kg/m² for men.[17,18] For the classification of body fat percentage, the parameters from Lohman[19] were used, which consider high fat accumulation when it is ≥ 32% for women and ≥ 25% for men.

Biochemical markers

Approximately 20 mL of peripheral venous blood was collected by a trained laboratory technician from the individuals' antecubital region after an 8- to 10-hour fast.[20] For blood collection, tubes containing EDTA (Vacutainer® system BD Biosciences - Abingdon, UK) or separator gel (Vacutainer® system BD Biosciences - Abingdon, UK) were used.

Glycemic metabolism was determined and expressed using fasting glucose in mg/dL, via the enzymatic method, glycated hemoglobin in %, via the ion-exchange chromatography method, and fasting insulin in µUI/mL, determined by the immunometric chemiluminescence assay. The lipid profile consisted of total cholesterol, HDL-c, and triglycerides, which were determined by the colorimetric enzymatic method. Low-density lipoprotein (LDL-c) was calculated using the Friedewald, Levy, and Fredrickson equation [(total cholesterol - HDL-c) - (triglycerides / 5)] in mg/dL.[21] Non-HDL-c was obtained by subtracting HDL-c from total cholesterol.

Serum 25OHD levels were determined using microparticle chemiluminescence. All biochemical analyses were performed according to the manufacturers' instructions and validated methodologies.

For the analysis of the adequacy of fasting glucose and glycated hemoglobin in individuals with type 2 diabetes (T2D), the values used were, respectively, between 80 and 130 mg/dL and < 7.0%.[22] Based on an analysis of HOMA-IR values for the Brazilian population, people with a value > 2.71 units are classified as having insulin resistance.[23,24]

Regarding the lipid profile: normocholesterolemia was defined if total cholesterol was < 190 mg/dL; normotriglyceridemia was defined when triglycerides were < 150 mg/dL; and adequate HDL-c levels were defined as > 40 mg/dL.[25] Serum vitamin D levels were considered adequate when 20 ng/mL for adults (up to 59 years old) with type 2 diabetes (T2D) or 30 ng/mL for elderly individuals (60 years and older) with T2D. Values below these reference ranges were classified as hypovitaminosis D.[26]

Statistical analyses

Statistical analysis was performed using STATA® software, version 14.0 for Windows®. The normality of the variables was analyzed using the Shapiro-Wilk normality test; if the result was < 0.05, the data's normality was rejected, and nonparametric tests were used. Continuous variables were presented as mean and standard deviation when the data distribution was symmetric, and as median and interquartile range when asymmetric. Categorical variables were described using categories and frequency. The association between serum 25OHD levels and the other parameters was verified using Spearman's correlation for all variables, taking into account the sample size. The strength of the correlations was classified according to Mukaka's indicators:[27] The strength of the correlations was classified as follows: 0.90 to 1.00 very high correlation; 0.70 to 0.89 high correlation; 0.50 to 0.69 moderate correlation; 0.30 to 0.49 low correlation and; 0.00 to 0.29 insignificant correlation. The indicators were considered independent of the correlation's direction.

RESULTS

The sample consisted of 20 individuals, with a predominance of female sex (55%), 81.8% of whom were at the physiological stage of menopause. Individuals of the male sex had a mean age of 61 years, and the female sex had a mean age of 57 years (Table 1).

Table 1. Characterization of individuals with type 2 diabetes mellitus and overweight. Florianópolis, SC, Brasil, 2021-2023 (n=20)

Variables	Female sex (n=11)	Male sex (n=9)	Total (n=20)
Years (age)	56.55 ± 7.21	60.83 ± 8.08	58.35 ± 7.84
Menopause	81.82 (n=9)	-	-
Anthropometric data			
Weight (kg)	82.66 ± 10.83	89.6 ± 10.69	85.79 ± 11.06
Height (m)	1.58 ± 0.06	1.71 ± 0.08	1.64 ± 0.09
Body mass index (kg/m²)	33.05 ± 5.02	30.44 ± 2.55	31.88 ± 4.22
Waist circumference (cm)	107.78 ± 11.85	107.66 ± 7.02	107.72 ± 9.73
Body composition data			
Bone Mineral Density (g/cm²)	1.16 ± 0.10	1.24 ± 0.10	1.19 ± 0.11
Bone Mineral Content (g)	2.44 ± 0.54	3.19 ± 0.49	2.77 ± 0.63
AMMI (kg/m²)	7.38 ± 0.98	8.55 ± 0.86	7.90 ± 1.08
Body fat (%)	42.22 ± 5.72	32.09 ± 4.27	37.72 ± 7.19
Biochemical analysis			
Glycated hemoglobin - HbA1c (%)	8.05 ± 1.26	8.13 ± 1.05	8.08 ± 1.14
Fasting glucose (mg/dL)	168.64 ± 51.48	149.56 ± 35.87	160.05 ± 45.07
Fasting insulin (µUI/mL)	21.26 (7.7 – 39.75)	13.67 (8.64 – 29.87)	17.51 (8.52 – 39.75)
HOMA-IR (un)	8.27 (3.32 – 20.39)	4.64 (2.77 – 13.05)	5.44 (3.24 – 16.93)
Triglycerides (mg/dL)	153 (117 – 181)	154 (130 – 219)	153.5 (117.5 – 186.0)
Total cholesterol (mg/dL)	155 (145 – 173)	149 (147 – 179)	153.5 (146.0 – 176.0)
LDL-c (mg/dL)	83.31 (78 – 99.5)	77.79 (57.23 – 98.53)	81.08 (75.5 – 99.01)
HDL-c (mg/dL)	46.72 ± 11.17	41.56 ± 12.48	44.4 ± 11.76
Non HDL-c (mg/dL)	120.09 ± 42.74	121.89 ± 53.12	120.9 ± 46.37
25OHD (ng/mL)	29.07 ± 6.49	26.87 ± 9.55	28.08 ± 7.86
Vitamin D supplementation			
Yes (%)	72.73 (n=8)	77.78 (n=7)	75.00 (n=15)
Serum 25OHD levels			
*Deficiency (%)	36.36 (n=4)	66.67 (n=6)	50.00 (n=10)
*Adequacy (%)	63.64 (n=7)	33.33 (n=3)	50.00 (n=10)
Antidiabetic drugs			
Biguanides (metformin)	100 (n=11)	100 (n=9)	100 (n=20)
Sulfonylureas	36.36 (n=4)	22.22 (n=2)	30.00 (n=6)
Thiazolidinediones	9.09 (n=1)	0 (n=0)	5.00 (n=1)
Insulin	45.45 (n=5)	66.67 (n=6)	55.00 (n=11)

n: number %: percentage kg: kilogram m: meters kg/m²: kilogram per square meter cm: centimeters g/cm²: grams per square centimeter g: gram DP: standard deviation HbA1c: glycated hemoglobin mg/dL: milligram per deciliter µUI/mL: microunits per milliliter LDL-c: low-density lipoprotein cholesterol HDL-c: high-density lipoprotein cholesterol ng/mL: nanogram per milliliter un: unit

*Vitamin D adequacy when values > 20 ng/mL in adults (up to 59 years old) and > 30 ng/mL in elderly individuals (60 years or older).[26]

Individuals of both sexes were classified as having grade I obesity by BMI and a very high risk for developing cardiovascular diseases based on waist circumference (WC). A high accumulation of body fat was observed in both sexes, by DXA analysis. The appendicular muscle mass index (AMMI) recorded adequate levels of lean body mass.

Regarding the biochemical parameters, a high average glycemic profile was notable, indicating hyperglycemia from the fasting glucose and glycated hemoglobin tests. The HOMA-IR marker confirmed the presence of insulin resistance. As for the lipid profile, individuals showed a median corresponding to normocholesterolemia, slight hypertriglyceridemia, and adequate average HDL-c levels. Based on the adequacy criteria for serum 25OHD levels, considering age and sex, approximately 63.6% of the female sex had adequate levels, while 66.7% of the male sex had a deficiency. Regardless of age and sex, 75% of the participants used vitamin D supplements.

When evaluating the correlation between serum 25OHD levels and the body composition, anthropometric, and biochemical parameters (Table 2), an inverse correlation was found between 25OHD levels and total cholesterol (moderate correlation) and non-HDL-c (low correlation). Figure 1 presents scatter plots of the correlation between 25OHD levels and total cholesterol and non-HDL-c. No significant correlation was observed in the assessment of the other parameters, which may be a reflection of this study's sample size.

Table 2. Correlation between serum 25OHD levels and body composition, anthropometric, and biochemical parameters of individuals with type 2 diabetes mellitus and overweight.. Florianópolis, SC, Brasil, 2021-2023 (n=20).

Parameters	r	p-value
Age	-0.19	0.42
Weight	-0.37	0.11
Body Mass Index	-0.41	0.07
Waist circumference	-0.41	0.07
Bone Mineral Density	0.03	0.91
Bone Mineral Content	0.04	0.87
T-Score	-0.06	0.81
AMMI	-0.22	0.37
Body fat (%)	-0.37	0.13
Glycated hemoglobin	0.08	0.73
Fasting glucose	-0.13	0.58
Fasting insulin	-0.37	0.12
HOMA-IR	-0.41	0.08
Triglycerides	-0.22	0.34
Total cholesterol	-0.52	0.02
LDL-c	-0.31	0.18
HDL-c	-0.05	0.83
Non HDL-c	-0.47	0.04

r: correlation coefficient for each variable versus serum vitamin D concentration. LDL-c: low-density lipoprotein cholesterol. HDL-c: high-density lipoprotein cholesterol. *Correlation used for all tests: Spearman's correlation.

Figure 1. Scatter plots regarding the correlation between total cholesterol, non-HDL cholesterol, and serum 25OHD levels in individuals with type 2 diabetes mellitus and excess weight. Florianópolis/SC, Brasil, 2021-2023 (n=20)

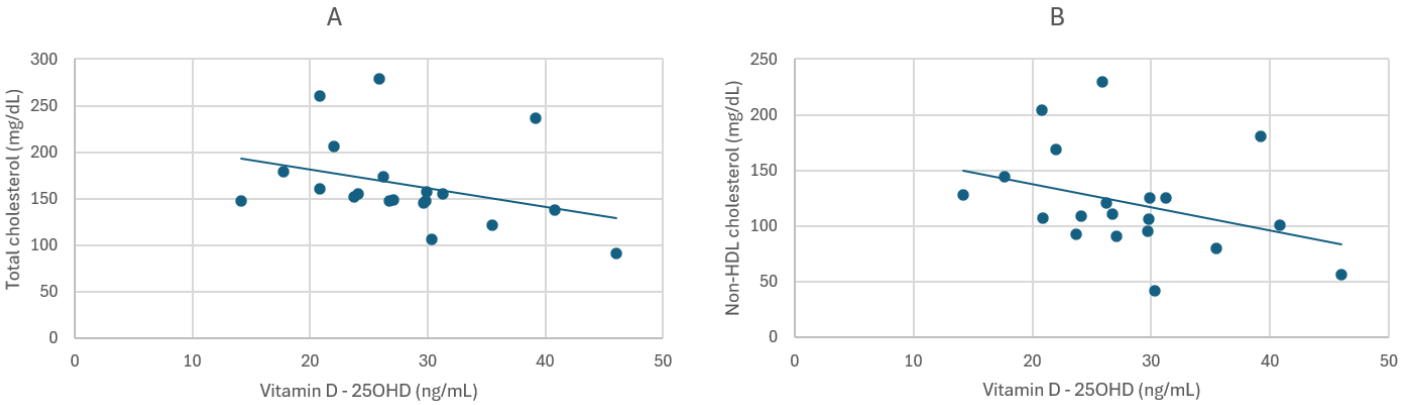

Chart A: Correlation between serum 25OHD levels and total cholesterol of the 20 monitored individuals.Chart B: Correlation between serum 25OHD levels and non-HDL cholesterol of the 20 monitored individuals.mg/dL: milligram per deciliter. Non-HDL cholesterol: non-high-density lipoprotein cholesterol. ng/mL: nanogram per milliliter. 25OHD: 25-hydroxyvitamin D.

DISCUSSION

Based on our results, an inverse correlation was found between an increase in serum 25OHD levels and a decrease in total cholesterol and non-HDL-c. In addition, preserved muscle compartments were observed along with the presence of excessive body fat accumulation. The presence of hyperglycemia and insulin resistance was also confirmed. It's important to highlight that the highest degree of 25OHD deficiency was found in males, who also had the lowest use of vitamin D supplements.

Regarding the effect of vitamin D on the lipid profile, a clinical trial that administered 4,500 IU of vitamin D per day for 2 months to 68 individuals with T2D, aged between 40 and 60 years, revealed that participants with high 25OHD levels (> 61 ng/mL) had lower concentrations of total cholesterol and LDL-c compared to those in the lower percentiles.[28] This result is consistent with the findings of the present study, which indicate that the higher the serum 25OHD levels, the lower the total cholesterol and non-HDL-c values. This finding was also observed in a cross-sectional study with 472 individuals with T2D aged over 20, which showed that low 25OHD levels are associated with high levels of HbA1c, LDL-c, and triglycerides, highlighting the important role of vitamin D in the homeostasis of the lipid profile.[29]

The influence of vitamin D deficiency on dyslipidemia is, in part, due to its effects on hepatic lipid metabolism (assisting in its maintenance)[30] and on intestinal calcium absorption. This calcium, along with fatty acids, creates insoluble complexes that inhibit lipid absorption.[31] As a result, vitamin D increases calcium levels and reduces the formation of triglycerides and hepatic secretion.[32] Additionally, vitamin D can abnormally affect lipid metabolism due to altered calcium availability. Therefore, vitamin D deficiency impacts the proper function of lipid metabolism and calcium availability, resulting in a dysregulation of the lipid profile, which represents a double burden. Studies that clarify this dual influence (vitamin D and calcium) in individuals with T2D and overweight are scarce.[31]

In overweight individuals, because it is a fat-soluble micronutrient, vitamin D accumulates in excess adipose tissue. This reduces its availability for other body tissues, such as the liver, which is responsible for the synthesis of lipoproteins and needs the vitamin for its balanced function.[33] In individuals with type 2

diabetes (T2D), overweight can influence glycemic metabolism and, consequently, insulin resistance, intensifying the inflammatory process that contributes to the dysregulation of the lipid profile.[3,4] In individuals with T2D, vitamin D can also influence insulin production by regulating the flow of calcium through the cell membrane of β-cells and vitamin D receptors.[34] Thus, both overweight and T2D constitute a dual effect that tends to dysregulate the lipid profile due to physiological changes and vitamin D deficiency.

When compared to individuals without T2D (n=208), those with T2D (n=198) had significantly lower values of HDL, 25OHD, free vitamin D, and bioavailable vitamin D. They also showed significantly higher values of triglycerides, remnant cholesterol, and CRP. This suggests that the inflammation observed in T2D may increase the concentrations of vitamin D-binding protein and decrease the levels of bioavailable vitamin D.[10]

Individuals with obesity have lower serum 25OHD levels (approximately 20% less) compared to those with a weight within the adequate range. The serum 25OHD concentration is inversely correlated with body weight, BMI, and the amount of adipose tissue.[8,35,36] Vitamin D deficiency in obesity plays a significant role in the development of insulin resistance and the onset of T2D. This is because vitamin D has a direct influence on adipogenesis, the modulation of insulin sensitivity in peripheral tissues, the regulation of insulin secretion, and the control of the immune system.[37]

Our study found that half of the participants had a 25OHD deficiency, which may have led to a medical prescription for supplementation to correct the hypovitaminosis. This finding shows that this population tends to have reduced vitamin D levels, which can result in complications in the health-disease process. In other words, the 25OHD deficit may have influenced the lipid profile. However, an important limitation of this study is the absence of a retrospective assessment of 25OHD levels and the lipid profile, which prevents subsequent comparisons.

A high concentration of body fat was found in both sexes by analyzing the percentage of fat provided by DXA. There was no evidence of muscle mass reduction among the participants in this study based on the AMMI. In contrast, Misnikova, Kovaleva, Polyakova & Dreval[38] found, after evaluating the AMMI in individuals with T2D and overweight, that the higher the age, the smaller the muscle compartments and the greater the fat accumulation, which aligns with the BMI for overweight and obesity.

Gupta et al.,[39] through a systematic review and meta-analysis of 20 observational studies using DXA, found that the presence of type 2 diabetes (T2D) is associated with twice the odds of having low muscle indices. In women, elevated visceral fat was correlated with up to 4 times the odds of a T2D diagnosis.

BMD rates are higher in individuals with T2D[40] and obesity.[41] To date, no BMD reduction has been observed in individuals with T2D and obesity however, there is evidence suggesting that bone fragility is related to changes in bone quality.[40] T2D, in both individuals with obesity and those with adequate weight, presents an increased risk of fragility fractures.[42] Insulin has unfavorable anabolic effects on bones, and excess insulin is associated with reduced bone turnover.[43]

Considering that a significant proportion of patients with type 2 diabetes (T2D) also have overweight, it is challenging to distinguish the individual influences of these two conditions on bone health.[40] In a clinical trial with 112 men between 35 and 65 years old, affected by obesity with and without T2D, which analyzed biochemical parameters of bone metabolism, body composition, BMD, bone microstructure, and strength, it was evident that the coexistence of obesity and T2D is related to a decrease in the rate of bone turnover, as well as a deterioration in the bone's trabecular microarchitecture and bone strength, when compared to the condition of obesity without T2D. These findings suggest that bone health may be more compromised in the setting of obesity associated with T2D.[44]

Establishing a reference point to evaluate total body BMD and BMC using DXA is necessary for the analysis of bone health in people with T2D and overweight. This type of monitoring can provide crucial information about the interrelationships between hyperglycemia and bone metabolism over time, as studies have concluded that bone and glucose homeostasis are directly and dependently related.[45]

Beyond the results, our study presented relevant points, such as the comprehensive analysis of different mechanisms of the body (body composition, anthropometric, and biochemical data) and their influence on the health-disease process. It also highlighted the influence of vitamin D on important parameters for body homeostasis. The following limitations were identified: the sample size, which may have restricted the correlations found; the wide age range (adults and elderly), which can make the sample more heterogeneous; and the inherent limitation of the cross-sectional study design, which makes it impossible to infer a causal relationship.

CONCLUSION

There is an association between serum 25OHD levels and the lipid profile of individuals with T2D and overweight, demonstrating an inverse correlation where higher 25OHD levels are associated with lower concentrations of total cholesterol and non-HDL-c. No correlations were observed with body composition.

Future studies should further investigate the impact of 25OHD levels on the lipid profile in larger and more diverse populations. They should also explore the underlying mechanisms of this inverse correlation and evaluate the effects of different doses and durations of vitamin D supplementation on lipid markers in individuals with T2D and overweight..

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