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VITAMIN D STATUS IN PATIENTS WITH PREDIABETES AND TYPE 2 DIABETES MELLITUS DEPENDING ON THE DISTRICTS OF ANDIJAN REGION

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Abstract: This article examines the prevalence of vitamin D, zinc, and calcium deficiencies among patients with disorders of carbohydrate metabolism (prediabetes, impaired glucose tolerance, type 2 diabetes mellitus) in the Andijan region. A comparative analysis of the levels of these microelements in rural and urban populations was conducted. It was found that patients with type 2 diabetes had significantly lower levels of vitamin D and calcium compared to individuals without carbohydrate metabolism disorders. A significant correlation was also identified between reduced zinc levels and the presence of insulin resistance. The results highlight the need for a comprehensive approach to the diagnosis and prevention of carbohydrate metabolism disorders, including monitoring and correcting vitamin D, zinc, and calcium levels.

Keywords: vitamin D, zinc, calcium, carbohydrate metabolism disorder, prediabetes, type 2 diabetes mellitus

Introduction: In 2021, the International Diabetes Federation (IDF) published new data showing that 537 million adults worldwide live with diabetes—a 16% increase (74 million) compared to previous IDF estimates in 2019. The latest 10th edition of the IDF Diabetes Atlas reports that the global prevalence of diabetes has reached 10.5%, with nearly half (44.7%) of adults undiagnosed. IDF projections indicate that by 2045, one in eight adults worldwide will live with diabetes. This represents a 46% increase, more than double the expected population growth (20%) over the same period.

The study of the molecular basis of vitamin D's role in the development of insulin resistance, type 1 and type 2 diabetes, gestational diabetes, metabolic syndrome, and cardiovascular diseases has attracted considerable attention in recent years and remains a topic of discussion among specialists. Many epidemiological and observational studies have found a link between vitamin D deficiency and the incidence of type 1 and type 2 diabetes [11-15]. In this regard, numerous studies have reported various mechanisms that may explain the potential role of vitamin D in glucose metabolism, such as preserving β-cell function and slowing the deterioration of residual β-cell function in patients with type 1 diabetes and latent autoimmune diabetes [16,17]. The vitamin D receptor (VDR), which mediates the systemic effects of vitamin D, is also expressed in tissues with high insulin sensitivity (pancreas, adipose tissue, and muscles) [30]. In the body, vitamin D acts as an epigenetic factor, modulating transcription levels and enhancing insulin sensitivity.

Objective of the study: To investigate the frequency of vitamin D, zinc, and calcium deficiencies in individuals with impaired fasting glucose (IFG), impaired glucose tolerance (IGT), and type 2 diabetes mellitus among rural and urban populations of the Andijan region.

Materials and Study Design:
To achieve the objectives of this research, we conducted a cross-sectional epidemiological study including men and women aged 30 to 75 years living in rural and urban areas of the Andijan region. Screening was performed among 1,800 individuals over 30 years old in the Marhamat district of the Andijan region and 1,600 individuals over 40 years old in the city of Andijan.

The study was conducted in three stages, including at the clinic of Andijan State Medical Institute (AndSMI).

Stage 1: A population screening of 1,800 individuals was performed using questionnaires to identify non-communicable diseases and their risk factors, as well as the FINDRISC questionnaire to detect prediabetes and type 2 diabetes. At this stage, data were collected directly from participants through surveys.

Stage 2: Individuals with a high risk of developing prediabetes and type 2 diabetes were selected. In this high-risk group, a series of tests were conducted, including an oral glucose tolerance test (OGTT) and glycated hemoglobin (HbA1c) measurement.

Stage 3: Key risk factors for non-communicable diseases were identified and assessed according to WHO criteria (2014). For each participant, the following were measured: serum levels of 25(OH)D3, zinc, calcium, glycated hemoglobin, glucose, and insulin; HOMA-IR index; body mass index (BMI); lipid profile; presence of hypertension and harmful habits; level of physical activity; and low intake of fruits and vegetables.

Reagents used included: insulin – Vector Best (Russia), total cholesterol – Human (Germany), HDL – Human (Germany), LDL – Human (Germany), triglycerides – Cypress Diagnostics (Belgium), glycated hemoglobin – Human (Germany), calcium – Human (Germany), zinc – DAC-SpectroMed, vitamin D – Diagnostics Biochem Canada Inc. [25-hydroxyvitamin D or 25(OH)D].

The diagnostic criteria of the World Health Organization (WHO, 1999) were used for the diagnosis of diabetes, IFG, and IGT [8].

Statistical Analysis:
Statistical analysis was performed using Statistica 6.0 software. Spearman's rank correlation method was used to calculate correlation coefficients. The significance of differences between proportions was assessed using Pearson's chi-square test (χ^2). Differences were considered statistically significant at $p < 0.05$.

Results and Discussion:
As shown in Figure 1, in the Marhamat district of the Andijan region, impaired fasting glucose (IFG) was detected in 19% of cases, impaired glucose tolerance (IGT) in 30%, combined IFG+IGT in 53%, type 2 diabetes in 52%, and individuals without carbohydrate metabolism disorders in 30% of cases.

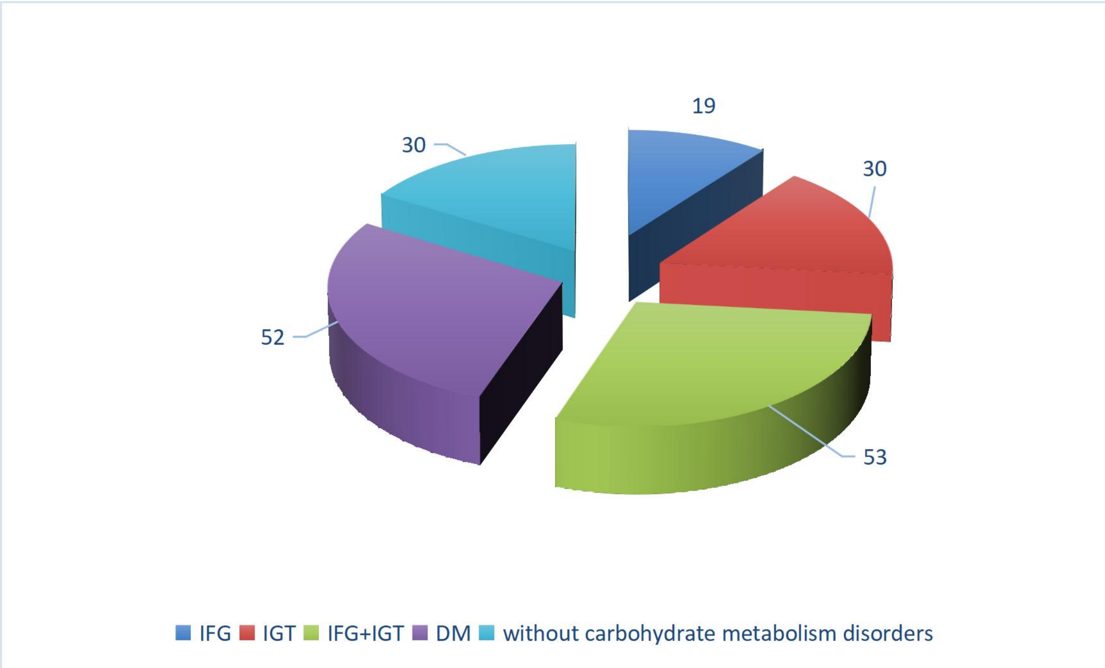

Fig. 1. Frequency of carbohydrate metabolism disorders in the studied groups in the Marhamat district.

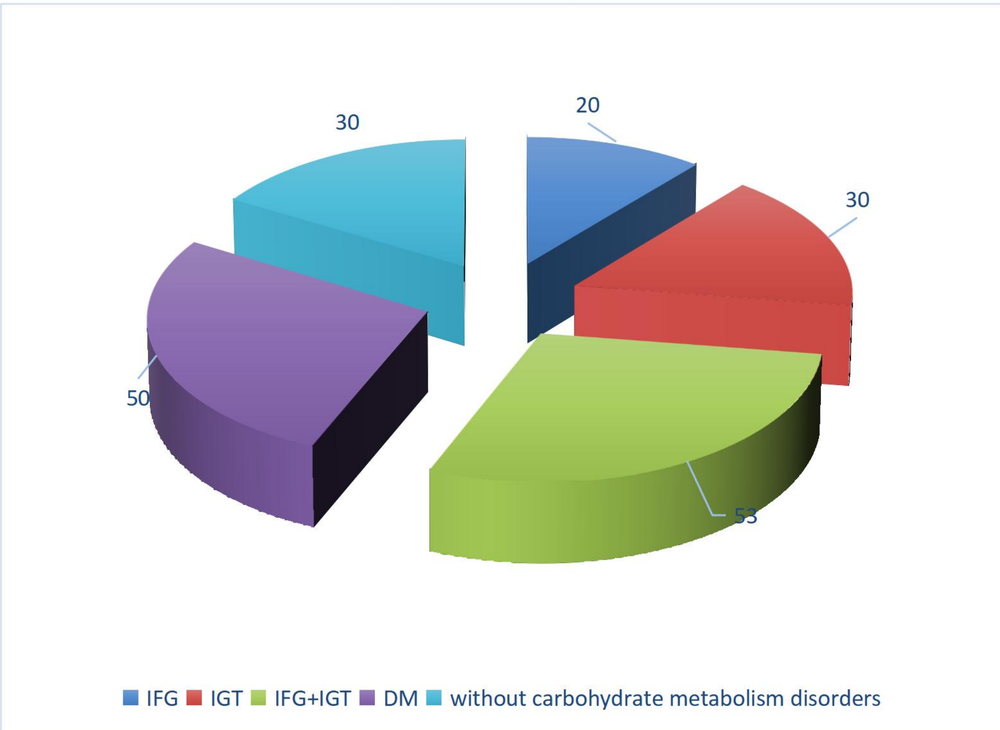

Fig. 2. Frequency of carbohydrate metabolism disorders in the studied groups in the city of Andijan.

As shown in Fig. 2, in the city of Andijan, impaired fasting glucose (IFG) was detected in 20% of cases, impaired glucose tolerance (IGT) in 30%, combined IFG+IGT in 53%, type 2 diabetes in 50%, and individuals without carbohydrate metabolism disorders in 30% of cases.

The next step was to examine the frequency of carbohydrate metabolism disorders by sex in the Marhamat district and the city of Andijan (Figs. 3 and 4).

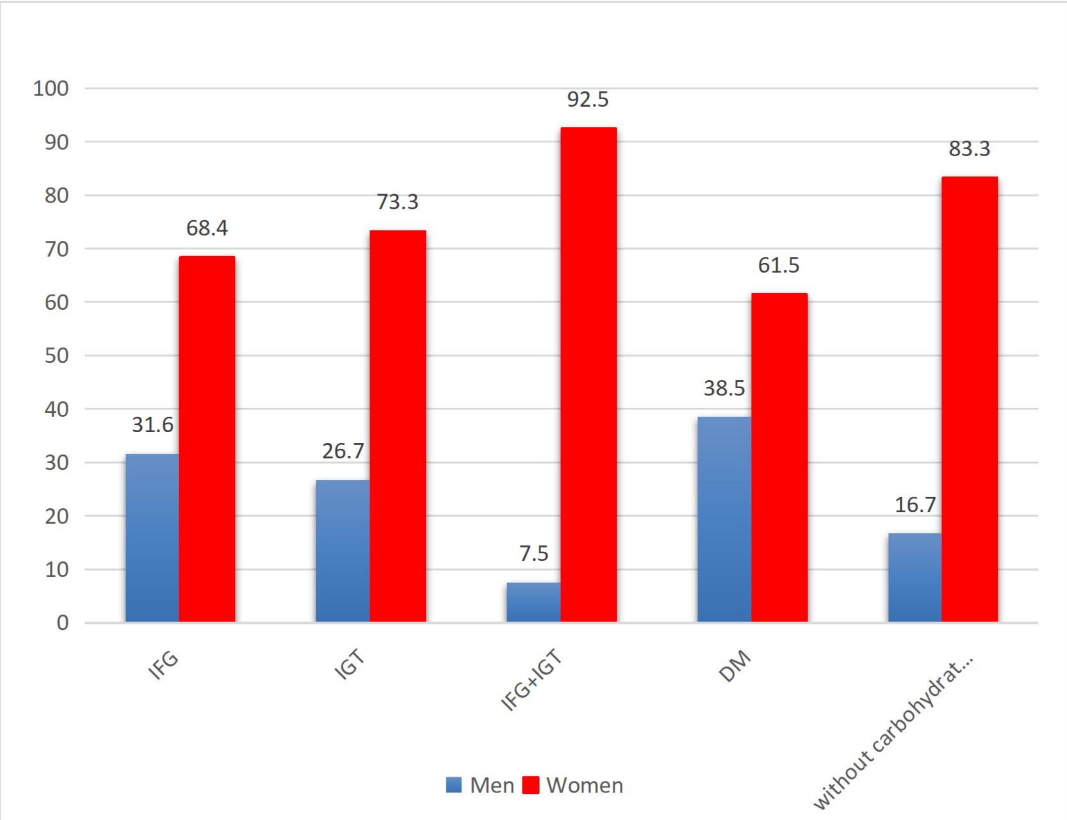

Fig. 3. Frequency of carbohydrate metabolism disorders by sex in the Marhamat district

As shown in Fig. 3, in the Marhamat district, the highest proportion of patients was observed in the combined IFG+IGT group (7.5% men / 92.5% women) and among individuals without carbohydrate metabolism disorders (16.7% men / 83.3% women). The distribution for other groups was as follows: IFG – 31.6% men / 68.4% women, IGT – 26.7% men / 73.3% women, and type 2 diabetes – 38.5% men / 61.5% women.

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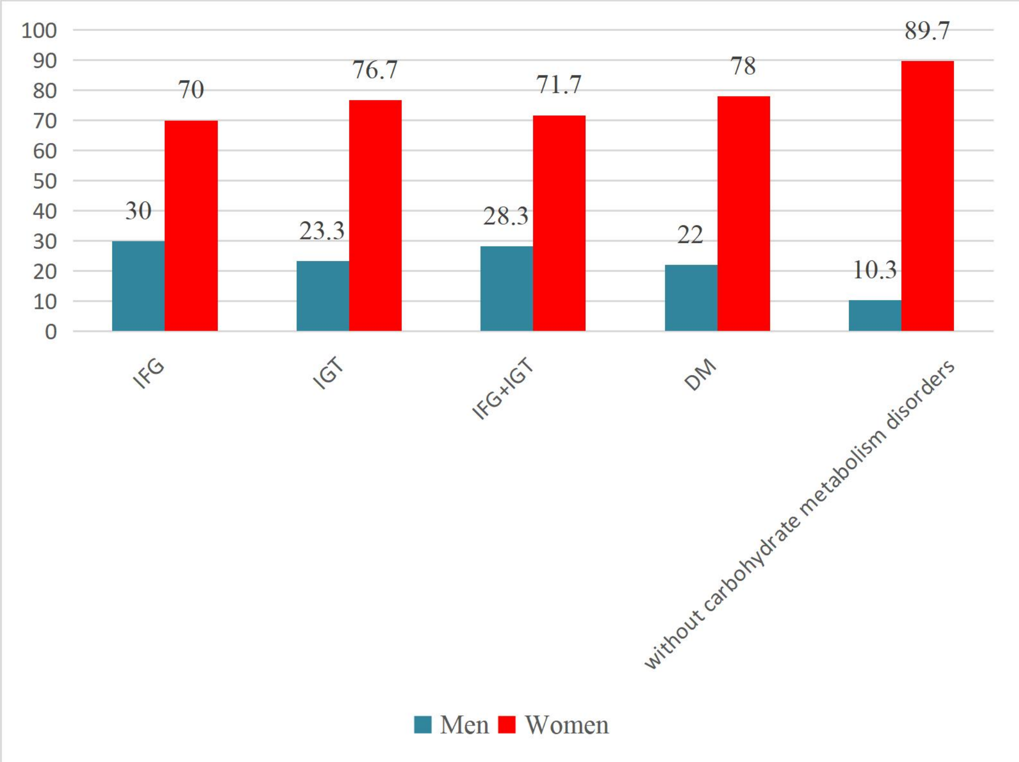

Fig. 4. Frequency of carbohydrate metabolism disorders by sex in the city of Andijan

As shown in Fig. 4, in the city of Andijan, the highest proportion of patients was among individuals without carbohydrate metabolism disorders (10.3% men / 89.7% women). The distribution for other groups was: IFG – 30% men / 70% women, IGT – 23.3% men / 76.7% women, and type 2 diabetes – 22% men / 78% women.

The next step was to examine the mean levels of vitamin D, zinc, and calcium in the studied groups (Table 3.1). According to the data in Table 1, compared to the NGM (normal glucose metabolism) group, patients with IGT in both the Marhamat district and the city of Andijan had significantly lower levels of vitamin D and calcium.

Table 1
Biochemical indicators by group depending on the region

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Note:
- significantly different compared to the NGM (normal glucose metabolism) group (-P<0.05)

Group	Vitamin D average level (ng/ml)		Calcium average level (mmol/l)		Zinc average level (µmol/l)	
	Marhamat	Andijan	Marhamat	Andijan	Marhamat	Andijan
IFG	12,8±1,0	13,2±0,77	0,98±0,020	1,03±0,020	11,4±0,76	16,8±0,94
IGT	16,1±1,0*	14,7±1,0	1,05±0,022*	1,04±0,018	12,7±0,78	15,5±0,83
IFG+IGT	14,5±0,75*^^	12,5±0,5*	0,97±0,017**	1,07±0,015	11,6±0,55	13,6±0,48**^
T2DM	11,8±0,87*^^^&&&	13,3±0,79	0,84±0,036**^^^&&&	0,93±0,030*^^&&&	13,3±0,74	14,7±0,63*
without carbohydrate metabolism disorders	28,7±0,9*^^^&&&	19,0±1,3***^&##	1,09±0,018^&&#	1,08±0,015##	14,4±0,90*&	18,1±0,81&

^- significantly different compared to the IGT group (^^-P<0.01; ^^^-P<0.001)
&- significantly different compared to the IFG+IGT group (&&&-P<0.001)
#- significantly different compared to the T2DM group (#-P<0.05)

Compared to the IFG+IGT group, zinc levels were significantly lower in patients with type 2 diabetes residing in the Marhamat district and the city of Andijan. Compared to the T2DM group, vitamin D and calcium levels were significantly lower in residents of the Marhamat district and the city of Andijan.

In connection with the above, we studied the mean vitamin D levels in women and men depending on the region (Figs. 5 and 6).

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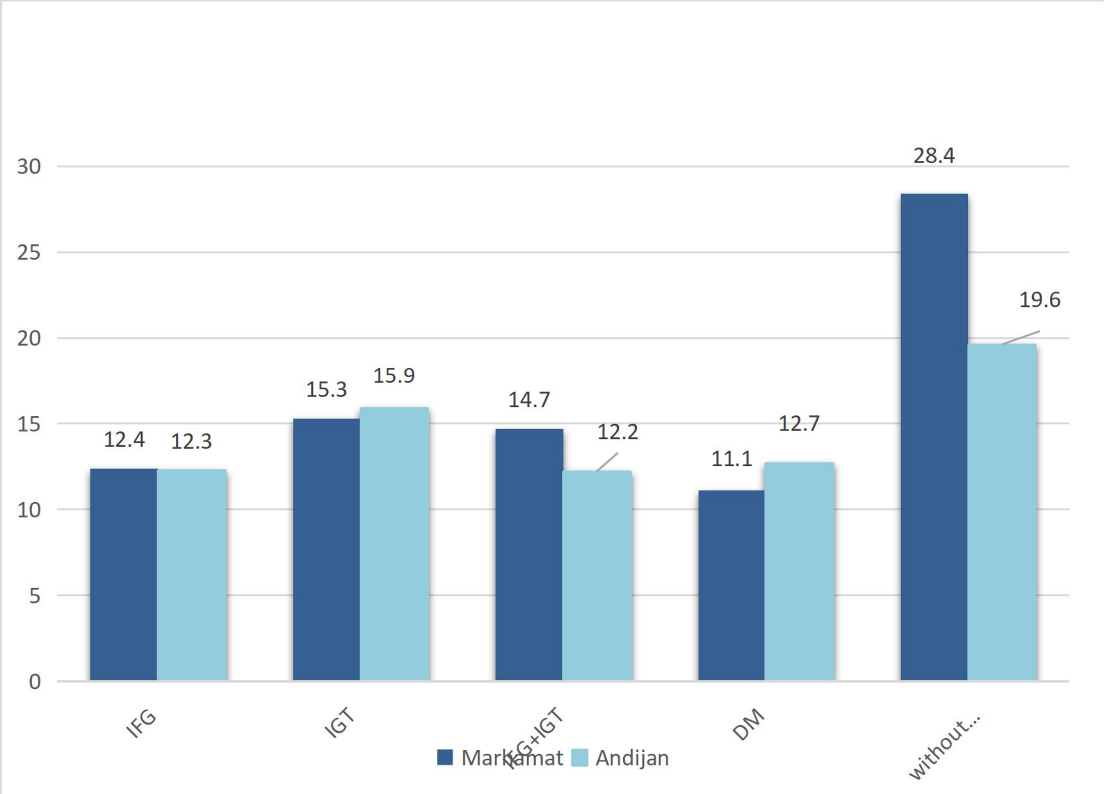

Fig. 5. Mean vitamin D levels in women by region

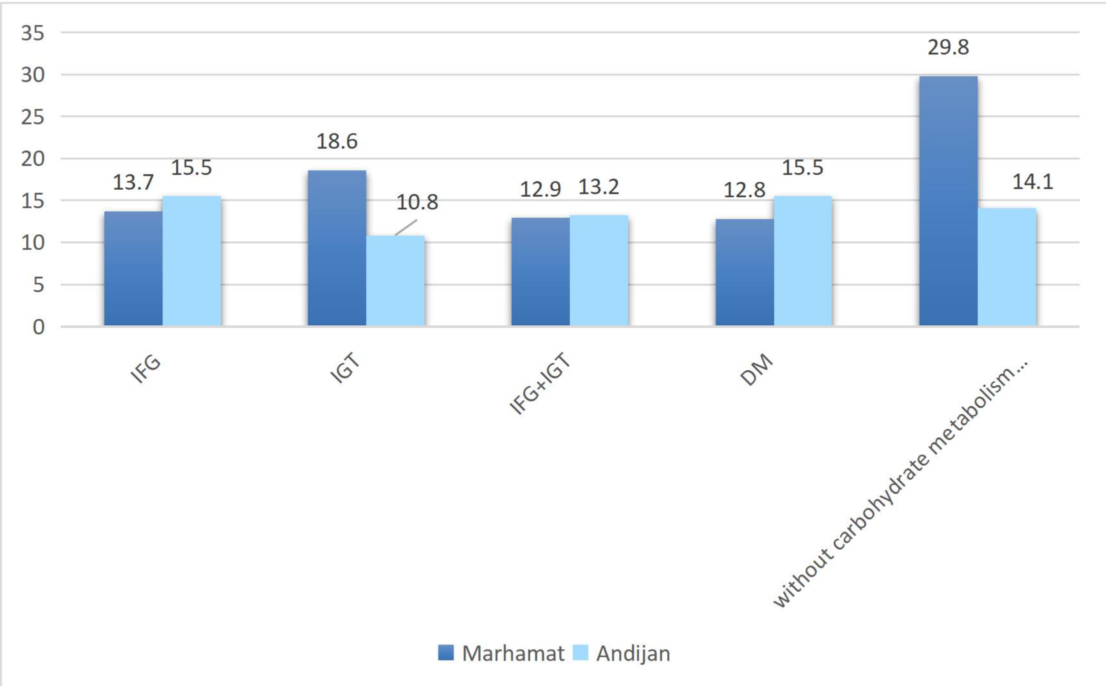

Fig. 6. Mean vitamin D levels in men by region

Note:

- significantly different compared to the NGM (normal glucose metabolism) group (-P<0.05)

^- significantly different compared to the IGT group (^-P<0.05; ^^-P<0.01; ^^^-P<0.001)
&- significantly different compared to the IFG+IGT group (&-P<0.05; &&-P<0.01; &&&-P<0.001)
#- significantly different compared to the T2DM group (##-P<0.01; ###-P<0.001)

As shown in Fig. 5, the mean vitamin D levels in women were low across all study groups compared to the group without carbohydrate metabolism disorders, with the combined IFG+IGT group showing lower levels in the city of Andijan compared to the Marhamat district.

As shown in Fig. 6, the mean vitamin D levels in men were also low in all study groups compared to the group without carbohydrate metabolism disorders. Specifically, in the IFG group, levels were lower in the Marhamat district; in the IGT group, lower in the city of Andijan; in the IFG+IGT group, levels were nearly the same in both regions; and in the type 2 diabetes group, levels were lower in patients from the Marhamat district.

According to Puri M., serum zinc concentration was significantly lower in patients with at least two microangiopathic complications ($p < 0.05$). The authors attribute this to the side effects of high glucose concentrations, which reduce zinc reabsorption in the kidneys [143]. In our patients, mean zinc levels were significantly lower than in the control group in IFG (district, $p<0.05$), IGT (district, $p<0.05$), IFG+IGT (district/city, $p<0.05$), and type 2 diabetes (district/city, $p<0.05$).

Calcium homeostasis is disrupted in type 2 diabetes, contributing to impaired cellular regulation in erythrocytes, cardiac muscle, platelets, and skeletal muscles [141]. Studies have shown a complex relationship between calcium levels and the pathogenesis of type 2 diabetes. Reduced β-cell function has been associated with abnormal calcium regulation [144].

Conclusions

The study revealed a high prevalence of vitamin D, zinc, and calcium deficiencies among patients with carbohydrate metabolism disorders (IFG, IGT, type 2 diabetes) in the Andijan region.

The mean vitamin D level in patients with type 2 diabetes was significantly lower compared to individuals without carbohydrate metabolism disorders, indicating a potential role of vitamin D deficiency in the pathogenesis of diabetes.

Significant regional differences were observed: vitamin D levels were lower in rural residents compared to urban residents, likely due to differences in diet, lifestyle, and access to healthcare.

Zinc concentration was significantly reduced in patients with type 2 diabetes compared to the group without disorders, confirming its important role in glucose metabolism regulation and the development of insulin resistance.

Calcium deficiency was more common in patients with carbohydrate metabolism disorders, consistent with existing data on its influence on pancreatic β-cell functional activity.

These results highlight the need for a comprehensive approach to the diagnosis and prevention of carbohydrate metabolism disorders, including monitoring and correcting blood levels of vitamin D, zinc, and calcium in patients.

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