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Excess Body Weight and Abdominal Obesity as Determinants of Carbohydrate Metabolism Disorders

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Abstract This study is devoted to assessing the prevalence of prediabetes and type 2 diabetes mellitus among the rural and urban population of the Andijan region, as well as identifying the relationship between the degree of obesity and carbohydrate metabolism disorders. 3400 individuals over 40 years of age were included in the study. BMI, waist and hip circumference, and their ratio were assessed. It was established that excess body weight prevailed in both populations, and obesity of I-II degree was reliably associated with a higher frequency of IGT, IFG, and DM2. The abdominal type of obesity was a characteristic feature of groups with impaired carbohydrate metabolism. The identified differences between rural and urban populations emphasize the need for a differentiated approach to screening and prevention of metabolic diseases.

Keywords Pre-diabet, BMI, Obesity, Waist circumference (WC), Hip circumference (HB)

1. Introduction

Pre-diabetes is an intermediate hyperglycemic state or a non-diabetic hyperglycemic state without symptoms or with minimal symptoms [1]. That is, it is a condition in which blood glucose levels are above normal but below the threshold value for a clinical diagnosis of diabetes.

Prediabetes can progress to DM2 in 50% of cases within 5 years [2]. In this regard, in attempts to delay the onset of DM2, prevent or delay microvascular and macrovascular complications, increasing attention has been paid to pre-diabetes.

In China, the prevalence of prediabetes among adults reaches 50%.

The prevalence of IFG with age adjustment was high in low-income countries such as Nepal. A recent meta-analysis from Nepal showed a high prevalence of pre-diabetes (9.2%) based on IFG and IGT [1]. The prevalence of pre-diabetes is especially high in the urban conditions of South Asian countries, reflecting the growth of urbanization and the transition to a high-calorie diet and sedentary lifestyle [2].

In Russia, the prevalence of prediabetes (NATION program) diagnosed according to HbA1c levels using ADA criteria can be 19.3%, with regional variations from 10.3% to 22% [4], and for GN levels - from 18-28.1% according to WHO criteria (and the Russian Endocrinology Association) to 54.8% according to ADA criteria [3].

The prevalence of prediabetes worldwide is increasing as the prevalence of obesity increases [4].

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Research objective: to assess the frequency of prediabetes and type 2 diabetes mellitus occurring depending on aIGTropometric indicators.

2. Materials and Methods of Research

To implement the goals and objectives of the dissertation research, we conducted a simultaneous epidemiological study involving men and women aged 35 to 75 living in rural areas and cities. The survey was conducted among 1,800 individuals over 40 years of age in the Markhamat district of Andijan region and 1,600 individuals over 40 years of age in the city of Andijan. The study was conducted in 3 stages. The phased approach in implementing the monitoring assumes that at the first stage, data on the main risk factors are collected using questionnaires (1st stage). Then, in the second stage, the simplest physical examinations are conducted (2nd stage), and only then is it recommended to take blood samples for biochemical studies (3rd stage). The diagnosis of prediabetes was established in accordance with the criteria proposed by the WHO and the recommendations developed by experts of the Russian Endocrinology Association (2017), EACD and ADA (2015, 2018). Pre-diabetes was defined as IFG or IGT. Hyperglycemia included a diagnosis of diabetes or prediabetes.

Carbohydrate metabolism parameters were assessed based on the assessment of capillary blood glycemia levels using glycometers. The HbAls level was determined by us using a set of reagents from the company "HUMAN" with automatic determination of blood hemoglobin levels and calculation of the percentage ratio of HbAls to the total.

The aIGTropometric study was conducted as follows: the height was determined in the "standing" position with an accuracy of up to 0.5 cm (without shoes), with the subject's heels, buttocks, and shoulders touching the measuring pole, and the head positioned so that the connecting line was horizontal. Body weight was measured without shoes on a standard scale with an accuracy of up to 0.1 kg. To study excess body weight (BMI) and obesity, the following were performed: the calculation of the body mass index (BMI) was carried out according to the Ketle index (BMI) - the ratio of body mass in kg to the square of the height value in meters according to the formula, the level of obesity was calculated (Table 1).

$$BMI = \frac{\text{body weight (kg)}}{\text{height (cm 2)}}\pm$$

The waist circumference is measured during exhalation using a centimeter tape, without inhaling or protruding the abdomen, waist circumference (WC) is measured by a centimeter tape at the level of the navel along a horizontal line in cm, hip circumference (HB) is measured by a centimeter tape along the most protruding points in cm. For the Asian population, the waist circumference norm is <94 cm for men and <80 cm for women. The examined individuals' data were recorded in the questionnaire.

Statistical processing of the research results was performed using the Statistica 6.0 application software package. The Spearman rank correlation method was used to calculate the correlation coefficients. To assess the significance of the difference in shares, the Pearson's square criterion x^2 will be used. Differences are considered significant at a significance level of $p<0.05$.

3. Research Results

From the data presented in Table 2, it follows that in Marhamat district, excess body weight ranked 1st - 69 patients (37.5±5.8%), obesity 1st degree ranked 2nd - 56 individuals (30.4±6.2%), and obesity 2nd degree ranked 3rd (9.2±1.2%). In addition, in the Marhamat district, patients with excess body weight were most common in the group with IFG+ IGT - 21 observations (39.6±6.8%), IFG - 9 individuals (47.4±11.8%), and DM 2 - 19 cases (36.5±6.7%). At the same time, 3rd-degree obesity was observed in only 3 cases out of 184 observations (3.5%), while 1st and 2nd-degree obesity were observed in 56/17 (30.4/9.2%) cases, respectively. Patients with type 2 diabetes mainly had excess body weight - 19 cases (36.5±6.7%).

A similar analysis was performed in the patients of the studied groups in Andijan (Table 3).

From the data presented in Table 3, it follows that in Andijan, 66 patients (36.3±5.7%) had excess body weight in 1st place, 51 individuals (28.0±7.3%) had obesity of the 1st degree, and 32 patients (17.6±5.7%) had obesity of the 2nd degree in 3rd place.

It was established that in the city of Andijan, among the examined, patients with excess body weight were most common in the group with IFG+ IGT and DM 2 - 17/17, respectively (32.1±6.5%/32.1±6.5%), IFG 7 individuals (35.0±10.9%) and DM 2 - 17 cases (36.7±8.9%). At the same time, 3rd-degree obesity was observed in only 6 cases out of 180 observations (3.3%), while 1st and 2nd-degree obesity were observed in 51/32 (28.0/17.6%) cases, respectively. Patients with type 2 diabetes mainly had excess body weight - 17 cases (32.1±6.5%).

Further, we conducted similar studies in measuring the WC/HB coefficient, as well as HB, WC - in the studied groups (Table 4). From the data presented in Table 4, it can be seen that a comparative analysis of aIGTropometric indicators, in particular, waist circumference (WC), hip circumference (HB), and their ratio (WC/HB), showed statistically significant differences between groups with various carbohydrate metabolism disorders and the control group.

Table 1. Classification of obesity (WHO, 1997)

Body mass deficiency	Normal body weight	Excess body weight	1st degree obesity	Obesity grade 2	Obesity grade 3
<18.5	18.5-24.9	25-29.9	30-34.9	35-39.9	≥40

Table 2. Body mass index by groups, Marhamat, n=184

Group	BMI norm 18.5-24.9		Excess body weight 25-29.9		1 cm obesity 30-34.9		2nd degree of obesity 35-39.9		3rd degree of obesity 40 and higher	
	abs.	%	abs.	%	abs.	%	abs.	%	abs.	%
IFG, n=19	1.	5.3±5.3	9.	47.4±11.8	7.	36.8±11.4$^{@}$	2.	10.5±7.2$^{@}$	-	-
IGT, n=30	7.	23.3±7.9	10.	33.3±8.8	8.	26.7±8.2	5.	16.7±6.9$^{@}$	-	-
IFG+ IGT, n=53	6.	11.3±4.4	21.	39.6±6.8$^{@}$	15.	28.3±6.2	9.	17.0±5.2	2.	3.8±2.6$^{@}$
DM, n=52	16.	30.8±6.5	19.	36.5±6.7	15.	28.8±6.3*	1.	1.4±1.6	-	-
Without carbohydrate metabolism disorders, n=30	7.	23.3±7.9	10.	33.3±8.8	11.	36.7±9.8$^{*\wedge\&}$	-	-	1.	3.3±3.3$^{@}$
Total	37.	20.1±6.1	69.	37.5±5.8	56.	30.4±6.5*	17.	9.2±1.2	3.	1.6±0.4

Note_ IFG- impaired glycemia on an empty stomach, IGT- impaired glucose tolerance, DM-diabetes mellitus.
Note: @-significant compared to normal indicators (@-P<0.05)
- significantly compared to the indicators of the IGT group (-P<0.05)
^- significantly compared to the indicators of the IGT group (^-P<0.05)
&- significantly compared to the indicators of the NTG+NTG group (&-P<0.05)

Table 3. Body mass index by groups, Andijan city, n=182

Group	BMI norm 18.5-24.9		Excess body weight 25-29.9		1 cm obesity 30-34.9		2nd degree of obesity 35-39.9		3rd degree of obesity 40 and higher	
	abs.	%	abs.	%	abs.	%	abs.	%	abs.	%
IFG, n=20	3.	15.0±8.2	7.	35.0±10.9	8.	40.0±11.2*	2.	10.0±6.9^&	-	-
IGT, n=30	4.	13.3±6.3	11.	36.7±8.9*	8.	26.7±8.2	6.	20.0±7.4	1.	3.3±3.3^^&#
IFG+ IGT, n=53	6.	11.3±7.4	17.	32.1±6.5*	14.	26.4±6.1	13.	24.5±5.9	3.	5.6±4.4*^^^&&#
DM, n=50	7.	14.0±5.0	17.	32.1±6.5*	13.	26.0±6.3	11.	22.0±5.9	2.	4.0±2.8*^^^&&#
Without carbohydrate metabolism disorders, n=30	8.	26.7±8.2	14.	46.6±12.8*	8.	26.7±8.2	-	-	-	-
Total	28.	15.4±6.	66.	36.3±5.7	51.	28.0±7.3	32.	17.6±5.7	6.	3.3±0.9

Note: *- significantly compared to the indicators of the IFG group (*-P<0.05; **-P<0.01)
^- significantly compared to the indicators of the IGT group (^-P<0.05)
&- significantly compared to the indicators of the IFG+ IGT group (&-P<0.05; &&-P<0.01)

In individuals with impaired glucose tolerance (HTG, n=19), the average BP value was 94.6±1.9 cm, BP - 103.6±3.6 cm, with an average BP/BP ratio of 0.93±0.055. In the group with impaired glycemia on an empty stomach (IFG, n=30), the indicators were significantly higher: OT - 101.0±2.2 cm, OB - 112.8±2.2 cm, with a lower WC/HBratio - 0.90±0.015 (P<0.05 compared to the NTG group).

In patients with combined disorders of GNN+NTG (n=53), OT was 94.8±2.0 cm, OB - 105.4±1.5 cm, and the WC/HBratio was 0.90±0.014, which also statistically significantly differed from the group with isolated IFG, (P<0.05). Similar data were obtained in the group with newly diagnosed type 2 diabetes mellitus (DM, n=52): OT - 94.9±1.6 cm, OB - 104.2±1.9 cm, WC/HB- 0.92±0.011 (P<0.05 compared to the IGT group).

In individuals without carbohydrate metabolism disorders (control group, n=30), OT was 93.9±3.0 cm, OB - 105.7±2.9 cm, WC/HB ratio - 0.90±0.037. These indicators also differed significantly from the data of the group with IGT (P<0.05).

Thus, the highest values of the waist and hip circumference were observed in individuals with IFG, while the highest WC/HB ratio was observed in patients with isolated IGT, which may indicate differences in the type of abdominal obesity in various forms of carbohydrate metabolism disorders.

Table 4. Average VL/VL values by groups (Marhamat district)

Group	WC average value	HB average value	WC/HB ratio average value
IFG, n=19	94.6±1.9	103.6±3.6	0.93±0.055
IGT, n=30	101.0±2.2*	112.8±2.2*	0.90±0.015
IFG+ IGT, n=53	94.8±2.0^	105.4±1.5^	0.90±0.014
DM, n=52	94.9±1.6^	104.2±1.9^	0.92±0.011
Without carbohydrate metabolism disorders, n=30	93.9±3.0^	105.7±2.9^	0.90±0.037

Note: *- significantly compared to the indicators of the IFG group (*-P<0.05)
^- significantly compared to the indicators of the IGT group (^-P<0.05)

Similar calculations were carried out for WC/HB groups (Andijan city).

From Table 5, it follows that the analysis revealed significant differences in aIGTropometric indicators between the groups of individuals examined. Against the background of the progression of carbohydrate metabolism disorders, there is a tendency towards an increase in the waist circumference (WC) and hip circumference (HB), which indicates an increasing obesity, including abdominal obesity associated with insulin resistance.

In individuals with impaired glucose tolerance (IGT) included in the study (two subgroups - n=20 and n=30), the average values of OT were 90.2±3.2 cm and 93.8±3.2 cm, OB - 97.5±1.4 cm and 100.7±2.6 cm, respectively. In the combined group of patients with IFG and/or IGT (n=53), these indicators were even higher: OT - 95.7±2.1 cm, OB - 105.1±1.9 cm.

In patients with type 2 diabetes mellitus diagnosed for the first time (DM2, n=50), the average waist circumference was 95.6±2.2 cm, hip circumference - 104.8±2.0 cm. Thus, in this group, abdominal obesity parameters remain at a high level, similar to the indicators of the IFG±NTG group, which may indicate the presence of long-term metabolic disorders before the manifestation of DM2.

In individuals without carbohydrate metabolism disorders (control group, n=30), significantly lower values were noted in the waist circumference (87.6±2.8 cm, *p<0.05 compared to groups with IGT, IFG±IGT, and DM2) and hip circumference (96.5±2.6 cm, ^p<0.05 compared to groups with IGT and DM2), which confirms a correlation between the degree of obesity and metabolic disorders.

The ratio of hip circumference to hip circumference (H/B circumference) in all groups varied within 0.9±0.01-0.02 and remained relatively stable. However, even with similar BP/AB values, the absolute values of the waist and hips were higher in patients with carbohydrate metabolism disorders, indicating pronounced general and abdominal obesity, especially dangerous in the context of insulin resistance development, cardiovascular diseases, and type 2 diabetes mellitus [1,2].

Table 5. Average values of AT/AB for groups (Andijan city)

Group	WC average value	HB average value	WC/HB ratio average value
IFG, n=20	90.2±3.2	97.5±1.4^	0.9±0.02
IGT, n=30	93.8±3.2	100.7±2.6	0.9±0.02
IFG ± IGT, n=53	95.7±2.1	105.1±1.9	0.9±0.01
DD, n=50	95.6±2.2	104.8±2.0	0.9±0.01
Without carbohydrate metabolism disorders, n=30	87.6±2.8*	96.5±2.6^	0.9±0.02

Note: *- significantly compared to the indicators of IGT, IFG ± IGT, and group DM (*-P<0.05)
^- significantly compared to the indicators of IGT, IFG ± IGT, and group DM (^-P<0.05)

The obtained data indicate that in the examined population, both with and without carbohydrate metabolism disorders, there is a predisposition to abdominal obesity, which is one of the factors of both diabetes mellitus and prediabetes.

4. Conclusions

1. The conducted research showed that both rural (Marhamat district) and urban (Andijan city) populations of Andijan region show high prevalence of excess body weight and obesity, which corresponds to the global trend of obesity growth in low- and middle-income countries [1,2]. The identified data indicate a significant burden on alimentary-dependent diseases, including metabolic disorders.
2. Among the rural population, individuals with excess body weight (BMI 25.0-29.9 kg/m2) and obesity of the 1st degree (30.0-34.9 kg/m2) predominate, while in urban sample, more severe forms of obesity (II and III degrees) are more common. This may be due to differences in the nature of nutrition, physical activity level, economic security, stress stress, and access to medical care, as indicated in studies conducted in other regions with similar demographic characteristics [3,4].
3. Differences between rural and urban residents in BMI indicators, waist circumference, hip circumference, and WC/HB coefficient are statistically significant ($p < 0.05$), which confirms the heterogeneity of the epidemiological profile and requires the development of targeted prevention programs for obesity, differentiated by place of residence [5]. Early diagnosis of carbohydrate metabolism disorders in individuals with the abdominal type of obesity, which is more closely associated with insulin resistance, is particularly relevant [6].
4. The obtained results indicate the need to strengthen sanitary and educational work among the population, as well as to implement regional pre-diabetes and type 2 diabetes screening programs. Systematic observation of a IGT topometric indicators can be an effective tool for early prevention of metabolic diseases and cardiovascular complications [7,8].

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