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ANTHROPOMETRIC RISK FACTORS FOR TYPE 2 DIABETES MELLITUS

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The article presents the results of determining the anthropometric risk factors for type 2 diabetes mellitus (T2DM). Studies have confirmed that obesity is an important risk factor for detecting T2DM and found that the highest degree of association with the disease, regardless of gender, adjusted for age, has an index of the ratio of the waist circumference and height (WC/H), which turned out to be a more sensitive marker for diabetes the second type, hypertension and cardiovascular disease. The increase in the incidence of type 2 diabetes among therapeutic patients is due to a sharp increase in the incidence of a combination of this disease with obesity and hypertension. It was found that in men, the gradient of increased risk of T2DM was observed with an increase in the waist circumference, while in women, with an increase in the body mass index. Anthropometric measurements among women found a relationship between an increase in body mass index (BMI), abdominal circumference, hips, and belonging to the group of patients with type 2 diabetes. A peculiarity of the prevalence of type 2 diabetes among residents of the region is the tendency to increase incidence after 39 years of age with maximum values of 51-60 years and a subsequent decrease in frequency. Regarding gender differences, it was found that after 65 years of age, the frequency of the disease in women decreases, and among men, on the contrary, it continues to grow, which can be explained by a milder course of the disease among men and higher mortality of sick women in old age. Waist circumference is a more reliable predictor of the development of cardiovascular complications and mortality than BMI. The prospect of further research is the confirmation and refinement of data obtained with large sample sizes. There is a need to search for new and test known risk factors for the disease to create an effective program for the early diagnosis and prevention of type 2 diabetes.

Keywords: *type 2 diabetes mellitus, obesity, anthropometric indices, hypertension.*

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АНТРОПОМЕТРИЧНІ ФАКТОРИ РИЗИКУ ЦУКРОВОГО ДІАБЕТУ ДРУГОГО ТИПУ

У статті наведені результати визначення антропометричних факторів ризику цукрового діабету другого типу (ЦД2). Проведені дослідження підтвердили, що ожиріння є важливим фактором ризику виявлення ЦД2 та встановили, що найбільший ступінь асоціації із захворюванням незалежно від статі з урахуванням поправок на вік має індекс співвідношення обводу талії і росту (ОТ/ріст), який виявився більш чутливим маркером для цукрового діабету другого типу, гіпертонії і серцево-судинних захворювань. Зростання частоти випадків ЦД2 серед терапевтичних хворих обумовлене різким збільшенням випадків поєднання цього захворювання з ожирінням і артеріальною гіпертензією. Виявлено, що в чоловіків градієнт збільшення ризику ЦД2 відзначався при збільшенні обводу талії, в той час як у жінок – при збільшенні індексу маси тіла. Антропометричні вимірювання серед жінок виявили зв'язок між збільшенням індексу

маси тіла (ІМТ), обводу живота, стегон та належністю до групи хворих на ЦД2. Особливістю поширеності цукрового діабету другого типу серед мешканців області є тенденція підвищення захворюваності після 39-річного віку з максимальними величинами в 51-60 років та подальшим зниженням частоти. Щодо гендерних відмінностей встановлено, що після 65-річного віку частота захворювання в жінок знижується, а серед чоловіків, навпаки, продовжує зростати, що можна пояснити більш легким перебігом хвороби серед чоловіків та більш високою смертністю хворих жінок у похилому віці. Обвід талії є більш надійним предиктором розвитку серцево-судинних ускладнень і смертності, ніж ІМТ. Перспективою подальших досліджень є підтвердження та уточнення даних, отриманих на великих розмірах вибірки. Наголошується на необхідність пошуку нових та тестування відомих факторів ризику захворювання для створення ефективної програми ранньої діагностики та профілактики діабету 2 типу.

Ключові слова: *цукровий діабет 2 типу, ожиріння, антропометричні індекси, гіпертонія.*

One of the most important problems of the healthcare system in Ukraine and in the world is the spread of type 2 diabetes, which accounts for 90% of all cases of diabetes [1].

The prevalence of type 2 diabetes (T2DM) is increasing in developing countries due to urbanization, an aging population, lack of physical activity, and a high prevalence of obesity. Identification of risk factors for the development of T2DM is a necessary step in the planning of preventive measures to reduce the burden of disease [2].

Type 2 diabetes mellitus is associated with a large number of severe chronic diseases, accompanied by pathological changes in the genitourinary, nervous, cardiovascular and other body systems. The World Health Organization (WHO) and the International Diabetes Federation (IDF) predict an increase in the incidence rate in 2030 of 553 million people (9.9% or 1 patient per 10 healthy adults), and by 2035 - up to 592 million (10.1%). However, in the report of the experts of the International Diabetes Federation (IDF 2010) in relation to Ukraine, a small number of diagnosed patients with type 2 diabetes and the lack of epidemiological data on this disease recorded by the World Health Organization are indicated) [3].

Currently, testing and comparison of the effectiveness of using anthropometric indices in various ethnic and age groups, in patients with different risk of developing insulin-independent diabetes, cardiovascular disease; differences are assessed, epidemiological studies are conducted to identify the most accurate correlation of indices in ethnic populations[4].

In southern Ukraine, there are no clinical studies evaluating the anthropometric characteristics of patients diagnosed with type 2 diabetes mellitus, which actualizes this issue.

The purpose of this study was to study the dynamics of the prevalence of type 2 diabetes among patients in the endocrinology department of the Kherson Regional Clinical Hospital and to determine the anthropometric risk factors for the development of the disease.

METHODS

The study involved 56 patients with type 2 diabetes (29 men and 27 women) who were treated in the endocrinology department of the Kherson Regional Clinical Hospital. The examination of patients included the collection of complaints about well-being, the study of the medical history, determination of anthropometric indicators.

This work was carried out in accordance with the requirements of the Helsinki Declaration “Ethical Principles for Conducting Scientific Medical Research with the Participation of Man” (2000). Patients underwent anthropometric measurements (body weight, height, waist and hips, blood pressure). The girth of the abdomen and hips was measured with a textile centimeter tape at the level of maximum transverse dimensions in a standing position. A sphygmomanometer was

used to measure blood pressure. The pressure was measured twice with an interval of 5 minutes, in case of differences in the results of more than 10 mm Hg carried out the third measurement, determined the arithmetic mean of these two or three measurements. Obesity was diagnosed with a BMI of ≥ 30 kg / m^2. The circumference of the waist was determined in a standing position by a standard method. Abdominal obesity was observed at waist circumference ≥ 102 cm in men and ≥ 88 cm in women.

To analyze the results of measuring quantitative indicators, their arithmetic mean and standard deviation were calculated (x ± SD). The comparison was carried out according to the design of the cross-sectional study. Statistical analysis was performed by the method of variation statistics. The difference between the indicators was considered significant at $p < 0.05$. The value of the indicator $0.05 < p < 0.1$ confirmed the tendency to the probability of discrepancy between the values of the studied indicators.

RESULTS

At the first stage of the study, based on an analysis of the medical history, we determined the dynamics of the frequency of hospitalizations of patients with type 2 diabetes mellitus (T2DM) at different time periods (Table 1).

Among women and men, the incidence of T2DM increased in 2017-2019 compared to the period 2010-2012 on average 1.3 times. Given that obesity is the most common risk factor for developing T2DM, and hypertension is the most common complication of T2DM, cases of the combination of T2DM with obesity and AH were analyzed separately and together. Regardless of gender, the incidence of type 2 diabetes without obesity and without arterial hypertension was about 11,5-14,6% and did not significantly change at different time periods.

Table 1

The incidence of type 2 diabetes in patients in different years (% ± SD)

diagnosis	Females (n=27)		Males (n=29)	
	2010-2012 years	2017-2019 years	2010-2012 years	2017-2019 years
T2DM (total)	74,0 ± 3,4	94,8 ± 4,1	80,3 ± 5,2	98,6 ± 3,8
T2DM (obesity and AH absent)	11,5 ± 2,8	5,3 ± 1,8	14,6 ± 2,2	12,6 ± 2,5
T2DM + obesity	3,4 ± 1,3	6,5 ± 1,2	5,2 ± 1,4	8,5 ± 1,2
T2DM + AH	32,3 ± 3,2	24,4 ± 2,3	31,8 ± 3,4	25,3 ± 3,7
T2DM + obesity + AH	26,8 ± 2,2	58,6 ± 3,4	28,8 ± 4,2	52,2 ± 3,6

T2DM: type 2 diabetes mellitus; AH: arterial hypertension

A similar situation was found in the frequency of cases of a combination of type 2 diabetes and obesity - this value, regardless of gender, was about 3,4-8,5%. The frequency of combination of T2DM with AH was about 24,4-31,8% and did not change significantly at different time periods. But regarding the association of T2DM with obesity and hypertension, the situation was identified was the opposite. In 2010-2012, the combination of type 2 diabetes with obesity and hypertension accounted for 26,8% of the total prevalence of type 2 diabetes among women and 28.8% among men, and in the period 2017-2019 – 58,6 and 52,2 % respectively. Thus, the increase in the frequency of all cases of type 2 diabetes mellitus among therapeutic patients is due to a sharp increase in the incidence of this disease, combined with obesity and hypertension.

A characteristic feature of the prevalence of type 2 diabetes among of the population of the region is the tendency to a sharp increase in the incidence after 39 years of age with maximum

values of 51-60 years and a subsequent decrease in frequency. A common pattern is a higher incidence of women compared with men, which can be clearly seen in all age groups.

At the second stage of the study, we needed to determine the possibility of using anthropometric indicators of patients as markers of development T2DM. An analysis of the data showed that the age of patients is slightly different between both sexes. The number of patients, regardless of gender, is significantly higher among people of the 51-60 age groups.

To analyze the dependence of the values of the studied indicators on body weight, patients were divided into groups: group 1 - men with excess body weight (BMI = 25-30; n = 7); group 2 - obese men (BMI = 30-35; n = 11); group 3 - women with overweight - (n = 5); group 4 - obese women (n = 16). The age of the examined patients in groups 1-4 was: 52.4 ± 4.8; 53.2 ± 5.0; 55.5 ± 3.3 and 61.5 ± 4.2 years, respectively. Anthropometric data indicate gender differences in body mass index, hip circumference in men compared with women (table 2).

Table 2

Gender, age and anthropometric characteristics of patients

Gender (number of persons)	Age (years), $\bar{x} \pm SD$	BMI, (kg/m^2), $\bar{x} \pm SD$	WC (cm), $\bar{x} \pm SD$	WH (cm), 95% CI	SBP (mm Hg), $\bar{x} \pm SD$	DBP (mm Hg), 95% CI
Total (56)	69,4±8,4	30±5	101,9±12,8	104,4 (103-105)	143,3±22,8	83(82-84)
Males (29)	70,2±9,4	27,8±4,6	100,0± 9,6	98,7 (96-107)	139,8±18,6	80(75-85)
Females (27)	68,5±7,9	32,2±5,3	103,8±16,0	110 (106-113)	146,7±24,0	85(80-90)

BMI - Body mass index; WC - Waist circumference; WH - Waist hips; SBP - systolic blood pressure;
DBP - Diastolic blood pressure.

Risk of metabolic complications increased at WC > 94 cm in men, at WC > 80 cm in women and significantly increased with WC > 102 cm in men and WC > 88 cm in women. 56 of 59 patients (94.9%) had arterial hypertension (AH) of various stages. Blood pressure (BP) levels did not significantly differ in patients of the selected groups: the systolic blood pressure in groups 1–4 was 148.5 ± 9.1; 143.7 ± 7.2; 145.9 ± 8.1 and 154.7 ± 6.3; diastolic blood pressure - 87.7 ± 3.3; 86.3 ± 4.1; 85.2 ± 4.2 and 92.3 ± 3.1, respectively.

On the table.3 presents the results of a survey of males and females with overweight and obesity, patients with T2DM. An anthropometric examination revealed the abdominal type of fat deposition in most examined patients according to IDF criteria: all women had a waist circumference of more than 80 cm; among men, a waistline of more than 96 cm was found in 85% of overweight patients and in 100% of patients with obesity. Regardless of gender, all overweight patients had almost the same anthropometric index of the ratio of the waist circumference to the circumference of the hips, which ranged from 0.96-1.06 ± 0.04-0.06 units, can be used as a prognostic sign of the risk of disease. Thus, as a result of the study, we have confirmed that obesity is an important risk factor for the presence of type 2 diabetes. In the future, we included one more anthropometric index in the analysis - the ratio of the waist circumference to height (WC/H).

Table 3

The results of anthropometric measurements in patients with overweight and obesity

Patient groups	Results of anthropometric measurements					OR ($p < 0,05$)
	Body mass (kg)	BMI (kg/m^2)	WC, cm	WH, cm	WC/WH	
Overweight men (n = 7)	84,8±6,3	28,0±1,8	101,1 ± 8,7	97,9 ± 5,6	1,04± 0,06	0,0001
Obese men (n = 11)	104,1 ± 7,7	33,9±2,6	111,2 ± 5,6	106,6± 4,4	1,06± 0,05	0,0287
Overweight women (n = 9)	75,6 ± 4,9	28,8±1,0	98,2 ± 5,1	102,4± 4,4	0,96± 0,04	0,0030
Obese women (n = 16)	95,5± 13,5	35,7±4,2	105,9± 8,9	112,3± 8,0	0,98± 0,04	0,0001

The results of the analysis of the data are presented in table 4. According to table 4, the anthropometric index of the ratio of the waist circumference to height was equally high in sick men and women. But in women, this indicator increased linearly with the age of patients (from 44.2 ± 4.5 in the age period of 21-30 years to 81.2 ± 6.8 in the age of 71-80 years).

Table 4

Dynamics of anthropometric index WC/H in patients of different ages

Age (years)	Height (m)		Anthropometric index WC/H, waist circumference (cm) / height (m) x 100	
	Males	Females	Males	Females
21-30	1,85 ± 0,2	1,63±0,1	34,6 ± 3,7	44,2 ± 4,5
31-40	1,78 ± 0,3	1,73±0,5	49,6 ± 5,1	45,5 ± 6,7
41-50	1,78 ± 0,5	1,67±0,8	51,3 ± 4,5	47,3 ± 5,3
51-60	1,74 ± 0,3	1,62± 0,7	60,1 ± 8,7	67,3 ±7,8
61-70	1,72 ± 0,3	1,56±0,3	69,4 ± 3,2	73,5 ± 4,6
71-80	1,70 ± 0	1,56±0,4	71,1 ± 6,4	81,2 ± 6,8
Average	1,76 ± 0,4	1,63±0,5	56,0 ± 5,3	59,8 ± 6,0

A similar trend was observed in patients with type 2 diabetes in men (from 34.6 ± 3.7 at the age of 21-30 years to 71.1 ± 6.4 at the age of 71-80 years), but without a linear relationship. This index can serve as the best screening model for assessing cardiovascular risk, exceeding the significance of body mass index and waist circumference index.

DISCUSSION

The higher incidence of type 2 diabetes in women compared with men is clearly observed in all age groups. In Ukraine, after 69 years of age, the frequency of the disease in women decreases, and among men, on the contrary, it continues to grow, which indicates a milder course of T2DM among men and a higher mortality rate of sick women in old age. The likelihood of diabetes also changes with age. The prevalence of the disease among children and adolescents ranges from 15.0 to 112.0 and is mainly associated with the incidence of type 1 diabetes. A

further increase in the incidence of diabetes to 39 years of age to 316.0 cases per 100,000 of the population is caused precisely by the appearance of type 2 diabetes. In older age groups, type 2 diabetes is dominant; incidence rates are growing rapidly until the age of 59 with a maximum in the age group of 65-69 years ($p < 0.001$).

An anthropometric examination revealed the abdominal type of fat deposition in most patients according to IDF criteria: all women had a waist circumference of more than 80 cm; among men, a waistline of more than 96 cm was found in 85% of overweight patients and in 100% of patients with obesity, which is consistent with published data [5].

The main feature of the prevalence of T2DM among residents of southern Ukraine is the tendency to a sharp increase in the incidence after 39 years of age with maximum values of 51-60 years and a subsequent decrease in frequency. A common pattern is a higher incidence of women compared with men, which can be clearly seen in all age groups.

Obesity is an important risk factor for the presence of type 2 diabetes. The greatest degree of association with the disease, regardless of gender, adjusted for age, has girth of the neck, waist, hips and the ratio of the latter. We found that the highest degree of association with type 2 diabetes mellitus, regardless of gender, taking into account age-related adjustments, has an indicator of the ratio of the waist circumference and height compared with other anthropometric indices (BMI, WC, WC/WH). We also established a statistically significant relationship between the waist circumference / height index and prediabetes - the stage of impaired glucose metabolism before the debut of type 2 diabetes. This is especially important, since with timely detection of persons with prediabetes in 60% of cases, the development of the disease can be prevented.

It was found that in men, a gradient of increased risk of DM-2 was noted with an increase in waist circumference, while in women, with an increase in body mass index. Anthropometric comparisons among women found a relationship between an increase in BMI, abdominal circumference, thighs, neck and belonging to the T2DM.

CONCLUSIONS

Studies have confirmed that obesity is an important risk factor for the detection of type 2 diabetes and found that the highest degree of association with the disease, regardless of gender, adjusted for age, has an index of the ratio of the waist circumference and height (WC/H), which turned out to be a more sensitive marker for type 2 diabetes, hypertension and cardiovascular disease. The index WC/H does not involve weighing the patient and has a very simple interpretation: "waist circumference should not exceed half the patient's height".

It was found that in men, a gradient of increased risk of T2DM was noted with an increase in waist circumference, while in women, with an increase in body mass index. Anthropometric measurements among women found a relationship between an increase in body mass index (BMI), abdominal circumference, hips, and belonging to the group of patients with type 2 diabetes. It is proposed to use BMI as an accurate predictor of the development of hypertension in the elderly.

The prospect of further research is the confirmation and refinement of the data obtained on large sample sizes. The search for new ones and testing of known risk factors should be continued in order to create an effective program for the early diagnosis and prevention of type 2 diabetes. Identification of risk groups will allow for activities aimed at reducing body weight and preventing the risk of complications of diabetes and cardiovascular mortality.

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