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Research Article

Trends of the Burden of Type 2 Diabetes Mellitus Attributable to High Body Mass Index, Hypertension, Dyslipidemia in Fertile Age Group (20-44 Years) in Bulgaria

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Abstract

Surprisingly, many researchers have noted an increase in the prevalence of type 2 diabetes (T2D) in people between the ages of 20 and 40 (Young Adult-Onset Type 2 Diabetes). *Aim*: To provide a more accurate picture of the real health status of the young fertile population (20-44 years) in the country, by assessing the incidence of diabetes among them and examining the role of classic risk factors for diabetes/prediabetes (obesity/overweight, arterial hypertension, impaired serum lipid levels). *Material and Methods:* 936 subjects were distributed into three age groups: 20-44 years - 342 (36.5%), 45-59 years - 301 (32.2%) and 60-79 years - 293 (31.3%). Diabetes status was defined according to the criteria of the WHO/IDF Report'2016 and the data were evaluated according to age and gender. Standard OGTT (oral glucose tolerance test) was performed with measurement of plasma glucose and HbA1c was also examined. Height and weight were measured, BMI (kg/m^2) was calculated. Arterial hypertension (AH) was defined according to the IDF consensus (2012) for T2D recommending arterial pressure levels up to 130/80 mmHg and the same recommendation in the last Guideline of European Society of Hypertension (ESH'2023). *Results:* In the young fertile age group (20-44 years) the incidence of diabetes/prediabetes is 14.4% (49/340), and the incidence of risk factors in them is: obesity and overweight are present in 56% (191/340); 85.7% (12/14) of young diabetics have BMI ≥ 25 kg/m^2; AH is nearly 17% (57/342) among individuals in the young group; almost 1/5 of young men have AH; in 42.9% (6/14) there is a combination of AH and diabetes versus 12.9% (38/293) with AH only; the highest incidence of low serum HDL-cholesterol level (67.5%) is in the young age group; in 1/5 of them hypertriglyceridemia is present. *Conclusion*: It is necessary to develop strategies for the prevention of diabetes, which should be aimed at controlling the trend of increasing obesity/overweight, timely diagnosis and adequate treatment of AH, control of lipid levels. The increase in the incidence of diabetes in the young age group (20-44 years) means an increase in fertility problems, the course and completion of pregnancy. These are very serious health complications that require early diagnosis, but the main thing is prevention. It is necessary to introduce educational programs among the population, which should be informed about the need for lifestyle changes (nutritional habits and physical activity), personal concern and systematic care for one's own health.

Keywords

Young Adult, Type 2 Diabetes, Obesity, Hypertension, Dyslipidemia

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1. Introduction

Diabetes mellitus (DM) is defined as heterogeneous group of metabolic disorders characterized by hyperglycemia. It is associated with anomalies in the metabolism of carbohydrates, fats, proteins and can lead to chronic complications, which include microvascular, macrovascular and neuropathic disorders [1]. Diabetes mellitus is a serious health issue related to aging of the population, increased urbanization, unhealthy dietary habits, decreased physical activity and other harmful behavioral and lifestyle habits. The prevalence of diabetes is rising and it is one of the leading causes of disability and death worldwide, affecting people regardless of their residence, age group or gender [2]. Approximately 11% of the world population (537 million people) aged 20-79, lived with diabetes in 2021 [3].

Type 2 diabetes (T2D) is the prevailing type of diabetes, which accounts for more than 90-96% of diabetes cases worldwide in 2021, that is why analyses focus primarily on this type of diabetes. Monitoring trends in the prevalence of diabetes is crucial for its management and health policy directions [4]. The surprise is that the prevalence of T2D is increasing in people between the ages of 20 and 40, which is defined as Young Adult-Onset Type 2 Diabetes [1]. T2D was previously considered a disease affecting individuals in their middle to later stages of life, but now doctors have to take care of young patients threatened by much longer duration of the disease. The disease significantly alters the lives of patients with early-onset T2D, including potential pregnancies, and the emergence of comorbid conditions, compounded by advancing age. Young patients with T2D have to adapt their lives to ensure effective management of their disease [5].

At the same time, cases of diabetes are increasing not only at young age but also during pregnancy. In 2015-2016, cases of diabetes among pregnant women were already 5.6% in the United States [6]. Data published by the Centers for Disease Control and Prevention (CDC) in 2023 show that pregnancy-related diabetes has risen by 56% over 10 years in the studied population (2000-2010) [7]. Maternal diabetes during pregnancy is one of the strongest risk factors for T2D, which accounts for part of the increase of this disease among young people over the past few decades [8]. The example given with the participants in the SEARCH Case-Control Study, whose mothers had diabetes during pregnancy, shows that this generation has a sevenfold increased risk of T2D compared to their counterparts with healthy mothers [9].

Our previous study in pregnant Bulgarian women found a frequency of hyperglycemia of 14.4% (79/547), which now raises the question of clarifying the frequency of diabetes/prediabetes in a young fertile group of Bulgarians, i.e. in a non-pregnant population. It was determined that in the group of pregnant women studied five years ago, women with a higher body mass index (BMI) before pregnancy were at a greater risk of developing glucose tolerance disorders during pregnancy. Regarding BMI before pregnancy, this relationship was significant when comparing the mean ranks for hyperglycemia - total (Mean Rank 260.42 against 354.44 - Mann-Whitney Test, $p < 0.001$). Of all pregnant women, who were screened, 2.4% (13/547) developed arterial hypertension (AH) during their pregnancy. Hyperglycemia was found in 38.5% (5/13) of the pregnant women with AH and in 13.9% (74/534) of the women without AH, $p < 0.028$ [10, 11]. It was demonstrated that obesity has posed a serious threat by causing glucose metabolism disorders. Moreover, the increased number of young people with T2D is associated with the rise of obesity rates in this age group, which has been observed in many countries [12].

In 2018, Allen AJ. et al. reported that in the UK, 55% of pregnancies complicated by pre-gestational diabetes were due to T2D, while in 2003, this figure was only 27% [13].

The findings from the recent meta-analysis by Clement NS. et al. (2024), which included an international population of 84 421 pregnancies with T2D, 34 751 with type 1 diabetes (T1D), 243 243 with gestational diabetes (GDM) and 5 398 613 healthy controls, are very significant. The main conclusion is that pregnant women with T2D are associated with the highest rate of perinatal mortality. The authors believe that there should be an increase in the prevention of T2D risk, as well as awareness of the adverse effects of T2D on pregnancy [14].

European multicenter SWEET Registry was created in 2008, which includes a network of care centers for individuals under the age of 25, suffering from diabetes. In 2011, this project became a global non-profit initiative supported by the International Society for Paediatric and Adolescent Diabetes (ISPAD). The SWEET Registry serves as an important global tool for monitoring the development and prevalence of different types of diabetes and objectively monitored the increase in the proportion of new cases of T2D in the decade from 2012 to 2021. The rising incidence of young people with T2D from all continents demonstrated the urgent need for strong preventive measures on a global scale [15]. It can be summarized that T2D has a negative effect on the overall health and quality of life of individuals. Therefore, T2D in young people poses a social, clinical, and economic threat with significant impact on the health system. In order to apply effective treatment and useful strategies for prevention it is important to analyze the clinical characteristics in diagnosing young patients with T2D [16, 17].

A previous study on the dynamics of diabetes in Bulgaria showed an increase in its incidence over the past 18 years (2006-2024) in all age groups (an increase in diabetics by 199%, i.e. doubling). For comparison the data of the IDF Diabetes Atlas (2021) show that in 2007 the total number of diabetics in the world was 246 million, while in 2021 it reached 537 million, i.e. an absolute increase of 218% which is double increase [3]. The fact that the incidence of diabetes among the young fertile age group (20-44 years) has significantly increased made a very strong impression. For the

decade 20-29 years the dynamics are insignificant (from 0% in 2006 to 1.5% in 2024, NS), while for the decade 30-39 years significant changes occur (from 0.9% in 2006 to 4.5% in 2024, $p < 0.002$) [18].

After all these facts, the AIM of the present study is to assess the incidence of diabetes specifically among the young fertile population (20-44 years) in the country, to examine the role of the classic risk factors for diabetes/prediabetes (obesity/overweight, arterial hypertension, impaired serum lipid levels) in this age category and compare it with the other two ages (45-59 years and 60-79 years), thereby providing a clearer picture of the real health status of the fertile population in the country.

2. Material and Methods

According to the Report of the National Statistical Institute (NSI) as of 31.12.2022, the Bulgarian population (aged 20-79 years) is 4 904 382 inhabitants - men 2 367 262 (48.26%) and women 2 537 120 (51.73%) [19]. This study included 936 individuals, distributed by gender and age groups according to the latest 2022 population census by the National Statistical Institute.

The data from the present study were obtained on the basis of a multi-center cross-sectional study of the Bulgarian Endocrinology Society, March 25-May 16, 2024. The regions for the study were selected after consultation and statistical analysis, and the optimal representative number of the individuals from each region was determined. The study was conducted in 16 regions with 51 nests across the country. A total number of 1 352 people aged ≥ 20-79 years, selected randomly from the institutional registers based on age, gender and residence, were invited to participate. A total of 936 individuals (69.2%) from those who had been invited, agreed to take part, including 479 women (51.2%) and 457 men (48.8%); 695 participants (74.2%) reside in urban areas and 241 (25.7%) are rural residents; the subjects were distributed into three age groups: 20-44 years - 342 (36.5%), 45-59 years - 301 (32.2%) and 60-79 years - 293 (31.3%).

The choice of the age groups of the participants chosen for the study was in accordance with the methodology of the International Diabetes Federation (IDF) for assessing the prevalence of diabetes among adults (ages 20-79) [20].

At the start of the study all 936 respondents (69.2% of those invited) were informed about the nature of the studies and signed a form for Informed Consent, which had been previously reviewed and approved by the local Ethics Committee. Participants completed a questionnaire that included some demographic data, their current health status, previous illnesses, family history of major chronic diseases (hypertension, diabetes, thyroid diseases, kidney or liver diseases), past and present treatments, and smoking habits. A member of the research team measured each participant's height, weight, and sitting blood pressure after a minimum of 5 minutes of rest. Blood was drawn from participants in all 16 regions between 7:00 and 9:00 a.m. after a 12-hour overnight fast. The 936 studied individuals came from the following 16 regions of the country: Vratsa, Gulyantsi, Troyan, Veliko Tarnovo, Razgrad and their adjacent villages; Nessebar, Yambol, Nova Zagora, Smolyan, Dimitrovgrad, Mineral Baths-Haskovo, Kardzhali and their adjacent villages; Sandanski, Petrich, Kyustendil, Sofia, and their adjacent villages. The studied individuals were distributed into groups by their age and gender according to the latest population census conducted in December 2022 [19].

A total of 479 women (51.2%) and 457 men (48.8%), with average age of 50.57 ± 13.61 years (aged 20-79), were distributed by gender and age into groups, while maintaining the ratio between the two genders—overall and by age groups — as shown in Table 1.

Table 1. *Distribution by gender and age of 936 subjects and the ratio between the two genders—in total and in the three age groups.*

	20-44 y	**45-59 y**	**60-79 y**	**Total**
Gender, age, number (%)				
Women	159 (33.2%)	148 (30.9%)	172 (35.9%)	479 (100%)
Men	183 (40.0%)	153 (33.5%)	121 (26.5%)	457 (100%)
Total	342 (36.5%)	301 (32.2%)	293 (31.3%)	936 (100.0%)
Ratio between the two genders				
Women	159 (46.5%)	148 (49.2%)	172 (58.7%)	479 (51.2%)
Men	183 (53.5%)	153 (50.8%)	121 (41.3%)	457 (48.8%)
Total	342 (100%)	301 (100%)	293 (100%)	936 (100%)

Height, weight and BMI (kg/m^2) were measured. The established criteria for classification according to BMI were used: normal (BMI < 25 kg/m^2), overweight (BMI ≥ 25 - 29.9 kg/m^2), obesity (BMI ≥ 30 kg/m^2). Arterial blood pressure was measured in seated position after five minutes of rest. Hypertension was defined according to the IDF consensus for T2D, which recommends arterial pressure levels up to 130/80 mmHg [21] and the same recommendation in the last Guideline of European Society of Hypertension (ESH) 2023 [22].

Diabetes status was defined according to the criteria of the WHO/IDF 2016 report [23]. Standard OGTT (oral glucose tolerance test) was performed with measurement of plasma glucose on the day of blood sampling. HbA1c was also examined by a certified and standardized method NGSP and standardized according to the Diabetes Control and Complications Trial (DCCT) [24]. Analysis was performed based on the criteria from the WHO/IDF 2016 report for determining the actual status of diabetes in our country [23].

Venous blood samples were taken from the cubital vein after a 12-hour overnight fasting. Glycemia was examined at baseline and at 120 minutes during a standard OGTT of 75 g glucose in 200 ml water. Exceptions were made only in individuals who presented evidence of existing diabetes. Two individuals refused to undergo OGTT and were excluded from the study. All laboratory tests were performed in a certified central laboratory on the day of blood sampling. OGTT results which are presented in Table 2, were interpreted according to the Report of WHO/IDF Consultation, Geneva 2016.

Table 2. *Criteria for diagnosing Diabetes, Impaired Glucose Tolerance (IGT) and Impaired Fasting Glucose (IFG).*

DIABETES should be diagnosed if one or more of the following criteria are met	IMPAIRED GLUCOSE TOLERANCE (IGT) should be diagnosed if both of the following criteria are met	IMPAIRED FASTING GLUCOSE (IFG) should be diagnosed if the first or both of the following are met
Fasting Plasma glucose ≥ 7.0 mmol/L or	Fasting Plasma glucose < 7.0 mmol/L And	Fasting Plasma glucose 6.1-6.9 mmol/L and if measured
Two-hour plasma glucose ≥ 11.1 mmol/L after 75g oral glucose load (oral glucose tolerance test - OGTT) or	Two-hour Plasma glucose ≥ 7.8 < 11.1 mmol/L after 75 g oral glucose load (oral glucose tolerance test - OGTT)	Two-hour Plasma glucose < 7.8 mmol/L after 75 g oral glucose load (oral glucose tolerance test - OGTT)
HbA1c ≥ 6.5% or		
Random plasma glucose in the presence of symptoms of hyperglycaemia > 11.1 mmol/L		

a) *Diagnosis Diabetes is made if plasma glucose on fasting is ≥ 7.0 mmol/L or plasma glucose at 120 minutes from OGTT ≥ 11.1 mmol/L or HbA1c ≥ 6.5% or Random plasma glucose > 11.1 mmol/L*
b) *Diagnosis Impaired Glucose Tolerance (IGT) is made if two criteria are present: plasma glucose on fasting < 7 mmol/L and plasma glucose at 120 minutes from OGTT ≥ 7.8 ÷ < 11.1 mmol/L.*
c) *Diagnosis Impaired Fasting Glucose (IFG) is made if two criteria are present: plasma glucose on fasting 6.1-6.9 mmol/L and plasma glucose at 120 minutes from OGTT < 7.8 mmol/L.*

Based on these criteria, the participans in the study were divided into three groups:

1) Individuals without diabetes - healthy
2) Individuals with diabetes
3) Individuals with prediabetes-impaired glucose tolerance (IGT) and impaired fasting glycemia (IFG)

Laboratory analysis

Venous blood was collected in tubes containing Na2EDTA and NaF, which serve as glycolysis inhibitors to stabilize glucose levels in the samples. The samples were transported to the laboratory after centrifugation. All samples were analyzed in a central laboratory on the same day when the blood sample was collected. Glucose was quantitatively determined using enzyme reference method with hexokinase (Roche reagent) on Cobas e501 analyzer. The results are presented in mmol/L. Assessment of precision and controls:

1) Intra-assay: Level 1 (n=6) CV=1.12%; Level 2 (n=6) CV=0.42%
2) Inter-assay: Level 1 (n=30) CV=1.25%; Level 2 (n=30) CV=1.58%
3) Two levels of intra-laboratory quality control have been conducted on a daily basis. The laboratory participates in two EQA systems - the Bulgarian EQAS and INSTAND and holds a certificate for this parameter.

Venous blood was taken separately in a special tube with the anticoagulant EDTA for the determination of HbA1c by immunoturbidimetric method after hemolysis of a whole blood sample. The method was certified following the National Program for Standardization of Glycated Hemoglobin (NGSP) and standardized according to the Diabetes Control

and Complications Trial (DCCT) [24].

Statistical Analysis

a) Descriptive and evaluation methods - Variance analysis of quantitative variables - mean, median, standard deviation, standard error of the mean, 95% confidence interval of the mean and median, minimum, maximum.

Frequency analysis of qualitative variables (nominal and rank), which includes absolute frequencies, relative frequencies (in percentages), cumulative relative frequencies (in percentages).

b) Hypothesis Testing Methods - Chi-square test or Fisher's exact test - search for a relationship between two qualitative variables. Logistic regression analysis for odds ratios (OR).

The statistical analysis was performed using IBM SPSS Statistics 25. The critical significance level we used was $\alpha = 0.05$. The corresponding null hypothesis is rejected when the P-value is less than α.

3. Results

a) *Diabetes / Prediabetes*

Diabetes mellitus is present in 16.56% (155/936) of the subjects studied - men 10.58% (99/936) and women 5.98% (56/936), NS. In the male group 21.7% (99/457) have diabetes, while in the female group - 11.7% (56/479), NS. The distribution of diabetes frequency in the three age groups is as follows: 20-44 years - 4.1% (14/342); 45-59 years - 18.3% (55/301) NS; 60-79 years - 29.35% (86/293), $p < 0.02$ (young vs. elderly). The distribution of the 155 diabetics across the three age groups according to gender is shown in Table 3.

Table 3. *Distribution of Diabetics in the three age groups by gender and total.*

Gender, age, total (%)	20-44 years	45-59 years	60-79 years	total
Women	1 (1.8%)	19 (33.9%)	36 (64.3%)	56 (100%)
Men	13 (13.1%) **	36 (36.4%)	50 (50.5%)**	99 (100%)
Total	14 (9%) *	55 (35.5%)	86 (55.5%) *	155 (100%)

*p < 0.001; **p < 0.01

It is clear that the diabetes ratio between women and men in every age group and overall is higher for men, as shown in Table 4.

Table 4. *Gender ratio of diabetes frequency - overall and by age group.*

Gender, age, total (%)	Women	Men	Total
20-44 years	1 (7.1%)	13 (92.9%)	14 (100%)
45-59 years	19 (34.5%)	36 (65.5%)	55 (100%)
60-79 years	36 (41.8%)	50 (58.2%)	86 (100%)
Total	56 (36.1%)	99 (63.9%)	155 (100%)

als studied are overweight - men 19.8

It is should be noted that the most significant difference between the two genders is among the young group (20-44 years) - women 7.1% (1/14) against men 92.9% (13/14), NS. With advancing age, this ratio decreases and in the third age (60-79 years) women are 41.8% (36/56) and men 58.2% (50/99).

Prediabetes was present in 20.5% (192/936) of the individuals, distributed in the three age groups: young age (20-44 years) - 10.2% (35/342), middle age (45-59 years) - 22.2% (67/301), third age (60-79 years) - 30.7% (90/293), $p < 0.01$ (young vs. third age).

Distribution of people with prediabetes in the three age groups: young age (20-44 years) - 18.2% (35/192), middle age (45-59 years) - 34.9% (67/192), third age (60-79 years) - 46.9% (90/192), $p < 0.01$ (young vs. third age).

b) *Overweight*

It turned out that 35.1% (327/931) of the participants in the study were overweight - men 19.8% (184/931) and women 15.3% (143/931), NS. In the male group 40.5% (184/454) were overweight, and in the female group - 32.99% (143/447),

NS. The distribution between the two genders in the overweight group (n-327) is as follows: women 43.7% (143/327) and men 52.3% (184/327), NS. The following Table 5 presents the distribution of overweight by gender and age.

Table 5. *Distribution of overweight by gender and age.*

Gender, age, total (%)	20-44 years	45-59 years	60-79 years	Total
Women	38 (26.6%)	47 (32.9%)	58 (40.6%)	143 (100%)
Men	71 (38.6%)	66 (35.9%)	47 (25.5%)	184 (100%)
Total	109 (33.3%)	113 (34.6%)	105 (32.1%)	327 (100%)

Among the three age groups, there is an even distribution of the overweight - 32.0% (109/340) for 20-44 years, 37.7% (113/300) for 45-59 years and 36.1% (105/291) for 60-79 years. However, different dynamics can be observed in both genders with advancing age. In women, the prevalence increases from 26.6% (38/143) for 20-44 years and reaches 40.6% (58/143) for those aged from 60 to 79 years, while in men the prevalence decreases from 38.6% (71/184) for 20-44 years to 25.5% (47/184) for 60-79 years of age, NS. The important thing to note in this case is that overweight is present in 1/3 of people of young fertile age (20-44 years) - 32% (109/340) which is not a positive fact.

c) *Obesity*

Obesity was present in 33.3% (310/931) of the studied individuals - 19.98% men (186/931) and 13.3% women (124/931), NS. In the male group, 41% (186/454) were obese, while in the female group the percentage was lower - 26% (124/477), $p < 0.01$. The distribution between the two sexes in the obese group was as follows: women 40% (124/310) and men 60% (186/310), $p < 0.001$. The following Table 6 presents the distribution of obese individuals by gender and age.

Table 6. *Distribution of obese individuals by gender and age.*

Gender, age, total (%)	20-44 years	45-59 years	60-79 years	Total
Women	20 (16.1%)	36 (29.0%)	68 (54.8%)	124 (100%)
Men	62 (33.3%)	67 (36.0%)	57 (30.6%)	186 (100%)
Total	82 (26.5%)	103 (34.3%)	125 (40.3%)	310 (100%)

While in women with advancing age, obesity increases 3-fold - from 16.1% (20/124) for the young group 20-44 years to 54.8% (68/124) in the third group 60-79 years, $p < 0.01$. In male group the incidence of obesity in the three age groups is stable - from 33.3%, 36% to 30.6%, NS. When analyzing each of the three age groups, it should be emphasized that the incidence of obesity is lowest in the young group (20-44 years) - 24.1% (82/340) compared to the third group (60-79 years) - 42.9%, (125/291), $p<0.01$. In the middle age group (45-59 y) the incidence of obesity is 34.3%, (103/300).

The following Table 7 shows the incidence of each metabolic type (diabetes, prediabetes, healthy) for individuals in the respective age group according to BMI. A summary was also made for the entire group of respondents (n-931).

Table 7. *Incidence of diabetes, pre-diabetes and healthy in each BMI type by age (in total and in all three age groups).*

Age group	Metabolic type	BMI <25 kg/m^2	BMI 25-30 kg/m^2	BMI ≥30 kg/m^2	total
20-44 years	Diabetes	2 (14.3%) *	4 (28.6%) *	8 (57.1%) *	14 (100%)
	Pre-diabetes	4 (11.4%) **	15 (42.9%) **	16 (45.7%) **	35 (100%)
	Healthy	143 (49.1%)	90 (30.9%)	58 (19.9%)	291 (100%)
	Total	149 (43.8%)	109 (32.1%)	82 (24.1%)	340 (100%)

Age group	Metabolic type	BMI <25 kg/m^2	BMI 25-30 kg/m^2	BMI ≥30 kg/m^2	total
45-59 years	Diabetes	5 (9.3%) *	21 (38.9%) *	28 (51.9%) *	54 (100%)
	Pre-diabetes	9 (13.4%) **	24 (35.8%) **	34 (50.7%) **	67 (100%)
	Healthy	70 (39.1%)	68 (38.0%)	41 (22.9%)	179 (100%)
	Total	84 (28.0%)	113 (37.7%)	103 (34.3%)	300 (100%)
60-79 years	Diabetes	11 (12.8%) *	26 (30.2%) *	49 (57.0%) *	86 (100%)
	Pre-diabetes	17 (19.3%) **	36 (40.9%) **	35 (39.8%) **	88 (100%)
	Healthy	33 (28.2%)	43 (36.8%)	41 (35.0%)	117 (100%)
	Total	61 (21.0%)	105 (36.1%)	125 (43.0%)	291 (100%)
Total	Diabetes	18 (11.7%) *	51 (33.1%) *	85 (55.2%) *	154 (100%)
	Pre-diabetes	30 (15.8%) **	75 (39.5%) **	85 (44.7%) **	190 (100%)
	Healthy	246 (41.9%)	201 (34.2%)	140 (23.9%)	587 (100%)
	Total	294 (31.6%)	327 (35.1%)	310 (33.3%)	931 (100%)

*p < 0.001 diabetes in obese/overweight vs. healthy for the respective age and in total
**p < 0.001 prediabetes in obese/overweight vs. healthy for the respective age and in total

d) *Arterial hypertension*

Arterial hypertension (AH) was present in 44.87% (420/936) of the studied subjects, with 255 (60.7%) individuals having it at the time of the study, and 164 (39.3%) individuals already under antihypertensive treatment and normotensive at the time of the measurement. In 76% (319/420) AH was known and in 24% (101/420) - newly discovered (p < 0.001). In the group of men 50.1% (229/457) had AH, and in the group of women 39.9% (191/479), p < 0.05. In the group of hypertensives (n-420) the frequency of AH in women was 45.5% (191/420), and in men - 54.5% (229/420), p < 0.01. Table 8 presents the distribution of AH by age in both sexes, as well as the ratio between the two genders in the three age groups.

Table 8. *Frequency of hypertension by age in both sexes and in total, as well as the ratio between women and men in the three age groups.*

Gender, age, number (%)	20-44 years	45-59 years	60-79 years	Total
Women	13/191 (6.8%)	59/191 (30.9%)	119/191 (62.3%)	191 (100%)
Men	44/229 (19.2%)	88/229 (38.4%)	97/229 (42.4%)	229 (100%)
Total	57/420 (13.6%)	147/420 (35%)	216/420 (51.4%)	420 (100%)
Ratio between the two genders				
Women	13/57 (22.8%)	59/147 (40.1%)	119/216 (55.1%)	191/420 (45.5%)
Men	44/57 (77.2%)	88/147 (59.9%)	97/216 (44.9%)	229/420 (54.5%)
Total	57 (100%)	147 (100%)	216 (100%)	420 (100%)

The following two tables present the frequency of AH resp. normotension among diabetics and non-diabetics - Table 9, as well as the frequency of diabetes among normotensives and hypertensive patients - Table 10.

Table 9. *Frequency of AH resp. normotension among diabetics and non-diabetics.*

Diabetes	Normotension (number, %)	Hypertension (number, %)	Total (number, %)
Yes	40 (25.8%)	115 (74.2%) *	155 (100%)
No	476 (60.9%)	305 (39.1%) *	781 (100%)
Total	516 (55.13%)	420 (44.87%)	936 (100%)

*Fisher's Exact Test - 0.000

Table 10. *Frequency of diabetes among normotensive and hypertensive patients.*

Diabetes	Normotension (number, %)	Hypertension (брой, %)	Total (number, %)
Yes	40 (7.7%) *	115 (27.4%) *	155 (16.56%)
No	476 (92.3%)	305 (72.6%)	781 (83.44%)
Total	516 (100%)	420 (100%)	936 (100%)

*$p < 0.01$

The assessment is more precise when the devision is made in three groups according to the carbohydrade disorders - diabetes and prediabetes versus healthy so that the frequency of AH can be assessed in age groups, Table 11.

While the overall frequency of AH for the studied group is 44.87% (420/936), in the group with T2D it is 74.2% (115/155), in prediabetes it is 62.5% (120/192), and in the group of healthy individuals it is only 31.4% (185/589). The difference is significant when comparing the group with diabetes or prediabetes vs. healthy - $p < 0.001$.

Table 11. *Frequency of AH in individuals with diabetes, prediabetes and healthy persons according to their age.*

Age group	Metabolic disorder	With hypertension	Without hypertension	total
20-44 years	diabetes	6 (42.9%)	8 (57.1%)	14 (100%)
	prediabetes	13 (37.1%)	22 (62.3%)	35 (100%)
	healthy	38 (12.97%)	255 (87.03%)	293 (100%)
	total	57 (16.7%)	285 (83.3%)	342 (100%)
45-59 years	diabetes	35 (63.6%) **	20 (36.4%) **	55 (100%)
	prediabetes	42 (62.7%) ***	25 (37.3%) ***	67 (100%)
	healthy	70 (39.1%)	109 (60.9%)	179 (100%)
	total	147 (48.8%)	154 (51.2%)	301 (100%)
60-79 years	diabetes	74 (86.0%) *	12 (14.0%) *	86 (100%)
	prediabetes	65 (72.2%) *	25 (27.8%) *	90 (100%)
	healthy	77 (65.8%) *	40 (34.2%) *	117 (100%)
	total	216 (73.7%)	77 (26.3%)	293 (100%)
Total	diabetes	115 (74.2%) *	40 (25.8%) *	155 (100%)

Age group	Metabolic disorder	With hypertension	Without hypertension	total
	prediabetes	120 (62.5%) *	72 (37.5%) *	192 (100%)
	healthy	185 (31.4%)	404 (68.6%)	589 (100%)
	Total	420 (44.87%) ****	516 (55.13%) ****	936 (100%)

*p < 0.001; **p < 0.04; ***p < 0.037; ****p < 0.013

A summary of the incidence of diabetes/prediabetes in the hypertensive/normotensive groups and among individuals with both types of BMI - <25 kg/m^2 and >25 kg/m^2 was made in Table 12.

Table 12. *Role of BMI and AH for unlocking diabetes and prediabetes.*

Metabolic type	BMI <25 kg/m^2	BMI >25 kg/m^2
diabetes	11.7% (18/154) *	88.3% (136/154) *
prediabetes	15.8% (30/190) *	84.2% (160/190) *
Blood pressure	Normotonia	Arterial hypertension
diabetes	25.8% (40/155) *	74.2% (115/155) *
prediabetes	37.5% (72/192) *	62.5% (120/192) *

*p < 0.001 - diabetes / prediabetes with BMI >25 kg/m^2 versus normal weight or diabetes / prediabetes in AH versus normotension

e) *Dyslipidemia - low level of HDL-cholesterol and hypertriglyceridemia*

A low level of HDL-cholesterol is present in 64.0% (599/936) of the examined individuals compared to significantly fewer cases with normal levels at 36.0% (336/936), p < 0.001 (Table 13). In each of the three age groups, the proportion of individuals with low levels of HDL- cholesterol is a lot higher compared to the proportion of individuals with normal levels of this indicator.

Table 13. *Frequency of decreased levels of HDL-cholesterol in the three age groups.*

Age group	HDL-cholesterol <1.5 mmo/l	HDL-cholesterol >1.5 mmol/l	Total
20-44 years	231 (67.5%) *	111 (32.5%) *	342 (100%)
45-59 years	187 (62.1%) **	114 (37.9%) **	301 (100%)
60-79 years	181 (62.0%) ***	111 (38.0%) ***	292 (100%)
Total	599 (64.0%) ***	336 (36.0%) ***	936 (100%)

*p < 0.011; **p < 0.006; ***p < 0.001

In Table 14, the frequency of low levels of HDL-cholesterol is analyzed for Diabetics, Prediabetics and healthy individuals, as well as overall.

Table 14. *Frequency of low levels of HDL-cholesterol in Diabetes, Prediabetes and healthy individuals.*

Group	HDL-cholesterol < 1.5 mmo/l	HDL-cholesterol >1.5 mmol/l	Total
Diabetes	123 (79.9%) *	31 (20.1%) *	154 (100%)
Prediabetes	125 (65.1%) *	67 (34.9%) *	192 (100%)
Healthy	351 (59.6%)	238 (40.4%)	589 (100%)
Total	599 (64.1%)	336 (35.9%)	935 (100%)

*p < 0.001

The other disorder in lipid metabolism is hypertriglyceridemia, which is present in 26.7% (250/936) of the examined individuals, Table 15. The frequency of hypertriglyceridemia in the three age groups is between 20% and 34% and is significantly lower compared to the corresponding age group with normal levels of the indicator, p < 0.001. In the young group (20-44 years), the frequency of hypertriglyceridemia is 19.0% (65/342), in the middle group (45-59 years) it is 29.9% (65/301), p < 0.001, and in the older age group (60-79 years) it is 32.4% (95/293), p < 0.001.

Table 15. *Frequency of increased TGL by age.*

Age group	TGL > 1.7 mmol/l	TGL < 1.7 mmol/l	Total
20-44 years	19% (65/342) */**	81% (277/342) *	342 (100%)
45-59 years	29.9% (90/301) *	70.1% (211/301) *	301 (100%)
60-79 years	32.4% (95/293) */**	67.6% (198/293) *	293 (100%)
Total	26.7% (250/936)	73.3% (686/936)	936 (100%)

*p < 0.001; **p < 0.001

A significantly higher frequency of hypertriglyceridemia was established in diabetics compared to healthy individuals (without glycemic disturbances) - 47.7% (74/155) versus 17.8% (105/589), p < 0.001. In individuals with prediabetes, the frequency of hypertriglyceridemia is also significantly higher compared to healthy individuals - 37.0% (71/192) versus 17.8% (105/589), p < 0.01 (Table 16).

Table 16. *Frequency of increased TGL in Diabetics, Prediabetics, Healthy person.*

Group	TGL ≥ 1.7 mmol/l	TGL < 1.7 mmol/l	total
Diabetes	47.7% (74/155) *	52.3% (81/155)	155 (100%)
Prediabetes	37% (71/192) **	63% (121/192)	192 (100%)
Healthy	17.8% (105/589) */**	82.2% (484/589)	589 (100%)
Total	26.7% (250/936)	73.3% (686/936)	936 (100%)

*p < 0.001; **p < 0.01

4. Discussion

Diabetes is a serious health problem that significantly influence on the lives of those affected, their families, and society as a whole. Diabetes is one of the five non-communicable diseases prioritized in the UN and WHO plan [25, 26].

According to data from the National Health and Nutrition Examination (NHANES, 2021), the prevalence of diabetes in the US by 2020 was 16.6% (95% CI: 14.2-18.3), and after age adjustment, it was 14.8% (95% CI: 13.1-16.7) among 3 757 screened individuals, with men dominating at 17.7% (95% CI: 15.5-20.2) while women stood at 14.8% (95% CI: 12.2-17.7) [27].

Our data also show a high prevalence of diabetes in Bulgaria as of 2024 - 16.55% (155/936) - which aligns closely with US data regarding prevalence rates, age-related increases, and gender ratios: men at 10.58% (99/936) and women at 5.98% (56/936), NS. Notably, within the diabetic group, the prevalence of diabetes significantly increases with age. In the young group aged 20-44, it is 9% (14/155), and this rises to four times in the middle-aged group (45-59) to 35.5% (55/155) ($p < 0.05$), while it increases more than six fold in the elderly group aged (60-79) to 55.5% (86/155), $p < 0.001$ (Table 3).

There are significant differences in the age dynamics of diabetes between the two genders. A sharp increase was observed among women, with prevalence rising from 1.8% (1/56) in the 20-44 age group to 33.9% (19/56) in the 45-59 age group (NS), reaching 64.3% (36/56) in the 60-79 age group (NS). In contrast, the increase in prevalence among men is more gradual, rising from 13.1% (13/99) in the 20-44 age group to 36.4% (36/99) in the 45-59 age group (NS), and then shows a significant rise to 50.5% (50/99) in the 60-79 age group, $p < 0.01$.

Similar relationships appear when comparing the prevalence of diabetes across the three age groups: for 20-44 years - 4.1% (14/342), for 45-59 years - 18.3% (55/301) (NS), and for 60-79 years - 29.35% (86/293), $p < 0.02$ (comparing the elderly group to the young age group).

Prediabetes also increases with age, with the highest prevalence in the elderly group (60-79 years) when compared to the young group (20-44 years) - 46.9% (90/192) versus 18.2% (35/192), $p < 0.01$.

There are numerous risk factors that contribute to the development of T2D - obesity (≥20% of ideal body weight or BMI ≥ 25 kg/m^2); chronic lack of physical activity; arterial hypertension (AH) ≥140/90 mm Hg; low levels of high-density lipoprotein cholesterol (HDL-c) and/or high levels of triglycerides (TGL); family history; gestational diabetes mellitus (GDM) [28].

The aging of the population, the growth of the middle class, and the spread of urbanization are factors that contribute to the increase in obesity—a major risk factor for the development of diabetes [29]. Additionally, there is decreased physical activity due to modern transportation options and a lack of traditions and upbringing that promote systematic physical activity as part of a healthy lifestyle [30].

According to NHANES data from 2021, the prevalence of diabetes is 6.6% among individuals with normal weight, 10.3% among those who are overweight, and 23.3% among those with obesity. Men have a higher prevalence of diabetes than women in all three BMI categories, indicating that gender is a leading factor regardless of BMI [27].

The data is similar in our study - 6.1% (18/294) of individuals with a BMI < 25 kg/m ²have diabetes, 15.6% (51/327) of individuals with a BMI of 25-30 kg/m ², and 27.42% (85/310) of individuals with a BMI ≥ 30 kg/m ² ($p < 0.02$, obesity versus normal weight). A logistic regression model was also applied in the analysis to investigate the role of the BMI factor on diabetes as a dependent variable, and a significant effect was demonstrated (overweight versus normal weight - OR 2.833 (95% CI: 1.614-4.973), $p < 0.001$; obesity versus normal weight - OR 5.793 (95% CI: 3.382-9.922), $p < 0.001$) [18].

The prevalence of T2D is increasing, which is associated with a "Western" dietary style, rising obesity, and a sedentary lifestyle. At the same time, researchers from China have also reported an increase in obesity/overweight over a period of 30 years (1990-2019) and a corresponding rise in the prevalence of T2D, particularly among men [31]. Therefore, obesity/overweight and T2D represent a global health problem. We observed diabetes in 88.3% (136/154) of individuals with obesity/overweight compared to only 11.7% (18/154) with normal weight ($p < 0.001$), and prediabetes in 84.2% (160/190) of individuals with obesity/overweight compared to only 15.8% (30/190) with normal weight ($p < 0.001$). This demonstrates strong relationship between obesity/overweight on one hand and the development of carbohydrate metabolism disorders (diabetes and prediabetes) on the other - 86.04% (296/344) in those with BMI > 25 kg/m ²compared to 13.96% (48/344) in those with BMI < 25 kg/m ², $p < 0.001$ (Table 7).

If we summarize the analyses in the young fertile age group (20-44 years), only 43.8% (149/340) have a normal BMI < 25 kg/m ², while the remaining 56.2% (191/340) have a BMI > 25 kg/m ² - overweight (n=109) and obesity (n=82), $p < 0.001$ (Table 7). The data in the analysis show that nearly ¼ (24.1%, 82/340) of the individuals in the young fertile age group (20-44 years) are obese, placing them at high risk for diseases such as arterial hypertension and diabetes.

Out of the total 340 individuals analyzed from the young group (20-44 years), there are 14 (4.1%) diabetics, 35 (10.3%) with prediabetes, and 291 (85.6%) are healthy. But who have become diabetics in the young age group? Those with BMI ≥ 25 kg/m^2 became diabetic in 85.7% (12/14), and those with BMI < 25 kg/m^2 - only in 14.3% (2/14), NS. The ratios for prediabetes are similar - with BMI ≥ 25 kg/m^2 they are 88.6% (31/35), and with BMI < 25 kg/m^2 they are only 11.4% (4/35), $p < 0.01$. The same connection is observed in other age cat-

egories (Table 7).

It can be summarized that a total of 14.4% (49/340) of individuals in the young age group have diabetes/prediabetes, and 87.8% (43/49) of them are overweight/obese, compared to only 12.2% (6/49) with normal weight ($p < 0.001$). The increase in T2D among young people follows the rising obesity in this age group, which is observed in many countries [32]. The assessment of other authors is the same, that the main attributable risk factor for early onset type 2 diabetes in young people was the high body mass index in all regions with a corresponding sociodemographic index [1].

The data for all age groups regarding the frequency of diabetes, prediabetes, and healthy individuals according to BMI can be seen in Table 7. Concerning the relationship between obesity and diabetes, recently published research on the NLRP3 inflammasome-IL-1β pathway in T2D and obesity by D.T. Meier (2025) provides interesting and insightful findings that shed light on one of the mechanisms of their interaction. In their study, the authors found that elevated glucose levels lead to an increase in islet macrophages and locally increased production of IL-1β [33]. It turns out that a second signal is also necessary for the full realization of the process, which is present in obesity and diabetes and includes cholesterol, uric acid, NEFAs (non-esterified fatty acids), and hypoxia [34]. D.T. Meier et al. (2025) specifically note that even small "spikes" in glycemia in the early stages of T2D can contribute to the activation of IL-1β. Thus, under conditions of metabolic stress (increased levels of glucose, cholesterol, uric acid, and NEFAs), the number of islet immune cells and levels of cytokines increase, provoking chronic low-grade islet inflammation. However, it was noticed that IL-1β also has a physiological role, but only in acute and transient increases does it enhance insulin secretion. Chronic low-grade inflammation sustained by IL-1β, which was present in obesity, desensitizes beta cells. IL-1β is produced locally and acts in a paracrine manner. Measuring IL-1-dependent inflammatory markers such as C-reactive protein (CRP), IL-6, IL-8, and Interleukin-1 receptor antagonist (IL-1Ra) may be useful [33].

Arterial hypertension (AH) can be encountered two times more frequently in individuals with diabetes compared to people without diabetes. In addition, AH patients often have insulin resistance, which exposes them to a higher risk of diabetes compared to the normotensive individuals [35]. According to Akalu Y. et al. (2020), AH and T2D share common risk factors. Therefore, they can often be found together. Approximately 58% of individuals with diabetes have arterial hypertension [36].

The analysis of the relationship between AH and carbohydrate disorders showed a very strong connection between the two variables in our material - 74.2% of diabetics are also hypertensive. As expected, among hypertensives, the frequency of the disease increases with age - from 13.6% (57/420) in the 20-44 age group to 35% (147/420) for the 45-59 age group and 51.4% (216/420) for the third group, 60-79 years old. The increase is significant - 2.5 times for the middle age group and nearly 4 times for the third age group. While in men the increase is moderate, rising from 19.2% (44/229) among the young (20-44 years) to 42.4% (97/229) in the older age group (60-79 years) - a twofold increase, in women the jump is ninefold, increasing from 6.8% (13/191) among the young (20-44 years) to 62.3% (119/191) in the older age group (60-79 years), $p < 0.001$ (Table 8).

What is interesting in the analysis of the data in Table 8, is the significantly higher frequency of hypertension in young age (20-44 years) among men - 77.2% (44/57) compared to 22.8% (13/57) among women ($p < 0.001$), whereas in the third age group (60-79 years), women dominate - 55.1% (119/216) versus 44.9% (97/216) among men, NS. The frequency of hypertension within each age group increases, with hypertension being present in 16.7% (57/342) of the group aged 20-44 years, rising to 48.7% (147/301) in the 45-59 age group, and reaching 73.7% (216/293) in the third age group (60-79 years), $p < 0.001$ (comparing 20-44 years with the other two age groups).

As we noted, hypertension is present in 74.2% (115/155) of diabetics, 62.5% (120/192) of prediabetics, and 31.4% (185/589) of healthy individuals, i.e., those without glycemic disorders, Table 11. Thus, in total 67.6% (235/347) of individuals with diabetes/prediabetes have hypertension compared to 31.4% (185/589) of individuals with hypertension without glycemic disorders ($p < 0.001$). This fact highlights the very strong causal relationship between hypertension and diabetes. Table 9 presents the frequency of hypertension among diabetics and non-diabetics. The difference in the frequency of hypertension between diabetics and non-diabetics is highly significant—74.2% (115/155) compared to 39.1% (305/781)—Fisher's Exact Test - 0.000. Diabetes occurs in only 7.7% (40/516) of normotensive individuals, while among hypertensives it is found in 27.4% (115/420), $p < 0.01$ (Table 10).

The relationship between AH and carbohydrate disorders was investigated, and out of the 420 identified individuals with AH, 49% (206/420) do not have carbohydrate disorders, while 27.4% (115/420) have diabetes and 23.6% (99/420) have prediabetes. This means that in total 51% (214/420) of the hypertensive patients have carbohydrate disorders. Thus, hypertension ranks as the second strongest risk factor for the development of diabetes/prediabetes, following the much stronger factor of obesity/overweight, where 86.04% (296/344) of the cases are diabetes/prediabetes.

The analysis of the relationship between diabetes and hypertension across age groups showed an expectedly high prevalence of hypertension combined with diabetes in all three age groups of diabetics: young adults 42.9% (6/14), middle-aged 63.6% (35/55), and seniors 86% (74/86), $p < 0.05$ (young vs. senior group). With age, the prevalence of both conditions increases, as well as their combination. When comparing the prevalence of hypertension in diabetics to that in healthy individuals of the same age group, it is higher in diabetics: ages 20-44 - 42.9% (6/14) vs 12.97% (38/293), NS;

ages 45-59 - 63.6% (35/55) vs 39.1% (70/179), $p < 0.02$; ages 60-79 - 86% (74/86) vs 65.8% (77/117), $p < 0.01$ (Table 11).

The summary of the prevalence of diabetes in the groups of hypertensives/normotensives and among individuals with both types of BMI < 25 kg/m ²and BMI > 25 kg/m ²is shown in Table 10. The influence of the factor obesity/overweight, as well as hypertension, on the manifestation of diabetes is very strong: in those with BMI > 25 kg/m ², the prevalence is 88.3% (136/154) compared to 11.7% (18/154) in those with BMI < 25 kg/m ²($p < 0.001$), and correspondingly in hypertension - 74.2% (115/155) vs 25.8% (40/155) in normotensives, $p < 0.001$.

It should be emphasized that in the young age group of 20-44 years, the prevalence of AH is not small - 16.7% (57/342), with 8.18% (13/159) being women and 24.04% (44/183) being men, NS. Therefore, nearly 1 in 4 young men has hypertension, making them highly vulnerable to the development of metabolic disorders such as hyperglycemia and dyslipidemia.

T2D is characterized specifically by hyperglycemia and dyslipidemia due to insulin resistance. High-density lipoproteins-cholesterol (HDL-c) play an important role in preventing the onset of dyslipidemia and its complications. The protective functions of HDL-c include reducing oxidation, vascular inflammation and thrombosis. The anti-diabetic role of HDL-c is one of the most significant discoveries in recent years [37]. Dyslipidemia in diabetics is characterised by a decrease in high-density lipoproteins (HDL-c) as well as an increase in triglycerides (TGL). This type of dyslipidemia is caused mainly by impaired insulin sensitivity in the liver and adipose tissue [38]. Both disruptions in lipid metabolism are known to be associated with a higher frequency of diabetes [39]. This fact is emphasized by the authors of recent studies, namely that the level of HDL-c is inversely proportional to the incidence of diabetes [40].

The system studies for the project included two lipid indicators - HDL-c and TGL, in order to investigate the relationship between lipid metabolism disorders and diabetes, both for the overall group and within the three age groups. The low level of HDL-c is one of the well-known leading risk factors for diabetes, as we demonstrate in our material analysis. The percentage of individuals with low HDL-c is significantly higher, both for the entire group of subjects (64%) and within each age group, as shown in Table 13. The role of low HDL-c as a risk factor for diabetes proved to be significant, with the condition present in 79.9% of diabetic patients (123/154), while among non-diabetics it was only observed in 20.1% (31/154), $p < 0.001$. Low levels of HDL-c are nearly twice as common in individuals with prediabetes, with 65.1% (125/192) affected compared to 34.9% (67/192) with normal levels, $p < 0.001$, as shown in Table 14. It can be noticed that the highest frequency of low serum HDL-c levels 67.5% (231/342) is observed in the young age group of 20-44 years compared to the other two age groups (NS), as shown in Table 14. Undoubtedly, this risk factor plays a significant role in the development of diabetes even at young reproductive age (20-44 years).

There is also a significantly higher frequency of hypertriglyceridemia in diabetics compared to healthy individuals (i.e., those without glycemic disturbances) - 47.7% (74/155) versus 17.8% (105/589), $p < 0.001$. In individuals with prediabetes, the frequency of hypertriglyceridemia is also significantly higher compared to healthy individuals - 37.0% (71/192) versus 17.8% (105/589), $p < 0.01$ (Table 16). In the young age group (20-44 years), hypertriglyceridemia is present in 19% (65/342), indicating that nearly 1 in 5 young individuals have yet another risk factor for glycemic disturbances, as shown in Table 15.

5. Conclusion

The role of age on the expression of glycemic disturbances can be cleary seen in the overall analysis of the conducted cross-sectional study. Age turned out to be the strongest risk factor. Attention should be directed to some other critical risk factors for glycemic disturbances, such as obesity/overweight, arterial hypertension, dyslipidemia, and a specific assessment of their prevalence in the young fertile age group (20-44 years). The analysis of diabetes trends in our country over the past 18 years (2006-2024) revealed a significant increase in its prevalence, as well as its "younger onset," meaning it increasingly affects a larger proportion of the fertile age group (for 20-29 years from 0% in 2006 to 1.5% in 2024, NS; for 30-39years from 0.9% in 2006 to 4.5% in 2024, $p < 0.002$). Currently, the prevalence of diabetes/prediabetes is 14.4% (49/340) in the young fertile age group, and the prevalence of risk factors among them is as follows:

1) Obesity is present in nearly ¼ of individuals in the young group - 24.1% (82/340);
2) Overweight is present in 32% (109/340) of individuals in the young group;
3) Both obesity and overweight are present in 56% (191/340) of fertile age group (20-44 years);
4) In the young group, 85.7% (12/14) of diabetics have a BMI ≥ 25 kg/m^2;
5) Arterial hypertension is nearly 17% (57/342) among individuals in the young group;
6) Almost 1/5 of young men have arterial hypertension;
7) In the young age group, 42.9% (6/14) have a combination of arterial hypertension and diabetes, compared to 12.9% (38/293) with only arterial hypertension;
8) The highest prevalence of low serum HDL cholesterol level is 67.5% in the young group compared to other age groups;
9) Among 1/5 of individuals in the young age group, there is hypertriglyceridemia.

The high prevalence of obesity (24%) and arterial hypertension (17%) among the fertile age group stands out, as these risk factors are significantly associated with glycemic disturbances. Additional factors include lipid disorders in this

age group, specifically, 1/5 have hypertriglyceridemia, and the prevalence of low HDL-cholesterol is 67.5%.

Therefore, conclusions must be drawn regarding the identification of possible strategies for the prevention of diabetes/prediabetes, as this disease reduces the quality of life for both the affected individuals and their families, as well as posing a significant threat to the society and the health systems. The increase in the incidence of diabetes in the young age group (20-40 years) means an increase in fertility problems, problems in the onset of pregnancy, problems in the course and completion of pregnancy, complications for the mother and fetus. These are very serious health complications that require early diagnosis and adequate treatment, but the main thing is prevention. Our primary concern in preventive measures should be directed towards controlling the modern obesity/overweight epidemic. This is also the main risk factor for glycemia disorders. Of course, care is also needed for timely diagnosis and adequate treatment of hypertension and control of lipid levels. It is essential to introduce educational programs among the population to inform them about the need for lifestyle changes (dietary habits and physical activity) and to encourage them to take systematic care of their own health. Additionally, attention should be focused on organizing and regularly conducting systematic screenings for the young fertile age group in the face of an emerging epidemic of obesity and diabetes among them.

Abbreviations

DM	Diabetes Mellitus
T2D	Type 2 Diabetes Mellitus
CDC	Centers for Disease Control and Prevention
BMI	Body Mass Index
AH	Arterial Hypertension
UK	United Kingdom
GDM	Gestational Diabetes Mellitus
ISPAD	International Society of Pediatric and Adolescent Diabetes
NSI	National Statistical Institute
IDF	International Diabetes Federation
ESH	European Society of Hypertension
WHO	World Health Organization
oGTT	Oral Glucose Tolerance Test
HbA1c	Haemoglobin A1c
NGSP	National Program for Standardization of Glycated Haemoglobin
DCCT	Diabetes Control and Complications Trial
IGF	Impaired Glucose Tolerance
IFG	Impaired Fasting Glucose
SPSS	Statistical Package for the Social Sciences
HDL-c	High-density Lipoprotein-cholesterol
TGL	Triglycerides
UN	United Nation
NHANES	National Health and Nutrition Examination Survey
OR	Odds Ratio
NEFA	Non-Esterified Fatty Acids
IL-1β	Interleukin-1 Beta
CRP	C-reactive Protein
IL-1Ra	Interleukin - Receptor Antagonist

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Author Contributions

Anna-Maria Borisova: Conceptualization, Resources, Formal Analysis, Funding acquisition, Project administration, Supervision, Writing - original draft, Methodology

Boyana Trifonova: Investigation, Project administration, Supervision, Writing - review & editing

Lilia Dakovska: Data curation, Investigation

Mircho Vukov: Software, Formal Analysis, Validation

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Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Xie J, Maoqing Wang, Zhiping Long, Hua Ning, Jingkuo Li, Yukun Cao, et al. Research Global burden of type 2 diabetes in adolescents and young adults, 1990-2019: systematic analysis of the Global Burden of Disease Study 2019. BMJ. 2022; 379: e072385. https://doi.org/10.1136/bmj-2022-072385

[2] WHO STEP wise Approach to NCD Risk Factor Surveillance. Global, regional, and national burden of diabetes from 1990 to 2021, with projections of prevalence to 2050: a systematic analysis for the Global Burden of Disease Study 2021. The Lancet 2023; 402: 203-234. Published Online June 22, 2023. https://doi.org/10.1016/S0140-6736(23)01301-6

[3] International Diabetes Federation. (2021). IDF Diabetes Atlas, 10th edn. Brussels: International Diabetes Federation. https://www.idf.org/e-library/welcome/

[4] Pouya Saeedi, Inga Petersohn, Paraskevi Salpea, Belma Malanda, Suvi Karuranga, Nigel Unwin, Stephen Colagiuri, Leonor Guariguata et al. Global and regional diabetes prevalence estimates for 2019 and projections for 2030 and 2045: results from the International Diabetes Federation Diabetes Atlas, 9th edition. *Diabetes Res Clin Pract*; (2019). https://doi.org/10.1016/j.diabres.2019.107843

[5] Silva Arslanian, Fida Bacha, Margaret Grey, Marsha D. Marcus, Neil H. White, Philip Zeitler. Evaluation and Management of Youth-Onset Type 2 Diabetes: A Position Statement by the American Diabetes Association. Diabetes Care, 2018 Nov 12; 41(12): 2648-2668. https://doi.org/10.2337/dci18-0052

[6] National Center for Health Statistics. Health, United States, 2018. Hyattsville, MD. 2019.

[7] CDC, National Center for Health Statistics. Maternal and Infant Health, May 2023.

[8] Dabelea D, Knowler WC, Pettitt DJ. Effect of diabetes in pregnancy on offspring: follow-up research in the Pima Indians. J Matern Fetal Med 2000; 9(1): 83-88. https://doi.org/10.1002/(SICI)1520-6661(200001/02)9:1<83::AID-MFM17>3.0.CO;2-O

[9] Dana Dabelea, Elizabeth J. Mayer-Davis, Archana P. Lamichhane, Ralph B. D'Agostino Jr, Angela D. Liese, Kendra S. Vehik, K. M. Venkat Narayan, Phillip Zeitler, Richard F. Hamman. Association of intrauterine exposure to maternal diabetes and obesity with type 2 diabetes in youth: the SEARCH Case-Control Study. Diabetes Care 2008; 31(7): 1422-1426. https://doi.org/10.2337/dc07-2417

[10] Anna-Maria Borissova, Boyana Trifonova, Lilia Dakovska, Eugenia Mihailova, Mircho Vukov. Cross-sectional Study of Glucose Disturbances of Pregnant Women in Bulgaria. Clinical Medicine Research 2021; 10(1): 9-15. https://doi.org/10.11648/j.cmr.20211001.12

[11] Anna-Maria Borissova, Boyana Trifonova, Lilia Dakovska, Eugenia Michaylova, Mircho Vukov. Age, Obesity, Family History, Previous Gestational Diabetes Are Major Risk Factors for Hyperglycemia in Pregnant Bulgarian Women. European Journal of Preventive Medicine 2021; 9(2): 39-45. https://doi.org/10.11648/j.ejpm.20210902.12

[12] Amy S. Shah, Philip S. Zeitler, Jencia Wong, Alexia S. Pena, Brandy Wicklow, Silva Arslanian et al. (2022). ISPAD Clinical Practice Consensus Guidelines 2022. Type 2 diabetes in children and adolescents. Pediatr Diabetes 23(7): 872-902. https://doi.org/10.1111/pedi.13409

[13] Allen AJ, Snowden JM, Lau B, Cheng Y, Caughey AB. Type-2 diabetes mellitus: does prenatal care affect outcomes? J Matern Fetal Neonatal Med. 2018. Jan; 31(1): 93-97. https://doi.org/10.1080/14767058.2016.1276558

[14] Clement N. S, Abul A, Farrelly R, Murphy H. R, Forbes K, Simpson N. A. B, & Scott E. M. (2024). Pregnancy outcomes in type 2 diabetes: A systematic review and meta-analysis. American Journal of Obstetrics and Gynecology. Advance online publication. https://doi.org/10.1016/j.ajog.2024.11.026

[15] Rosaria Gesuita, Alexander J. Eckert, Stéphane Besançon, Nancy A. Crimmins, Fred Cavallo, Kim Craig Jefferies, Evelien F. Gevers, Anastasios Vamvakis, Sejal Shah, Shazhan Amed, Valentino Cherubini on behalf of the SWEET study group. Frequency and clinical characteristics of children and young people with type 2 diabetes at diagnosis from five world regions between 2012 and 2021: data from the SWEET Registry. Diabetologia (2025) 68: 82-93. https://doi.org/10.1007/s00125-024-06283-5

[16] Wu H, Patterson CC, Zhang X, Ghani R, Magliano D. J, Boyko E. J, Ogle G. D, & Luk A. O. Y. (2022). Worldwide estimates of incidence of type 2 diabetes in children and adolescents in 2021. Diabetes Res Clin Pract 185: 109785. https://doi.org/10.1016/j.diabres.2022.109785

[17] Perng W, Conway R, Mayer-Davis E, Dabelea D. (2023) Youth-onset type 2 diabetes: the epidemiology of an awakening epidemic. Diabetes Care 46(3): 490-499. https://doi.org/10.2337/dci22-0046

[18] Anna-Maria Borissova, Boyana Trifonova, Lilia Dakovska, Neriman Topchieva, Mircho Vukov. Changes in the Prevalence of Diabetes in Bulgaria over an 18-Year Period (2006-2024). Clinical Medicine Research 2024, Vol. 13, No. 4, pp. 45-54. https://doi.org/10.11648/j.crnr.20241304.12

[19] NSI. National population census in Bulgaria. National Statistical Institute. December 2022. https://www.nsi.bg/sites/default/files/files/publications/StatBook_Census2021.pdf

[20] Guariguata L, Whiting D, Weil C, Unwin N. The International Diabetes Federation Diabetes atlas methodology for estimating global and national prevalence of diabetes in adults. Diabetes Res Clin Pract. 2011; 94(3): 322-32. http://dx.doi.org/10.1016/j.diabres.2011.10.040

[21] International Diabetes Federation. Clinical Guidelines Task Force. Global Guideline for Type 2 Diabetes. Belgium, 2012.

[22] 2023 ESH Guidelines for the management of arterial hypertension. The Task Force for the management of arterial hypertension of the European Society of Hypertension Endorsed by the International Society of Hypertension (ISH) and the European Renal Association (ERA). Authors/Task Force Members: Giuseppe Mancia (Chairperson), Reinhold Kreutz (Co-Chair), Mattias Brunstrom, Michel Burnierd, Guido Grassie, Andrzej Januszewiczf et al. J. of Hypertension. 2023; Vol 41, Number 12. https://doi.org/10.1097/HJH.0000000000003480

[23] World Health Organization and International Diabetes Federation. Definition and diagnosis of diabetes mellitus and Intermediate hyperglycaemia. Report of a WHO/IDF Consultation, Geneva, 2016.

[24] The Diabetes Control and Complications Trial Research Group: The relationship of glycemic exposure (A1C) to the risk of development and progression of retinopathy in the Diabetes Control and Complications Trial. Diabetes. 1995; 44: 968-983. https://doi.org/10.2337/db07-1618

[25] World Health Organization (2013). Global action plan for the prevention and control of noncommunicable diseases 2013-2020. World Health Organization. https://iris.who.int/handle/10665/94384

[26] United Nation. Department of Economic and Social Affairs. Transforming our world: the 2030 Agenda for Sustainable. https://sustainabledevelopment.un.org/post2015

[27] National Health and Nutrition Examination Survey 2017-March 2020 Prepandemic Data Files—Development of Files and Prevalence Estimates for Selected Health Outcomes. Bryan Stierman, Joseph Afful, Margaret D. Carroll, Te-Ching Chen, Orlando Davy, Steven Fink, Cheryl D. Fryar, Qiuping Gu, Craig M. Hales, Jeffery P. Hughes, Yechiam Ostchega, Renee J. Storandt and Lara J. Akinbami. National Health Statistics Reports, 2021 Jan 14; Number 158. http://dx.doi.org/10.15620/cdc:106273

[28] Curtis L. Triplitt, Thomas Repas, and Carlos Alvarez. The role of SMBG in improving glycemic control in type 2 DM patients. In: Diabetes Mellitus, Chapter 74, Hardback, 2512 pages, 2016. McGraw-Hill Education.

[29] Lovic D, Piperidou A, Zografou I, Grassos H, Pittaras A, Manolis A. The growing epidemic of diabetes mellitus. Curr Vasc Pharmacol. 2020; 18(2): 104-109. https://doi.org/10.2174/1570161117666190405165911

[30] Popkin BM, Adair LS, Ng SW. Global nutrition transition and the pandemic of obesity in developing countries. Nutrition Rev. 2012; 70: 3-21. https://doi.org/10.1111/j.1753-4887.2011.00456.x

[31] Jianglin Wang, Lingyun Zhou, Wenjun Yin, Can Hu and Xiaocong Zuo. Trends of the burden of type 2 diabetes mellitus attributable to high body mass index from 1990 to 2019 in China. Front. Endocrinol. 2023, Vol 14: 1193884. https://doi.org/org/10.3389/fendo.2023.1193884

[32] Shah Amy S, Zeitler Philip S, Wong Jencia, Pena Alexia S, Wicklow Brandy, Arslanian Silva, Chang Nancy, Fu Junfen, Dabadghao Preeti, Pinhas-Hamiel Orit, Urakami Tatsuhiko, Craig Maria E. ISPAD Clinical Practice Consensus Guidelines 2022: Type 2 diabetes in children and adolescents. Pediatr Diabetes 23(7): 872-902, 2022. 11. https://doi.org/10.1111/pedi.13409 Epub 2022 Sep 25.

[33] Daniel T. Meier, Joyce de Paula Souza, Marc Y. Donath. Targeting the NLRP3 inflammasome-IL-1β pathway in type 2 diabetes and obesity. Diabetologia (2025) 68: 3-16. https://doi.org/10.1007/s00125-024-06306-1

[34] Dror E, Dalmas E, Meier DT, Wueest S, Thévenet J, Thienel C. et al. (2017). Postprandial macrophage-derived IL-1 [beta] stimulates insulin, and both synergistically promote glucose disposal and inflammation. Nat Immunol 18(3): 283-292. https://doi.org/10.1038/ni.3659

[35] John R. Petrie, Tomasz J. Guzik, Rhian M. Touyz. Diabetes, Hypertension, and Cardiovascular Disease: Clinical Insights and Vascular Mechanisms. Canadian Journal of Cardiology. 2018; 34(5): 575-584. https://doi.org/10.1016/j.cjca.2017.12.005

[36] Akalu Yonas, Belsti Yitaych. Hypertension and its associated factors among type 2 diabetes mellitus patients at debre tabor general hospital, Northwest Ethiopia. Diabetes Metab Syndr Obes. 2020; 13: 1621-1631. https://doi.org/10.2147/DMSO.S254537

[37] Ali Bayat Bodaghi, Erfan Ebadi, Mohammad Javad Gholami, Reza Azizi, Aref Shariati. A decreased level of high-density lipoprotein is a possible risk factor for type 2 diabetes mellitus: A review. Health Sci. Rep. 2023; 6(12): e1779. https://doi.org/10.1002/hsr2.1779

[38] Xepapadaki E, Nikdima I, Sagiadinou EC, Zvintzou E, Kypreos KE. HDL and type 2 diabetes: the chicken or the egg? Diabetologia. 2021; 64(9): 1917-1926. https://doi.org/10.1007/s00125-021-05509-0

[39] Fatemeh Mohammadi, Amirhossein Yadegar, Soghra Rabizadeh, Aryan Ayati, Seyed Arsalan Seyedi, Seyed Ali Nabipoorashrafi, Alireza Esteghamati and Manouchehr Nakhjavani. Correlates of normal and decreased HDL cholesterol levels in type 2 diabetes: a cohort-based cross-sectional study. Lipids in Health and Disease (2024) 23: 18. https://doi.org/10.1186/s12944-024-02010-6

[40] Liu H, Liu J, Liu J, Xin S, Lyu Z, Fu X. Triglyceride to high density lipoprotein cholesterol (TG/HDL-C) ratio, a simple but effective indicator in predicting type 2 diabetes mellitus in older adults. Front Endocrinol. 2022; 13: 828581. https://doi.org/10.3389/fendo.2022.828581