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Original article

RELATIONSHIP BETWEEN SOME LABORATORY INDICATORS AND ANTHROPOMETRIC PARAMETERS IN BULGARIAN PATIENTS WITH TYPE 2 DIABETES MELLITUS

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ABSTRACT

Introduction: Diabetes mellitus is becoming a rapidly growing health concern across the world due to the rapidly growing number of patients. The multidisciplinary approach to type 2 Diabetes mellitus (T2DM) requires, along with anthropometric parameters, monitoring of the patient's lipid profile and glycated hemoglobin levels.

The **purpose** of the present study is to study the correlations between the lipid profile indicators, as well as glycated hemoglobin levels, and some anthropometric parameters of Bulgarian patients with T2DM.

Material and Methods. The study included 136 males and 212 females with T2DM, divided into two age groups. Anthropometric parameters: waist (WaC) and hip (HiC) circumferences. Calculated indices: Body mass index (BMI) and Waist-hip ratio (WHR). Laboratory indicators: total cholesterol (TCH), triglycerides (TG), high-density lipoprotein (HDL), low-density lipoprotein (LDL), very low-density lipoprotein (VLDL) and glycated hemoglobin (HbA1c).

Results. In the present study, we have found eleven significant correlations between some anthropometric parameters and laboratory indicators in Bulgarian male patients with T2DM. They were the 1st age group 40-60 years: TCH/BMI, TCH/WaC, TCH/WHR, HDL/BMI, HDL/WaC, and LDL/HiC; 2nd age group 61-80 years: TG/BMI, VLDL/BMI, HbA1c/BMI, HbA1c/WaC, and HbA1c/HiC. We found three significant correlations between the anthropometric parameters and laboratory indicators in Bulgarian females with T2DM. They were the 1st age group, 40-60 years: BMI/HbA1c; 2nd age group, 61-80 years: BMI/TCH and BMI/LDL.

Conclusion: The number of correlations between the tested anthropometric parameters and laboratory values were greater in male patients than in women with T2DM. Sexual dimorphism in the impact of T2DM has been reported.

Keywords: Type 2 DM, correlations, anthropometry, lipid profile, glycated hemoglobin,

INTRODUCTION

Type 2 Diabetes mellitus (T2DM) is a metabolic disease associated with metabolic disturbance. Recently, it has gained more attention as a social problem due to the rapidly growing number of people affected by the disease worldwide. Globally, as of 2020, it was estimated that there were 285 million people with T2DM, and this was equivalent to about 6% of the world's adult population [1]. In Bulgaria, patients with T2DM amounted to about 6-8% of the population, with a trend of rapid growth. Diabetes is common both in developed and developing countries. Conducted surveys focused exclusively on clarifying the etiology, pathogenesis, clinical course and treatment of the disease. A limited number of studies aimed at clarifying the relationship between anthropological parameters governing human body constitution, and the lipid profile, as well as the glycated hemoglobin levels of T2DM patients [2, 3, 4, 5]. Both lipid profile and body fat have been shown to be very important predictors for metabolic disturbances, including dyslipidaemia, hypertension, diabetes, cardiovascular diseases, and hyperinsulinaemia [4].

The **aim** of the research was to look for correlations between the lipid profile indicators and glycated hemoglobin levels on the one hand, and some anthropometric parameters of Bulgarian patients with T2DM - on the other hand, in order to evaluate their prognostic role.

PATIENTS AND METHODS

The study included 348 patients (136 males and 212 females) with T2DM, diagnosed and followed by a specialist in endocrinology. The survey was conducted in the Clinic of Endocrinology and Metabolic disorders at the University Hospital "Saint George", Plovdiv. The duration of the disease was more than five years. All patients were

treated with oral antidiabetic drugs and were compensated for their condition. All patients were ethnic Bulgarians. They were divided into two groups: 1st group: 40-60 years of age – 58 male (mean 52.29±0.79 years) and 92 female patients (mean 52.87±0.56 years). 2nd group: 61-80 years of age – 78 male (mean 68.75±0.58 years) and 120 female patients (mean 68.95±0.57 years).

Anthropometric parameters. Directly measured anthropometric parameters: - body height, body weight, waist circumference (WaC) and hip circumference (HiC).

Calculated indices: Body mass index (BMI) and Waist-hip ratio (WHR).

Laboratory variables: Lipid panel consisting of total cholesterol (TCH), triglycerides (TG), high-density lipoprotein (HDL), low-density lipoprotein (LDL) and very low-density lipoprotein (VLDL) values, as well as glycated hemoglobin (HbA1c) levels.

Statistics Data were analyzed using statistical software SPSS version 23 (SPSS Inc., Chicago, IL). The independent Samples t Test was used to compare the laboratory indicators of two independent groups of patients in order to determine whether there was statistical evidence, that the means were significantly different. The values of $p<0.05$ were considered as statistically significant. We used Pearson's correlation analysis to assess associations between the laboratory and anthropometric variables. The value of Pearson's coefficient was used to rate the correlation's strength: low correlation 0.01-0.30; moderate 0.30-0.50; strong 0.50-0.70; high 0.70-0.90, and very high correlation >0.90. $P<0.05$ (two-tailed) was considered statistically significant.

RESULTS

Comparative presentation of the lipid profile indicators and glycated hemoglobin values between two age groups in Bulgarian patients with T2DM

The lipid profile and the glycated hemoglobin values of T2DM patients from both tested age groups are presented in Tables 1 and 2. In the lipid profile of both male age groups, we have found two significant differences: The levels of triglycerides and VLDL were significantly higher in the age group of 40-60 years than in the 61–80-year age group ($p<0.05$). The values of the other tested parameters did not differ statistically between the two age groups.

In the lipid profile of both female age groups, we revealed four significant differences: The levels of triglycerides, VLDL and HbA1c were significantly higher in the age group of 40-60 years than in the 61–80-year age group ($p<0.05$). On the contrary, the HDL-cholesterol levels were significantly higher in the 61–80-year age group than in the younger group ($p<0.05$).

Table 1. Comparative presentation of the lipid profile indicators and glycated hemoglobin values between both age groups of Bulgarian male patients with T2DM

	Male 40-60 years				Male 61-80 years				
Lipid profile parameter and HbA1c levels	**N**	Mean	SE	SD	N	Mean	SE	SD	P
Total cholesterol mmol/l *reference levels 5.2-6.2*	58	5.55	0.27	1.61	78	5.01	0.14	1.26	>0.05
Triglycerides mmol/l *reference levels 0.6-1.7*	58	4.63	1.17	6.94	78	1.84	0.21	1.87	**<0.05***
HDL-cholesterol mmol/l *reference levels 1.00-1.68*	58	1.14	0.09	0.37	78	1.1	0.07	0.38	>0.05
LDL-cholesterol mmol/l *reference levels 2.6-3.3*	58	3.47	0.42	2.5	78	4.15	0.12	1.01	>0.05
VLDL mmol/l *reference levels < 1 mmol/l*	58	2.11	0.53	3.15	78	0.84	0.1	0.85	**<0.05***
HbA1c % *reference levels 4.00-5.6*	58	9.1	0.3	1.38	78	8.84	0.3	1.68	>0.05

HDL-high-density lipoprotein cholesterol, LDL-low-density lipoprotein cholesterol, VLDL-very low-density lipoprotein, HbA1c-glycated hemoglobin, *significance

Table 2. Comparative presentation of the lipid profile indicators and glycated hemoglobin values between both age groups of Bulgarian female patients with T2DM

	Female 40-60 years				Female 61- 80 years				
Lipid profile parameter and HbA1c levels	N	Mean	SE	SD	N	Mean	SE	SD	P
Total cholesterol mmol/l reference levels 5.2-6.2	92	5.8	0.16	1.48	120	5.57	0.13	1.23	>0.05
Triglycerides mmol/l reference levels 0.6-1.7	92	2.8	0.41	3.7	120	1.96	0.12	1.13	**<0.05***
HDL-cholesterol mmol/l reference levels 1.00-1.68	92	1.21	0.08	0.37	120	1.4	0.09	0.46	**<0.05***
LDL-cholesterol mmol/l reference levels 2.6-3.3	92	4.5	0.22	2.02	120	4.68	0.12	1.15	>0.05
VLDL mmol/l reference levels< 1mmol/l	92	1.23	0.2	1.67	120	0.89	0.55	0.51	**<0.05***
HbA1c % reference levels 4.00-5.6	92	9.64	0.27	1.86	120	9.18	0.21	1.42	**<0.05***

HDL-high-density lipoprotein cholesterol, LDL-low-density lipoprotein cholesterol, VLDL-very low-density lipoprotein, HbA1c-glycated hemoglobin, *significance

Correlations between some anthropometric parameters, lipid profile indices and glycated hemoglobin values in Bulgarian patients with T2DM (Tables 3 and 4)

Table 3. Correlations between some anthropometric parameters, the lipid profile indicators and glycated haemoglobin values of 40-60-year-old Bulgarian male patients with T2DM.

Anthropometric	TCH		TG		HDL		LDL		VLDL		HbA1c	
parameters	PC	P	PC	P	PC	P	PC	P	PC	P	PC	P
BMI	0.55	**<0.05***	0.1	>0.05	-0.64	**<0.05***	0.23	>0.05	0.1	>0.05	0.07	>0.05
WaC	0.39	**<0.05***	-0.005	>0.05	-0.56	**<0.05***	0.26	>0.05	-0.005	>0.05	0.28	>0.05
HiC	0.06	>0.05	-0.25	>0.05	-0.4	>0.05	0.35	**<0.05***	0.18	>0.05	-0.25	>0.05
WHR	0.5	**<0.05***	0.3	>0.05	-0.35	>0.05	-0.05	>0.05	0.3	>0.05	0.27	>0.05

PC–Pearson correlation coefficient, BMI–Body mass index, waist circumference (WaC), hip circumference (HiC), WHR–waist/hip ratio, *significance

Table 4. Correlations between some anthropometric parameters, the lipid profile indicators and glycated haemoglobin values of 40-60-year-old Bulgarian female patients with T2DM.

Anthropometric	TCH		TG		HDL		LDL		VLDL		HbA1c	
parameters	PC	P	PC	P	PC	P	PC	P	PC	P	PC	P
BMI	-0.16	>0.05	0.02	>0.05	0.23	>0.05	-0.13	>0.05	0.22	>0.05	-0.33	**<0.05***
WaC	0.07	>0.05	0.24	>0.05	0.22	>0.05	0.02	>0.05	0.24	>0.05	-0.38	>0.05
HiC	0.08	>0.05	0.18	>0.05	0.2	>0.05	0.05	>0.05	0.18	>0.05	-0.36	>0.05
WHR	-0.003	>0.05	0.21	>0.05	0.12	>0.05	-0.06	>0.05	0.21	>0.05	-0.33	>0.05

PC–Pearson correlation coefficient, BMI–Body mass index, waist circumference (WaC), hip circumference (HiC), WHR–waist/hip ratio, *significance

In the age group of 40–60-year male patients with T2DM we discovered the following significant correlations: a strong positive correlation between the values of total cholesterol and BMI (r=0.55, p<0.05), and between total cholesterol and WHR (r=0.50, p<0.05); a moderate positive correlation between the values of waist circumference and total cholesterol (r=0.39, p<0.05). Negative strong correlations were found between the values of HDL and BMI (r=-0.64, p<0.05), and between the waist circumference and HDL (r=-0.56, p<0.05). The correlation between the values of hip circumference and LDL was also significant, positive and moderate (r=0.35, p<0.05). In the female age group of 40-60 years, we detected one significant correlation between BMI and HbA1c only. It was negative and moderate (r=-0.33, p<0.05). (Tables 5 and 6)

Table 5. Correlations between some anthropometric parameters, the lipid profile indicators and glycated haemoglobin values of 61-80-year-old Bulgarian male patients with T2DM.

Anthropometric	TCH		TG		HDL		LDL		VLDL		HbA1c	
parameters	PC	P	PC	P	PC	P	PC	P	PC	P	PC	P
BMI	0.18	>0.05	0.29	**<0.05***	-0.02	>0.05	-0.02	>0.05	0.29	**<0.05***	-0.42	**<0.05***
WaC	0.07	>0.05	0.21	>0.05	-0.11	>0.05	-0.1	>0.05	0.22	>0.05	-0.56	**<0.05***
HiC	0.11	>0.05	0.1	>0.05	-0.1	>0.05	0.03	>0.05	0.1	>0.05	-0.55	**<0.05***
WHR	-0.02	>0.05	0.21	>0.05	-0.05	>0.05	-0.19	>0.05	0.21	>0.05	-0.48	>0.05

PC–Pearson correlation coefficient, BMI–Body mass index, waist circumference (WaC), hip circumference (HiC), WHR–waist/hip ratio, *significance

Table 6. Correlations between some anthropometric parameters, the lipid profile indicators and glycated haemoglobin values of 61-80-year-old Bulgarian female patients with T2DM.

Anthropometric	TCH		TG		HDL		LDL		VLDL		HbA1c	
parameters	PC	P	PC	P	PC	P	PC	P	PC	P	PC	P
BMI	-0.21	**<0.05***	0.01	>0.05	-0.21	>0.05	-0.21	**<0.05***	0.1	>0.05	-0.14	>0.05
WaC	0.02	>0.05	0.23	>0.05	-0.13	>0.05	-0.03	>0.05	0.24	>0.05	-0.56	>0.05
HiC	-0.07	>0.05	0.18	>0.05	-0.16	>0.05	-0.1	>0.05	0.21	>0.05	-0.31	>0.05
WHR	0.13	>0.05	0.14	>0.05	-0.002	>0.05	0.09	>0.05	0.14	>0.05	-0.44	>0.05

PC–Pearson correlation coefficient, BMI–Body mass index, waist circumference (WaC), hip circumference (HiC), WHR–waist/hip ratio, *significance

In the age group of 61–80-year male patients with T2DM, we found two significant positive and moderate correlations between BMI and triglycerides, and between BMI and VLDL (r=0.29, p<0.05). We also revealed three significant negative correlations: two strong ones between the ÍbÀ1ñ value and waist circumference (r=-0.56, p<0.05), and between HbB1c value and hip circumference (r=-0.55, p<0.05); a moderate correlation was found between BMI and HbA1 (r=-0.42, p<0.05).

In the age group of 61–80-year female patients with T2DM, we disclosed two significant inverse correlations with low expression: between BMI and total cholesterol (r=-0.21, p<0.05) and between BMI and LDL (r=-0.21, p<0.05).

DISCUSSION

The lipid profile consists of detailed measurement of lipids in the blood. It includes exploration of total cholesterol, HDL, LDL, VLDL and triglycerides. Triglycerides are a very important component of the lipid profile in the human body. As an important energy source, they are certainly necessary for the successful function of the human organism. A high level of triglycerides is associated with the risk of cardiovascular disease and metabolic syndrome. Very low-density lipoproteins (VLDL) transport the endogenous triglycerides, phospholipids, and cholesterol and cholesterol esters. When comparing the lipid profile indicators of both age groups T2DM males, we have found that the levels of triglycerides and VLDL in the first group were about 2.5 times higher than in the second group. The mean values of both lipid indicators were above the reference levels in the group of younger men. These data correspond to the significantly higher values of weight and BMI in the group of 40–60-year-old men with T2DM, compared to the group of 61–80-year-old. We believe that it is a consequence of the human body aging [6].

Similarly, the values of triglycerides and VLDL in

female patients were significantly higher in 40-60- years-olds compared to those 61–80-years-olds, and the values of both lipid indicators exceeded the reference levels in the group of younger women only. Significantly higher levels of HDL-cholesterol were found in 61-80 years of age T2DM women in comparison with 40–60-year-old females. HDL and LDL are cholesterol transporters. We have found no risky low HDL-cholesterol values in our male and female patients of both age groups, which is a good prognostic sign. While the levels of LDL-cholesterol exceeded the reference range, no significant difference was found between the two age groups of both men and women with T2DM, thus all of them were at risk of atherosclerosis, heart attack or stroke.

Glycated hemoglobin (HbA1c %) is the main indicator which is used for the evaluation of glycemic control in Diabetes mellitus. The high levels of HbA1c were associated with an increased risk of complications in patients with Diabetes mellitus type 1 and type 2. A statistically significant association was found between the high levels of HbA1c and the mortality rates associated with Diabetes mellitus. If the value of HbA1c was ≥8%, the risk of death was 15.3% higher than of HbA1c <6%. In our T2DM female patients from both age groups, the HbA1c values exceeded the reference limits and were significantly higher in the first group than in the second. Moreover, HbA1c % exceeded the reference ranges in both age groups of both men and women with T2DM, which is a bad prognostic sign associated with an increased risk of complications and mortality rate.

Total cholesterol is the sum of different fats in the blood. High cholesterol levels are associated with the accumulation of fatty deposits in blood vessels and the development of cardiovascular diseases, atherosclerosis, heart attack, or stroke. Interestingly, the levels of total cholesterol were within normal limits in both T2DM age groups and both patient genders.

Anthropometric indices, particularly BMI and WHR, are mainly used to assess obesity in persons [7, 8, 9, 10]. WHR is closely linked with BMI and is an appropriate index of intra abdominal fat mass and total body mass. Obesity, particularly visceral or central, as evidenced by the waist hip ratio, is very common in T2DM. Positive correlations between the total cholesterol values and the anthropometric parameters (BMI, waist circumference and WHR) in the 40–60-year male age group correspond to the general obesity in this group. The negative correlations between HDL (good cholesterol) and BMI, as well as between HDL and waist circumference, also correspond to the general obesity in this group of T2DM male patients.

The positive correlation between hip circumference and LDL (bad cholesterol) is interesting. It showed an accumulation of fat tissue in the hip. In our previous studies, we reported significantly higher values of the hip circumference, in comparison with the waist circumference in T2DM men aged 40-60 years (p<0,001), and in comparison with the healthy controls [6] (p<0,001). The accumulation of visceral fat is significant for the disease's prognosis. This survey has not found a significant correlation between the waist circumference and LDL. Some of our results have been reported by other authors [4, 11, 12].

In the female group 40-60 years of age, we have found one significant correlation between BMI and HbA1c only. It was negative and moderate.

The available correlations between the values of the anthropometric parameters and those of the lipid profile indices in the male age group 61-80 years correspond to the changes in the human body with the growth of age: weight reduction and lower accumulation of fat tissue, compared to the age group of 40-60 years old men. The inverse significant correlations between the anthropometric parameters and HbA1c values awakened interest, as shown in Table 5. Similar correlations we have not found in the T2DM female patients aged 40-60 years, except that of BMI and HbA1c. The suggestion should be that as glycated hemoglobin levels increase, the final weight of T2DM patients decreases.

In the age group 61-80 years, female patients, we found two significant correlations (BMI/total cholesterol, and BMI/LDL) only. The correlations were negative, and their correlation strength was low. In general, in the female patients with T2DM, we found less significant correlations than in the male patients (3 vs. 11, respectively). The correlations between the anthropometric parameters and the lipid profile indicators, as well as glycated hemoglobin levels, were more typical for the male T2DM patients. We believe there is an expressed sexual dimorphism in the impact of T2DM. Certain related studies have been conducted by other authors too [13, 14, 15]. Some of them [17, 18, 19] reported results close to ours. Himabindu Y, et al. [11] reported correlations between BMI and VLDL, WHR and HDL-cholesterol.

CONCLUSION

This anthropological study is unique for the Bulgarian population. In the present survey, we found 11 significant correlations between the laboratory values and the anthropometric parameters in male patients and 3 significant correlations in female patients suffering from T2DM. Sexual dimorphism has been found in the impact of T2DM on the human body.

The study showed that correlations of anthropometric parameters predict the prognosis or susceptibility of patients to risky complications of the disease. The multidisciplinary approach to T2DM requires, along with anthropometric parameters, strict monitoring of serum lipids.

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