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An Anthropological Characteristic of the Distribution of Adipose Connective Tissue in Bulgarian Males with Type 2 Diabetes Mellitus

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

Introduction: The complex study of adipose connective tissue in men with type 2 diabetes mellitus (T2DM) is of importance to the clinical course and prognosis of the disease.
The purpose of this study was to investigate the distribution of adipose connective tissue in Bulgarian males with T2DM.
Patients and Methods: Subjects of the research were 73 men suffering from T2DM, with age range 40-60 years. The control group included 40 Bulgarian healthy men in the same age range. Directly measured parameters: body height, body weight, 9 skinfolds (sf) and Bioelectrical Impedance analysis. Calculated indexes: Body mass index (BMI), the ratio sfTrunk/sfLimbs, the ratio skinfolds upper half of body/skinfolds lower half of body, fat mass and subcutaneous fat mass.
Results: Statistically significant differences were found between the means of body weight, sfXrib, sfThigh, BMI, % body fat tissue, visceral fat tissue and fat mass between the diabetic and healthy men. The body composition of diabetic males aged 40-60 years contained a significant larger adipose component than the controls. The visceral adipose tissue which determines the body composition is a reliable indicator of the health risks in diabetic men.
Conclusion: In diabetic males aged 40-60 years the model of subcutaneous adipose tissue

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distribution was predominant in the upper torso region and less in the limbs. The common fat tissue and visceral adipose tissue in male patients suffering from T2DM were significantly more expressed than the healthy controls. These data revealed worse anthropological status of the body composition in male patients with T2DM.

Keywords: Type 2 diabetes mellitus; males; adipose tissue; skinfolds.

1. INTRODUCTION

As of 2015, the estimated 415 million people had diabetes worldwide, with type 2 DM it makes about 90% of the cases. This represents 8.3% of the adult population, with equal rates in both women and men. According to the International Diabetes Federation, the number of diabetes mellitus patients in Europe is expected to increase from 52 millions in 2014 to 68.9 millions by 2035, mostly due to increases in overweight and obesity, unhealthy diet and physical inactivity [1]. According to WHO this is about 10.3% of men and 9.6% of women aged 25 years and over (Today's Market Study of Diabetes, https://www.diabetesexpo.com/europe/). Across Europe, about 1 in 11 adults is affected and this number is set to rise as the population ages. In Bulgaria around 8-9% of the population suffers from this disease.

Most of the researchers are interested in etiology, pathogenesis, clinical course and treatment of the disease. The anthropological status of diabetic patients takes little attention. The fat accumulation in the body of diabetic patients occurs primarily in two locations: in the abdomen (central, abdominal, visceral) and subcutaneously (peripheral). Fat accumulation in the abdominal area is commonly associated with increased risk for T2DM [2,3,4,5]. Not many studies have been performed for the subcutaneous distribution of adipose connective tissue. World literature offers little data on the complex deposition of adipose connective tissue in patients with T2DM.

The purpose of this study was to investigate the distribution of adipose connective tissue in 40-60 years old Bulgarian males with T2DM.

2. SUBJECTS AND METHODS

2.1 Subjects

Subjects of the study were 73 men suffering from T2DM. The disease was diagnosed by a diabetes specialist and recruited from the Clinic of Endocrinology of St.George University Hospital at the Medical University of Plovdiv, Bulgaria. The study period was 2009-2014.

The inclusion criteria were: Bulgarian ethnicity, duration of the disease of no less than five years, compensated diabetes at the time of the study, age range 40-60 years (mean 52.29 ±0.79 SEM). The control group included 40 healthy men in the same age range (mean 50.80 ±1.08 SEM).

The exclusion criteria were: previous or existing metabolic, oncological and other disorders that could compromise the anthropological study.

2.2 Methods

The anthropological methods included:

2.2.1 Directly measured parameters

The body height, body weight and skinfold (sf) thicknesses were measured at 9 locations – sfTriceps, sfBiceps (brachii), sfForearm, sfSubscapular, sfXrib, sfAbdomen, sfSuprailiaca, sfThigh, and sfCalf, using Harpenden Skinfold Calipers (British Indicators Ltd) at standard sites, on the right side of the body.

2.2.2 Bioelectrical impedance analysis (BIA)

Body fat tissue and visceral fat tissue percent (%) - was measured with a Body Composition Monitor Tanita BC-532.

2.2.3 Calculated indexes

Body mass index (BMI); sfTrunk/sfLimbs ratio; skinfolds upper half of body/skinfolds lower half of body ratio; fat mass and subcutaneous fat mass.

2.3 Statistical Analysis

Data were analyzed using statistical software SPSS version 15 (SPSS Inc., Chicago, IL). Parametric statistical methods were relevant. Independent Samples t Test was used to compare the means of two independent anthropological parameters in order to determine whether there was statistical evidence that the means were significantly different. The one-way analysis of variance (ANOVA) was used to determine whether there were any significant differences between the means of three or more independent parameters. P<0.05 (two tailed) was considered statistically significant. We used Pearson's correlation to assess associations between variables, and Pearson's correlations coefficient (PC) was calculated. The values of the coefficient were 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; very high >0.90. P<0.05 (two tailed) was considered statistically significant.

3. RESULTS

In the present study a significant difference was found between the means of **weight**. It was very well expressed, the mean value of the diabetic men was significantly higher than the controls (p<0.001).

No statistical difference was detected among the thicknesses of *sfTriceps (brachii)* between the diabetic males and the controls (p>0.05). The sfTriceps (brachii) of the diabetic men was significantly thicker in comparison to the sfBiceps and sfForearm, but significantly thinner than sfSubscapular, sfXrib, sfSuprailiaca, sfAbdomen and sfThigh in the same group (ANOVA, p<0.001). The correlation analysis revealed many positive correlations between the thicknesses of sfTriceps and other skinfolds, as follows: the correlations were high to sfBiceps (r=0.82); strong to sfForearm and sfCalf (r=0.50-0.70) and moderate to sfSubscapular, sfXrib, sfSuprailiaca, sfAbdomen and sfThigh (r=0.30-0.50).

We didn't found a significant difference among the thicknesses of *sfSubscapular* in the diabetic males in a comparison to the controls (p>0.05). The sfSubscapular of the diabetic men was significantly thicker in comparison to the sfTriceps, sfSuprailiaca, sfBiceps, sfForearm, sfThigh and sfCalf of the same men (ANOVA, p<0.001). At the same time sfSubscapulare was significantly thinner than sfAbdomen (p<0.001). The correlation analysis revealed a lot of positive significant correlations (p<0.05) between the thicknesses of sfSubscapular and other skinfolds, as follows: high correlations to sfXrib and sfSuprailiaca (r=0.70-0.90); strong correlations to sfAbdomen, sfBiceps, sfForearm and sfThigh (r=0.50-0.70); moderate correlations to sfTriceps and sfCalf (r=0.30-0.50).

The thickness of **sfXrib** in the diabetic males was significantly higher than the healthy controls (p<0.05). The sfXrib of the diabetic men was significantly thicker compared to sfTriceps, sfBiceps, sfForearm, sfSuprailiaca, sfThigh and sfCalf of the same men, but it was thinner than sfAbdomen (ANOVA, p<0.001). The correlation analysis revealed many positive significant correlations (p<0.05) between the thicknesses of sfXrib and other skinfolds, as follows: high correlations to sfSubscapular and sfAbdomen (r=0.70-0.90); strong correlations to sfBiceps, sfSuprailiaca and sfForearm (r=0.50-0.70); moderate to sfTriceps, sfThigh and sfCalf (r=0.30-0.50).

It was not found a statistically significant difference among the thicknesses of *sfSuprailiaca* between the diabetic males and healthy controls (p>0.05). The sfSuprailiaca of diabetic men was thicker in comparison to sfTriceps, sfBiceps, sfForearm and sfCalf of the same men, but it was thinner than sfSubscapular, sfXrib and sfAbdomen (ANOVA, p<0.001). The correlation analysis revealed many positive correlations between the thicknesses of sfSuprailiaca and other skinfolds, as follows: high correlations to sfSubscapular and sfAbdomen in the same topographical area (r=0.70-0.90); strong correlations to sfXrib, sfForearm, sfBiceps and sfThigh (r=0.50-0.70); moderate - to sfTriceps and sfCalf.

No statistically significant difference was found among the thicknesses of *sfAbdomen* between the diabetic males and healthy controls (p>0.05). It was significantly the thickest skinfold among all studied skinfolds in the diabetic men (ANOVA, p<0.001). The correlation analysis revealed many positive correlations between thicknesses of sfAbdomen and other skinfolds (p<0.05), as follows: high correlation to sfSuprailiaca and sfXrib (r=0.70-0.90); strong - to sfForearm and sfSubscapular (r=0.50-0.70); moderate - to sfBiceps, sfTriceps, sfThigh and sfCalf.

The thickness of *sfBiceps* in the diabetic males was higher than the controls, but the difference was not of a statistical significance (p>0.05). SfBiceps and sfForearm were significantly the thinnest skinfolds in comparison to other studied skinfolds (ANOVA, p<0.05). The mean value of sfForearm was higher compared to sfBiceps, but without significant difference (p>0.05). The correlation analysis revealed many positive significant correlations to the thicknesses of the other studied skinfolds (p<0.05). The correlations were high to sfForearm and sfTriceps (r=0.70-0.90); strong - to sfXrib, sfSubscapular, sfSuprailiaca and sfThigh (r=0.50-0.70); moderate to sfAbdomen and sfCalf.

There was not found a significant difference among the thicknesses of *sfForearm* between the diabetic males and healthy controls (p>0.05). The sfForearm was significantly thinner among the other studied skinfolds (ANOVA, p<0.05), except sfBiceps. The correlation analysis revealed several positive significant correlations of the sfForearm thickness to the other skinfolds (p<0.001). The correlations were high to sfBiceps (r=0.79); strong to sfTriceps, sfSuprailiaca, sfXrib, sfAbdomen, sfSubscapular and sfThigh (r=0.50-0.70); moderate to sfCalf.

The thickness of **sfThigh** in the diabetic males was significantly lower than the controls (p<0.05). It was significantly thicker in comparison to the sfTriceps, sfBiceps, sfForearm and sfCalf, but significantly thinner than sfSubscapular, sfXrib and sfAbdomen (ANOVA, p<0.05). The correlation analysis revealed many positive correlations between the thickness of sfThigh and other studied skinfolds (p<0.05). The correlations were strong – to sfSubscapular, sfSuprailiaca, sfBiceps, sfForearm and sfCalf (r=0.50-0.70); moderate – to sfTriceps, sfXrib and sfAbdomen.

It was not found a statistically significant difference among the thicknesses of *sfCalf* between the diabetic males and healthy controls (p>0.05). It was significantly thicker than sfBiceps and sfForearm, but it was significantly thinner than sfSubscapular, sfXrib, sfAbdomen and sfThigh (ANOVA, p<0.001). The correlation analysis revealed several positive correlations between the sfCalf thickness and other skinfolds (p<0.05). The correlations were strong to sfTriceps and sfThigh (r=0.50-0.70); moderate to other studied skinfolds. All of the correlations of studied skinfolds were very well expressed (p<0.001).

The accumulation of subcutaneous adipose tissue in patients with Type 2 diabetes mellitus was higher in the torso, than in the limbs. In contrast, the controls exhibited an opposite distribution. In men with Type 2 diabetes mellitus the accumulation of subcutaneous adipose tissue was larger in the upper half of the body, than in the lower half. The controls exhibited the opposite distribution.

Table 1. Anthropological parameters of Bulgarian males aged 40-60 years with Type 2 diabetes mellitus compared to healthy controls at the same age

Parameters	Type 2 diabetes mellitus				Controls				P
	N	Mean	SEM	SD	N	Mean	SEM	SD	
Age (years)	73	52.29	0.79	5.48	40	50.80	1.08	6.39	>0.05
Height (cm)	73	170.83	0.94	6.53	40	172.47	1.00	5.91	>0.05
Weight (kg)	73	84.47	1.38	9.49	40	78.47	1.78	10.53	**<0.001***
sf Triceps (mm)	73	10.91	0.6	4.04	40	11.20	0.96	5.70	>0.05
sfSubscapular (mm)	73	23.85	1.42	9.62	40	20.24	1.51	8.94	>0.05
sf X rib (mm)	73	22.92	1.26	8.52	40	16.98	1.34	7.95	**<0.05***
sfSuprailiaca (mm)	73	17.83	1.37	9.32	40	20.86	1.60	9.48	>0.05
sfAbdomen (mm)	73	28.68	1.70	11.51	40	33.21	2.10	12.45	>0.05
sfBiceps (mm)	73	7.71	0.47	3.21	40	6.57	0.53	3.16	>0.05
sfForearm (mm)	73	8.20	0.51	3.47	40	7.48	0.60	3.48	>0.05
sfThigh (mm)	73	15.08	1.04	7.07	40	20.21	1.89	11.18	**<0.05***
sfCalf (mm)	73	10.51	0.86	5.87	40	11.39	0.91	5.38	>0.05

*sf = skinfold; * = significant*

Table 2. Anthropological indexes of Bulgarian males aged 40-60 years with Type 2 diabetes mellitus compared to healthy controls at the same age

	Type 2 diabetes mellitus	Controls
sf trunk/sf limbs	1.79	1.67
sf upper half of the body/ sf lower half of the body	1.07	0.75

sf = skinfold

Table 3. Body composition of males aged 40-60 years with Type 2 diabetes mellitus compared to healthy controls at the same age

Parameters	Type 2 diabetes mellitus				Controls				P
	N	Mean	SEM	SD	N	Mean	SEM	SD	
BMI	73	29.04	0.49	3.34	40	26.34	0.51	3.01	**<0.001***
% body fat tissue	73	28.71	1.11	5.97	40	24.75	0.86	5.12	**<0.05***
Visceral fat tissue (kg)	73	13.79	0.72	3.87	40	11.00	0.55	3.25	**<0.05***
Fat mass (kg)	73	24.02	1.30	6.88	40	19.83	1.07	6.35	**<0.05***
Subcutaneous fat mass (kg)	73	15.75	0.26	2.85	40	15.65	0.45	2.85	> 0.05

*BMI = Body mass index; * = significant*

Body composition parameters' results, investigated by Bioelectrical Impedance analysis: The BMI of the diabetic men was significantly higher than that of the healthy controls (p<0.001). The body composition of diabetic males demonstrated a larger amount of adipose tissue than the controls. The values of the % body fat tissue of diabetic men were significantly higher than the controls (p<0.05). The values of visceral fat tissue were significantly higher in the diabetic men, than in the controls (p<0.05). The mean value of fat mass in the diabetic patients was significantly higher than in the healthy controls (p<0.05). It wasn't detected any significant difference between the means of subcutaneous fat tissue in the compared groups (p>0.05).

4. DISCUSSION

This study is a part of a larger survey involving T2DM male patients 40-60 years, 60.01-80 years, as well as female patients from both age groups in Bulgaria. The anthropological parameters provided a large data base, specific for Bulgarian population. Using the anthropological parameters it will be possible to calculate the components of the somatotype by Heath and Carter method of somatotyping, as well as other indexes. They will reveal the anthropological status of Bulgarian patients suffering from T2DM.

It has been found that abdominal obesity, also known as central or visceral obesity, was more closely related to T2DM than the general obesity. The visceral fat was more metabolically active and produced more insulin resistance [6,7,8,9]. Similar data were observed in Bulgarian men aged 40-60, with a diagnosis T2DM. The values of the "% fat mass", "visceral adipose tissue" and "adipose tissue-FM" were statistically higher in men with T2DM than in the healthy controls. It was considered that this type of obesity increased the risk of pathological changes in other systems, along with the progress of T2DM [10,11,12,13].

Attention should be paid to the distribution of subcutaneous adipose tissue in patients with T2DM. It was found that in patients with T2DM the accumulation of subcutaneous adipose tissue was primarily in torso and less in the limbs. Moreover, the accumulation of adipose tissue consisted predominantly in the upper body as compared to the lower, the so-called "apple shaped". These patients have a worse anthropological status, that would lead to more severe clinical course of the disease [14,15,16, 17]. In controls the deposition of adipose tissue was predominantly in the limbs and mainly in the lower part of the body, the so-called "pear shaped".

This study revealed a lot of positive correlations among the skinfolds thicknesses. An interest induced the data indicating that skinfolds from topographically neighboring areas were in a stronger correlation with each other, than did skin folds from distant topographical areas. Some authors have reported the importance of adipose tissue accumulation in the anterior abdominal wall [18]. In this investigation the sfAbdomen was the thickest, compared to the other studied skinfolds in patients with T2DM, but it was not detected a significant difference compared to the thickness of the corresponding skinfold in the controls. Considerably greater thickness was measured in some skinfolds in the control group than in the corresponding skinfolds in patients with T2DM, as happened with sfTriceps, sfThigh and sfCalf, etc. These facts confirmed the greater importance of the accumulation of visceral fat than of subcutaneous fat for the prognosis of disease [19,20,21].

The levels of total weight and BMI were higher in diabetic men than the controls (p<0.001). They showed that men with T2DM were overweight and fattened compared to healthy controls, but these values had less importance for the prognosis of disease compared with the above-described parameters [22,23,24]. More original data about the anthropological status of Bulgarian patients with T2DM were published in other our publications [25].

5. CONCLUSION

The body composition of diabetic males aged 40-60 years contained a larger common adipose component than the controls. The values of weight and BMI in the diabetic patients were significantly higher than the controls.

The subcutaneous adipose tissue was accumulated mostly in the upper part of the torso in the diabetic men, opposite - in the group of healthy men (controls), the subcutaneous adipose tissue was accumulated mostly on the lower part of the body. In the group of diabetic men the subcutaneous adipose tissue was accumulated predominant in the torso, than in the peripheral part of the body (arms, thighs and lower legs). The thickness of sfXrib in the diabetic males was significantly higher than in the controls, but sf Calf was significantly thinner than the controls.

The bioelectrical impedance analysis of the body composition demonstrated that the common fat tissue and visceral adipose tissue in male patients suffering from T2DM was significantly more expressed than the healthy controls. These data revealed a worse anthropological status of the body composition in male patients with T2DM.

The complex study including anthropometry of adipose tissue in men suffering from T2DM would support the evaluation of the prognosis of the disease.

CONSENT

Informed consents were taken from all patients involved in the study.

ETHICAL APPROVAL

An ethical approval was taken for this study from the Ethics committee by Medical University-Plovdiv, Bulgaria.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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