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

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The purpose of this study was to investigate the distribution of adipose connective tissue in Bulgarian females with T2DM. Subjects: 120 women suffering from T2DM, with age range 61-80 years. Control group: 40 Bulgarian women at the same age range. Measured parameters: height, weight, 9 skinfolds (sf) - sfTriceps, sfBiceps brachii, sfForearm, sfSubscapular, sfXrib, sfAbdomen, sfSuprailiaca, sfThigh, and sfCalf; Bioelectrical Impedance analysis - % body fat tissue and visceral fat tissue. Calculated indexes: BMI, ratio sfTrunk/sfLimbs, ratio skin folds upper half of body/skin folds lower half of body, fat mass and subcutaneous fat mass. Statistically significant differences were found between the means of weight, sfTriceps, sfSuprailiaca, sfAbdomen, sfThigh, sfCalf and subcutaneous fat mass between the diabetic and healthy women. In diabetic females aged 61-80 years the model of subcutaneous adipose tissue distribution was mostly in the upper torso region and less in the limbs. In controls the accumulation of adipose tissue was mostly in the limbs and in the lower part of the body.

Key words: T2DM, females, adipose tissue, distribution

Introduction

In the recent years, Type 2 diabetes mellitus (T2DM) is gaining more signs of social problem due to the rapidly growing number of people affected by the disease worldwide [13]. 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, according to the International Diabetes Federation. Across Europe, around 1 in 11 adults is affected and this number is set to rise as the population ages. It's about 10.3% of men and 9.6% of women aged 25 years and over. In Bulgaria around 8-9% of the population suffers from the disease.

The most researchers are interested in etiology, pathogenesis, clinical course and treatment of the disease. The anthropological status of diabetic patients enjoys 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, 6, 12, 19]. Not much research has been performed on the subcutaneous distribution of adipose tissue. World literature offers little data on the complex deposition of adipose tissue in patients with T2DM. The purpose of this study was to investigate the distribution of adipose tissue in 61-80 years old Bulgarian females with T2DM.

Matherials and Methods

Subjects of the study were 120 women suffering from T2DM. They were 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 inclusion criteria were: Bulgarian ethnicity, duration of the disease of not less five years, compensated diabetes at the time of the study, age range 61-80 years (mean 68.95 ±0.57 SEM). The control group included 40 women at the same age range (mean 69.85 ±0.95 SEM). An ethical approval was taken for this study. Informed consents were taken from all patients involved in the study.

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

Directly measured parameters: The body height and body weight, 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.

Bioelectrical Impedance analysis (BIA): body fat tissue and visceral fat tissue percent (%) - was measured with a Body Composition Monitor Tanita. BC-532.

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.

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 anthropologic 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 value of the 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; very high >0.90. $P<0.05$ (two tailed) was considered statistically significant.

Results

In the present study significant differences were found between the means of **weight**- the mean value of the diabetic females was higher than the controls ($p<0.05$) and between the means of **height** – the mean value of the diabetic women was higher than the controls ($p<0.001$) **(Table 1)**.

The thickness of **sfTriceps** (brachii) of the diabetic females was significantly lower than the controls ($p<0.05$). The former, however was significantly thicker in comparison to sfBiceps, sfForearm and sfSuprailiaca of diabetic females, but significantly thinner than sfSubscapular, sfXrib and sfAbdomen (ANOVA, $p<0.05$). The correlation

Table 1. Anthropological parameters of elderly Bulgarian females aged 61-80 years with Type 2 diabetes mellitus compared to healthy controls at the same age

	Type 2 diabetes mellitus				Controls				
Parameters	N	Mean	SEM	SD	N	Mean	SEM	SD	P
Age (years)	120	68.95	0.57	5.80	40	69.85	0.95	5.88	>0.05
Height (cm)	120	156.94	0.45	4.66	40	153.93	0.89	5.51	**<0.001***
Weight (kg)	120	75.79	1.13	11.54	40	71.11	2.05	12.64	**<0.05***
sf Triceps (mm)	120	21.88	0.98	8.94	40	25.89	1.46	9.22	**<0.05***
sf Subscapular (mm)	120	24.82	1.20	10.18	40	27.22	1.85	11.38	>0.05
sf X rib (mm)	120	25.36	0.94	7.95	40	23.12	1.51	9.33	>0.05
sfSuprailiaca (mm)	120	18.59	0.78	6.60	40	22.01	1.51	9.28	<**0.05***
sfAbdomen (mm)	120	28.89	1.03	8.80	40	37.22	1.80	11.08	**<0.001***
sfBiceps (mm)	120	12.12	0.59	4.98	40	13.15	0.86	5.29	>0.05
sfForearm (mm)	120	10.71	0.42	3.60	40	10.38	0.66	4.07	>0.05
sfThigh (mm)	120	21.73	1.45	12.29	40	38.15	1.82	11.19	**<0.001***
sfCalf (mm)	120	19.66	1.08	9.18	40	26.79	1.24	7.65	**<0.001***

sf = skinfold

analysis revealed positive correlations (p<0.05) between the thicknesses of sfTriceps and other skinfolds, as follows: the correlations were high to sfForearm, sfSubscapular and sfXrib (r = 0.70-0.90); strong - to sfBiceps and sfAbdomen (r = 0.50-0.70) and moderate to sfSuprailiaca (r = 0.48).

The thickness of sfSubscapular in the diabetic females was not significantly different in comparison to the controls (p>0.05). The sfSubscapular of diabetic women was significantly thicker in comparison to sfTriceps, sfBiceps, sfForearm, sfSuprailiaca and sfCalf of the same women (ANOVA, p<0.05). The sfSubscapulare was significantly thinner than sfAbdomen.The correlation analysis revealed positive significant correlations (p<0.05) between the thicknesses of sfSubscapular and other skinfolds, as follows: high correlations to sfForearm, sfTriceps, sfXrib, sfSuprailiaca (r = 0.70-0.90); strong correlations to sfBiceps, sfAbdomen, and sfThigh (r = 0.50-0.70).

The thickness of sfXrib in the diabetic females was not significantly higher than the healthy controls (p>0.05). The sfXrib of diabetic women was significantly thicker compared to sfTriceps, sfBiceps, sfForearm, sfSuprailiaca, sfThigh and sfCalf of the same women, but it was thinner than sfAbdomen (ANOVA, p<0.05). The correlation analysis revealed significant positive correlations (p<0.05) between the thicknesses of sfXrib and other skinfolds, as follows: high correlations to sfTriceps, sfForearm and sfSubscapular (r = 0.70-0.90); strong correlations to sfBiceps, sfAbdomen, sfSuprailiaca and sfThigh (r = 0.50-0.70); moderate to sfCalf (r = 0.41).

A statistically significant difference was found in the thicknesses of **sfSuprailiaca** between the diabetic females and healthy controls (p<0.05). It was thicker in the healthy controls than in the diabetic females. The sfSuprailiaca of diabetic women was thicker in comparison to sfBiceps and sfForearm of the same women, but it was thinner than sfTriceps, sfSubscapular, sfXrib and sfAbdomen (ANOVA, p<0.001). The correlation analysis revealed positive correlations between the thicknesses of sfSuprailiaca and other skinfolds, as follows: high correlations to sfSubscapular and sfAbdomen in the same topographical area (r = 0.74-0.79); strong correlations to sfXrib, sfForearm and sfBiceps (r = 0.50-0.70); moderate - to sfThigh and sfTriceps.

A statistically significant difference was found in the thicknesses of **sfAbdomen** between the diabetic females and healthy controls ($p<0.001$). It was thicker in the healthy controls than in the diabetic females. The sfAbdomen was significantly the thickest skinfold among all studied skinfolds in the diabetic women. (ANOVA, $p<0.05$). The correlation analysis revealed positive correlations between the thicknesses of sfAbdomen and other skinfolds ($p<0.05$), as follows: high correlation to sfSuprailiaca and sfBiceps ($r = 0.70$-0.90); strong - to sfTriceps, sfForearm, sfXrib, sfSubscapular and sfThigh ($r = 0.50$-0.70); moderate - to sfCalf.

The thickness of sfBiceps in the diabetic females was lower than the controls, but the difference did not statistical significance ($p>0.05$). The sfBiceps was thicker than the sfForearm of diabetic women, however it was thinner than the other skinfolds of the same women (ANOVA, $p<0.05$). The correlation analysis revealed positive significant correlations to the thicknesses of the studied skinfolds ($P<0.05$). The correlations were high to sfForearm, sfAbdomen and sfThigh ($r = 0.70$-0.90); strong - to sfXrib, sfTriceps, sfSubscapular, sfSuprailiaca and sfCalf ($r = 0.50$-0.70).

The thickness of **sfThigh** in the diabetic females was significantly lower than the controls ($p<0.001$). It was thicker in comparison to the sfForearm and sfBiceps, but thinner than sfAbdomen and sfXrib (ANOVA, $p<0.05$). The correlation analysis revealed positive correlations between the thickness of **sfThigh** to the other studied skinfolds ($P<0.05$). The correlations were high to sfBiceps ($r = 0.73$) and sfCalf ($r = 0.84$); strong - to sfTriceps, sfForearm, sfXrib, sfSubscapular, sfAbdomen ($r = 0.50$-0.70); moderate – to sfSuprailiaca.

There was not found a significant difference in the thicknesses of sfForearm between diabetic females and healthy controls ($p>0.05$). The sfForearm was the thinnest among the other studied skinfolds (ANOVA, $p<0.05$). The correlation analysis revealed several positive significant correlations of the sfForearm thickness to the other skinfolds ($p<0.001$), except sfCalf. The correlations were high to sfBiceps, sfTriceps, sfSuprailiaca and sfXrib ($r = 0.70$-0.90); strong to sfAbdomen, sfSubscapular and sfThigh ($r = 0.50$-0.70).

The thickness of **sfCalf** in the diabetic females was significantly lower than in the healthy controls ($p<0.001$). It was thicker than sfForearm and sfBiceps, but it was thinner than sfSubscapular, sfXrib and sfAbdomen (ANOVA, $p<0.05$). The correlation analysis revealed positive correlations of the sfCalf thickness to the other skinfolds ($p<0.05$). The correlation was strong to sfBiceps ($r = 0.55$); moderate to sfXrib and sfAbdomen ($r = 0.30$-0.50).

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 the opposite distribution. In women 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 2).**

Body composition parameters' results, investigated by Bioelectrical Impedance analysis revealed that the values of the **subcutaneous fat tissue** in the controls were significantly higher compared to those of diabetic women ($p<0.001$).

We didn't detect any significant differences in other body composition parameters: % body fat tissue, visceral fat tissue and fat mass ($p>0.05$) between the diabetic females and healthy controls. It wasn't detected any significant difference in the BMI-indexes between both groups too ($p>0.05$). **(Table 3)**

The data concerning the fat tissue components determinates the body composition of diabetic patients as an important parameter regarding the prognosis of the T2DM.

Table 2. Anthropological indices of elderly Bulgarian females aged 61-80 years with Type 2 diabetes mellitus compared to healthy controls at the same age

	Type 2 diabetes mellitus	Controls
sf trunk/sf limbs	1,22	0,96
sf upper half of the body/ sf lower half of the body	1,11	0,79

sf = skinfold;

Table 3. Body composition of elderly females aged 61-80 years with Type 2 diabetes mellitus compared to healthy controls at the same age

	Type 2 diabetes mellitus				Controls				
Parameters	N	Mean	SEM	SD	N	Mean	SEM	SD	P
BMI	120	30.77	0.44	4.55	40	30	0.80	4.91	>0.05
% body fat tissue	120	41.34	0.86	5.4	40	40.02	1.18	7.26	>0.05
Visceral fat tissue (kg)	120	11.74	0.38	2.35	40	11.4	0.49	3.01	>0.05
Fat mass (kg)	120	31.87	1.36	9.87	40	29.87	1.66	10.48	>0.05
Subcutaneous fat mass (kg)	92	14.44	0.26	2.85	40	17.56	0.45	2.85	**<0.001***

BMI = Body mass index

Discussion

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 (3, 4, 16, 18). Similar data we observed in Bulgarian women aged 40-60, with a diagnosis T2DM. The means of the % body fat tissue, visceral fat tissue and fat tissue were statistically higher in these women with T2DM than in the healthy controls.

It was not found any significant differences in the mentioned parameters between the age group 61-80 years with T2DM and the healthy controls, except the accumulation of subcutaneous fat tissue. It was detected a tendency only, that the values of the mentioned parameters were higher in the diabetic group than the healthy controls ($p>0.05$). It can be explained with the aging of the body in this age group.

Attention should be paid to the distribution of subcutaneous adipose tissue in female patients with T2DM. It was found that in patients with T2DM the accumulation of subcutaneous adipose tissue was mostly in torso and less so in the limbs. Moreover, the accumulation of adipose tissue consisted predominantly in the upper part of the body compared to the lower, the so-called "apple shaped". These patients have a worse anthropological status, which would lead to a more severe clinical course of the disease [5, 20, 11, 14]. It was considered that this type of obesity increased the risk of pathological changes in other systems, along with the progress of T2DM [10, 9, 8].

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". An interest induced that skinfolds from topographically neighboring areas were in a stronger correlation with each other than skin folds from distant topographical areas. Some authors have reported the importance of adipose tissue accumulation in the anterior abdominal wall [15]. In this investigation the sfAbdomen was the thickest, compared to the other studied skinfolds in patients with T2DM and the thickness was significant greater in the controls than in the diabetic group. Moreover, significantly greater thickness was measured in some skinfolds in the control group than in the corresponding skinfolds in patients with T2DM: sfTriceps, sfSuprailiaca, sfAbdomen, sfThigh and sfCalf. These facts confirmed the greater importance of the accumulation of visceral than of subcutaneous fat for the course of the disease [7].

The levels of total body weight were higher in diabetic women. They showed that women with T2DM were overweight and fattened compared to healthy controls, but these values had less importance to the course of the disease compared with the above-described parameters [17]. More original data about the anthropological status of Bulgarian patients with T2DM were published in other our publications [1].

This study is part of a larger survey including female patients 40-60 and 61-80 years as well as male 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.

Conclusion

The body composition of diabetic females aged 61-80 years contained a larger common adipose component than the controls. The study revealed that the accumulation of subcutaneous fat tissue was significant more in the body of healthy controls than the patients ($p<0.001$). The subcutaneous adipose tissue was accumulated mostly on the upper part of the torso than the lower and predominant in torso than in the limbs.

In the group of healthy women (controls) the subcutaneous adipose tissue was accumulated mostly in the peripheral part of the body (arms, thighs and lower legs) and mostly in the lower half of the body than in the upper half of the body.

The bioelectrical impedance analysis of the body composition in this age group didn't demonstrate any significant differences between the female patients suffering from T2DM and healthy women.

The complex study including anthropometry of adipose tissue in women suffering from T2DM would support the evaluation of the clinical course, treatment and prognosis of the disease.

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