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Original Article

Assessment of Body Composition of Adult Bulgarian Patients with Type 1 Diabetes Mellitus by Bioelectrical Impedance Analysis

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Abstract

Aim: The aim of this study was to investigate how type 1 diabetes mellitus affects adult Bulgarians' body composition.

Materials and methods: One hundred and twenty patients (60 men and 60 women) aged 20 to 40 years, as well as 80 healthy men and women, were enrolled in the study. Bioelectrical impedance indicators: body fat tissue percentage (%BFT), total body water percentage (%TBW), visceral fat tissue (VFT), muscle mass (MM), and bone mass (BM) and derived indicators: total fat mass (TFM), active body mass (ABM), active body mass percentage (%ABM), ABM index (ABMI), and BMI were defined.

Results: The mean values of %BFT, VFT, TFM, and BMI were significantly higher in the female patients with type 1 diabetes mellitus while the mean values of %TBW, %ABM, and ABMI were significantly higher in healthy women. The mean values of VFM and ABMI were significantly higher in the male patients with type 1 diabetes mellitus while the mean values of MM and ABM were significantly higher in healthy men. Bioelectrical impedance analysis of the body composition in Bulgarian female patients exhibited an increase in the accumulation of adipose connective tissue both generally and viscerally. The total body water percentage in the female patients was significantly lower than in the healthy controls. The body composition of Bulgarian male patients exhibited an increase in the accumulation of visceral adipose tissue only. The skeletal muscle tissue in male patients exhibited a decrease in comparison to healthy men.

Conclusion: We believe that these findings are consequence of the impact of type 1 diabetes mellitus on the body composition in Bulgarian patients.

Keywords

anthropology, BIA, body composition, Bulgarians, T1DM

INTRODUCTION

Diabetes mellitus is a metabolic disorder that affects the body's ability to process energy. It is characterized by high blood sugar levels due to issues with insulin production, insulin action, or both. Type 1 diabetes mellitus (T1DM) is an autoimmune disorder that damages the insulin-producing cells in the pancreas, leading to a lack of insulin. Long-term high blood sugar levels can harm various organs such as the eyes, kidneys, nerves, heart, and blood vessels.[1,2]

The rapid increase in the number of people affected by diabetes mellitus worldwide has made it a significant so-

cial issue. An estimated 537 million individuals, or 8.8% of the adult population, suffer from the disease globally. In Bulgaria, approximately 6%–8% of the population suffer from diabetes mellitus. According to the IDF Diabetes Atlas 2021, this number will reach 643 million by 2030 and 783 million by 2045. Type 2 diabetes refers to around 90% of cases, while T1DM constitutes 5% to 15% of diabetic patients and often affects children.[3] The distribution in both sexes is similar.

Most researchers have been interested in the study of etiology, pathogenesis, proper treatment, and accurate prognosis of this disease. The anthropological status of diabetic patients is not in the focus of researchers' interest. Modern anthropology uses a bioelectrical impedance method to determine the changes in body composition caused by various diseases. This study is original for Bulgarian patients with type 1 diabetes mellitus. The lack of relevant data in this scientific field has provoked our interest in studying the changes of body composition of adult patients with T1DM in the age range of 20 to 40 years.

AIM

The present study aimed to explore the body composition changes in adult Bulgarians due to the impact of type 1 diabetes mellitus.

MATERIALS AND METHODS

Patients

One hundred and twenty subjects (60 male and 60 female patients) aged 20 to 40 years were enrolled in the study. The mean age was 29.09±1.29 years of the female patients and 30.08±1.16 years of the male patients. The research was conducted in the Clinic of Endocrinology and Metabolic Diseases at St George University Hospital in Plovdiv, Bulgaria between 2019 and 2022.

The inclusion criteria were Bulgarian ethnicity, type 1 diabetes mellitus, duration of the disease of no less than one year, and clinically controlled diabetes at the time of the study.

The study excluded individuals who had previous or current metabolic, oncological, or other disorders that could affect the study's results. These included thyroid-related diseases, adrenal gland-related diseases, carcinoma, type 2 diabetes mellitus, pregnant and breastfeeding women, heart, respiratory, renal, or hepatic failure, proliferative retinopathy, diabetic macroangiopathy, acute decompensation of metabolic disease during the study, hormonal (contraceptive) therapy within 3 months prior to the study, and treatment of chronic coexisting conditions that could affect hormonal markers. The control group included 40 healthy Bulgarian women and 40 healthy Bulgarian men aged 20 to 40 years. The mean age of the women was 30±0.47 years and 31.01±0.31 years for the men.

The study was approved by the Ethics Committee at the Medical University of Plovdiv (No. 4/08.06.2022). All participants provided written informed consent following the principles of the 1964 Declaration of Helsinki.

Methods

The Tanita (BC-532) body composition analyzer was used in the study. Two groups of indicators were researched.

Directly measured indicators:

1. Body fat tissue percentage (%BFT)
2. Total body water percentage (%TBW)
3. Visceral fat tissue (VFT)
4. Muscle mass (MM)
5. Bone mass (BM)

Derived indicators:

1. Total fat mass (TFM) (kg) TFM = (body weight*%BFT)/100
2. Active body mass (ABM) (kg) ABM = body weight – TFM
3. % Active body mass (%ABM) %ABM = (ABM*100)/weight
4. ABM index (ABMI) (%) ABMI = (height (m)/ABM)*100

Additional indicators:

Body mass index (BMI)BMI = body weight (kg)/height $(m)^2$

Statistical analysis

The obtained data were analyzed using SPSS v. 23 (SPSS Inc., Chicago, IL) and Instat v. 2.02. The Student *t*-test was used to compare the means of the two groups. Statistical significance was considered high at $p \leq 0.001$, moderate at $p \leq 0.01$, low at $p \leq 0.05$ and no significance at $p > 0.05$.

RESULTS

Body composition of female patients with type 1 diabetes mellitus and healthy controls

The mean values of % body fat tissue (%BFT) and visceral fat tissue (VFT) were significantly higher in the female patients than in healthy women ($p<0.05$; $p<0.001$). The mean value of % total body water was significantly higher in the healthy women ($p=0.01$). **(Table 1)**

The mean value of total fat mass (TFM) was significantly higher in female patients than in healthy controls ($p<0.05$). The mean values of % active body mass (%ABM) and ac-

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tive body mass index (ABMI) were significantly higher in healthy controls than in female patients ($p<0.05$; $p<0.01$). The mean value of BMI was significantly higher in female patients than in healthy women too ($p<0.001$). **(Table 2)**

The mean value of visceral fat tissue (VFT) was significantly higher in male patients than in healthy men ($p<0.001$). The mean value of muscle mass (MM) was significantly higher in healthy men than in male patients ($p<0.001$). **(Table 3)**

The mean value of active body mass (ABM) was higher in healthy controls than in male patients ($p<0.01$). The mean value of active body mass index (ABMI) was significantly higher in male patients than in healthy men ($p<0.01$). **(Table 4)**

Table 1. Women: bioelectrical impedance analysis

Female patients with type 1 diabetes mellitus						Healthy women (controls)					
Indicators	**Min**	**Max**	**Mean**	**SE**	**SD**	**Min**	**Max**	**Mean**	**SE**	**SD**	***P***
%BFT	11.10	45.50	28.20	1.74	9.52	7.00	40.30	23.98	1.22	7.49	<0.05
%TBW	39.50	61.90	50.26	1.11	6.07	43.10	64.00	53.23	0.76	4.69	0.01
VFT	1.00	10.00	3.30	0.46	2.49	1.00	6.00	1.50	0.18	1.11	<0.001
MM	34.90	50.30	41.12	0.64	3.45	28.20	50.50	40.82	0.62	3.79	>0.05
BM	1.90	2.70	2.20	0.03	0.18	1.90	5.00	2.34	0.11	0.66	>0.05

Table 2. Women: derived indicators

Female patients with type 1 diabetes mellitus						Healthy women (controls)					
Indicators	**Min**	**Max**	**Mean**	**SE**	**SD**	**Min**	**Max**	**Mean**	**SE**	**SD**	***P***
TFM	5.54	44.23	18.97	1.64	9.45	3.00	33.69	14.56	1.09	6.64	<0.05
ABM	36.85	52.97	43.43	0.61	3.53	36.52	53.20	43.22	0.56	3.39	>0.05
%ABM	54.50	88.90	71.18	1.64	9.40	59.70	93.00	75.92	1.24	7.57	<0.05
ABMI	3.31	4.25	3.71	0.04	0.22	3.25	4.42	3.85	0.04	0.23	<0.01
BMI	17.91	32.13	23.80	0.72	3.97	1.66	31.70	20.94	0.49	2.93	<0.001

Table 3. Men: bioelectrical impedance analysis

Male patients with type 1 Diabetes mellitus						Healthy men (controls)					
Indicators	**Min**	**Max**	**Mean**	**SE**	**SD**	**Min**	**Max**	**Mean**	**SE**	**SD**	***P***
% BFT	5.00	31.60	17.88	1.45	8.18	9.30	30.00	15.95	0.76	4.73	>0.05
%TBW	6.90	73.30	56.22	2.24	12.69	49.10	68.80	59.17	0.66	4.14	>0.05
VFT	1.00	11.00	5.18	0.60	3.46	1.00	10.00	2.62	0.32	2.02	<0.001
MM	38.70	68.60	55.18	1.25	7.21	48.90	77.00	60.42	0.90	5.91	<0.001
BM	2.10	5.00	3.00	0.09	0.50	2.30	4.00	3.14	0.05	0.33	>0.05

Table 4. Men: derived indicators

Male patients with type 1 diabetes mellitus						Healthy men (controls)					
Indicators	**Min**	**Max**	**Mean**	**SE**	**SD**	**Min**	**Max**	**Mean**	**SE**	**SD**	***P***
TFM	2.75	34.85	14.98	1.62	9.42	5.79	34.68	12.47	0.87	5.50	>0.05
ABM	40.82	76.15	59.24	1.37	7.96	51.46	80.92	63.49	0.92	5.83	<0.01
%ABM	68.40	95.00	81.39	1.45	8.48	70.00	90.70	84.11	0.74	4.68	>0.05
ABMI	2.34	3.94	2.99	0.06	0.34	2.31	3.31	2.82	0.03	0.20	<0.01
BMI	15.75	31.63	23.51	0.72	4.11	19.71	33.09	24.06	0.46	2.88	>0.05

DISCUSSION

The human body accumulates fat tissue mostly in two places: in the abdominal cavity (central, abdominal, or visceral) and under the skin (subcutaneously, peripherally). Abdominal fat accumulation is more closely associated with type 2 diabetes mellitus than subcutaneous fat deposition. Visceral fat tissue is more active metabolically, induces insulin resistance and disturbance of glucose homeostasis. The distribution of adipose tissue in patients suffering from type 1 DM has not been examined in detail. Most researchers have investigated the body composition changes in patients with type 2 DM.[4-6] A similar survey was conducted in Bulgaria as well.[7,8] Type 1 DM constitutes approximately 10% of all patients with DM. Many scientists have been focused in researching changes of body constitution in children with type 1 DM.[9-15] Study of changes in body constitution of patients suffering from type 1 DM in the age range 20-40 years has been out of the focus of most researchers. These facts have attracted our interest in this less-explored scientific field.

Our research team found significantly higher mean values of %BFT in female patients than in healthy women. This indicator presents the relative percentage of fat tissue in the human body. More important finding was that the mean value of VFT in female patients was significantly higher than in healthy women ($p<0.001$). This fact postulates that the fat tissue is predominantly deposited in the abdominal cavity of diabetic women. Similar results were reported by Parente et al. and Dube et al.[16,17] Momesso et al. and Falkowski et al. reported that the central fat deposition in young non-obese DM1 women was related to metabolic syndrome and insulin resistance.[18,19] The derived indicator TFM was also significantly higher in female patients than in healthy controls. The mean value of BMI of the female patients was significantly higher than in healthy women, too ($p<0.001$). A very interesting finding was that the mean value of BMI both in female patients (23.80) and in healthy women (20.94) did not show overweight or obesity according to the classification of the World Health Organization, 2021.[20] We did not detect any significant differences of indicators muscle mass (MM), bone mass (BM), and active body mass (ABM) between diabetic women and healthy controls. The disease has not caused a negative effect on the development of skeletal muscles and bones in women with type 1 DM. The mean value of total body water (TBW) in female patients was significantly lower than in healthy women. This finding is related to the relative dehydration, which is a consequence of the impact of type 1 DM.

We found a significantly higher mean values of VFT in male patients in comparison to healthy men. Other indicators characterizing the distribution of adipose connective tissue such as %BF, TFM, and BMI did not show any significant differences between male patients and healthy men. The men of both groups were not overweight or obese, and the mean value of BMI was in the reference range according to WHO (18.50-24.99).[20] The impact of type 1 DM on the adipose connective tissue was focused on its accumulation in the abdominal cavity of male patients.

Our survey revealed a reduction of skeletal muscles in male patients. The mean values of both indicators MM and ABM (known as fat-free or lean mass) were significantly lower in male patients. Similar results were reported by Abd El Dayem et al. and Musulin et al.[21,22] Type 1 diabetes did not appear to have a similar effect on female patients. We did not detect any effect of type 1 DM on the skeletal bones in Bulgarian patients of both sexes. Some of our results have been confirmed by other researchers, but they used other methods for the assessment of these changes.[23-26] Bioelectrical impedance analysis, according to our team, is the most precise technique for determining how type 1 diabetes mellitus affects a person's body over the long term.

CONCLUSION

Bioelectrical impedance analysis of the body composition of Bulgarian female patients exhibited an increase in the accumulation of adipose connective tissue both generally and viscerally in comparison to healthy women at the same age. Furthermore, the mean value of visceral adipose connective tissue in female patients was twice as high as that in healthy women. The total body water percentage in the female patients was significantly lower than that in healthy controls.

A bioelectrical impedance analysis of the body composition of male patients from Bulgaria showed that visceral adipose tissue accumulation had increased as well. Men with diabetes had mean values of visceral fat tissue that were roughly twice as high as those of healthy men. The skeletal muscle tissue was reduced in male patients in comparison to that of healthy men.

These findings are a consequence of the impact of type 1 diabetes mellitus on the body composition in Bulgarian patients aged 20-40 years.

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Funding

The authors have no funding to report.

Competing Interests

The authors have declared that no competing interests exist.

Ethics approval

All patients gave their informed consent to participate in the study. The study was approved by the Ethics Committee at the Medical University of Plovdiv (No. 4/08.06.2022).

Author contributions

All authors took part in the study. M.O. and M.G. diagnosed and investigated the patients. A.B., Z.H., F.P., and T.P. investigated the healthy controls. A.B. and M.O. analyzed the data. T.P. and M.G. created the tables. A.B., F.P., and Z.H. wrote and translated the manuscript. All authors have seen and approved the manuscript and have contributed significantly for the paper.

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Оценка состава тела пожилых болгарских пациентов с сахарным диабетом 1 типа методом биоимпедансного анализа

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Резюме

Цель: Целью данного исследования было изучение того, как сахарный диабет 1 типа влияет на состав тела пожилых болгар.

Пациенты и методы: В исследовании приняли участие сто двадцать пациентов (60 мужчин и 60 женщин) в возрасте от 20 до 40 лет, а также 80 здоровых мужчин и женщин. Были определены показатели биоэлектрического импеданса: процент жировой ткани тела (%BFT), общий процент воды в организме (%TBW), висцеральная жировая ткань (VFT), мышечная масса (MM) и костная масса (BM) и производные показатели: общая жировая масса (TFM), активная масса тела (ABM), процент активной массы тела (%ABM), индекс ABM (ABMI) и ИМТ.

Результаты: Средние значения %BFT, VFT, TFM и ИМТ были значительно выше у женщин с сахарным диабетом 1 типа, в то время как средние значения %TBW, %ABM и ABMI были значительно выше у здоровых женщин. Средние значения VFM и ABMI были значительно выше у пациентов мужского пола с сахарным диабетом 1 типа, в то время как средние значения MM и ABM были значительно выше у здоровых мужчин. Анализ биоэлектрического импеданса состава тела у болгарских пациентов женского пола показал увеличение накопления жировой соединительной ткани как в целом, так и висцерально. Общий процент воды в организме у пациентов женского пола был значительно ниже, чем у здоровых лиц контрольной группы. Состав тела болгарских пациентов мужского пола показал увеличение накопления только висцеральной жировой ткани. Скелетная мышечная ткань у пациентов мужского пола показала снижение по сравнению со здоровыми мужчинами.

Заключение: Мы считаем, что эти результаты являются следствием влияния сахарного диабета 1 типа на состав тела у болгарских пациентов.

Ключевые слова

антропология, BIA, состав тела, болгары, СД1