Nutrition 29 (2013) 132–137

Contents lists available at ScienceDirect

Nutrition

journal homepage: www.nutritionjrnl.com

Applied nutritional investigation

Elderly subjects with type 2 diabetes show altered tissue electrical properties

Roberto Buffa Ph.D. [a], Bruno Saragat M.Sc. [a], Valeria Succa M.Sc. [a], Rossella Ruggiu M.Sc. [a], Luciano Carboni M.D. [b], Paolo F. Putzu M.D. [b], Elisabetta Marini Ph.D. [a,*]

[a] Department of Experimental Biology, Anthropological Science Section, University of Cagliari, Cagliari, Italy
[b] Geriatrics Division, SS. Trinità Hospital, Cagliari, Italy

ARTICLE INFO

Article history:
Received 27 January 2012
Accepted 9 May 2012

Keywords:
Body composition
Extracellular/intracellular water
Bioelectrical impedance vector analysis
Elderly
Type 2 diabetes

ABSTRACT

Objective: The aim of the present research was to show the characteristics of body composition in a sample of elderly subjects with type 2 diabetes compared with healthy controls matched by age and body mass index (BMI) by bioelectrical impedance vector analysis.
Methods: The sample consisted of 144 free-living patients (84 women and 60 men) with type 2 diabetes 60 to 84 y old and 209 age-matched controls (116 women and 93 men). Anthropometric measurements (weight; height; upper arm, hip, waist, and calf circumferences; biceps; triceps; and subscapular and suprailiac skinfolds) were taken. Blood samples for the assessment of plasma glucose and glycated hemoglobin were collected. The BMI, upper arm muscular area, and waist-to-hip ratio were calculated. Bioelectrical impedance vector analysis was applied. The analysis was performed in the entire diabetic sample and the healthy BMI-matched groups.
Results: Compared with healthy subjects, patients had greater weight ($P < 0.01$ in women), higher BMI ($P < 0.01$ in women), smaller muscular area ($P < 0.01$ in men), and thicker skinfolds ($P < 0.01$ in women and men). Female and male patients showed larger phase angles ($P < 0.01$). Moreover, female patients showed a shorter vector length and lower resistance ($P < 0.01$) and male patients showed a higher reactance ($P < 0.01$). The BMI-matched analysis confirmed that patients were characterized by larger phase angles.
Conclusions: Older patients with type 2 diabetes were characterized by peculiar anthropometric and bioelectrical patterns, which can be related to their smaller appendicular muscular area and lower extracellular/intracellular water ratio.

Introduction

Type 2 diabetes is often associated with obesity [1] and can be associated with alterations of the water compartment [2]. Excess body weight, particularly abdominal obesity, is recognized as one of the most important risk factors contributing to the upsurge in diabetes worldwide [3]. About 90% of people with type 2 diabetes are obese or overweight [4]. The role of weight loss in diabetic prevention is well established. Several clinical trials have shown that weight loss is the predominant predictor of a decreased diabetes incidence [5]. According to the Diabetes Prevention Program Research Group [6], the greatest risk decrease is seen in overweight individuals older than 60 y.

Type 2 diabetes mainly affects aged individuals [7] who are characterized by physiologic body mass and composition variations. Normal aging is associated with a first phase of increasing body mass, followed by a decreasing trend. The decrease is due mainly to the loss of fat-free mass, especially muscle mass [8]. Sarcopenia, and especially the combination of decreased muscle mass and strength, and excess weight play a major role in the pathogenesis of frailty and can lead to a significant increase of morbidity [9]. Moreover, elderly individuals, especially the oldest ones, are usually at risk of dehydration because of the decreased functional capacity of the kidney and impaired thirst perception [10]. However, cellular hydration does not seem to be affected in healthy aging, i.e., total body water, intracellular water (ICW), and extracellular water (ECW), decrease with age in proportion to the decrease of fat-free mass, whose hydration remains unchanged [11].

Older diabetics are particularly exposed to the risk of sarcopenia and dehydration [2,12]. Park et al. [13] found that older adults with diagnosed or undiagnosed type 2 diabetes are characterized by a more rapid loss of appendicular lean mass compared with non-diabetic individuals.

This research was financially supported by the University of Cagliari.
* Corresponding author. Tel.: +0039-070-675-6607; fax: +0039-070-675-6616.
E-mail address: emarini@unica.it (E. Marini).

0899-9007/$ - see front matter
http://dx.doi.org/10.1016/j.nut.2012.05.007

Effective health-promotion programs for the control of type 2 diabetes in the elderly need better definitions of the age-related variations of body mass and composition. However, research specifically directed to the assessment of body composition in older diabetics is scarce [13–15]. The reason for this lack of knowledge can be due in part to methodologic problems. The most accurate methods for the assessment of body composition, e.g., imaging techniques, and of hydration status, e.g., dilution techniques, are impractical in routine applications. Anthropometry and bioelectrical impedance analysis (BIA) are easy, time-saving, and cost-effective techniques but they are not very accurate. Bioelectrical impedance vector analysis (BIVA) [16] is based on the electrophysiologic analysis of the dielectric and conductive properties of human tissues, and it provides a semi-quantitative estimation of body cell mass and hydration. BIVA is more accurate than classic BIA because there is no need for predictive equations or models of the electrical properties of human tissues, whose application can lead to substantial estimation errors, especially in elderly or unwell individuals [17]. BIVA has been proved useful in clinical practice (see reviews by Kyle et al. [18], Barbosa-Silva and Barros [19], and Lukaski [20]) and in the assessment of nutritional status in the elderly [21–24].

The aim of the present research was to show the characteristics of body composition, as assessed by anthropometry and the BIVA procedure, in a sample of elderly subjects with type 2 diabetes compared with healthy controls matched by age and body mass index (BMI).

Material and methods

The sample consisted of 144 free-living patients (84 women and 60 men) with type 2 diabetes 60 to 84 y of age and 209 age-matched controls (116 women and 93 men). The mean age of the diabetic subjects was 69.6 ± 5.7 y for men and 71.6 ± 5.7 y for women, and that of the controls was 71.3 ± 5.8 y for men and 72.7 ± 6.3 y for women.

The patients were chosen from the Diabetes Service, Geriatrics Division, SS. Trinità Hospital, Cagliari, Italy. The diagnosis of diabetes was made according to the criteria of the Associazione Medici Diabetologici [25]. None of the patients were on insulin therapy. The control group did not include individuals who had been admitted to the hospital in the 3 mo before the investigation or were currently under medical treatment. Individuals with physical handicaps and/or uncompensated chronic diseases were excluded. According to the recommendations of the Declaration of Helsinki of 1975 as revised in 2008, all subjects were informed about the objectives and methods of the research, and they consented to participate in the study.

Blood samples for the assessment of plasma glucose and glycated hemoglobin were collected in a subsample of 93 patients (61 women and 32 men). Male and female patients were divided into two subgroups based on the glycated hemoglobin level using a cutoff of 6.5%, which can be considered an indicator of the disease and the risk of long-term complications [26]. Within each sex, the bioelectrical characteristics in the two groups were compared by Student's *t* test.

Anthropometric measurements (weight; height; upper arm, hip, waist, and calf circumferences; biceps; triceps; and subscapular and suprailiac skinfolds) were taken according to standard international criteria [27]. The BMI, upper arm muscular area (AMA), and waist-to-hip ratio were calculated [27]. Anthropometric measurements indicative of body composition (skinfolds and AMA) were adjusted for weight by covariance analysis. Anthropometric characteristics were compared between patients and controls by Student's *t* test (sexes separated).

Resistance (R) and reactance (Xc) were measured with a single-frequency impedance analyzer (BIA 101, Akern srl, Florence, Italy). Impedance measurements were taken using the standard positions of the outer and inner electrodes on the right hand and foot [28]. The phase angle was calculated as arctan(Xc/R) and the impedance vector as $(R^2 + Xc^2)^{0.5}$. As required by BIVA [16], the R and Xc values were standardized by height. Individual vectors were plotted in the tolerance ellipses, which were drawn using the bioelectrical values of healthy controls. The vector position in the plane allows the analysis of body composition: the minor axis indicates cell mass (larger cell mass on the left side) and the major axis refers to hydration status (dehydrated individuals toward the upper pole).

Mean impedance vectors in the diabetic and control groups were compared statistically with the Hotelling T^2 test. To eliminate the effect of size, the analyses were repeated in subgroups defined by BMI cutoffs [29] indicative of normal weight (BMI 18.5–24.9 kg/m^2), overweight (BMI >25 kg/m^2), and obesity (BMI >30 kg/m^2).

Results

Compared with controls, men with type 2 diabetes had thicker skinfolds and smaller AMAs (Table 1). Women showed more marked differences: greater weight; larger upper AMA, waist, and calf circumferences; greater waist-to-hip ratio; thicker skinfolds; and a higher BMI (Table 1). After adjustment

Table 1
Descriptive and comparative statistics of anthropometric values

	Men					Women				
	Control ($n = 93$)		Patients ($n = 60$)		*P*	Control ($n = 116$)		Patients ($n = 84$)		*P*
	Mean	SD	Mean	SD		Mean	SD	Mean	SD	
Weight (kg)	73.6	11.4	76.5	11.8	—	65.0	12.5	70.4	12.0	†
Stature (cm)	161.5	5.9	163.0	6.1	—	149.5	6.2	150.2	6.0	—
Upper arm circumference (cm)	28.5	3.0	28.9	2.9	—	28.7	3.6	29.9	4.1	*
Waist circumference (cm)	98.7	9.5	96.0	9.2	—	91.5	12.3	95.6	12.0	*
Hip circumference (cm)	102.6	8.0	101.4	7.8	—	105.6	10.8	107.1	11.1	—
Calf circumference (cm)	35.6	3.2	35.0	3.9	—	34.4	3.5	35.6	4.1	*
Biceps skinfold (mm)	9.5	4.8	14.1	8.0	†	17.0	7.2	21.4	10.0	†
Triceps skinfold (mm)	14.7	6.4	24.4	8.3	†	27.0	8.4	32.2	10.2	†
Subscapular skinfold (mm)	20.6	7.3	25.6	8.2	†	26.5	8.6	31.3	10.8	†
Suprailiac skinfold (mm)	26.3	8.6	27.3	12.7	—	28.2	9.6	32.8	11.7	†
AMA (cm^2)	46.1	11.3	36.6	9.9	†	33.5	11.6	31.8	8.3	—
BMI (kg/m^2)	28.2	4.1	28.8	4.4	—	29.0	4.8	31.2	5.1	†
WHR	0.96	0.06	0.95	0.05	—	0.87	0.07	0.89	0.07	*
Values adjusted for body weight										
Biceps skinfold (mm)	9.1	4.4	13.2	7.5	†	17.9	6.6	21.4	9.2	†
Triceps skinfold (mm)	14.2	5.8	23.4	7.6	†	27.9	7.7	32.2	9.0	†
Subscapular skinfold (mm)	19.7	6.4	23.7	6.5	†	28.3	6.8	31.3	9.1	†
Suprailiac skinfold (mm)	24.8	7.9	25.0	10.2	—	29.9	9.3	32.9	9.7	*
AMA (cm^2)	44.6	9.6	33.6	10.0	†	36.2	9.7	31.8	7.9	†

AMA, arm muscular area; BMI, body mass index; WHR, waist-to-hip ratio
* $P < 0.05$.
† $P < 0.01$.