Prediyabetik Obezler Kadınlarda Vücut Kompozisyonunu Etkileyen Klinik ve Biyokimyasal Faktörler

Clinical and Biochemical Factors Influence the Body Composition in Prediabetic Obese Women

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Abstract

Background: Obesity is a public-health problem related with important chronic diseases such as diabetes. We aimed to investigate the clinical utility of bioelectrical impedance analysis (BIA) in determination of body composition and influence of body fat and visceral fat on clinical and metabolic parameters in premenopausal obese women with prediabetes.

Methods: Sixty normoglycemic subjects (group 1), 65 subjects with impaired fasting glucose (IFG) (group 2) and 33 subjects with impaired glucose tolerance (IGT) or IFG+IGT (group 3) were included.

Results: Visceral fat mass (VF) and percentage of fat free mass (FFM%), body fat (BF%) determined by BIA were similar in both groups. BF% and VF has been found to be correlate with other body composition parameters such as height, weight, body mass index (BMI), waist circumference (WC), hip circumference (HC); additionally, VF showed positive correlation with AST ($p<0.001$) and ALT levels ($p=0.003$) in prediabetic study population (groups 2 and 3).

Conclusion: Parameters determined by BIA correlate with standard methods used in clinical practice such as weight, BMI, WC and HC suggest us the validity of the method in determining body composition. Further studies are needed to examine the association between transaminases and VF measured by BIA in hepatosteatosis and in other conditions.

Key words: Obesity, body composition, visceral fat, transaminases

Özet

Amaç: Obezite, diyabet gibi önemli kronik hastalıklara yol açan bir halk sağlığı problemidir. Bizde prediyabetik premenapozal obez kadınlarda biyoelektriksel empedans analiz (BEA) yönteminin vücut kompozisyonunu saptamada klinik kullanımını ve vücut yağının ve visseral yağın klinik ve biyokimyasal parametrelere etkisini incelemeyi amaçladık.

Materyal Metod: Çalışmaya 60 normoglisemikler kadın (grup 1), 65 bozulmuş açlık glikozu (BAG) olan kadın (grup 2), 33 bozulmuş glukoz toleransı (BGT) veya BAG+BGT olan kadın (grup 3) dahil edildi.

Bulgular: BEA ile saptanan visseral yağ kütlesi (VYK) ve yağsız kütle oranı (%YK), vücut yağ oranı (%VY) tüm gruplarda benzerdi. %VY ve VYK; boy, kilo, vücut kütle indeksi (VKI), bel çevresi (BÇ), kalça çevresi (KÇ) gibi parametreler ile korele bulundu. Ayrıca VYK prediabetik gruplarda (grup 2 ve 3) AST ($p<0.001$) ve ALT ($p=0.003$) seviyeleri ile korele bulundu.

Sonuç: BEA ile saptanan parametrelerin klinik pratikte kullanılan kilo, VKI, BÇ ve KÇ gibi parametreler ile korele olması vücut kompozisyonunu saptamada geçerli bir metot olduğunu göstermektedir. Transaminazlar ve BEA ile saptanan visseral yağ arasındaki ilişkinin hepatosteatoz ve diğer durumlarda araştırılması için kapsamlı çalışmalara ihtiyaç vardır.

Anahtar kelimeler: Obezite, vücut bileşimi, visseral yağ, transaminazlar

Introduction

Obesity is an important health problem, with implications for risk of diseases such as diabetes, cardiovascular disease and some cancers (1). Obesity has been shown to mediate these pathologic conditions by triggering other cardiovascular risk factors such as dyslipidaemia, hypertension and glucose intolerance (2-4). Increase in body fat alters the cellular response to insulin, leads to insulin resistance, and also creates a proinflammatory state, which increase the risk of thrombosis (5).

Body mass index (BMI) is frequently used to define and classify obesity in clinical practice, though it is not able to distinguish between lean and fat body mass (6). Increased body fat is closely related with metabolic and cardiovascular risk in both healthy and obese population (5, 7, 8). Dual-energy X-ray absorptiometry (DEXA), bioelectrical impedance analysis (BIA) and anthropometry are indirect methods, which are used to estimate body adiposity. Waist circumference (WC) and waist-to-hip ratio (WHR) are anthropometry measurement for detecting abdominal visceral adiposity. The other method, BIA, is based on the conduction of an electrical current throughout the body for estimating total body fat (9). There are no enough data about the clinical significance of these indirect methods and their impact on several clinical and metabolic variables.

In this study, we aimed to compare the clinical utility of BIA, BMI, WC and WHR in determination of body composition and to detect clinical and metabolic parameters having influence on body fat and visceral fat in obese women with prediabetes.

Material and methods

Study population

The current study included 158 obese (BMI $\geq$ 30 kg/m^2) women which were selected from patients referred to endocrinology outpatient unit for evaluation obesity. The participants aged from 18 to 65 years stratified into 3 groups according to their standard 75 gr oral glucose tolerance test (OGTT) results. Group 1 (n=60) were composed of normoglycemic subjects, whereas group 2 (n=65) subjects with impaired fasting glucose (IFG) and group 3 (n=33) subjects with impaired glucose tolerance (IGT) or IFG+IGT. Patients with DM, ischemic heart disease, cerebrovascular disease, chronic liver and renal diseases, thyroid dysfunction and uncontrolled hypertension were excluded. Height, weight, WC, hip circumference (HC), systolic and diastolic blood pressures were recorded. Informed consent obtained before study inclusion. The study protocol conforms to the principles of the Helsinki Declaration and approved by the local Medical Ethics Committee.

Measurements of Adiposity

Blood pressure and anthropometric indexes were

measured by the same trained assistant. BMI (kg/m2) was computed from measurements of weight and height with the participant in light clothes and without shoes. WC, HC and WHR were determined at the same visit. WC was obtained from the thinnest part of the participant at the end of the expiration, and HC was measured at the maximum circumference over the buttocks. Body composition including visceral fat mass (VF) and percentage of fat free mass (FFM%), body fat (BF%) were determined by BIA method (Omron BF510, Omron Healthcare Co. Ltd., Kyoto, Japan). The instrument calculated these parameters automatically by the after input of age, sex and height.

Biochemical measurement

Venous blood samples were collected after an overnight fast. Samples were centrifuged immediately and serum samples were stored at -80 ^{o}C until analysis. Fasting glucose, urea, creatinine, aspartate aminotransferase (AST), alanine aminotransferase (ALT), total-cholesterol (TC), HDL-cholesterol (HDL-C), and triglyceride (TG) levels were determined by photometric method using commercial kits (Abbott, U.S.A). LDL-cholesterol (LDL-C) was calculated using the Friedewald formula. Thyrotropin (TSH) was analysed by electrochemiluminescence immunoassay (ECLIA) with Modular Analytics E170 immunoassay (Roche Diagnostics). Then a standard 75-gr OGTT was performed.

Statistical analysis

The statistical analysis was conducted using SPSS for Windows 15.0 (SPSS, Chicago, IL, USA). Continuous variables were expressed as mean ± standard deviation (SD) and categorical variables were expressed as percentages. Analysis of normality of the continuous variables was performed with the Kolmogorov–Smirnov test. Comparison of categorical variables between the three groups was performed using the $\chi 2$ test. Comparison of continuous variables between the three groups was performed using the one-way ANOVA with Bonferoni correction. The correlation between OPG, CIMT and continuous clinical and laboratory parameters was assessed by the Pearson correlation test. A two-tailed $p < 0.05$ was considered statistically significant.

Results

Demographic characteristics the study groups are shown in Table 1. Mean age, height, body weight, BMI, WC, HC, WHR, systolic and diastolic blood pressures, urea, creatinine, TSH, AST and ALT levels, lipid parameters, VF, FFM% and BF% of the study groups were similar. Mean A1c of group 3 was significantly higher than group 1 (p=0.001). Mean fasting plasma glucose levels were significantly higher in both groups 2 and 3 when compared group 1; the mean 2nd hour plasma glucose level of group 3 was significantly higher than both groups 1 and 2 (all p<0.001). Mean HOMA-IR of the group 1 was significantly lower when compared with both groups 2 and 3 (p<0.001 and p=0.043, respectively) (Table 2).

In prediabetic study population (groups 2 and 3), BF% has been found to be correlate with height (p=0.017), weight (p<0.001), BMI (p<0.001), WC (p<0.001), HC (p<0.001) and FFM% (p<0.001); VF showed positive correlation with age (p<0.001), height (p=0.034), weight (p=0.001), BMI (p<0.001), WC (p<0.001), HC (p<0.001), AST (p<0.001) and ALT levels (p=0.003) (Table 3).

Discussion

We evaluated the clinical and biochemical factors which may have influence on body composition parameters of obese women with pre-diabetes. To our knowledge this is the first study in which body composition is assessed by an indirect method in this patient population. We observed that (i) any of the prediabetic states in obese women is not affected by

body composition parameters; (ii) BF% and VF measured by BIA were correlates with other anthropometrics measurement such as weight, BMI, WC, HC and WHR; (iii) VF shows positive correlation with hepatic transaminases.

Although it does not distinguish between lean body mass and fat body mass, BMI is the most tool which is used to determine body composition in clinical practice and studies. Computed tomography is accepted the most accurate and reproducible technique for abdominal fat assessment; however, its expensive cost and exposure to ionizing radiation limits its use (10). Recent reports revealed that BIA is superior to BMI in terms of accurate estimation of body fat and it is efficient, safe and reproducible technique for clinical and epidemiologic purposes (11, 12).

Previous studies have shown that central adiposity correlates with glucose intolerance in lean subjects but not in obese ones (13, 14). Yunxian et al. demonstrated that high truncal obesity was associated with increased odds of prediabetes and lower insulin sensivity in normal or overweight women (15). In a meta-analysis, BMI, WC and WHR have shown to predict the presence of type 2 DM (16). Unwin et al. reported that BMI, WC and WHR were associated with glucose intolerance in non-obese subjects (17). No correlation has been found between anthropometrics measurement (BMI, WC, WHR and central and total fat) and insulin resistance indexes and prediabetic conditions in our finding about the obese prediabetic women.

In clinical practice, BMI is usual method used for determination of obesity and it has been shown to associate with several cardiovascular risk factors, such as hyperglycemia, high blood pressure, metabolic syndrome, albuminuria, left ventricular hypertrophy and low-grade inflammation (18). Furthermore, WC and WHR significantly associate with cardiovascular risk (19). We found that BF% and VF on BIA were both correlated with weight, BMI, WC, HC and WHR. We also showed that BMI is an independent predictor of BF% in our study. Further studies showing the relationship between the measurements obtained by BIA and the surrogate markers of cardiovascular risk, such as left ventricular hypertrophy, carotid intima-media thickness and markers of inflammation will be more suggestive for the clinical utility of BIA in determination of body composition.

Association between hepatic transaminases and VF has been reported in a few studies in which researchers measured VF with conventional methods such as computed tomography or DEXA (20-24). The use of BIA in estimation of VF is a recent development in the research area and the data about the efficacy of the method in clinical practice is growing (25-27). To our knowledge the relationship between hepatic transaminases and VF measured by BIA has never been reported before. We found VF correlate with transaminase levels prediabetic obese women. As mentioned before, BIA is safe, practical and efficient method when compared with computed tomography. The clinical importance of VF measurement by BIA in hepatic steatosis need to be further investigated.

Parameters determined by BIA correlate with standard methods used in clinical practice such as weight, BMI, WC, HC and WHR indicating the validity of the method in determining body composition. Furthermore, body composition parameters obtained with BIA do not predict any of the prediabetic states in obese women as it has been shown before in studies using standard BMI, WC, and WHR. However, further studies are needed to examine the association between hepatic steatosis and VF measured by BIA in different population and the role of BIA in estimating cardiovascular risk instead of BMI, WC and WHR in prediabetic obese women.

Table 1: Demographic characteristics of study groups

Parameters	**Group 1 (n=60)**	**Group 2 (n=65)**	**Group 3 (n=33)**	**p**
Age (year)	39.7±11.5	42.2±9.9	44.3±7.6	0.096
Smoking (yes/no)	12/48	12/53	7/26	0.945
Hypertension history (yes/no)	12/48	15/50	12/21	0.200
Height (cm)	155.3±6.3	155.3±5.0	155.7±6.1	0.947
Weight (kg)	99.1±16.2	96.6±13.2	99.8±12.7	0.490
BMI (kg/m^2)	41.1±6.5	40.1±5.6	41.3±5.5	0.559
Waist circumference (cm)	115.0±9.6	112.6±10.7	15.4±9.5	0.283
Hip circumference (cm)	127.4±8.8	126.6±9.7	128.8±10.4	0.576
Waist-hip ratio	0.9±0.05	0.9±0.05	0.9±0.06	0.298
SBP (mmHg)	123.3±12.1	127.4±9.9	123.6±12.2	0.111
DBP (mmHg)	77.3±8.3	79.1±8.1	78.2±10.1	0.645

Abbreviations: BMI: body mass index, DBP: diastolic blood pressure, SBP: systolic blood pressure

Table 2: Biochemical characteristics of study groups

Parameters	Group 1 (n=60)	Group 2 (n=65)	Group 3 (n=33)	p
Parameters	**Group 1 (n=60)**	**Group 2 (n=65)**	**Group 3 (n=33)**	**p**
Urea (mg/dL)	25.4±7.2	23.8±5.9	23.6±5.5	0.279
Creatinine (mg/dL)	0.7±0.1	0.6±0.1	0.6±0.1	0.297
AST (U/L)	18.8±6.5	19.9±7.7	21.3±7.8	0.234
ALT (U/L)	21.7±11.4	22.9±12.1	24.4±13.1	0.556
T-C (mg/dL)	191.6±33.0	203.4±38.5	195.8±44.7	0.214
LDL-C (mg/dl)	114.5±31.2	124.8±33.3	116.9±43.7	0.236
HDL-C (mg/dl)	43.7±7.9	47.9±10.3	46.2±10.9	0.051
TG (mg/dl)	167.0±84.6	153.3±71.7	163.6±90.9	0.624
A1c (%) [a]	5.9±0.4	6.0±0.4	6.2±0.4	0.001
TSH (μU/l)	2.5±1.3	2.1±1.0	2.0±1.2	0.120
Body fat (%)	49.6±5.5	50.1±4.0	50.6±4.2	0.540
Visceral fat mass (kg)	10.9±2.4	11.4±3.1	12.2±2.2	0.074
Fat free mass (%)	22.8±2.7	22.6±1.9	22.1±2.0	0.322
Glucose 0.hour (mg/dl) [b]	89.9±6.6	107.3±6.0	106.1±12.7	<0.001
Glucose 2. hour (mg/dl) [c]	107.2±18.7	107.1±22.6	156.2±10.2	<0.001
HOMA-IR [d]	2.1±1.6	3.9±2.1	3.1±2.0	<0.001

Abbreviations: AST: aspartate aminotransferase, ALT: alanine aminotransferase, HDL-C: high density lipoprotein cholesterol, HOMA-IR: Homeostasis Model of Assessment - Insulin Resistance, LDL-C: low density lipoprotein cholesterol, TG: triglyceride, TC: total cholesterol, TSH: thyroid stimulant hormone.

[a]: between group 1 and group 3 p=0.001

[b]: between group 1 and group 2; between group 1 and group 3 p<0.001

[c]: between group 1 and group 3; between group 2 and group 3 p<0.001

[d]: between group 1 and group 2 p<0.001; between group 1 and group 3 p=0.043

Table 3: Correlation analysis of the demographic and clinical parameters with body fat and visceral fat

	Body fat (%)		Visceral fat mass (kg)	
	Body fat (%)		Visceral fat mass (kg)	
	r	p	r	p
Age (year)	-0.044	0.666	0.553	<0.001
Height (cm)	-0.241	0.017	-0.215	0.034
Weight (kg)	0.531	<0.001	0.330	0.001
BMI (kg/m^2)	0.572	<0.001	0.363	<0.001
Waist circumference (cm)	0.503	<0.001	0.492	<0.001
Hip circumference (cm)	0.553	<0.001	0.482	<0.001
Waist-hip ratio	0.043	0.675	0.138	0.176
SBP (mmHg)	0.068	0.504	-0.058	0.568
DBP (mmHg)	0.130	0.201	-0.102	0.320
Urea (mg/dL)	-0.048	0.641	0.075	0.465
Creatinine (mg/dL)	-0.042	0.679	0.093	0.362
AST (U/L)	-0.147	0.149	0.397	<0.001
ALT (U/L)	-0.113	0.427	0.292	0.003
T-C (mg/dL)	-0.138	0.174	0.153	0.132
LDL-C (mg/dl)	-0.171	0.093	0.141	0.166
HDL-C (mg/dl)	0.111	0.278	0.001	0.991
TG (mg/dl)	-0.029	0.776	0.062	0.542
A1c (%)	0.006	0.940	0.085	0.286
TSH (µU/l)	-0.102	0.319	0.086	0.398
Body fat (%)	-	-	0.157	0.124
Visceral fat mass (kg)	0.157	0.124	-	-
Fat free mass (%)	-0.901	<0.001	-0.107	0.297
Glucose 0.hour (mg/dl)	-0.091	0.374	0.007	0.946
Glucose 2. hour (mg/dl)	0.082	0.425	0.136	0.181
HOMA-IR	-0.134	0.188	0.026	0.799

Abbreviations: AST: aspartate aminotransferase, ALT: alanine aminotransferase, BMI: body mass index, DBP: diastolic blood pressure, HDL-C: high density lipoprotein cholesterol, HOMA-IR: Homeostasis Model of Assessment - Insulin Resistance, LDL-C: low density lipoprotein cholesterol, SBP: systolic blood pressure, TG: triglyceride, TC: total cholesterol, TSH: thyroid stimulant hormone

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References:

1) Haslam DW, James WPT. Obesity. Lancet 2005;366:1197–1209.

2) Pi-Sunyer FX. Health implications of obesity. Am J Clin Nutr 1991;53:1595–1603.

3) World Health Organization. Prevention of Coronary Heart Disease. Report of a WHO Expert Committee. Technical Report Series. WHO: Geneva, 1982;678.

4) Welty TK. Health implications of obesity in American Indians and Alaska Natives. Am J Clin Nutr 1991;53:1616–1620.

5) Wang C, Hou XH, Zhang ML, Bao YQ, Zou YH, Zhong WH, Xiang KS, Jia WP. Comparison of body mass index with body fat percentage in the evaluation of obesity in Chinese. Biomed Environ Sci 2010;23(3):173-179.

6) Peltz G, Aguirre MT, Sanderson M, Fadden MK. The role of fat mass index in determining obesity. Am J Hum Biol 2010;22(5):639-647.

7) Lee K, Lee S, Kim YJ, Kim YJ. Waist circumference, dual-energy X-ray absortiometrically measured abdominal adiposity, and computed tomographically derived intra-abdominal fat area on detecting metabolic risk factors in obese women. Nutrition 2008;24(7-8):625-631.

8) Dervaux N, Wubuli M, Megnien JL, Chironi G, Simon A. Comparative associations of adiposity measures with cardiometabolic risk burden in asymptomatic subjects. Atherosclerosis 2008;201(2):413-417.

9) Lukaski HC. Methods for the assessment of human body composition: traditional and new. Am J Clin Nutr 1987;46(4):537-556.

10) Berker D, Koparal S, Işik S, Paşaoğlu L, Aydin Y, Erol K, Delibaşi T, Güler S. Compatibility of different methods for the measurement of visceral fat in different body mass index strata. Diagn Interv Radiol 2010;16(2):99-105.

12) Nagaya T, Yoshida H, Takahashi H, Matsuda Y, Kawai M. Body mass index (weight/height2) or percentage body fat by bioelectrical impedance analysis: which variable better reflects serum lipid profile? Int J Obes Relat Metab Disord 1999;23:771-774.

13) Peltz G, Aguirre MT, Sanderson M, Fadden MK. The role of fat mass index in determining obesity. Am J Hum Biol 2010;22(5):639-647.

14) Gómez-Ambrosi J, Silva C, Galofré JC, Escalada J, Santos S, Gil MJ, Valentí V, Rotellar F, Ramírez B, Salvador J, Frühbeck G. Body adiposity and type 2 diabetes: increased risk with a high body fat percentage even having a normal BMI. Obesity (Silver Spring) 2011;19(7):1439-1444.

15) Chang CJ, Wu CH, Lu FH, Wu JS, Chiu NT, Yao WJ. Discriminating glucose tolerance status by regions of interest of dual-energy X-ray absorptiometry. Clinical implications of body fat distribution. Diabetes Care 1999;22(12):1938-1943.

16) Yu Y, Venners SA, Wang B, Brickman WJ, Zimmerman D, Li Z, Wang L, Liu X, Tang G, Xing H, Xu X, Wang X. Association of central adiposity with prediabetes and decreased insulin sensitivity in rural Chinese normal-weight and overweight women. Metabolism 2010;59(7):1047-1053.

17) Qiao Q, Nyamdorj R. Is the association of type II diabetes with waist circumference or waist-to-hip ratio stronger than that with body mass index? Eur J Clin Nutr 2010;64(1):30-34.

18) Unwin N, Harland J, White M, Bhopal R, Winocour P, Stephenson P, Watson W, Turner C, Alberti KG. Body mass index, waist circumference, waist-hip ratio, and glucose intolerance in Chinese and Europid adults in Newcastle, UK. J Epidemiol Community Health 1997;51(2):160-166.

19) Hofsø D, Nordstrand N, Johnson LK, Karlsen TI, Hager H, Jenssen T, Bollerslev J, Godang K, Sandbu R, Røislien J, Hjelmesaeth J. Obesity-related cardiovascular risk factors after weight loss: a clinical trial comparing gastric bypass surgery and intensive lifestyle intervention. Eur J Endocrinol 2010;163(5):735-745.

20) Huxley R, Mendis S, Zheleznyakov E, Reddy S, Chan J. Body mass index, waist circumference and waist:hip ratio as predictors of cardiovascular risk--a review of the literature. Eur J Clin Nutr 2010;64(1):16-22.

21) Mochizuki K, Miyauchi R, Misaki Y, Shimada M, Kasezawa T, Tohyama K, Goda T. Accumulation of visceral fat is positively associated with serum ALT and γ-GTP activities in healthy and preclinical middle-aged Japanese men. J Nutr Sci Vitaminol (Tokyo) 2011;57(1):65-73.

22) Eguchi Y, Mizuta T, Sumida Y, Ishibashi E, Kitajima Y, Isoda H, Horie H, Tashiro T, Iwamoto E, Takahashi H, Kuwashiro T, Soejima S, Kawaguchi Y, Oda Y, Emura S, Iwakiri R, Ozaki I, Eguchi T, Ono N, Anzai K, Fujimoto K, Koizumi SJ. The pathological role of visceral fat accumulation in steatosis, inflammation, and progression of nonalcoholic fatty liver disease. Gastroenterol 2011;46:70-78.

23) Verrijken A, Francque S, Mertens I, Talloen M, Peiffer F, Van Gaal L. Visceral adipose tissue and inflammation correlate with elevated liver tests in a cohort of overweight and obese patients. Int J Obes (Lond) 2010;34(5):899-907.

24) Ruhl CE, Everhart JE. Trunk fat is associated with increased serum levels of alanine aminotransferase in the United States. Gastroenterology 2010;138(4):1346-1356. Song HR, Yun KE, Park HS. Relation between alanine aminotransferase concentrations and visceral fat accumulation among nondiabetic overweight Korean women. Am J Clin Nutr 2008;88(1):16-21.

25) Fernandes RA, Rosa CS, Buonani C, Oliveira AR, Freitas Junior IF. The use of bioelectrical impedance to detect excess visceral and subcutaneous fat. J Pediatr (Rio J) 2007;83:529–534.

26) Ryo M, Maeda K, Onda T, Katashima M, Okumiya A, Nishida M, Nishida M, Yamaguchi T, Funahashi T, Matsuzawa Y, Nakamura T, Shimomura I. A new simple method for the measurement of visceral fat accumulation by bioelectrical impedance. Diabetes Care 2005;28:451–453

27) Watson S, Blundell HL, Evans WD, Griffiths H, Newcombe RG, Rees DA. Can abdominal bioelectrical impedance refine the determination of visceral fat from waist circumference? Physiol Meas 2009;30(7):53-58.