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CORRELATION OF VISCERAL FAT AREA WITH METABOLIC RISK FACTORS IN ROMANIAN PATIENTS: A CROSS-SECTIONAL STUDY

Anca Hâncu ✉, *Gabriela Radulian*

University of Medicine and Pharmacy „Carol Davila", Bucharest, Romania

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Abstract

Background and Aims: *The aim of the present study was to investigate the relationship between visceral fat area (VFA), estimated by bioimpedance, and cardiovascular risk factors independent of BMI and waist circumference in a cohort of Romanian patients.* ***Material and Methods:*** *This was a cross-sectional study, in which were collected data from 751 patients ≥18 years of age from Cluj-Napoca. Anthropometric, biochemistry, body composition and medical history parameters were recorded from patients' files.* ***Results:*** *Compared with the participants with VFA <100 cm^2, those with VFA ≥100 cm^2 had significantly worse levels of the laboratory parameters describing the glycemic metabolism, lipid metabolism and liver functions (p <0.05 for all). A higher percentage of participants with VFA ≥100 cm^2 had diabetes, obesity, hypertension, hypertriglyceridemia and hypo-HDL cholesterolemia (p <0.05 for all). VFA was correlated with systolic and diastolic blood pressure, total and LDL-cholesterol levels, triglycerides, ALT, previous diagnosis of diabetes, hypertriglyceridemia and hypo-HDL cholesterolemia independent of BMI and waist circumference.* ***Conclusions:*** *Among this cohort of Romanian adults, an increasing level of visceral adiposity was correlated with worse lipid and glucose metabolism parameters as well as with increased levels of ALT, which probably reflects liver fat deposition.*

key words: *visceral fat area, metabolic risk factors, body mass index, waist circumference*

Background and aims

Although it has been recognized as a major risk factor for chronic diseases, such as diabetes [1,2], and national programs have been implemented worldwide to increase the population awareness for its complications, obesity remains a major public health problem worldwide [3]. The most recent data reported by the World Health Organization showed that more than five hundred million persons were obese in 2014 [3]. For Romania, two recent researches reported a crude prevalence of obesity of 21.3% [4] and an age and gender-adjusted prevalence of 31.4% [5].

The diagnosis of overweight and obesity is based on two anthropometric parameters: the body mass index (BMI) and the waist circumference [6,7]. Although cheap and easy to be determined, these parameters can only provide a rough estimation of the body fat accumulation [6]. BMI has been shown to have a good correlation with the total body fat, but it cannot differentiate between the lean and fat

✉ Tel.: +40723203101; *corresponding author e-mail*: ancahancu@gmail.com

mass and does not provide information on the body fat distribution. Clinical studies have depicted the association of the visceral fat accumulation (irrespective of the total body fat quantity, as assessed by BMI), with metabolic risk factors [8,9], and consecrated it as a predictor for metabolic disorders including dyslipidemia [10], all forms of glucose metabolism disorders [11,12], and metabolic syndrome [13]. Today it is recognized that excess visceral adiposity precedes the clinical manifestations of the metabolic syndrome and, in the absence of an appropriate clinical management, this will worsen and will finally lead to type 2 diabetes mellitus and cardiovascular diseases (CVDs) [14].

Therefore, waist circumference, which takes into consideration the body fat distribution, has been proposed for a better evaluation of obesity. Waist circumference has been shown to have a good association with CVD risk factors especially diabetes [15]. However, waist circumference cannot accurately differentiate between the visceral fat accumulation and the subcutaneous one [16].

Dual-energy X-ray absorptiometry is considered the gold standard for the assessment of total and regional fat and lean mass [17]. However, it is not widely available due to high cost of the equipment, and its use is associated with a risk of radiation exposure. In recent years, advances in bioelectrical impedance analysis and its low costs have increased the acceptance of bioelectrical impedance analysis in assessing body composition in research and clinical settings. Furthermore, in the past 10 years it has become the most commonly used method of assessing the body composition in clinical settings in Romania. However, only a limited number of studies assessing the association of body composition, evaluated by bioimpedance, with cardiovascular risk factors are available [18-20].

The aim of the present study was to investigate the relationship between visceral fat area (VFA), as estimated by the bioimpedance method, and cardiovascular risk factors independent of BMI and waist circumference in a cohort of Romanian patients.

Material and Methods

Study design and participants

This was a cross-sectional study, in which we collected data from the files of men and women ≥18 years of age who had visited an outpatient clinic from Cluj-Napoca, Romania, for a nutrition, diabetes or obesity consultation. Patients were included if they had complete data on body fat composition, metabolic investigations (fasting plasma glucose [FPG], total cholesterol, HDL-cholesterol, triglycerides) and blood pressure measurements. No data were collected from pregnant or lactating women or from patients with a prior history of malignancy or liver diseases, including viral hepatitis, autoimmune hepatitis, primary biliary cirrhosis, drug or alcohol induced liver disease.

Ethical Issues

Only anonymized data were collected; no name, initials or file number were recorded in the database. The institutional review board approved the collection of these data.

Data collected

The following anthropometric data were recorded: age (years), height (cm), weight (kg), waist circumference (cm), and hip circumference (cm). Waist to hip ratio was calculated as waist circumference (cm)/ hip circumference (cm). BMI was calculated as weight (kg)/ [height $(m)]^2$. Abdominal obesity was defined as a waist circumference ≥80 cm in women and ≥94 cm in men according to the 2009 consensus statement of the International Diabetes Federation;

National Heart, Lung and Blood Institute; American Heart Association; World Heart Federation; International Athersclerosis Society and International Association for the Study of Obesity [21].

Biochemical measurements recorded were: FPG, aspartate aminotransferase (AST), alanine aminotransferase (ALT), total cholesterol, HDL-cholesterol and triglycerides. If triglycerides levels were <400 mg/dl, LDL-cholesterol was calculated using the Friedewald equation [22]: LDL-cholesterol= total cholesterol – HDL-cholesterol – triglycerides/5.

Hypertriglyceridemia was defined when triglycerides levels were ≥150 mg/dL, hypo-HDL cholesterolemia was considered when HDL levels were <40 mg/dL in men or <50 mg/dL in women. Hyper-LDL cholesterolemia when the LDL-cholesterol was ≥100 mg/dL. The diagnosis of diabetes and arterial hypertension was recorded from participants' files.

VFA (cm) and body fat mass (BFM, kg) were measured by bioelectric impedance, using InBody (720) device (Biospace, Korea). InBody (720) is a multifrequency impedance plethysmograph body composition analyzer, which takes readings from the body using an eight-point tactile electrode method, measuring resistance at five specific frequencies (1 kHz, 50 kHz, 250 kHz, 500 kHz, and 1 MHz) and reactance at three specific frequencies (5 kHz, 50 kHz, and 250 kHz). These are pre-set by the manufacturer to assess extracellular fluid and total body water and introduced into the body in ascending order of frequency. VFA and BFM are automatically determined when the patient is staying on the electrodes embedded within the scale platform of each octapolar analyzer.

Statistical analysis. Statistical analysis was carried out using the SPSS-PC 17.0 (SPSS Inc., Chicago, IL, USA) software. The distribution of variables was tested with the Kolmogorov-Smirnov test. Statistical data is presented as mean ± standard deviation (SD) for normally-distributed variables, median (1st quartile; 3rd quartile) for variables with abnormal distribution and percentage for categorical variables. For variables with a normal distribution means were compared by Student t-test; for variables with abnormal distribution medians were compared by Mann-Whitney U test. The relationship between VFA, BFM, anthropometric measurements and biochemical measurements was assessed by Pearson and Spearman correlation coefficients. For all tests p-value was considered statistically significant if <0.05 and the two tailed p value was calculated.

Results

We collected data from 751 participants (55.1% men) with a mean age of 46.2 years (Table 1). Of the enrolled participants 376 (50.1%) had diabetes, 452 (60.2%) obesity and 452 (60.2%) hypertension. Based on the laboratory results, 405 (53.9%) had hypertriglyceridemia, 397 (52.9%) had hypo-HDL cholesterolemia and 491 (65.4%) had hyper-LDL cholesterolemia. 647 (86.2%) participants had elevated VFA (≥100 cm^2). Among the patients with hypertriglyceridemia 56 had triglycerides levels above 400 mg/dl. For these patients the LDL-cholesterol could not be calculated and they were not included in the analyses related to LDL-cholesterol.

Table 1. Anthropometric, body composition analysis and metabolic characteristics of study participants.

Parameter	Value
Age, years	46.2±13.6
Men, n (%)	414 (55.1%)
Weight, kg	94.6±21.9
BMI, kg/m^2	32.3±6.7
Waist circumference, cm	107.4±16.5
Waist to hip ratio	0.98 (0.94; 1.03)
VFA, cm^2	152.4±50.0
BFM, kg	34.8±14.2
SBP, mmHg	133.1±20.6
DBP, mmHg	83.9±12.1

FPG, mg/dl	119.0 (96.0; 171.5)
Total-cholesterol, mg/dl	189.0 (156.0; 221.0)
HDL-cholesterol, mg/dl	43.0 (35.0; 53.0)
LDL-cholesterol, mg/dl	110.3±43.7
Triglycerides, mg/dl	158.0 (105.0; 229.0)
AST, UI/l	25.0 (10.0; 32.75)
ALT, UI/l	27.0 (19.05; 41.9)
Diabetes, n (%)	376 (50.1%)
Obesity, n (%)	452 (60.2%)
Arterial hypertension, n (%)	452 (60.2%)
Smoking, n (%)	100 (13.3%)

BMI, body fat mass; VFA, visceral fat area; BFM, body fat mass; SBP, systolic blood pressure; DBP; diastolic blood pressure; FPG, fasting plasma glucose; AST, aspartate aminotransferase; ALT, alanine aminotransferase

Compared with the participants with VFA <100 cm^2, those with VFA ≥100 cm^2 were older and had significantly higher weight, BMI, waist circumference and waist to hip ratio (Table 2). Except for LDL-cholesterol, all laboratory parameters describing the glycemic metabolism, lipid metabolism and liver functions were significantly worse in participants with VFA ≥100 cm^2 than in those with VFA <100 cm^2 ($p <0.05$ for all). Furthermore, a significantly higher percentage of participants with VFA ≥100 cm^2 had diabetes, obesity, hypertension, hypertriglyceridemia and hypo-HDL cholesterolemia ($p <0.05$ for all).

Table 2. Comparison of anthropometric, body composition analysis and metabolic characteristics between participants with visceral fat area <100 cm^2 and ≥100 cm^2.

Variable	VFA <100 cm^2	VFA ≥100 cm^2	p
Age, years	34.5±12.7	48.1±12.8	<0.001
Men, n (%)	24 (23.1%)	390 (60.3%)	<0.001
Weight, kg	70.7±11.9	98.5±20.7	<0.001
BMI, kg/m^2	25.0±4.1	33.5±6.3	<0.001
Waist circumference, cm	85.2±10.5	110.9±14.3	<0.001
Waist to hip ratio	0.88 (0.84; 0.9)	1.0 (0.96; 1.04)	<0.001
BFM, kg	20.7±8.7	37.0±13.6	<0.001
SBP, mmHg	118.1±19.5	135.5±19.7	<0.001
DBP, mmHg	74.9±10.9	85.3±11.7	<0.001
Total-cholesterol, mg/dl	95.0 (85.0; 133.0)	124.0 (100.0; 176.0)	<0.001
HDL-cholesterol, mg/dl	178.0 (149.0; 197.0)	191.0 (158.0; 222.0)	0.010
LDL-cholesterol, mg/dl	50.5 (40.1; 62.5)	42.0 (34.4; 51.1)	<0.001
Triglycerides, mg/dl	104.4±42.1	111.2±43.9	0.147
AST, UI/l	102.5 (79.9; 139.0)	168.0 (115.0; 240.0)	<0.001
ALT, UI/l	22.0 (18.0; 29.0)	25.4 (20.0; 33.5)	0.044
Total-cholesterol, mg/dl	19.0 (14.0; 27.0)	28.5 (21.0; 44.0)	<0.001
Diabetes, n (%)	35 (33.7%)	341 (52.7%)	<0.001
Obesity, n (%)	12 (1.5%)	440 (68.1%)	<0.001
Arterial hypertension, n (%)	20 (19.2%)	432 (66.8%)	<0.001
Hyper-LDL cholesterolemia, n (%)	68 (68.0%)	428 (71.9%)	0.473
Hypertriglyceridemia, n (%)	21 (20.2%)	384 (59.4%)	<0.001
Hypo-HDL cholesterolemia, n (%)	44 (42.3%)	353 (54.6%)	0.026
Smoking, n (%)	17 (26.6%)	83 (21.6%)	0.474

BMI, body fat mass; VFA, visceral fat area; BFM, body fat mass; SBP, systolic blood pressure; DBP; diastolic blood pressure; FPG, fasting plasma glucose; AST, aspartate aminotransferase; ALT, alanine aminotransferase

Patients with abdominal obesity were significantly older, had a higher weight, BMI, VFA and BFM compared to the patients without abdominal obesity ($p <0.001$ for all). Additionally the systolic and diastolic blood pressure were significantly higher. In terms of biochemical determinations, a significant difference between the two groups was observed only in terms of HDL-cholesterol which was lower in those with abdominal obesity when compared to the ones without abdominal obesity and triglycerides which were significantly higher in patients with abdominal obesity. No difference was observed for the FPG, total cholesterol and LDL-cholesterol levels and neither in terms of the frequency of diabetes and hyper-LDL cholesterolemia (Table 3).

Table 3. Comparison of anthropometric, body composition analysis and metabolic characteristics between participants with and without abdominal obesity.

Variable	Without abdominal obesity	With abdominal obesity	p
Age, years	39.1± 15.0	46.8 ± 13.4	<0.001
Men, n (%)	33 (55.9%)	381 (55.1%)	0.897
Weight, kg	65.2 ±9.2	97.1±20.8	<0.001
BMI, kg/m^2	22.8 ± 2.7	33.1± 6.3	<0.001
Waist to hip ratio	0.88 (0.83; 0.9)	0.99 (0.95; 1.04)	<0.001
VFA, cm^2	76.2 ±33.3	158.9 ±45.6	<0.001
BFM, kg	16.0 ± 5.9	36.4 ± 13.5	<0.001
SBP, mmHg	122.8±23.6	134.0± 20.1	<0.001
DBP, mmHg	76.8±13.5	84.5±11.8	<0.001
FPG, mg/dl	112 (87; 212)	120 (97; 170)	0.6614
Total-cholesterol, mg/dl	180 (147; 224)	190 (157; 221)	0.3077
HDL-cholesterol, mg/dl	50 (39; 64)	42.3 (34.6; 52)	0.0006
LDL-cholesterol, mg/dl	108.6 ±50.2	110.4 ± 43.1	0.3837
Triglycerides, mg/dl	110 (87.1; 178)	160 (107; 237.5)	0.0001
AST, UI/l	21.9 (18; 28.7)	25 (20; 33)	0.0036
ALT, UI/l	19 (13; 31)	28 (20; 43.8)	<0.001
Diabetes, n (%)	29 (49.15%)	346 (50.0%)	0.901
Arterial hypertension, n (%)	18 (50.5%)	434 (62.7%)	<0.001
Hyper-LDL cholesterolemia, n (%)	42 (72.41	454 (71.3%)	0.854
Hypertriglyceridemia, n (%)	40 (67.8%)	306 (44.2%)	<0.001
Hypo-HDL cholesterolemia, n (%)	36 (61.0%)	318 (46.0%)	0.026
Smoking, n (%)	6 (19.35%)	94 (22.5%)	0.919

BMI, body fat mass; VFA, visceral fat area; BFM, body fat mass; SBP, systolic blood pressure; DBP; diastolic blood pressure; FPG, fasting plasma glucose; AST, aspartate aminotransferase; ALT, alanine aminotransferase

Table 4. Comparison of anthropometric, body composition analysis and metabolic characteristics between participants with and without obesity as assessed by body mass index.

Variable	BMI <30 kg/m2	BMI ≥30 kg/m2	p
Age, years	46.6±14.4	45.9±13.1	0.490
Men, n (%)	155 (52.0%)	259 (57.3%)	0.177
Weight, kg	76.0±11.3	107.0±18.2	<0.001
Waist circumference, cm	93.5±10.7	116.5±12.8	<0.001
Waist to hip ratio	0.93 (0.88; 0.97)	1.02 (0.99; 1.06)	<0.001
VFA, cm^2	117.9±38.6	175.2±43.2	<0.001
BFM, kg	22.7±6.1	42.8±12.2	<0.001
SBP, mmHg	129.9±21.6	135.2±19.6	<0.001
DBP, mmHg	81.4±12.5	85.5±11.7	<0.001
FPG, mg/dl	127.0 (94.0; 182.5)	117.0 (98.0; 166.0)	0.263
Total-cholesterol, mg/dl	188.0 (156.0; 223.5)	190.0 (156.0; 219.5)	0.963
HDL-cholesterol, mg/dl	45.9 (36.5; 57.3)	42.0 (34.0; 51.1)	0.019
LDL-cholesterol, mg/dl	107.8 (79.8; 138.2)	105.0 (79.5; 133.2)	0.412
Triglycerides, mg/dl	142.0 (93.0; 206.5)	167.0 (115.0; 241.5)	0.013
AST, UI/l	23.0 (18.4; 29.9)	26.6 (21.0; 35.2)	<0.001
ALT, UI/l	23.0 (16.0; 35.4)	30.0 (22.0; 47.8)	<0.001
Diabetes, n (%)	171 (57.4%)	204 (45.1%)	0.001
Arterial hypertension, n (%)	149 (50.0%)	302 (66.8%)	<0.001
Smoking, n (%)	45 (25.3%)	55 (20.3%)	0.406

BMI, body fat mass; VFA, visceral fat area; BFM, body fat mass; SBP, systolic blood pressure; DBP; diastolic blood pressure; FPG, fasting plasma glucose; AST, aspartate aminotransferase; ALT, alanine aminotransferase

Participants with obesity as quantified by BMI had significantly higher weight, waist circumference, VFA, BFM, systolic and diastolic blood pressure, triglycerides and liver enzymes (Table 4, p <0.001 for all). No difference between the two groups was observed with regards to FPG, total cholesterol and LDL-cholesterol (p >0.05 for all).

Correlation coefficients between VFA, BMI and waist circumference and clinical/metabolic parameters are displayed in Table 5. All these parameters were correlated with systolic and diastolic blood pressure, HDL-cholesterol, triglycerides, AST, ALT, arterial hypertension and the presence of the hypo-HDL cholesterolemia. Both VFA and waist were correlated with age, sex, FPG, hypertriglyceridemia and hyper-LDL cholesterolemia. The variable with which both VFA and BMI were correlated was the diagnosis of diabetes (Table 5).

After adjustment for BMI and waist circumference VFA remained significantly correlated with systolic and diastolic blood pressure, total and LDL-cholesterol, triglycerides, ALT, previous diagnosis of diabetes, hypertriglyceridemia and hypo-HDL cholesterolemia (Table 6).

Table 5. Correlation coefficients for visceral fat area, body mass index, waist circumference and clinical and metabolic characteristics.

Variables	VFA		BMI		Waist circumference	
	coefficient	p	coefficient	p	coefficient	p
Age, years	0.371	<0.001	-0.017	0.641	0.168	<0.001
Sex	-0.433	<0.001	-0.033	0.366	-0.326	<0.001
SBP, mmHg	0.297	<0.001	0.125	0.001	0.243	<0.001
DBP, mmHg	0.293	<0.001	0.175	<0.001	0.267	<0.001
FPG, mg/dl	0.219	<0.001	-0.058	0.110	0.138	<0.001
Total-cholesterol, mg/dl	0.028	0.449	-0.060	0.102	-0.041	0.262
HDL-cholesterol, mg/dl	-0.229	<0.001	-0.144	<0.001	-0.275	<0.001
LDL-cholesterol, mg/dl	-0.011	0.756	-0.074	0.042	-0.079	0.031
Triglycerides, mg/dl	0.271	<0.001	0.143	<0.001	0.272	<0.001
AST, UI/l	0.237	<0.001	0.206	<0.001	0.247	<0.001
ALT, UI/l	0.322	<0.001	0.267	<0.001	0.328	<0.001
Diabetes, n (%)	0.151	<0.001	-0.170	<0.001	0.042	0.253
Arterial hypertension, n (%)	0.395	<0.001	0.211	<0.001	0.311	<0.001
Hyper-LDL cholesterolemia	0.075	0.041	0.069	0.058	0.076	0.037
Hypertriglyceridemia	-0.175	<0.001	-0.070	0.055	-0.176	<0.001
Hypo-HDL cholesterolemia	-0.179	<0.001	-0.112	0.002	-0.220	<0.001

BMI, body fat mass; VFA, visceral fat area; BFM, body fat mass; SBP, systolic blood pressure; DBP; diastolic blood pressure; FPG, fasting plasma glucose; AST, aspartate aminotransferase; ALT, alanine aminotransferase

Table 6. Correlation coefficients for visceral fat area adjusted for body mass index and waist circumference with different clinical and metabolic parameters.

Variables	VFA	
	coefficient	p
SBP, mmHg	0.160	<0.001
DBP, mmHg	0.128	0.001
FPG, mg/dl	0.064	0.098
Total-cholesterol, mg/dl	0.106	0.006
HDL-cholesterol, mg/dl	0.020	0.607
LDL-cholesterol, mg/dl	0.078	0.044
Triglycerides, mg/dl	0.084	0.029
AST, UI/l	0.042	0.283
ALT, UI/l	0.107	0.006

Table 6. *Continued.*

Variables	VFA	
	coefficient	p
Diabetes, n (%)	0.161	<0.001
Arterial hypertension, n (%)	0.195	<0.001
Hyper-LDL cholesterolemia	0.015	0.706
Hypertriglyceridemia	-0.144	0.003
Hypo-HDL cholesterolemia	0.112	0.004

VFA, visceral fat area; SBP, systolic blood pressure; DBP; diastolic blood pressure; FPG, fasting plasma glucose; AST, aspartate aminotransferase; ALT, alanine aminotransferase

Discussion

The main finding of our study was the correlation between VFA and cardiovascular risk factors – i.e. diabetes, arterial hypertension, hypertriglyceridemia, hyper-LDL cholesterolemia and hypo-HDL cholesterolemia. After adjustment for BMI and waist, the correlations between VFA, diabetes, arterial hypertension, hypertriglyceridemia and hypo-HDL cholesterolemia remained statistically significant. Although after adjustment for BMI and waist circumference the correlation between VFA and hyper-LDL cholesterolemia was no longer significant, the VFA remained significantly correlated with the LDL-cholesterol values. These suggests that BMI and waist do not account for the relationship between the VFA and the glucose and lipid metabolism. It has long been recognized that the excessive accumulation of adipose tissue and especially its central distribution with abdominal accumulation as visceral fat is a risk factor for cardiovascular diseases, type 2 diabetes mellitus, non-alcoholic fat liver disease, neoplasia, polycystic ovary syndrome, and chronic kidney disease [8,10,11,13-15,23-29]. Visceral fat is considered a trigger of metabolic dysfunction due to increased lipolysis and the consequent release of free fatty acids, increased cytokine expression and impaired secretion of adipokines as compared to other fat depots [30].

In the present study, in participants with VFA ≥100 cm^2, all laboratory parameters describing the glycemic metabolism, lipid metabolism and liver functions were significantly worse than in those with VFA <100 cm^2 ($p < 0.05$ for all). Additionally the VFA was significantly correlated with total cholesterol, LDL-cholesterol and triglycerides after controlling for BMI and waist circumference. These results are similar to the ones reported by Xu et al who showed that VFA was correlated with FPG and Hb1Ac after controlling for age and BMI [31]. Hayashi et al analyzed the data from 128 adults followed for 10 to 11 years and showed that an increase of VFA is associated with a 3.82 higher risk of developing impaired glucose tolerance and the association remained statistically significant after adjustment for total fat area, total subcutaneous fat area, or abdominal subcutaneous fat area [11].

In terms of lipid metabolism, correlations between visceral adiposity and HDL-cholesterol and triglycerides were previously reported [32,33]. In our study the VFA was correlated with HDL-cholesterol levels but this correlation was no longer significant after controlling for the BMI and waist circumference, thus suggesting a relationship between subcutaneous adipose tissue and HDL-cholesterol levels or between other fat depots and HDL-cholesterol. However, previously it was shown that visceral adipose tissue remained correlated with lipid parameters after control for abdominal subcutaneous adipose tissue and that the later one was not correlated with the lipid profile after controlling for visceral adipose tissue [34]. Therefore, we can hypothesize that other fat depots are correlated with the HDL-cholesterol levels.

An interesting observation was the higher AST and ALT levels in participants with VFA ≥100 cm^2 compared to the ones with VFA <100 cm^2 and the correlation between the VFA and ALT levels, which was independent of BMI and waist circumference. The results presented here are consistent with those of other studies suggesting that visceral adipose tissue may play a key role in the pathogenesis of non-alcoholic fatty liver disease. Stranges et al [35] showed that central obesity, independent of BMI, predicts increased levels of ALT, but not AST. Recently, Ruhl et al [36] used the 1999–2004 National Health and Nutrition Examination Survey (NHANES) cohort to evaluate ALT as a function of trunk fat mass, trunk lean mass, extremity fat mass, and extremity lean mass measured by DXA. Although in the initial evaluation all four body composition measurements correlated positively with a risk of ALT elevation, multivariate adjustment revealed that trunk fat was associated independently with ALT. The authors concluded that trunk fat is a determinant of increased ALT, supporting the hypothesis that liver injury can be induced by metabolically active intraabdominal fat.

The present study has several limitations resulting from its cross-sectional design with collection of data from participants' files. This is known to be associated with a high risk of missing data, especially on some cofounders. However, the physical examinations would have limited the ability to enroll this large sample of participants.

Conclusion

This study shows that among Romanian adults, an increasing level of visceral adiposity was correlated with the lipid and glucose metabolism parameters as well as with increased levels of ALT, which probably reflects liver fat deposition. Prospective studies are warranted to confirm these findings.

Ethical Issues. Only anonymized data were collected; no name, initials or file number were recorded in the database. The institutional review board approved the collection of this data.

Conflict of Interest. The authors declare no conflict of interest in relation to the current manuscript.

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